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HABITAT SELECTION BY COUES WHITE-TAILED DEER IN
RELATION TO GRAZING INTENSITY

THE UNIVERSITY OF ARIZONA

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HABITAT SELECTION BY COUES WHITE-TAILED DEER
IN RELATION TO GRAZING INTENSITY

by

Mark Timothy Brown

A Thesis Submitted to the Faculty of the
DEPARTMENT OF WILDLIFE ECOLOGY
In Partial Fulfillment of the Requirements
For the Degree of
MASTER OF SCIENCE
In the Graduate College
THE UNIVERSITY OF ARIZONA

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PREFACE

It is the policy of the Program of Wildlife Ecology in the School of Renewable Natural Resources that theses be prepared in the format of a technical publication to facilitate immediate publication in a scientific journal. This policy was approved by the Graduate College as noted in a memo from Pat Bailes to Dr. N. S. Smith dated February 14, 1983. This thesis has been written according to the format specifications of THE JOURNAL OF WILDLIFE MANAGEMENT.

I gratefully acknowledge the assistance of N. S. Smith in the planning of this study and in the preparation of this manuscript. P. R. Krausman and P. F. Ffolliott also provided support, and their comments and review of this manuscript are appreciated. I am grateful to B. A. Maurer and R. O. Kuehl for assistance with the statistical analyses.

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ABSTRACT

The effects of grazing by domestic cattle on the selection of habitat by Coues white-tailed deer (Odocoileus virginianus couesi) were studied in the Santa Rita Mountains of southeastern Arizona between February 1981 and May 1982. Habitat and utilization variables were measured on 252 50-m transects. Cattle utilization accounted for 21% of the variation in habitat selection by deer. Deer used the Prosopis-Fouquieria association less than all other associations ($P=0.05$) and used north exposures more than any other exposure. Cattle may affect the vegetative community by consuming forage or by altering the vegetative composition; these are likely explanations for deer's avoidance of sites with high cattle utilization. Behavioral interactions had little bearing on habitat selection.

INTRODUCTION

Coues white-tailed deer occupy an estimated 28,000 km² of land in Arizona, excluding Tribal lands. Most of the animal's habitat is in the isolated desert mountain ranges of southeastern Arizona (Anonymous 1980). Most of this range is grazed by domestic cattle. Grazing by livestock has often been cited by land management agencies and recreational users as a reason for low numbers of deer. As Arizona's population grows and puts increased demand on this resource, it becomes ever more important to learn the effects of cattle on white-tailed deer populations to better manage rangelands for deer.

Julander (1955) concluded that forage may be used more efficiently when the range is shared by mule deer (O. hemionus) and domestic cattle. Thilenius and Hungerford (1967) drew the same conclusion about cattle and white-tailed deer, and stated that deer may benefit from increased basal growth of browse stimulated by cattle use. However, Anthony and Smith (1977) determined that Coues white-tailed deer in Arizona eat a greater diversity of plant species than mule deer, and interpreted this to mean that Coues white-tailed deer were more adapted to a climax or undisturbed plant community. Over-grazing by cattle is probably one of the factors influencing vegetational changes in southern Arizona during the past century (Hastings and Turner 1965). Cattle grazing may also decrease plant diversity. Removal of vegetation can maintain the community in a younger successional stage, increase water

runoff, and cause a depletion of nutrients in the system (Odum 1969). Competition for forage may also influence how deer select habitat. In Texas, McMahan (1964) found that seasonal forage competition between white-tailed deer and cattle was moderate to heavy. Finally, behavioral interactions may cause deer to shift their use areas in the presence of cattle, as noted in observations by Ellisor (1969), Kramer (1973) and Hood and Inglis (1974).

Deer populations could respond in a couple of ways to the presence of cattle or cattle use areas: (1) the deer could remain in the same area as the cattle and compete or coexist with the cattle. Response of deer to the presence of cattle could be reflected in reproductive and mortality rates, or in the physical condition of the population; or (2) the deer could shift their use areas into alternate sites that are less influenced by cattle. This shift could either be to less optimal sites, or into only the best deer habitat. I designed this study to test the second hypothesis.

My objectives were to detect if deer altered their selection of habitat types in response to the presence of cattle or cattle use areas and to identify the factors causing this shift if it occurred.

I gratefully acknowledge the assistance of N. S. Smith in the planning of this study and in the preparation of this manuscript. P. R. Krausman and P. F. Ffolliott also provided support, and their comments and review of this manuscript are appreciated. I am grateful to B. A. Maurer and R. O. Kuehl for assistance with the statistical analyses.

STUDY AREA

The study area includes approximately 170 km² on 3 grazing allotments on USDA Forest Service land in the southern portion of the Santa Rita Mountains, Arizona. Cattle graze the area on a deferred rotational system and are present on some part of the system year-round. Coues white-tailed deer are abundant. The area has had a history of localized overuse by cattle, with ridgetops, canyon bottoms, gentle slopes, and areas near water sources receiving the most grazing pressure.

The study area has striking vegetational differences with changes in altitude and aspect. The 3 major communities represented overlapped considerably because of topographical features. The lower elevations (1300-1550 m) are semidesert grassland (scrub-grassland) with remnants of oak woodland in the valleys and northerly exposures. Much of the grassland has been invaded by mesquite (Prosopis velutina), ocotillo (Fouquieria splendens), and cactus (Opuntia spp.). Fairy duster (Calliandra eriophylla), wait-a-minute (Mimosa biuncifera), and Mimosa dysocarpa are abundant low-growing shrubs. Dominant grasses include side oats grama (Bouteloua curtipendula) and slender grama (Bouteloua repens). The terrain of the lower elevations varies from gently sloping alluvial fans to low hills with steep sides and narrow tops.

At the middle elevations (1350-1700 m) an open encinal (oak) community replaces the vegetation of the lower elevations. Dominant tree species include gray oak (Quercus grisea), emory oak (Quercus emoryi), and alligator juniper (Juniperus deppeana). Dominant grasses

are side oats grama, plains lovegrass (Eragrostis intermedia), and cane beardgrass (Bothriochloa barbinodis). Mesquite has also invaded many sites in the oak woodland. Mimosa dysocarpa is a common shrub. At higher elevations in the oak woodland, cover becomes denser; gray oak is replaced by Arizona white oak (Quercus arizonica) and emory oak becomes more abundant. Alligator juniper is common at all but the lowest elevations.

At upper elevations (1600-2100 m) an oak-pine community dominates; Mexican pinyon (Pinus cembroides) and alligator juniper dominate in the closed overstory along with the associated evergreen oaks Arizona white oak, emory oak, and silverleaf oak (Quercus hypoleucoides). Mountain mahogany (Cercocarpus breviflorus) and silktassel (Garrya wrightii) are locally important. Little bluestem (Schizachryrium scoparium) and pinyon ricegrass (Piptochaetium fimbriatum) are important, often dominant grasses. The terrain of the upper elevations is varied but is typically of tall, steep hills divided by canyons with narrow bottoms. The nomenclature of all plant species mentioned is taken from Lehr (1978). The classification of major biotic communities is after Brown et al. (1979).

METHODS

Between February 1981 and May 1982 I selected 252 sample areas by locating deer and cattle. I observed the animals and recorded their social behavior and feeding, resting, and escape activities until they left the immediate area. Then, on the site where I had first observed the animals, I located a fecal group of the species observed and

centered a 50-m transect on it. When I was not able to find animals quickly, I centered the transect on the first fecal group I found. Each day, I stopped searching for animals in time to complete 2 transects while daylight lasted. The 50-m transect had 2 equal segments, the first segment in a random compass direction, the second at a 90° angle to the first. I marked the transect with a plastic measuring tape. Within 1 m of either side of the tape, I counted deer pellet groups of all ages and estimated the volume of cattle feces to get a measure of deer and cattle use. In each transect 0.01 ha was searched for feces.

To examine deer's selection of habitat under different grazing intensities, I measured vegetational and physical variables so similar sites could be identified and compared. I measured grass and forb cover in 20 randomly located 0.1m² plots along the transect line (Daubenmire 1959). Grasses and forbs were identified and separately recorded. Coverage of each species was estimated on each plot. I measured utilization of each species using Schmutz' (1978) visual estimation technique. To analyze the data, I combined the averaged percentage cover and percentage utilization of all grasses on each transect. To avoid overrepresenting the utilization of relatively rare, but palatable species in the overall utilization figure, I weighted the utilization of each species with the formula:

$$\sum_{i=1}^n u_i c_i / \sum_{i=1}^n c_i = \text{total percentage utilization}$$

where u_i is the percentage utilization of a given species and c_i is the

percentage cover of that species. Cover and utilization of forbs were treated similarly.

I selected shrub and overstory plants along the transect lines using Cole's (1960) closest plant sampling technique. Availability, amount of past utilization, and percentage of present leader utilization was also measured (Cole 1960). The selection of plants by this technique also gave a relative estimate of plant density, species composition, and relative abundance of species. For the analysis of data, the abundance of a given species was simply the number of plants encountered with this sampling procedure.

I measured slope (in degrees) with a clinometer. An altimeter was used to measure altitude, and a compass to determine aspect (slope-exposure). I measured distance to cover by pacing to the nearest spot where an adult deer could be hidden from my sight. I determined average fawn cover by measuring (in 4 compass directions) the distance from the transect center to where a bedded fawn would be hidden from my sight.

I marked the location of each transect on 1:20,000 aerial photographs. All permanent water sources were located by searching aerial photographs and USFS allotment maps and by reconnaissance during field work. I estimated the distance from the nearest water source for each transect by measuring linear distance on the aerial photographs; this was a relative measurement that did not take into account inconsistencies in scale among the aerial photographs and differences in topography throughout the study area. I also estimated percentage canopy cover of overstory species on each transect from the aerial photographs

by placing a circular cutout over the aerial photographs at each transect location, and visually estimating canopy coverage to the nearest 5%.

Ten vegetation associations represented distinct habitats on the study area. I used the dominant overstory plant or plants to classify each transect into one of 10 vegetation associations: (1) Prosopis velutina-Fouquieria splendens, (2) Quercus grisea, (3) Quercus emoryi, (4) Q. grisea-Q. emoryi, (5) Quercus arizonica-Juniperus deppeana-Q. emoryi, (6) Pinus cembroides-Q. emoryi-Q. arizonica, (7) Q. grisea-Q. arizonica, (8) Quercus hypoleucoides-Q. arizonica-P. cembroides, (9) Q. grisea-P. velutina, and (10) Cercocarpus breviflorus-Garrya wrightii.

RESULTS

I collected information from 252 transects and recorded observations on 337 white-tailed deer in 146 groups (2.3/group) and 556 cattle in 91 groups (6.2/group).

Square root transformations of the number of deer pellet groups and cattle feces gave the best residual distributions for those variables. These variables will hereafter be called the "deer index" and the "cattle index." I used the deer index as the dependent variable in a stepwise multiple regression analysis of all other variables, excluding vegetation association and slope-exposure. Relationships and associations were accepted as significant at the 0.05 level in all statistical analyses. Thirty-nine percent of the variation in habitat selection by deer could be explained by 7 variables (Table 1). I considered the cattle index and grass use to be indicators of cattle

presence. The two independent variables were highly correlated; a Pearson correlation between the two variables had an r^2 value of 0.6993 ($P < 0.001$). If the cattle index variable was removed from the regression, percentage utilization of grasses became the most important variable (increase in $r^2 = 0.2022$, $P < 0.001$) and was negatively related to the deer index.

I suspected that the increase in the r^2 value attributed to altitude may actually have been a function of the different vegetation associations which were not included in the stepwise regression. If each vegetation association was found at a discrete altitude, then the altitude and vegetation variables would be highly correlated and could account for the deer index being lower at the lower elevations I examined. I first examined the means of the altitudes at which each of the vegetation associations were found. The vegetation associations with means that were not significantly different (Bonferroni test) fell into either a low altitude group that included most of the oak associations or a higher altitude group that included the coniferous associations. Within each of these groups, I calculated simple regressions with the deer index as the dependent variable and altitude as the independent variable. Altitude contributed to the variability of the deer index in the first group ($r^2 = 0.0666$, $P = 0.002$), but in the second group it did not ($P = 0.9492$). The deer index increased as altitude increased in the oak associations, but there was no relationship in the coniferous associations. The regression equations indicate that the deer index would have the same value for both groups

at an altitude of 1560 m. Only 4 transects in the coniferous vegetation associations occurred lower than 1560 m; deer did not prefer them over the oak associations. However, 33 transects in the oak vegetation associations did occur above 1560 m, and at these higher elevations it appears that deer select the oak associations over the coniferous.

All other variables that were examined in the stepwise regression analysis, including distance to water, percentage overstory cover, slope, grass and forb cover, distance to cover, and relative density of all other common overstory and shrub species, had F-levels too low to be included in the stepwise regression.

Vegetation association and slope-exposure were treated separately, as these variables did not have numerical values. I examined the relationships of the deer index to the cattle index with transects grouped by vegetation association in a multiple linear regression analysis. I tested for differences in the slope and intercept of each group within the regression equation. The effect of slope-exposure on the relationship of the deer index to the cattle index was examined similarly.

The deer index was negatively related to the cattle index in all vegetation associations ($r^2=0.3843$, $P<0.001$). The slopes of the regression lines were not significantly different for any association. The Y intercept value for the Prosopis-Fouquieria vegetation association was 2.9 units less than that for a grouping of all other associations

($P < 0.001$) (Fig 1). The Y intercepts of the regression lines in all other vegetation associations did not differ significantly.

The deer index was also negatively related to the cattle index on all slope-exposures ($r^2 = 0.2533$, $P < 0.001$). The slopes of the regression lines were not significantly different for any slope-exposure. The Y intercept value for north exposures was 1.5 units greater than that for all others when grouped ($P < 0.01$) (Fig 2). The Y intercepts of the regression lines on east, south, and west exposures did not differ significantly.

I also examined the relationship of cattle and deer indices to vegetative diversity by calculating Shannon-Weaver diversity values (as modified by Lloyd et al. 1968) for all transects, treating grasses separately from shrubs and trees. Correlations between the cattle index and diversity values and between the deer index and diversity values showed no associations.

DISCUSSION

Regression statistics do not establish causal patterns (Neter and Wasserman 1974). The regressions developed in this study do, however, express empirical relationships between the presence of deer and the other variables that I measured. Because I examined what I believe to be most of the relevant variables, it is likely that these relationships are the ones that explain why deer select habitat as they do.

In the stepwise regression, 21% of the variation in the deer index could be attributed to the cattle index. Admittedly, a large amount of the variance remains unaccounted for, perhaps due to imprecise

measurements of variables, interactions between these variables that in combination may have explained more of the variance, or other variables I did not measure either because I did not recognize them or they were not easily quantified. However, of the variables I measured, the single most important factor explaining habitat selection by deer was the amount of use by cattle. Stocking rates were reduced in the 3 years preceding this study (up to a 60% reduction in the number of cattle in some areas), and the range quality appeared to be improving. I would expect the results to have been more pronounced under heavier stocking rates or on deteriorating rangeland.

My observations of deer and cattle indicate that interspecific behavioral interactions have little effect on habitat selection. Michael (1967) observed some competition for bedding sites between white-tailed deer and cattle, but most encounters involved mutual indifference. In my study, most encounters between cattle and deer also involved mutual indifference, and at most, deer merely moved away as cattle approached. At no time did I observe overt aggression by either cattle or deer. Chances for contact between deer and cattle in this study were apparently low because of the tendency for cattle to congregate in certain localized areas and because of the conservative stocking rates. The average stocking rate was 3 head/km², but because of the deferred rotational stocking system, densities in any currently stocked area were probably twice this amount. Possibly, deer select habitat to avoid coming into contact with cattle, but I consider this unlikely, given the generally indifferent response of deer to cattle.

If deer were avoiding the physical presence of cattle, one would expect to see a negative response when the animals were near each other.

The reasons that deer avoid sites with high cattle utilization are not obvious. I suspect a complex interaction of factors, of which the impact of cattle on the vegetative community is a part, along with other, less quantitative factors. Competition for forage is potentially a factor, especially on those sites heavily used by cattle. Forage competition was not examined in this study. Such competition would be difficult to demonstrate since deer apparently avoid high-use cattle sites. Deer may be avoiding competition by avoiding the areas where it could occur. Competition studies (Davis 1952, Julander 1955, McMahan 1964, McMahan and Ramsey 1965, Mackie 1970) have shown seasonal dietary overlap and potential for forage competition, especially on overstocked ranges where food becomes a limiting factor for cattle and they make more use of browse. Except in localized areas, forage was abundant for both cattle and deer in this study, and actual forage competition was probably minimal; this would not be true on heavily overstocked ranges where deer have no place to retreat to avoid cattle, or in times of lowered quality and production of forage (such as during drought).

According to Hastings and Turner (1965), cattle grazing coupled with hotter and drier conditions in Arizona is causing an upward altitudinal shift of the life zones. Anthony and Smith (1977) described white-tailed deer range in Arizona as islands surrounded by a sea of unsuitable habitat. As the more mesic life zones retreat upslope, white-tailed deer habitat shrinks accordingly. Hastings and Turner

(1965) stated that the impact of cattle is greatest in the desert grassland community. The Prosopis-Fouquieria vegetation association is a shrub-invaded desert grassland, and the lower encinal community, which makes up a major portion of white-tailed deer range, is structurally desert grassland with scattered stands of evergreen oaks, and probably is affected similarly. Therefore, the lower elevations of white-tailed deer habitat are the most likely communities to change vegetatively as a result of the presence of cattle. Such changes may explain several things, although other factors certainly are involved. First, vegetational change could explain the lower utilization of the Prosopis-Fouquieria vegetation association by deer in contrast to all other vegetation associations. Possibly rather marginal white-tailed deer habitat to begin with, the vegetation in this zone has changed the most, which probably influences the deer's selection for it. Second, the higher deer utilization of north slopes, which are microhabitats representative of higher elevations and perhaps less subject to the type of vegetative change detrimental to deer populations, may be explained by vegetative change on other slope-exposures. Higher elevations and north slopes may be more productive because of higher rainfall and less evaporation and therefore more attractive to deer, but I believe this is only part of the explanation. If this were true, than one would expect altitude, ground and overstory cover, and number of plants to play a more important role in the regression model than they do.

This explanation of vegetative change as the factor causing deer to avoid high cattle-use areas is speculative, as I was not able to

document significant differences in the vegetative communities under different intensities of grazing. There was no correlation between the cattle index and vegetative diversity. If cattle utilization changes the vegetative community, it did not affect the overall diversity in this study. Additionally, deer do not appear to select the more vegetatively diverse sites, as there was no correlation between the deer index and vegetative diversity.

The answer may lie in changes in the number and species of plants. My methods of measuring vegetation may not have discriminated such changes under different grazing intensities. Of the four browse species that explained variation in the stepwise regression, probably gray oak is the most likely to decrease in numbers due to the influence of cattle grazing. Anthony and Smith (1977) surveyed the lower oak zones in the Dos Cabezas and San Cayetano Mountains in southeastern Arizona and found the oaks to be remnant populations with little reproduction. While I was unable to demonstrate that vegetative change as a result of the presence of cattle is a key factor influencing the selection of habitat by deer, I still believe that it is a likely explanation.

On range that generally was improving in quality at the time of this study, there was a negative relationship between cattle and deer presence. If stocking rates were higher or if the range was deteriorating, the influence of cattle on deer populations could be severe. The effect of cattle on the vegetative community, either as they consume forage or as they alter the species composition through grazing, trampling, or loss of nutrients via erosion, is the most likely

factor explaining a shift of deer utilization away from areas of higher cattle utilization. Cattle presence probably affects deer populations the most at the lower elevations because this is where the impact on the vegetative community is the greatest. In these less preferred types of habitat, such as the Prosopis-Fouquieria vegetation association, fewer cattle are needed to eliminate white-tailed deer (Fig 1). This may be true of marginal habitats in general.

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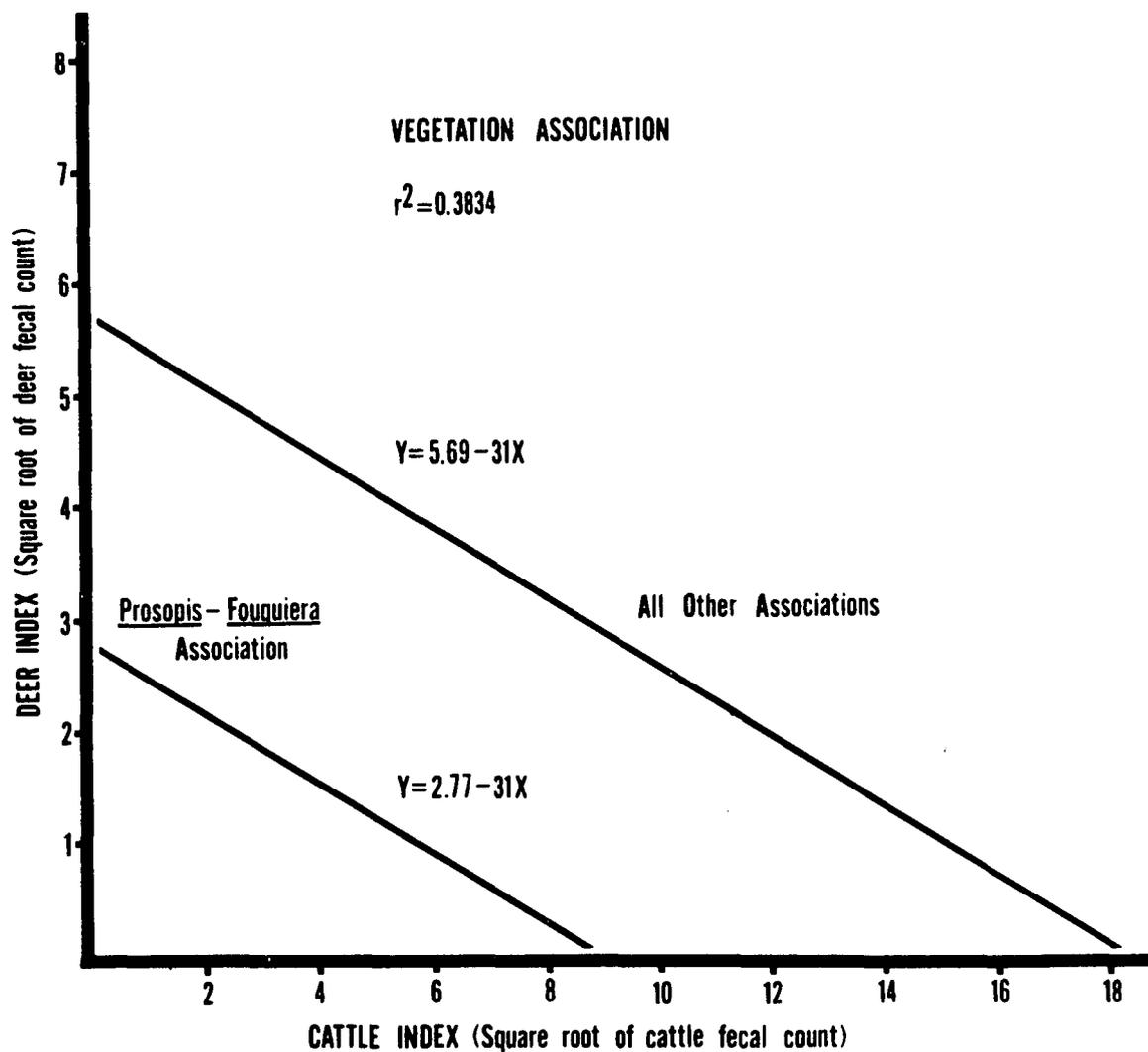


Fig. 1. Regression of deer index to cattle index with transects grouped by vegetation association for analysis. The Prosopis-Fouquieria association had a significantly lower intercept than all other associations.

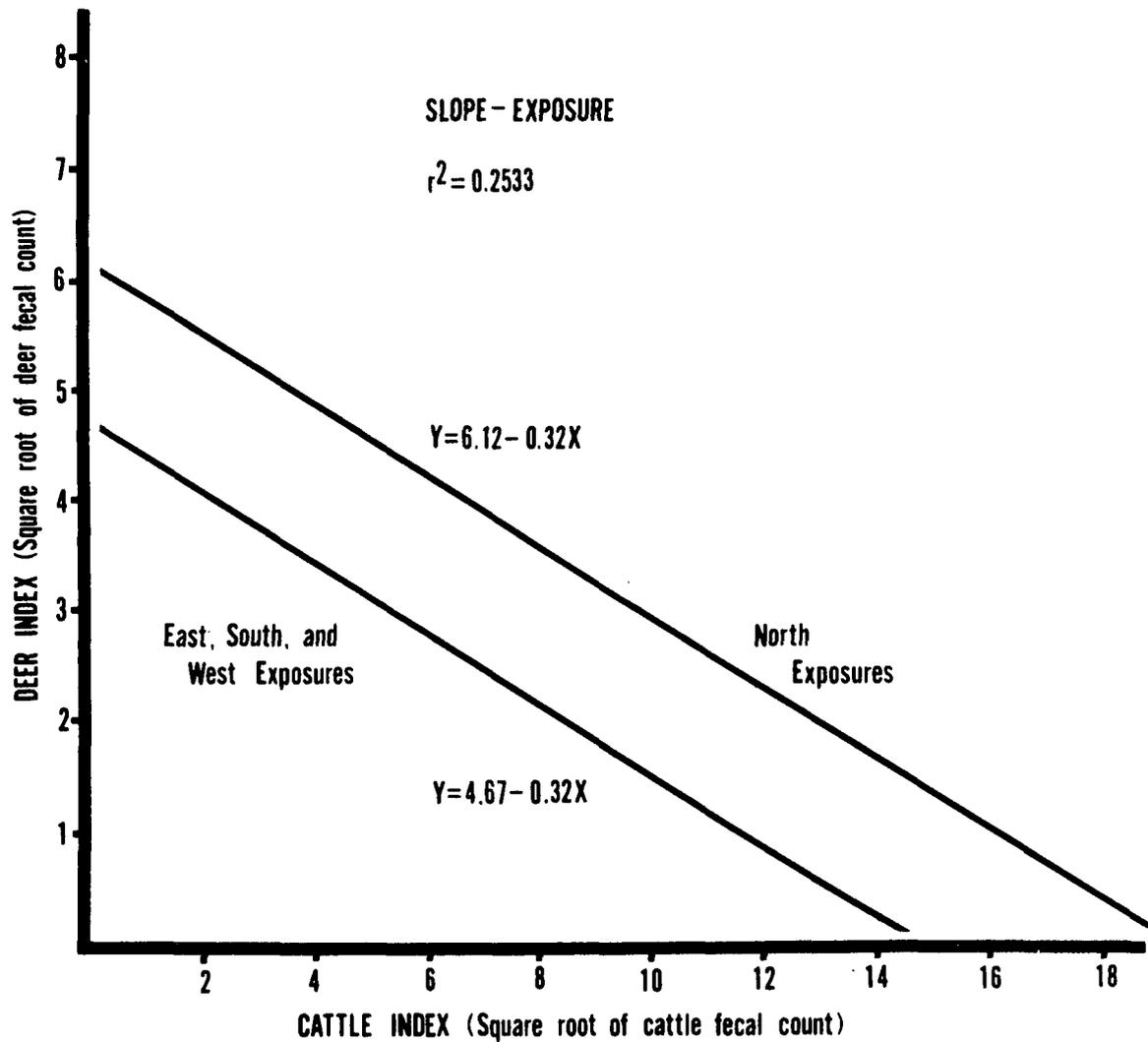


Fig. 2. Regression of deer index to cattle index with transects grouped by slope-exposure for analysis. The north exposures had a significantly higher intercept than all other exposures.

Table 1. Variables entered in stepwise multiple linear regression with the deer index as the dependent variable (F-to-enter = 4.00).

Step no.	Variable entered	Regression coefficient	Multiple r^2	Increase in r^2	F-to-enter
1	Cattle index	-0.286	0.2100	0.2100	65.90
2	Altitude	0.261	0.2826	0.0726	25.00
3	<u>Q. grisea</u>	0.223	0.3200	0.0375	13.55
4	<u>J. deppeana</u>	0.202	0.3421	0.0221	8.22
5	<u>M. dysocarpa</u>	0.150	0.3580	0.0159	6.04
6	Grass use	-0.210	0.3758	0.0178	6.92
7	<u>Rhus trilobata</u>	-0.128	0.3893	0.0136	5.37