WHITE-TAILED DEER HABITAT USE
ON
SURFACE-MINED AREAS IN EASTERN KENTUCKY

A Thesis

Presented to

the Faculty of the College of Science and Technology

Morehead State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Biology

---

by

Devetta A. Hill

July 2, 1993

Accepted by the faculty of the College of Science and Technology, Morehead State University, in partial fulfillment of the requirements for the Master of Science degree.

Director of Thesis

Master's Committee: ______________________, Chairman

____

____

____

7-2-93

Date

ABSTRACT

WHITE-TAILED DEER HABITAT USE ON SURFACE-MINED AREAS IN EASTERN KENTUCKY

Devetta A. Hill
Morehead State University, 1993

Director of Thesis: Jerry F. Howell, Jr.

White-tailed deer (*Odocoileus virginianus*) habitat use was studied on four reclaimed areas, two contour areas and two mountaintop removal areas, on a surface coal mine in eastern Kentucky. Vegetation was sampled through identification of species and estimation of plant cover. All areas were dominated by Kentucky-31 fescue (*Festuca arundinacea*). Cover densities of five legumes were significantly different in the four areas. Legumes were yellow sweet clover (*Melilotus officinalis*), F=10.52, P=0.0005; white clover (*Trifolium repens*), F=6.83, P=0.0036; Korean lespedeza (*Lespedeza stipulacea*), F=3.30, P=0.0475; and black locust (*Robinia pseudoacacia*), F=4.57, P=0.0170. Vegetation diversity was determined by the Shannon-Weaver diversity index. Indices were highest on the two mountaintop removal areas, MTR (H'=0.497) and SKB (H'=0.406). Habitat use was estimated by monthly pellet counts and biweekly by direct observations during two time periods per day and spotlighting during one time period per day. Due to high variability in the afternoon direct observation time period (RSE = 60.9%), the period was eliminated and the morning time period was combined with the spotlight counts. The percentage of deer observed was greatest on the contour area, SS2 (42.9%) and least on MTR(1.5%). Wilcoxon's Rank Sum test for the mean combined deer observations indicated deer use of MTR was significantly different from all areas (P=0.0001 in all comparisons) at the P=0.05 level. The percentage of pellet groups counted was greatest on SS1 (52.1%) and least on MTR (0%). Wilcoxon's Rank Sum test for the mean pellet group comparison indicated MTR was significantly different from all areas (P=0.0001 in all comparisons) at the P=0.05 level.

Accepted by: Jerry F. Howell Jr., Chairman
Howard L. Setser
Leo Meade
Roland L. Burns

ACKNOWLEDGMENTS

I wish to thank Dr. Jerry Howell, Jr. for his help in completing this project. I also thank the other committee members, Dr. Les Meade, Dr. Howard Setser, and Dr. Roland Burns, for their suggestions.

I would like to thank Martin County Coal Company, especially Mr. Raymond Bradbury and Mr. Joe Evans, for allowing me access to their surface mines.

I am deeply grateful to a number of employees of the Kentucky Department for Fish and Wildlife Resources: Mr. Kenneth Goforth, Mr. Greg Powers, Mr. Larry Short, and Mr. Steve Bonney. I especially wish to thank Mr. Scott Hale for the time and effort he spent statistically analyzing the data for this research.

I also appreciate the efforts of several Department for Surface Mining Reclamation and Enforcement employees: Mr. Lee Henderson, Mr. Bennett Muncy, Mr. Neil Stinson, Mr. John Heinz, Mr. Vernon Robinson, Mr. Jim Hill, Ms. Brenda Parks, Mr. John Mark Clements, and Mr. Richard Daye.

I am indebted to Ms. Peggy Measel, Ms. Sue Minks, and Mr. Fred Faulkner for their help and encouragement.

My sincere thanks go to my family. Mr. Kenneth B. Hill, Ms. Wilma LeMaster, Mr. Dean Hill, and Mr. Richard Kelly proved to be excellent deer spotters. My mother, Ms. Irene Hill, was my right-hand "woman." She helped with all the pellet counts and collecting data.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure

INTRODUCTION

Appalachian coal fields cover approximately 72,000 square miles in parts of nine states. These fields extend from Pennsylvania to Alabama, with eastern Kentucky, Virginia and the southern third of West Virginia forming the central portion (Vogel, 1987). In eastern Kentucky, the fields comprise approximately 11,000 square miles and contain the highest elevations and areas of greatest local relief in Kentucky (Kentucky Department for Surface Mining Reclamation and Enforcement, 1988).

The Big Sandy River Basin is the epicenter of the eastern Kentucky-Virginia coal fields and its Levisa-Tug Fork region derives much of its economy from coal mining and its related industries (Cox and Howell, 1980). Much of the mining conducted in this region is surface or strip mining, a method that can degrade and permanently alter existing ecosystems due to the adverse effects of resource depletion and pollution. Thousands of acres in the Basin have been destroyed by contour cuts, mountaintop removals, hollowfills, and other mining practices (Cox and Howell, 1980), carelessly planned with little regard for their environmental impact prior to strict federal and state regulatory efforts. Contour cuts and mountaintop removals are the two surface mining methods considered in this study.

Contour mining removes coal by making contiguous cuts along the contour of a hillside. The resultant vertical highwall is required, by law, to be eliminated and backfilled to the approximate original contour. Because the mining method can determine the post-mining land use, contour mined areas are frequently reclaimed to forestry or fish and wildlife habitat. Usually, these areas are unsuited for hayland or pasture due to slope steepness. Mountaintop removal mining methods extract the coal by cutting the top off the mountain (usually down to the lowest coal seam economically feasible to mine). Mountaintop removal methods generally leave the area fairly flat or with gently rolling slopes, usually capable of supporting most post-mining land uses, including hayland or pasture.

Because surface mining methods can have potentially devastating effects upon land and water ecosystems, the coal industry and state government work together to minimize the destruction wrought in pursuit of one of Kentucky's most valuable natural resources. Kentucky's permanent program regulations for surface coal mining and reclamation operations mandate that coal operators minimize disturbances and adverse impacts on fish, wildlife, and related environmental values, and achieve enhancement of those resources, where practicable, as per 405 KAR 16:180, Section 1,1. The coal operator is required to create a post-mining land use equal to or surpassing the pre-mining land use. Where wildlife habitat is eliminated or temporarily disturbed and the land form is modified, the coal operator must develop a reclamation plan to reconstruct disturbed areas to meet or exceed pre-mining standards.

A reclamation plan encompasses all aspects of the reconstruction process. The plan must address the construction of final ground configurations, re-topsoiling, revegetation (including seeding, fertilizing, and mulching), and describe how the selected post-mining land use will be achieved. Even though each coal company must address the same criteria for each reclamation plan, no two plans are exactly alike due to differences in mining methods used and site-specific topography.

An acceptable reclamation plan takes into account the effects surface mining have on local plant and wildlife species and tries to reconstruct a functional habitat. One of the most important considerations in creating suitable wildlife habitat is vegetation. Kentucky's surface mining regulations require the seed mix to include species from several categories, such as legumes, temporary and permanent grasses, and where applicable, trees. The best seed mixes do not limit themselves to one species per category and should not include Kentucky-31 fescue (*Festuca arundinacea*) or sericea lespedeza (*Lespedeza cuneata*), both of which have a low value for wildlife (Vogel, 1987).

White-tailed deer (*Odocoileus virginianus*) are impacted tremendously by surface mining operations. Sparrowe and Springer (1970) and Wiggers and Beason (1986) found deer relied heavily on dense cover for protection. In the early stages of mining, dense cover is eliminated by clear-cutting the forest to expose the soil and the underlying coal seams. Forest clear-cutting also eliminates food sources that deer utilize, especially during winter months (Brenner and Musaus, 1977). As mining progresses, an enormous amount of sedimentation is created, and if left unchecked, will adversely affect both ground and surface water sources on which deer depend.

All these changes force deer to seek habitats that can meet their requirements for survival. The return of deer to mined areas may depend on what mining method was used, how long ago the areas were reclaimed, and the plant species used to revegetate.

The objective of this study was to determine to what extent deer utilize reclaimed contour and mountaintop surface-mined areas. All of the study areas have fish and wildlife post mining land uses. The mining method used and the vegetation used to reclaim the areas were two major variables considered. The influence of free-grazing cattle was also considered. This evaluation focused on composition, density, and diversity of vegetation and quantification of habitat use by deer.

MATERIALS AND METHODS

Study Area

Data were collected from four surface-mined areas on Martin County Coal Company property, approximately 9.7km northwest of Moree, Martin County, Kentucky. The area is located in rugged mountainous terrain on a high plateau, with elevations ranging from 366m to 427m. The region has a temperate climate, with a mean annual temperature of 15°C and a mean annual precipitation of 113.6cm (Kentucky Climate Center, 1981). Vegetation on the unmined areas adjacent to the study sites consisted of second growth forest with the uplands dominated by northern red oak (*Quercus rubra*), black oak (*Quercus nigra*), chestnut oak (*Quercus prinus*), and hickory (*Carya spp.*), and the lowlands dominated by sycamore (*Platanus occidentalis*) and tulip poplar (*Liriodendron tulipifera*).

The study area consisted of four surface mining permit areas; two utilized contour mining and two utilized mountaintop removal. Reclamation began in 1984 and 1985 for the contour areas and 1985 and 1987 for the mountaintop removal areas. Approximately 205.6ha have been reclaimed; 98.4ha were contour mined and 107.2ha were mountaintop removed (Figure 1). The reclamation process consisted of highwall elimination on all contoured areas, replacement of the soil horizons, seedbed preparation, seeding, fertilizing, and mulching. The seed mixes varied slightly, but had the following species in common: white clover (*Trifolium repens*), red clover (*Trifolium pratense*), birdsfoot trefoil (*Lotus corniculatus*), Kentucky-31 fescue (*Festuca arundinacea*), and black locust (*Robinia pseudoacacia*). All of the reclaimed areas were grazed by approximately 75 head of free-roaming cattle.

Vegetation Sampling

Plant species were sampled in August, 1988 on four-, three-, and one-year-old reclaimed sites. Each area was sampled by five systematically-placed line transects oriented in random compass directions (Medcraft, 1984). On each transect, eight 0.5m^2

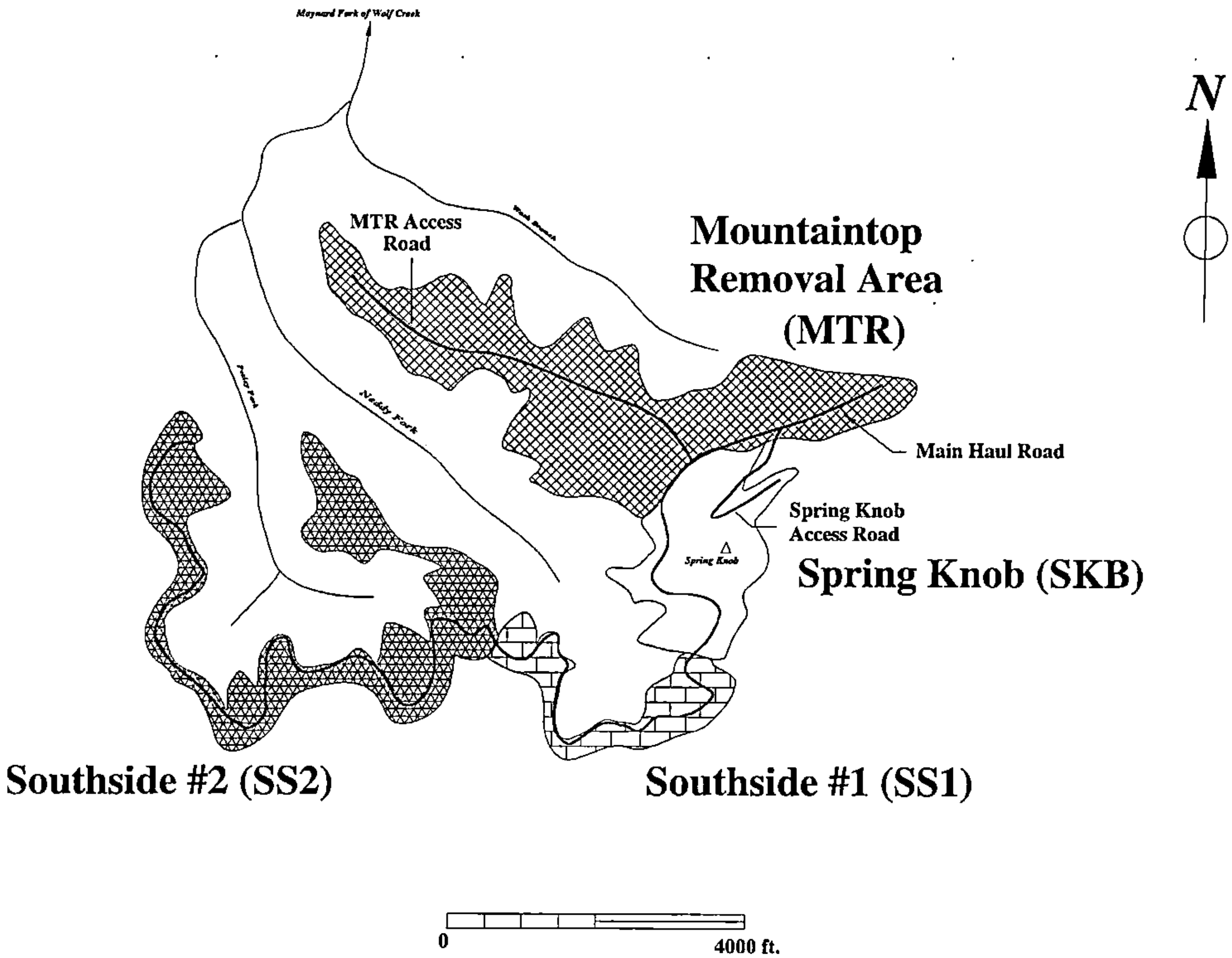

Figure 1. Reclaimed study areas with survey routes.

plots were sampled at points located at 5m intervals. The number of individuals and the percent cover (to the nearest 5%) of each plant species were estimated for each plot (Medcraft, 1984). Shannon-Weaver species diversity indices (Smith, !986) were calculated for each area and averaged for each reclaimed area.

Habitat Use Surveys

The deer population was estimated by using the spotlight census method the Kentucky Department of Fish & Wildlife Resources uses for deer spotlight surveys (Mitchell, 1986). A total of seven spotlight surveys were conducted and the mean number of deer observed was determined. The area of visibility was determined by stopping every 0.10km and estimating the area clearly visible. Visibility was estimated only once for this set of surveys. Hectares of visibility was divided by the mean deer seen to arrive at the hectares per deer ratio. Total surface mine hectares were divided by the hectares per deer ratio to calculate the total deer observed.

Habitat use by white-tailed deer was estimated by three methods: direct observations, spotlight surveys, and pellet counts. Direct observations and spotlight surveys were performed biweekly; pellet counts were performed monthly. Sampling was conducted from July, 1988 to March, 1989.

Direct observations were conducted by driving a 9.7km route over mine roads (Figure 1). The first 4.2km of the survey route allowed observation of 107.2ha of the reclaimed mountaintop removal areas and the next 5.5km of survey route covered 98.4ha of the reclaimed contour-mined areas. Four direct observation surveys were conducted biweekly over a two-day period by driving the entire route at the same times (sunrise to 0900 hrs and 1100 hrs to 1300 hrs) each day.

Deer observed by direct observation were categorized by number of individuals and habitat type where observed. The number of individuals observed per km of survey route in each habitat type was used to determine habitat use (Medcraft, 1984).

Two spotlight surveys, utilizing a 200,000 candlepower spotlight and the same 9.7km route, were conducted biweekly over a two-day period at the same time (sunset to 2100hrs) each day. Spotlighting was done from a vehicle traveling approximately 15km/hr. When deer were spotted, the vehicle was stopped and the deer were counted. After the deer were counted, the observers made loud noises to jump any deer that remained hidden. The number of individuals and the habitat type where observed were recorded. The number of individuals observed per km of survey route in each habitat type was used to represent habitat use (Medcraft, 1984).

Pellet counts were conducted on five transect lines (200m long) established in random compass directions on each of the four areas. Monthly pellet counts were made by walking the transect lines and counting the number of fresh pellet groups encountered within a 2m corridor along the transect line. Each pellet group of 30 pellets or more (Neff, 1968) was recorded and spray painted with bright orange paint to indicate the group had been counted. To lessen observer error, all five transects on each study site were walked by the same two observers each time. Habitat use was estimated by adjusting pellet group densities to a per ha basis and multiplying by the area of each study site (Loft and Kie, 1988).

Statistical Analysis

Analyses were performed to indicate differences in plant densities among the four habitats, and seek correlations between plant densities, species diversity, and habitat use. For each major plant species, analysis of variance was performed with PROC GLM (SAS, 1988) to determine if differences in percent cover were significant at the P=0.05 level, and among which habitats they differed. Simple linear correlations were conducted among mean percentages of plant cover, the Shannon-Weaver diversity indices, total observations, the mean percentage of vegetation and total pellet counts of the combined four areas with PROC CORR (SAS, 1988). Significance was also defined as being at the P=0.05 level.

Comparisons of deer use in each of the four areas were made from annual totals for morning and afternoon direct observation, spotlight, and pellet count methods. Means and associated standard errors were determined for each observation period and pellet counts. Observation periods and pellet counts in each area were further examined through determining relative standard errors (RSE), calculated as the standard error divided by the mean and expressed as a percentage. In addition to describing the variability during each period, calculation of the RSE was used to estimate sample size necessary to produce reasonable statistical comparisons (RSE $\leq$ 20%). The sample size formula was:

$$N = \left(\frac{\text{standard deviation}}{0.2 \times \text{mean}} \right)^2$$

Wilcoxon's Rank Sum tests were used as an option in the PROC NPAR1WAY procedure to indicate differences between observation periods for each area (where appropriate). The same method was applied to pellet count data.

Wilcoxon's Rank Sum tests were again used to indicate differences in habitat use. Habitats were tested in pairs for each method of observation and tests of all possible permutations were performed. Overall conclusions were based on comparisons of these results. All tests were conducted at the P=0.05 level.

RESULTS

Vegetation

Kentucky-31 fescue was the dominant plant species in all areas (Table 1). Mean fescue cover ranged from 41.8% of SKB to 57% of SS2. Legumes made up the next largest composition percentage while incidentals, such as *Digitaria spp.* and *Robinia pseudoacacia*, contributed 4% or less to the plant mix.

Percentages of vegetation cover differed among some species in the four areas (Table 2). The densities of five species, all legumes, were significantly different: *Melilotus officinalis* (F=10.52, P=0.0005), *T. repens* (F=6.83, P=0.0036), *L. corniculatus* (F=11.39, P=0.0003), *Lespedeza stipulacea* (F=3.30, P=0.0476), and *R. pseudoacacia* (F=4.57, P=0.0170).

The areas where these five legumes were significantly different can be inferred from Tables 1 and 2. *M. officinalis* was found only on the two mountaintop removal areas, with SKB having the largest percentage, 21.6%. SKB and SS1 had small percentages of *T. repens*, 6.0% and 5%, respectively, and were the only areas to have this species. SS2 was the only area that did not have *L. corniculatus* in the vegetative mix. *L. corniculatus* was a significant contributor to the vegetative mix on MTR (33.8%), SKB (24.0%) and SS1 (36.2%). *R. pseudoacacia* was found only on the SS1 area and contributed a small percentage, 4.0%, to the vegetative mix. MTR and SS2 had small percentages, 7.0% and 19.0% respectively, of *L. stipulacea*.

The two mountaintop removal areas (MTR and SKB) had higher Shannon-Weaver diversity indices (Table 3) than the contour areas (SS1 and SS2). The more-recently reclaimed MTR had the highest diversity index, H' = 0.497, and the older SS2 had the lowest value, H' = 0.363. The Shannon-Weaver diversity indices were significantly correlated with the total number of deer observed (P=0.0179, R= -0.9821). Diversity was inversely related to deer use of the four reclamation sites.

Table 1. Mean percentage of vegetative species in each study area.

Species	Mountaintop Removal MTR	Spring Knob SKB	Southside #1 SS1	Southside #2 SS2
Festuca arundinacea	51.6	41.8	49.0	57.0
Trifolium pratense	13.6	20.0	4.0	26.2
Melilotus officinalis	14.6	21.6		
Trifolium repens		6.0	5.0	
Lotus corniculatus	33.8	24.0	36.2	
Coronilla varia			6.0	
Digitaria spp.				3.0
Robinia pseudoacacia			4.0	
Lespedeza stipulacea	7.0			19.0

Table 2. Comparison of mean percent of vegetative cover for each study area using one-way analysis of variance.

Species	F - Value	P≥F
Festuca arundinacea	1.32	0.3068
Trifolium pratense	2.35	0.1112
Melilotus officinalis	10.52	0.0005
Trifolium repens	6.83	0.0036
Lotus corniculatus	11.39	0.0003
Coronilla varia	2.67	0.0829
Digitaria spp.	1.0	0.4182
Robinia pseudoacacia	4.57	0.0170
Lespedeza stipulacea	3.30	0.0476

Table 3. Shannon-Weaver diversity indices for vegetation on reclaimed areas in August, 1988.

Area	Reclamation Age	Diversity
Mountaintop Removal (MTR)	1987	0.497
Spring Knob (SKB)	1985	0.406
Southside #1 (SS1)	1985	0.380
Southside #2 (SS2)	1984	0.363

Habitat Use

Relative standard errors of the combined mean observations in all four areas were calculated for each time period (Table 4) to evaluate sampling precision. High variability in the 1100 to 1300 hrs time period (RSE = 60.9%) resulted in elimination of that sampling period for analysis. Variability in data collected during sunrise to 0900 hrs (RSE = 15.1%) and sunset to 2100 hrs (RSE = 18.2%) were acceptable. Relative standard errors for mean observations in each area and sample sizes required for RSE's ≤ 20% are summarized in Table 5.

After tests were performed for significant differences between early and late time periods in each area (Table 6), it was decided to combine the sunrise to 0900 hrs and the sunset to 2100 hrs time periods. Table 7 contains the relative standard errors and sample sizes for the combined time periods. The RSE-predicted sample sizes for SKB, SS1, and SS2 were similar to the combined sample sizes for early and late time periods (n=80) used in this study. As a result, sampling on these areas was assumed to be adequate. The sample size needed for an RSE ≤ 20% for MTR was n=987, an impractical sample size (twelve times greater than the sample sizes for the other areas).

The percentage of deer observed during the combined time periods of sunrise to 0900 hrs and sunset to 2100 hrs (Table 8) was greatest on SS2 (42.9%) and least on MTR (1.5%). The other mountaintop removal area, SKB, had usage similar to the two contour areas.

Wilcoxon's Rank Sum test for the mean combined deer observations (Table 9) indicated deer usage for MTR was significantly different from all other areas. The comparison of MTR with the other three areas (SKB,SS1, and SS2) yielded P=0.0001 in all cases, which is significantly lower than 0.05.

The percentage of pellet groups counted (Table 10) was greatest on the SS1 area (52.1%) and least on MTR (0.0%). Wilcoxon's Rank Sum test for the mean pellet groups comparison (Table 11) indicated deer usage of MTR was significantly less than the 0.05 level (P=0.0001 in all comparisons).

The relative standard errors and sample sizes required for RSE ≤ 20% for pellet counts on each area are in Table 5. The RSE predicted sample sizes for SKB, SS1, and SS2 were adequate for analysis, but, again the sample size required for MTR (n=1587) was impractical.

Wilcoxon's Rank Sum test for the mean pellet groups comparison (Table 9) indicated that MTR was significantly different from all areas at the P=0.05 level.

Table 4. Relative Standard Errors (RSE) for all observations for all time periods.

Time	Relative Standard Error (%)
Sunrise to 0900 hrs	15.1
1100 to 1300 hrs	60.9
Sunset to 2100 hrs	18.2

Table 5. Relative Standard Errors (RSE) for all observation times per km of survey route and pellet counts. The sample sizes required for RSE ≤ 20% are in parentheses. * = not enough data to calculate.

Method		Mountaintop Removal MTR	Spring Knob SKB	Southside #1 SS1	Southside #2 SS2
Observation Times	sunrise - 0900	100 (1000)	26.3 (69)	26.1 (68)	23.3 (54)
	1100 - 1300	*	100 (1000)	100 (1000)	100 (1000)
	sunset - 2100	100 (1000)	33.8 (114)	22.2 (49)	33.2 (114)
Pellet Counts		70.4 (1587)	18.8 (113)	16.4 (85)	20.6 (101)

Table 6. Comparisons of mean deer observations for the time periods of sunrise to 0900 hrs and sunset to 2100 hrs, using the Wilcoxon's Rank Sum test.

Area	Z score	Probability > |z|
Mountaintop Removal (MTR)	0.0178	0.9858
Spring Knob (SKB)	0.8174	0.4137
Southside #1 (SS1)	-0.7211	0.4709
Southside #2 (SS2)	1.0169	0.3092

Table 7. Relative Standard Errors (RSE) for all observation times per km of survey route for the combined time periods of sunrise to 0900 hrs and sunset to 2100 hrs. The sample sizes required for RSE ≤ 20% are in parentheses.

Method	Mountaintop Removal MTR	Spring Knob SKB	Southside #1 SS1	Southside #2 SS2
Observations	70.3 (987)	20.8 (86)	16.9 (57)	20.0 (80)

Table 8. Percentages of deer observed for each study area for the time periods of sunrise to 0900 hrs and sunset to 2100 hrs.

Area	Number of Deer Observed	Percentage
Mountaintop Removal (MTR)	2	1.5
Spring Knob (SKB)	31	23.3
Southside #1 (SS1)	43	32.3
Southside #2 (SS2)	57	42.9

Table 9. Comparisons of mean deer observations per km of survey route for the combined time periods of sunrise to 0900 hrs and sunset to 2100 hrs, using Wilcoxon's Rank Sums test. (P-values listed with z-scores in parentheses.)

Areas	Southside #2 SS2	Southside #1 SS1	Spring Knob SKB
Mountaintop Removal MTR	0.0001 (-5.360)	0.0001 (5.323)	0.0001 (-4.369)
Spring Knob SKB	0.3306 (0.9730)	0.4667 (0.7279)	
Southside #1 SS1	0.6854 (0.4050)		

Table 10. Percentage of pellet groups for each study area.

Area	Number of Pellet Groups	Percentage
Mountaintop Removal (MTR)	0	0
Spring Knob (SKB)	7	14.6
Southside #1 (SS1)	25	52.1
Southside #2 (SS2)	16	33.3

Table 11. Comparisons of mean pellet groups per km of transect, using Wilcoxon's Rank Sums test. (P-values listed with z-scores in parentheses.)

Areas	Southside #2 SS2	Southside #1 SS1	Spring Knob SKB
Mountaintop Removal MTR	0.0001 (-6.1500)	0.0001 (6.2588)	0.0001 (-4.9924)
Spring Knob SKB	0.0953 (1.6681)	0.0766 (1.7707)	
Southside #1 SS1	0.9329 (0.0842)		

DISCUSSION

Vegetation

All ecosystems, including reclaimed surface-mined lands, experience succession. Majumdar et al. (1987) found mined lands would eventually return to the natural regional climax stage of succession unless they were specifically managed. Holechek et al. (1982), by observing a reclaimed mine site in Montana that had very little invasion of native species, determined natural succession could be very slow. Areas revegetated with exotics often lack the plant diversity and stability that existed prior to mining (Majumdar et al., 1987). Exotics tend to transform areas into monocultures and exclude intrusion by native species. Native species are adapted to the environmental conditions of an area and are more likely to persist and develop permanent diverse plant communities than exotics (Vogel, 1987).

Because natural succession increases plant community diversity, reclaimed mined lands revegetated with native species should reach the climax stage quicker. In Kentucky, the standard practice is to plant a mixture of two species of grasses [usually Kentucky-31 fescue and perennial ryegrass (*Lolium perenne*)] and two species of legumes (birdsfoot trefoil and red clover). All of these species have been introduced into Kentucky. Revegetating surface mined areas with native species or encouraging natural succession would establish diverse and stable plant communities in a shorter period of time, when compared to using only non-native grass-legume mixtures (Majumdar et al., 1987).

The reclaimed areas in this study were revegetated with a non-native grass-legume mixture that contributed to lower diversity. The more recently reclaimed mountaintop removal areas had higher Shannon-Weaver diversity indices when compared with the older contour areas. This is just the exact opposite of traditional thinking on natural succession.

One explanation could be the competitive success with the passage of time of some species over others. Pederson and Lacefield (1989) found most legumes will not persist for long periods of time in mixtures with tall fescue. Birdsfoot trefoil is less aggressive than most legumes (Department for Surface Mining, Reclamation and Enforcement, 1983) and has weak seedling vigor, making it difficult to establish with some grass mixtures (Evangelou and Barnhisel, 1982). Crownvetch has a slow rate of establishment (Evangelou and Barnhisel, 1982), thus the stands are susceptible to more aggressive species. Yellow sweet clover, unlike crownvetch, could suppress slower growing plants, under good conditions, due to its rapid establishment (Department for Surface Mining, Reclamation and Enforcement, 1983).

Another possible explanation could be the intense grazing by free-roaming cattle on the two older contour areas. Because the contour areas have been reclaimed for a longer period of time, compared to the two mountaintop areas, grazing could have caused changes in the plant species composition. Total loss of less persistent plant species could result from overgrazing (Sell, 1977). For example, crownvetch stands can be weakened or lost to overgrazing (Department for Surface Mining, Reclamation and Enforcement, 1983). In mixed stands of grasses and legumes, taller grass growth and selective legume grazing by cattle encourage grass domination (Evans and Lacefield, 1981). Most biennial legumes, such as red clover, require short grazing periods with long rest periods to maintain stands under grazing pressures (Sell, 1977). Continuous close grazing of red clover with moderate to heavy grazing pressure may reduce stands (Evans and Lacefield, 1981).

Plant cover can be explained in the same way. Because the mountaintop areas were more recently reclaimed, they did not experience long grazing periods. Sell (1977) found annual forage regrowth largely dependent on leaf area and the stem remaining at the plant base after grazing. Intense grazing could result in small to non-existent leaf area and stem size which would slow regrowth of the species.

The dominance of Kentucky-31 fescue on the study areas is characteristic of this species. Fowler and Adkisson (1980) found the tall, rank growth of Kentucky-31 fescue tended to exclude other herbaceous plants and tree seedlings through shading and competition for soil nutrients and moisture. Also, Kentucky coal operators tend to use large amounts of Kentucky-31 fescue seed to reclaim mined areas because it requires little maintenance and can provide a quick growing ground cover suitable for erosion control.

The dominant legume on all areas, except the Southside #2 area, was birdsfoot trefoil. There are several explanations for this dominance. Birdsfoot trefoil can tolerate the lowest pH (4.5) of all the legumes identified in this study (Rafaill and Vogel, 1978), and it has a high tolerance to the salt and excess manganese found in mine soils. Like Kentucky-31 fescue, birdsfoot trefoil is very beneficial for erosion control, so the tendency is to increase the poundage of birdsfoot trefoil in the seed mix.

Habitat use

John Phillips (1989), Deer Coordinator for the Kentucky Department of Fish and Wildlife Resources, estimated the 1988 deer population for Martin County to be 448 deer. Phillips estimated the population using a computer model based on hunter, road, and predator kill information and by estimating illegal kills and crippling losses. Hayne (1984) believed computer models had difficulty making assumptions about population self-limitations and the effect hunting mortality had on natural mortality and reproduction rates. Because Martin County Coal Company does not allow hunting on its property and there are no public roads on the property, the deer population on the mine site was not accurately reflected in Phillips' population estimate. The population estimate in the current study was based solely on Martin County Coal Company's permitted acreage of 3400ha.

The precision of the population estimate depended on how well the biases of the survey method were overcome. The roadside spotlight census method used in this study has disadvantages that can affect the legitimacy of the estimate. Some of the factors are: (1) effects of weather conditions (fog, rain, etc.), (2) activity of the deer as affected by hour, food, and weather, and (3) roadside cover conditions (Schemnitz, 1980). To minimize the adverse effects of these factors, additional precautionary measures were taken in the census process.

The 24.2km route encompassed several different habitat types, including mined and unmined areas. Different habitat types were censused to limit bias in the overall sample due to any preference of deer for one habitat. Because a deer's seasonal home range radius usually does not greatly exceed 1.6km (Severinghaus and Cheatham, 1956), sampling more habitat types increased the likelihood of sampling a larger proportion of home ranges of different deer.

To reduce any bias deer activity might have on the census, all surveys began approximately one hour after sunset and lasted until the survey route was completed in two to three hours, depending on the number of deer seen. This was the time period Progulske and Duerre (1964) and Montgomery (1963) found deer to be the most active.

To minimize the adverse effects of food, weather, and seasonal cover, all seven censuses were conducted within a twenty-three day period. By limiting the amount of time between each census, changes in food availability, seasonal weather and seasonal cover were less likely to affect the overall estimate. The effects of weather were also reduced by avoiding unusual weather conditions during censusing (Schemnitz, 1980).

Surface mining in eastern Kentucky has created thousands of hectares of open areas in the otherwise dense second growth forests. These open areas are beneficial to white-tailed deer because of the "edge effect" that is created. The "edge effect" or ecotone is the area between two vegetative types that usually has an increased diversity of plant species (Schemnitz, 1980). Harlow (1984) believed that a wide diversity of plant species and large quantities of food produced the best habitat conditions for supporting deer.

The created edges in this study consisted of second growth oak trees, producers of mast preferred by deer (Shrauder, 1984), and herbaceous vegetation that varied little between the four study areas. Contrary to Harlow's (1984) findings, white-tailed deer in this study preferred the two contour areas that had the lowest diversity, but provided easy access to cover.

Vogel (1973), Herriges (1986) and Compton, et al. (1988) found deer preferred relatively dense and extensive patches of woody cover, especially in areas of increased human activity, such as a surface mine. The two contour areas consisted of reclaimed areas approximately 150 meters wide and 2600 meters long with second growth oak-hickory forest on either side of the cut. The narrow open strips of the contour areas were easier for deer to utilize for food and to seek cover from when needed. Hirth (1977) found deer moving across open areas were never more than approximately 50 meters from woods. McGinnes (1969) found that long, narrow clearcuts created more edge effect, and, hence benefited deer.

Unlike the contour areas, the two mountain top removal areas were wide expanses of open areas. The smaller mountaintop removal, Spring Knob (SKB), averaged approximately 300 meters wide and 790 meters long with second growth forest around approximately three-quarters of the perimeter. The larger area, Mountaintop Removal (MTR), averaged approximately 400 meters wide and 2000 meters long with second growth oak-hickory forest around approximately half of the perimeter.

The SKB area received the third highest percentage of usage and the MTR area was clearly avoided by the deer. By comparison, the SKB area provided more edge effect, had narrower width and was more secluded than the larger MTR area. Also, SKB was adjacent to the Southside #1 (SS1) area, a high usage area; there was a narrow strip of forest between the two areas.

The presence of the free-roaming cattle may have influenced white-tailed deer behavior. Compton, et al. (1988) reported the presence of cattle influenced the density distribution of deer. In their study, deer were more often observed in areas where cattle were absent. Nixon et al. (1988) found that deer utilized wooded pastures in late winter and early spring, but appeared to avoid these pastures when cattle were present. Ellison (1969) observed the movement of deer from his study area to an adjoining ranch in response to the study area being stocked with cattle. This avoidance appears to be directly related to diet overlap of the two species.

White-tailed deer are considered selective feeders (Verme and Ullrey, 1984 and Kroll, 1991) because they carefully choose the plants and plant parts they will consume. This careful selection usually ensures the deer's diet will meet its nutritional needs (Verme and Ullrey, 1984). According to Kroll (1991), among herbaceous plants, deer prefer forbs which are highly nutritious and easily digested. Mast is very important to deer, but is an unpredictable food source. Reproductive success of yearling does and antler sizes of bucks in Kentucky were related to acorn availability (Barber, 1984). Kentucky deer populations utilize browse only when primary food sources are depleted (Barber, 1984).

Deer do shift from preferred to alternate food sources (Schemnitz, 1980), the study areas provided a diversity of food choices. The reclaimed surface areas were excellent sources of forbs, with a maximum of four legume species in most study areas. The second growth mixed mesophytic forest that bordered each study area provided a plentiful supply of mast and browse species, primarily oak, hickory, and dogwood.

When late summer's herbaceous forage has matured or been eaten, competition may be high in mutually preferred habitats because of diet overlap (Austin and Urness, 1985). Thill and Martin, Jr. (1986) and Mitchell (1980) found cattle and deer could coexist if the areas were not heavily stocked with cattle. If cattle overstocking occurred, food competition was greatest during winter, when vegetation diversity and abundance were low (Thill and Martin, Jr., 1986). If resources are plentiful, significant competition may not occur, even if diet overlap is high (Sale, 1974). Loft et al. (1991) found when herbaceous forage and cover were abundant, female mule deer shifted habitat types less frequently in response to competition with cattle, than when herbaceous forage and cover were less abundant.

In this study, deer were never observed in the presence of free roaming cattle. During many observed time periods, the deer appeared to avoid study areas grazed by cattle. Because many of the cattle had collars equipped with cow bells, deer may also have avoided them because of the noise generated.

Not only were cattle avoided, but the deer avoided the study areas during the early afternoon as well. Hahn (1949) and Halloran (1943) found white-tailed deer restricted their activity, usually bedding down, from mid-morning to mid-afternoon or late afternoon. This study concurred with their findings.

One possible explanation for mid-day inactivity could be temperature, especially in the summer. On the study areas, very little shade was available. For the deer to have adequate shade cover, they had to retreat to the second growth edges or the forest itself.

Lack of cover also increased the possibility of predation. Bobcats and tame/feral dogs are known predators of white-tailed deer, especially the young and sick. Dogs can harass deer to the point of exhaustion and death (Progulske and Baskett, 1958). The presence of predators intimidate deer resulting in reduced resource use. Numerous bobcat and dog sightings were made in and around the four study areas.

Another explanation for the lack of mid-day deer activities was mining activities. Even though the four areas observed were mined out and reclaimed, mining was still occurring around these areas. The main haul road, part of the survey route used in the study, either cut through or bordered the reclaimed areas and maintained a moderate amount of traffic.

Daylight and spotlight direct observations used to sample habitat use in this study have accuracy limits. According to Sanderson (1966), direct observations have several disadvantages, such as limiting the number of individuals studied at one time, consuming time, and require the observer to be close to the observed animal, influencing its movements. One advantage is identification accuracy. Other advantages are easier observation of the animal activity and the determination of intraspecific and interspecific relationships (Sanderson, 1966).

Daylight direct observations, compared to spotlight surveys, have several advantages. Daylight surveys are more accurate when determining deer activities; the deer are not alerted to the observer's presence. Also, daylight surveys can be done with one observer, compared to spotlight surveys which, in most cases, require two observers.

McCullough (1982) found one of the disadvantages of spotlighting was the underrepresentation of males and fawns in the counts, compared to the known ratio. Progulski and Duerre (1964) concluded that the nighttime temperature affected the number of deer seen in spotlight counts because as the temperature fluctuated over a period of several nights, deer counts generally had the same pattern. Also, spotlight surveys can be influenced by the thickness of the cover surveyed (McCullough, 1982).

The third method used was the pellet-group count technique. Loft and Kie (1988) used pellet groups to determine habitat use and found the counts to be good predictors of use when compared to radio-telemetry. They also found pellet group counts as accurate indicators of habitat use during the summer months.

Leopold et al. (1984) concluded that habitat use rankings of mule deer determined by pellet-group counts and direct observations were similar. But Collins (1981) reported that pellet-group counts were not reliable estimations of mule deer preference for habitat sub-units because deer defecation rates are directly related to vegetation consumed and activity.

Another problem with pellet-group counts is physically locating the groups. Dense vegetation can prevent observers from locating all pellet groups along the transects. Also, warm weather encourages pellet-group decay at a faster rate than cold weather. During warm weather periods, dung beetles can consume pellet groups (Phillips, 1993).

Management Considerations

In Kentucky, coal operators are becoming increasingly aware of potential wildlife damage from surface and deep mining operations. Many operators are opting for the fish and wildlife post mining land use as one way to repair damage and encourage wildlife re-establishment. When white-tailed deer are used as the target species for reclamation enhancement, several factors must be addressed.

The results of this study indicate that white-tailed deer prefer small open areas. To encourage deer use on a large mountaintop removal area, the area should be broken into subareas by planting trees and shrubs in patches to create travel lanes, which would link the created edge effect with the reclaimed area. This would provide deer an easier transition from undisturbed areas to the reclaimed areas. Windrowing, the placing of cut trees and other woody debris along the sides of hollowfills, can be beneficial because it provides browse, when first cut, and cover.

Another factor is providing a good vegetative mix that appeals to the deer. A seed mix that provides a good mixture of legumes, especially *Trifolium spp.*, would be an excellent food source for deer. Most legumes should be re-seeded biannually and fertilized to produce the best stands.

Grass species used should be those species that do not dominate and, thus, decrease the amount of vegetative diversity. Kentucky-31 fescue is not recommended because of its aggressiveness and low food source value. Orchard grass (*Dactylis glomerata*), timothy (*Phleum pratense*) and deertongue (*Panicium clandestinium*) are beneficial grasses for deer. The seed mix should include temporary or quick cover species, such as wheat (*Triticum aestivum*) or rye (*Secale cereale*), to provide a temporary food source until the permanent species are established.

Trees and shrubs planted for cover should also provide mast and browse. Oak (*Quercus spp.*), black locust, and flowering dogwood (*Cornus florida*) are some trees that produce mast and browse that deer prefer. Examples of shrubs from which deer would benefit are autumn olive (*Elaeagnus umbellata*), sumacs (*Rhus spp.*) and *Viburnum spp.* Again, trees and shrubs should be row planted to develop travel lanes. The amount of black locust planted should be small; it has a tendency to dominate other seedlings, especially when hydroseeded with a grass-legume seed mix.

If the reclaimed area will be used for cattle grazing as well as wildlife habitat, additional precautions must be taken. To ensure well-established vegetation, the area should not be opened to grazing for a three- to five-year period. Also, legumes should be re-seeded biannually because they are usually poor reseeders. Periodic pasture rotation will prevent cattle from selectively grazing preferred foods from the vegetation mix. It will also encourage diversity by allowing reclaimed areas to rest and reseed by natural intrusion.

APPENDIX

Table 12. Monthly white-tailed deer pellet groups on reclaimed areas.

Month	Mountaintop Removal Area	Spring Knob Area	Southside #1 Area	Southside #2 Area	Totals
July					
August		1	3	1	5
September			4	2	6
October		1	3	1	5
November		2	5	3	10
December		1	4	3	8
January			2		2
February			1	2	3
March		2	3	4	9

Table 14. Means and standard errors for all observations and pellet counts. The means are above and the standard errors are below in parentheses. * = not enough data to calculate.

Method		Mountaintop Removal MTR	Spring Knob SKB	Southside #1 SS1	Southside #2 SS2
Observation Times	sunrise to 0900	0.0114 (0.0114)	0.2250 (0.0592)	0.1979 (0.0517)	0.2419 (0.0563)
	1100 to 1300	*	0.0125 (0.0125)	0.0208 (0.0208)	0.0081 (0.0081)
	sunset to 2100	0.0114 (0.0114)	0.1625 (0.0549)	0.2500 (0.0554)	0.2177 (0.0734)
Pellet Counts		0.0037 (0.0026)	0.1088 (0.0204)	0.1953 (0.0319)	0.2065 (0.0360)

LITERATURE CITED

Austin, D.D. and P.J. Urness. 1985 Values of four communities for mule deer on ranges with limited summer habitat. J. Range Mgt. 38:167-17.

Barber, H.L. 1984. Eastern mixed forest. *In*: white-tailed deer ecology and management, ed. L.K. Halls, pp. 345-354. Stackpole Books, Harrisburg, PA. 870pp.

Brenner, F. J. and M. J. Musaus. 1977. Selectivity of browse species by white-tailed deer on strip-mine lands in Mercer County, Pennsylvania. Proc. Penn. Acad. Sci. 51:105-108.

Collins, W. R. 1981. Habitat preferences of mule deer as rated by pellet-group distributions. J. Wildl. Mgt. 45(4):969-972.

Compton, B. B., R. J. Mackie, and G. L. Dusek. 1988. Factors influencing distribution of white-tailed deer in riparian habitats. J. Wildl. Mgt. 52(3):544-548.

Cox, G. C. and J. F. Howell, Jr. 1980. A social, economic and environmental assessment of the Levisa Fork Drainage (Big Sandy River Basin, Kentucky and Virginia). U.S. Army Corps Eng., Huntington, WVA. 172pp.

Department for Surface Mining, Reclamation and Enforcement. 1983. Revegetation of Kentucky surface mined Lands. Unpublished. 105pp.

Ellison, J. E. 1969. Mobility of white-tailed deer in south Texas. J. Wildl. Mgt. 33(1):220-222.

Evangelou, V.P. and R. I. Barnhisel. 1982. Revegetation guide for surface-mined land in Kentucky. Univ. of Ky. Coll. of Agric., Lexington. 7pp.

Evans, J.K. and G. Lacefield. 1981. Efficient pasture systems. Univ. of Ky., Coll. of Agric., Lexington. 4pp.

Fowler, D. K. and L. F. Adkisson. 1980. Survival and growth of wildlife shrubs and trees on acid mine spoil. TVA Tech. Note b-37, TVA, Nashville. 48pp.

Hahn, H. C., Jr. 1949. A method of censusing deer and its application in the Edwards Plateau of Texas. Div. of Wildl. Restor., Texas Game, Fish and Oyster Comm., Austin, TX. 24pp.

Halloran, A. F. 1943. Management of deer and cattle on the Aransas National Wildlife Refuge, Texas. J. Wildl. Mgt. 7(2):203-216.

Harlow, R.J. 1984. Habitat evaluation. *In*: White-tailed deer: ecology and management, ed. L.K. Halls, pp. 629-646. Stackpole Books, Harrisburg, PA. 870pp.

Hayne, D.W. 1984. Population dynamics and analysis. *In*: White-tailed deer: ecology and management, ed. L.K. Halls, pp. 203-210. Stackpole Books, Harrisburg, PA. 870pp.

Herriges, J. D. 1986. Movement, activity, and habitat use of white-tailed deer along the lower Yellowstone River. M.S. Thesis, Montana State Univ., Bozeman. 132pp.

Hirth, D. H. 1977. Social behavior of white-tailed deer in relation to habitat. Wildl. Mono. 53:1-55.

Holechek, J. L., E. J. Depuit, J. Coenenberg and R. Valdez. 1982. Long-term plant establishment on mined lands in southeastern Montana. J. Range Mgt. 35(4):522-525.

Kentucky Climate Center. 1981. Climate of Pikeville, Kentucky. Western Kentucky Univ., Bowling Green, Pamphlet. 4pp.

Kentucky Department for Surface Mining, Reclamation and Enforcement. 1988. Kentucky Coal Geology: An Introduction. Unpublished. 603pp.

Kroll, J.C. 1991. A practical guide to producing and harvesting white-tailed deer. Center for Applied Studies in Forestry, School of Forestry, Stephen F. Austin State Univ., Nacogdoches, TX. 551pp.

Leopold, B. B., P. R. Krausman, and J. J. Hervert. 1984. Comment: the pellet-group census technique as an indicator of relative habitat use. Wildl. Soc. Bull. 12: 325-326.

Loft, E. R. and J. G. Kie. 1988. Comparison of pellet-group and radio-triangulation methods for assessing deer habitat use. J. Wildl. Mgt. 52(3):524-527.

Loft, E. R., J. W. Menke and J. G. Kie. 1991. Habitat shifts by mule deer: the influence of cattle grazing. J. Wildl. Mgt. 55(1):16-26.

McCullough, D. R. 1982. Evaluation of night spotlighting as a deer study technique. J. Wildl. Mgt. 46(4):963-973.

McGinnes, B. S. 1969. How site and distribution of cutting units affect food and cover of deer. *In*: White-tailed deer in the southern forest habitat, pp. 66-70. Proc. Sym. Nacogdoches, Tex. New Orleans: USDA For. Serv., South For. Exp. Stn. 130pp.

Majumdar, S. K., F. L. Brenner and E. W. Miller. 1987. Environmental consequences of energy production: problems and prospects. The Penn. Acad. of Sci. 121pp.

Medcraft, J. R. 1984. Wildlife and surface mine reclamation in northeastern Wyoming. M. S. Thesis, Iowa State Univ., Ames. 105pp.

Mitchell, W.A. 1986.. Deer spotlight census. Technical Report EL-86-53, U.S. Army Corps Eng., Dept. of the Army, Vicksburg, MS. 21pp.

——.1980. Evaluation of white-tailed deer and cattle diets in two southeastern pine forests. Vols. I and II. PhD Thesis, Miss. St. Univ., Vicksburg. 368pp.

Montgomery, G. G. 1963. Nocturnal movements and activity rhythms of white-tailed deer. J. Wildl. Mgt. 27(3):422-427.

Neff, D. J. 1968. The pellet-group count technique for big game trend, census, and distribution: a review. J. Wildl. Mgt. 32:597-614.

Nixon, C. M., L. P. Hansen and P. A. Brewer. 1988. Characteristics of winter habitats used by deer in Illinois. J. Wildl. Mgt. 52(3):552-555.

Pederson, J. F. and G. D. Lacefield 1989. Tall fescue. University of Ky., Coll. Agric., Lexington. 5pp.

Phillips, J. 1989. Computer data, KY Dept. Fish Wildl. Res. Personal comm. 14pp.

——.1993. KY Dept. Fish Wildl. Res. Personal comm.

Progulske, D.R. and D.C. Duerre. 1964. Factors influencing spotlighting counts of deer. J. Wildl. Mgt. 28(1):27-34.

Progulske, D. R. and T. S. Baskett. 1958. Mobility of Missouri deer and their harassment by dogs. J. Wildl. Mgt. 22(2):184-192.

Rafaill, B. L. and W. G. Vogel. 1978. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. FWS/OBS-78/84, USDA For. Serv., Berea, KY. 89pp.

Sale, P.F. 1974. Overlap in resource use and interspecific competition. Oecologia. 17:245-256.

Sanderson, G. C. 1966. The study of mammal movements-a review. J. Wildl. Mgt. 30(1):215-235.

SAS. 1988. SAS Institute, Inc. SAS/STAT user's guide, release 603 edition. Cary, N.C. SAS Institute, Inc. 1028pp.

Schemnitz, S. D., ed. 1980. Wildlife Management Techniques Manual. The Wildlife Society, Washington, D. C. 686pp.

Sell, W.H. 1977. Southern regional beef cow-calf handbook: grazing systems. Univ. of Ky., Coll. Agric., Lexington. 4pp.

Severinghaus, C.W. and E.L. Cheatham. 1956. Life and times of the white-tailed deer. *In*: The deer of North America, ed W.P. Taylor, pp. 57-186. Stackpole Books, Harrisburg, PA. 668pp.

Shrauder, P.A. 1984. Appalachian mountains. *In*: White-tailed deer: ecology and management, ed. L.K. Halls, pp. 629-646. Stackpole Books, Harrisburg, PA. 870pp.

Smith, R. L. 1986. Elements of ecology. Harper and Row Publishers, Inc., New York, NY. 677pp.

Sparrowe, R. D. and P. F. Springer. 1970. Seasonal activity patterns of white-tailed deer in eastern South Dakota. J. Wildl. Mgt. 34(2):420-431.

Thill, R.E. and A. Martin, Jr. 1986. Deer and cattle diet overlap on Louisana pine-bluestem range. J. Wildl. Mgt. 50(4):707-713.

Verme, L.J. and D.E. Ullrey. 1984. Physiology and nutrition. *In* White-tailed deer: ecology and management, ed. L. K. Halls, pp. 91-118. Stackpole Books, Harrisburg, PA. 870pp.

Vogel, W. G. 1987. A manual for training reclamation inspectors in the fundamentals of soils and revegetation. Soil and Water Conser. Soc., Ankeny, IA. 178pp.

Vogel, W.O. 1973. The relationship of white-tailed and mule deer to agriculture in Gallatin Valley. M.S. Thesis, Montana State Univ., Bozeman. 86pp.

Wiggers, E. P. and S. L. Beason. 1986. Characterization of sympatric or adjacent habitats of 2 deer species in west Texas. J. Wildl. Mgt. 50(1):129-134.

BIBLIOGRAPHY

Alexander, B. G. 1968. Movements of deer in northeast Texas. J. Wild. Mgt. 32(3): 618-620.

Anthony, R. G. and N. S. Smith. 1974. Comparison of rumen and fecal analysis to scribe deer diets. J. Wildl. Mgt. 38(3): 535-540.

Byers, C. R. and R. K. Steinhorst. 1984. Clarification of a technique for analysis of utilization-availability data. J. Wildl. Mgt. 48(3):1050-1053.

Cairns, A. L. and E. S. Telfer. 1980. Habitat use by four sympatric ungulates in boreal mixwood forest. J. Wildl. Mgt. 44(4): 849-857.

Clark, W. R. and J. R. Medcraft. 1986. Wildlife use of shrubs on reclaimed surface-mined land in northeastern Wyoming. J. Wildl. Mgt. 50(4):714-718.

Dearden, B. L., R. E. Pegau, and R. M. Hansen. 1975. Precision of microhistological estimates of ruminant food habits. J. Wildl. Mgt. 39(2):402-407.

Fagen, R. 1988. Population effects of habitat change: a quantitative assessment. J. Wildl. Mgt. 52(1):41-46.

Gill, J. D. 1957. Effects of pulpwood cutting practices on deer. Proc. Soc. Amer. For. 1957:137-146.

Hahn, H. C., Jr. 1945. The white-tailed deer in the Edwards Plateau region of Texas. Texas Game, Fish and Oyster Comm., Austin., TX. 52pp.

Hahn, H. C., Jr. and W. P. Taylor. 1950. Deer movements in the Edwards Plateau. Texas Game and Fish. 8(12):4-9.

Harlow, R. F. 1961. Fall and winter foods of Florida white-tailed deer. Quart. J. Fla. Acad. Sci. 24(1):19-38.

Johnson, D. H. 1980. The comparison of usage and availabilty measurements for evaluating resource preference. Ecology. 61(1):65-71.

McArthur, R.H. and E.R. Pianka. 1966. On optimal use of a patchy environment. Am. Nat. 100:603-609.

McCullough, D. R., D. H. Hirth and S. J. Newhouse. 1989. Resource partitioning between sexes in white-tailed deer. J. Wildl. Mgt. 53(2):277-283.

Medcraft, J. R. and W. R. Clark. 1986. Big game habitat use and diet on a surface mine in northeastern Wyoming. J. Wildl. Mgt. 50(1):135-142.

Michael, E. D. 1965. Movements of white-tailed deer on the Welder Wildlife Refuge. J. Wildl. Mgt. 29(1):44-52.

Porter, W. F. and K. E. Church. 1987. Effects of environmental pattern on habitat preference analysis. J. Wildl. Mgt. 28(1):27-34.

Slick, B. M. and W. R. Curtis. 1985. A guide for the use of organic materials as mulches in reclamation of coal mine soils in the Eastern United States. General Technical Report NE-98, USDA For. Serv., Northeastern For. Exp. Stn. 144pp.

Suring, L. H. and P. A. Vohs, Jr. 1979. Habitat use by Columbian white-tailed deer. J. Wildl. Mgt. 43(3):610-619.

Thomas, J. W., J. G. Teer and E. A. Walker. 1964. Mobility and home range of white-tailed deer on the Edwards Plateau in Texas. J. Wildl. Mgt. 28(3):463-468.

Tierson, W. C., G. F. Mattfeld, R. W. Sage, Jr. and D. F. Behrend. 1985. Seasonal movements and home ranges of white-tailed deer in the Adirondacks. J. Wildl. Mg 49(3):760-769.

Tilghman, N. G. 1969. Impacts of white-tailed deer on forest regeneration in Northwestern Pennsylvania. J. Wildl. Mgt. 53(3):524-532.

VanVreede, G., L. C. Bradley, F. C. Bryant and T. J. Deliberto. 1989. Evaluati forage preference indices for white-tailed deer. J. Wildl. Mgt. 53(1):210-213.