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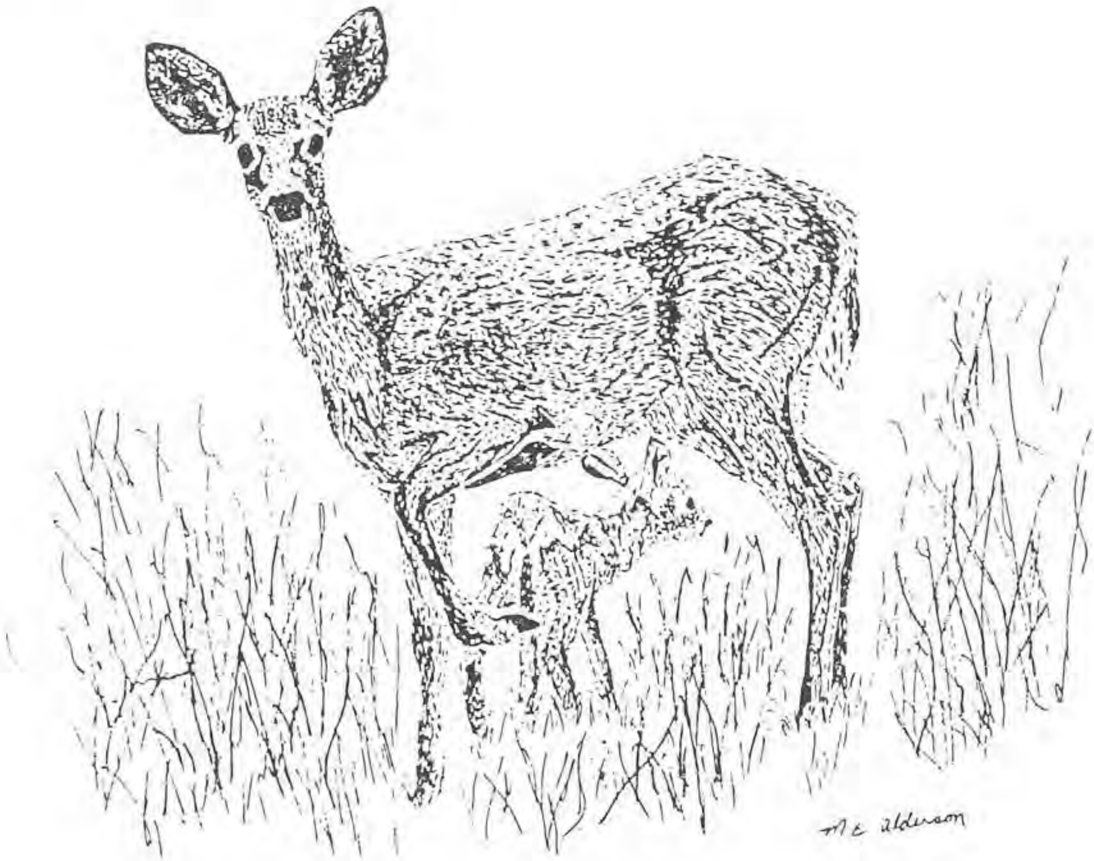
MULE DEER FAWN SURVIVAL ON CATTLE-GRAZED AND UNGRAZED DESERT RANGES

RONALD G. HOREJSI



A FINAL REPORT
AUGUST 1982

ARIZONA GAME AND FISH DEPARTMENT

FEDERAL AID IN WILDLIFE RESTORATION
PROJECT W-78-R

Research Branch
Arizona Game and Fish Department

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Federal Aid in Wildlife Restoration Project W-78-R
Work Plan 2, Job 17
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Prepared by: Ronald G. Horejsi, Research Biologist
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INTRODUCTION

Mule deer (Odocoileus hemionus) herds throughout Arizona exhibited a strong decline in population densities during the early and mid-60's. Studies were undertaken on the Three Bar Wildlife Area to determine the causes of these declines. LeCount (1977) found significant differences between fawn survival rates in a predator-free enclosure with that of adjacent areas where predators were present. Smith and LeCount (1979) reported a strong association between mule deer fawn survival, winter forb yield, and October/April rainfall of the winter-spring period preceeding the fawning period. Their results suggsted that forage conditions are probably not the factor limiting fawn survival in the herd outside the predator-free enclosure, but are interacting with predation in some manner on the ungrazed Three Bar Wildlife Area.

The controversy over the effects of livestock grazing on wildlife populations has been growing in recent years. In response to this controversy and the implications of the earlier Three Bar mule deer study, this project was initiated in hopes of determining the relationships between mule deer fawn survival and trends in coyote and alternate prey species on cattle-grazed and ungrazed desert ranges and the relationships between mule deer fawn survival and the quality and quantity of preferred deer forage items on cattle-grazed and ungrazed desert ranges.

Study Area

This study was conducted on 2 adjacent areas: the Three Bar Wildlife Area (closed to grazing since 1947) and the Tonto Basin Study Area (under National Forest cattle grazing permit) north of the Three Bar Wildlife Area. The 2 areas are situated in the Tonto Basin area of central Arizona on the east slope of the Mazatzal mountain range and extend from Roosevelt Dam on the south to Punkin Center in the north (Fig. 1). Elevational differences range from about 2,000 ft (609m) to over 7,600 ft (2,316m). The Three Bar Wildlife Area is comprised of approximately 63 mi^2 (16,317ha) with 45 mi^2 (11,655ha) considered mule deer habitat while the Tonto Basin area contains approximately 65 $mi.^2$ (16,835ha) with 42 $mi.^2$(10,878ha) of mule deer habitat. Vegetation is diverse and ranges from Upper Sonoran Desert subdivision (Brown et al. 1979) to ponderosa pine type ,with the majority of the mule deer habitat in Sonoran desertscrub, desert grassland, chaparral and riparian woodland communities.

Precipitation on the area (ave.=14 inches/yr = 60.96cm) is primarily in the form of rainfall during 2 distinct periods with the majority (60%) coming during the winter (Oct.-April). Table 1 provides a monthly breakdown of both temperature averages and rainfall. Figure 2 shows moisture patterns during the 5-year study period. The summer monsoons (July-Sept.) provide minor relief from the summer drought in the form of high intensity, localized thunderstorms. Annual and perrenial forbs, grasses, and half shrubs respond to these summer rains with brief green-ups. The peak of mule deer fawning also occurs during this period.

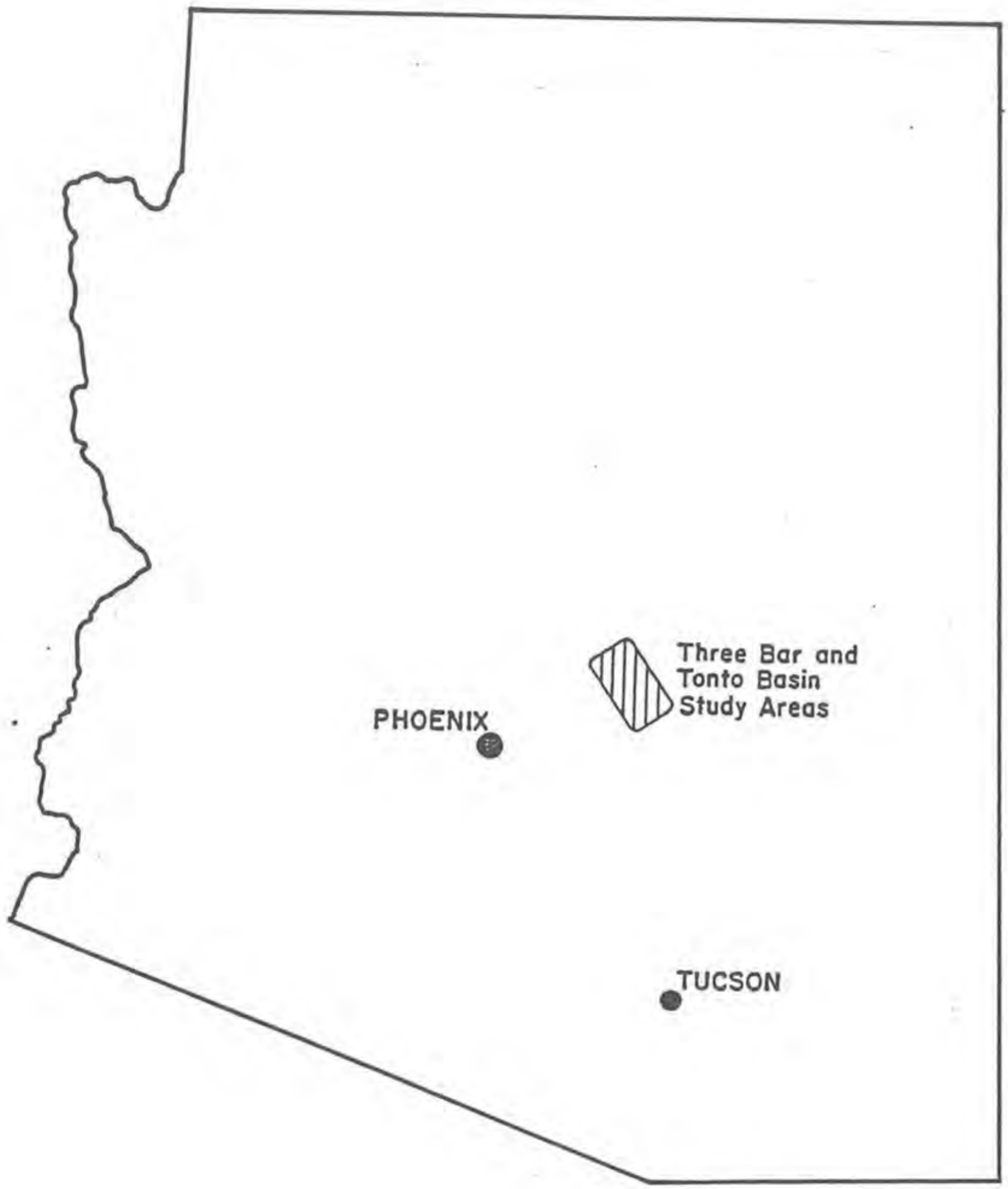

Figure 1. Three Bar Wildlife Area and Tonto Basin Study Area locations.

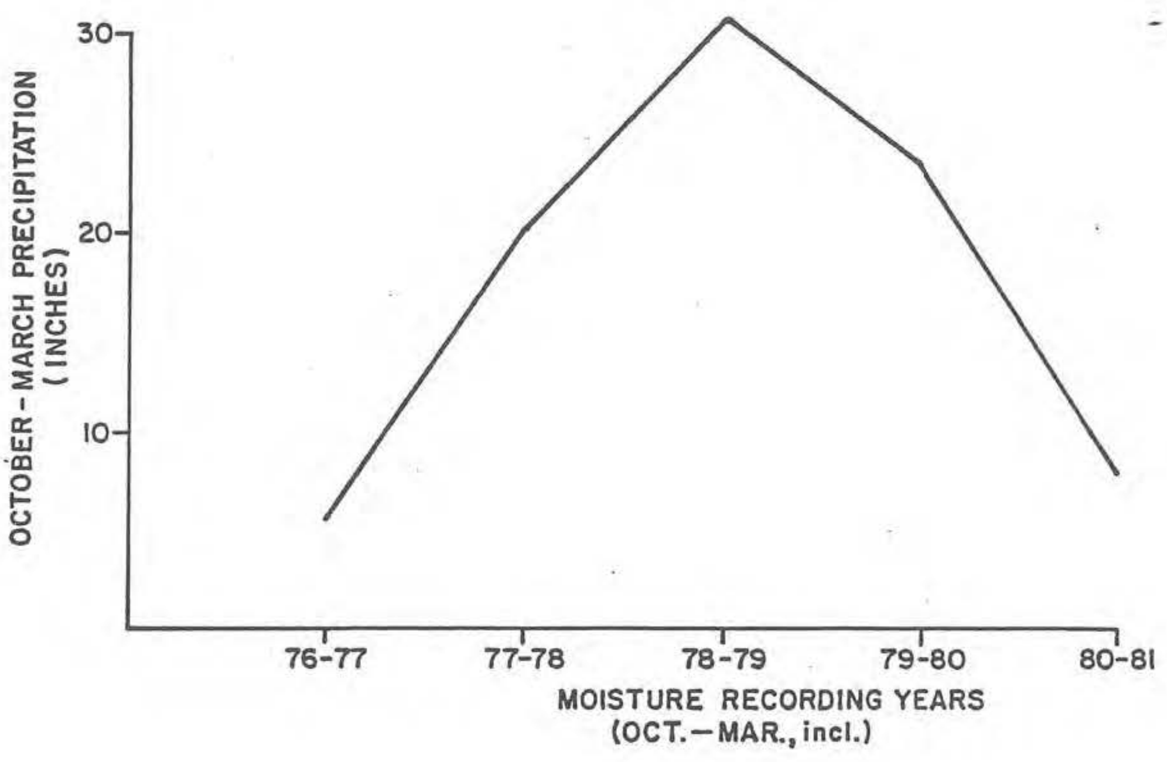

Figure 2. October to March precipitation patterns from 1976-1981.

Table 1. Average monthly temperatures and precipitation on the Three Bar Wildlife Area, Arizona.

MONTH	AVERAGE DAILY TEMPERATURE (F) MAXIMUM	MINIMUM	AVERAGE MONTHLY PRECIPITATION (INCHES)
January	54.2	33.4	1.90
February	61.8	35.8	1.47
March	63.7	38.2	1.48
April	75.0	43.7	0.35
May	81.6	50.8	0.33
June	96.7	61.8	0.32
July	98.8	68.5	1.49
August	95.2	66.0	1.83
September	90.0	60.2	1.40
October	79.0	51.0	1.44
November	65.4	36.8	1.16
December	59.4	32.4	2.18

Wildlife species inhabiting the study area include desert mule deer, Coues white-tailed deer (Odocoileus virginianus), mountain lion (Felis concolor), black bear (Ursus americanus), javelina (Pecari tajacu), black-tailed jackrabbit (Lepus californicus), desert cottontail (Sylvilagus audubonii), coyote (Canis latrans), gray fox (Urocyon cinercoargenteus), bobcat (Lynx rufus). ringtail cat (Gassariscus astutus), badger (Taxidea taxus), racoon (Procyon lotor), 2 species of skunks, 14 species of rodents, 6 species of bats, whitewing dove (Zenaida asiatica), mourning dove (Zenaidura macroura), Gambel quail (Lophortyx gambelii) and numerous species of passerine birds.

The Tonto Basin Study Area contains 2 cattle grazing allotments, both running cow-calf and yearling operations. Grazing permit numbers established by the Forest Service for the 7/K allotment (17,521 acres: 7,090ha) are 150 cows from January 1 through December 31 on a seasonal rotation basis plus 119 yearlings from January 1 through May 31. The George T. Cline trust allotment (125,000 acres: 50,586ha) includes 666 mother cows from January 1 through

December 31, plus 483 yearlings from January 1 through May 31 on a year-long continuous grazing basis. Only a portion of the George T. Cline trust allotment is located in the Tonto Basin Study Area.

Both areas were closed to mule deer hunting and the taking of predators and furbearers for the duration of the study.

Methods

Data for this study were collected over a 5 year period from April 1977 through June 1982.

1. Rodent and rabbit populations:

Rodent populations were monitored during the peak of mule deer fawning each year (1st week of August) by snap trapping on 5 sets of parallel trap lines on each treatment (grazed and ungrazed). One trap line set was composed of 2 parallel lines 15 yards (13.7m) apart with 10 stations per line also set 15 yards (13.7m) apart. Each station had 1 modified rat trap and 1 mouse trap baited with cotton soaked in peanut butter and rolled oats. Trap lines were run for 4 consecutive days.

Rabbit surveys were conducted by driving approximately 20 miles (32.2km) of dirt road on each of the 2 transects. Surveys were begun 30 minutes before sunrise and were run for 4 consecutive days. Two survey periods were run each year (pre-fawning and peak of fawning). Rabbit numbers were also recorded during the spring quail call count surveys. A lagomorph population index by track count was derived from predator scent post surveys run in mid-September of each year.

2. Cover, density and frequency of trees, shrubs and half shrubs:

Line intercept and belt transects were surveyed the 1st and last years of the study in 4 habitat types (Sonoran Desertscrub, Desert Grassland, Interior Chaparral, and Riparian Woodlands) on both treatments. A total of 1,000 ft. (304.8m) of line intercept and 20,000 ft^2 (0.19ha) of belt transect were sampled for each habitat type on each treatment for each survey year. Line intercept data was recorded by cover height category and total cover.

3. Fruit, nut and berry production:

Six major species: mesquite beans (Prosopis juliflora); prickly pear tunas (Opuntia engelmannii); catclaw acacia beans (Acacia greggii); jojoba nuts (Simmondsia chinensis); palo verde beans (Cercidium spp.); and turbinella oak acorns (Quercus turbinella) were sampled during late summer in each of the first 3 years of the study. Sixteen individuals of each species were partially or totally harvested on each treatment, dried and weighed, and then converted into a pounds/acre estimate for each treatment. A 2nd technique was substituted the last 2 years of the study to increase sample size and reduce variation. The new method employed a 5-point ranking system and eliminated the harvesting procedures.

4. Spring green forage production:

Green forage production of grasses, forbs, and selected half shrubs was estimated from a variation of the double-sampling technique described by Wilm, et al. (1944). Two hundred, 10 ft^2 ($0.929m^2$) were sampled on each treatment. Total herbage green weight, % contribution of each forb and half shrub species, and the % contribution of all grass species combined were estimated ocularly on each plot. Twenty percent of the plots were clipped of all current growing vegetation; samples were oven-dried and weighed to obtain a regression estimate of oven-dried weight of all herbage on the plot as well as the contribution of each species.

5. Nutritional quality of key forage species:

Standard laboratory analysis of key vegetation species was carried out by a private feeds lab. Species analyzed included saguaro fruits (Carnegiea gigantea), prickly pear tunas, turbinella oak leaves and acorns, mesquite beans, catclaw acacia beans, jojoba leaves and nuts, and calliandra leaves (Callinadra eriophylla). Nutritional analysis included % moisture, protein, fat, fiber, calcium, phosphorous, ash and total digestible nutrients.

6. Mule deer population densities:

Mule deer densities were estimated on both the grazed and ungrazed areas by means of sample pellet group counts. A total of 1,000, 100 ft^2 ($9.29m^2$) plots 2 chains apart on line transects were read and cleared on each treatment annually in December. A defecation rate of 13 groups per day per deer was used to calculate deer densities (Smith, et al. 1969).

7. Buck/doe/fawn ratios in mid-winter:

Fawn/doe and buck/doe deer ratios were determined from counts made annually in January. Approximately 1 manday per square mile (258.99ha) was spent classifying deer on 58-foot and horseback survey routes distributed over the 2 treatments. Survey data provided a measure of mid-winter fawn survival and herd composition. The predator-free Walnut Canyon enclosure (603 acres: 244 ha) deer herd was monitored each November by a drive count to determine fawn surviva and herd composition. This enclosure herd was used as an ungrazed, unhunted and predator-free control.

8. Predator population surveys:

Predator population indices were developed from the coyote scent post survey (Roughton 1975) run annually in September on each treatment. In addition, scat collection routes were run monthly to determine average number of scats per mile of road.

9. Coyote food habits:

Coyote scats collected on the monthly collection routes were analyzed for species composition.

10. Deer and cattle food habits:

Food habits of mule deer and cattle were determined using the microhistological examination of plant fragments in fecal material as outlined by Sparks and Malechek (1968). Twenty-five fresh fecal samples each from cattle and mule deer on the grazed treatment and 25 mule deer fecal samples from the ungrazed area were collected during each of the 4 major seasons for a 3-year period. Microscopic analysis was performed by the Range & Wildlife lab at Texas Tech University, Lubbock.

11. Vegetation mapping of the Three Bar Wildlife Area:

A detailed mapping of the Three Bar and Tonto Study Areas was accomplished under contract with the Office of Arid Land Studies, University of Arizona.

RESULTS AND DISCUSSION

1a. Rodent populations:

Rodent populations were monitored each year of the study. Results of the trapping effort are summarized in Table 2 Data was converted into average catch/trap night for comparison of the 2 treatments. An analysis of variance test was run among years (1978-81) on the same area and between areas during the same year (1978-81). Duncan's multiple range tests (d = 0.10) were used for testing all pairs of yearly means. In Table 2, those means underlined by the same line are not significantly different.

Table 2. Rodent population indices on grazed and ungrazed desert ranges.

AVERAGE CATCH PER TRAP NIGHT	1977[1]	1978	1979	1980	1981
THREE BAR	0.034	0.057	0.029	0.028	0.034
TONTO BASIN	0.055	0.058	0 048	0.041	0.050

[1]University of Arizona data (Danner, pers. comm.) not included in AOV.

Results of the AOV indicated a significant difference existed in total rodent population indices among years on the Three Bar only. The multiple range test procedures indicated that the 1978 index was higher than all other years. Data for pack rats (Neotoma albigula) was broken out and tested since pack rats were a major part of the coyote's rodent diet. AOV indicated significant difference ($P \leq 0.047$) between years on the Three Bar only for Neotoma. The Duncan range test again showed that the 1978 index was higher than any other year.

An AOV test was also performed for difference in rodent and Neotoma population indices between areas within the same year. Only the total rodent population indices for 1979 and 1981 were found to be significantly different between the Three Bar and Tonto areas (Table 3). None of the Neotoma population indices between areas were significantly different.

Table 3. AOV results for total rodent population indices between areas during the same year.

YEAR	3 BAR	TONTO	P[1]
1978	0.057	0.058	0.922
1979	0.029	0.048	0.058
1980	0.028	0.041	0.264
1981	0.034	0.050	0.025

[1]Probability of Type I error.

There was not a significant linear relationship between the rodent population index and the fawn survival index on either Three Bar or Tonto.

1b. Rabbit population indices:

The 3 different techniques utilized for rabbit population indices (rabbit road surveys, quail call count surveys, and predator scent post plots) gave conflicting results of trends among years and areas. The rabbit counts made during the spring quail call count surveys were a reversal of the rabbit indices indicated by the summer rabbit road surveys. The rabbit track counts from the predator scent post surveys also did not show any consistent relationship with the other two methods. The summer road surveys did indicate a consistently higher lagomorph population index on the grazed Tonto Basin area than on the ungrazed Three Bar in all years except the last, 1981. The implications of both the rodent and rabbit population indices will be discussed further under the coyote food habits section. Results of the three rabbit survey mehtods are shown in Table 4.

Table 4. Rabbit population indices developed from three survey techniques: Summer rabbit road surveys, spring quail call count routes, and fall predator scent post surveys[1].

	COTTONTAIL RABBITS				JACKRABBITS		ALL LAGOMORPHS			
	THREE BAR		TONTO BASIN		THREE BAR	TONTO BASIN	THREE BAR		TONTO BASIN	
YEAR	ROAD ROUTES RABBITS/MI	QUAIL ROUTES RABBITS/MI	ROAD ROUTES RABBITS/MI	QUAIL ROUTES RABBITS/MI	ROAD ROUTES RABBITS/MI	ROAD ROUTES RABBITS/MI	ROAD ROUTES	SCENT PLOTS	ROAD ROUTES	SCENT PLOTS
1977	0.47	0.81	0.70	0.27	0.09	0.18	0.55	119	0.87	148
1978	0.45	0.49	0.49	0.11	0.05	0.12	0.50	243	0.62	204
1979	0.60	0.58	0.68	0.10	0.13	0.16	0.73	216	0.84	205
1980	0.65	0.68	0.57	0.19	0.01	0.18	0.67	106	0.76	113
1981	0.42	0.33	0.32	0.14	0.01	0.06	0.43	86	0.38	47

Note 1. Summer rabbit road survey and quail call count route results are expressed as average number of rabbits/mile of survey.

Predator scent post survey results are expressed as index of visitation: $\frac{\text{\# rabbit visits}}{\text{\# plot nights}} \times 1{,}000$

An AOV was also run for Three Bar roadside count indices to test for variation in total lagomorph and cottontail population indices (roadside counts) among years and between areas. The AOV of lagomorph indices did not find significant variation among years ($P \leq 0.187$), on Three Bar, although the Duncan's multiple range test (Table 5) did show that the 1981 index was significantly lower than either 1979 or 1980. Likewise for cottontail-only indices, the AOV did not show significant variation among years ($P \leq 0.299$). The Duncan's test showed the 1981 cottontail index to be significantly lower than 1980.

Table 5. Duncan's multiple range tests (?=0.10) for differences among years for lagormorph and cottontail population indices, 3 Bar and Tonto Basin study areas.[1]

YEAR	1981	1978	1977	1980	1979
3 BAR LAGOMORPHS	0.43	0.55	0.60	0.67	0.72

YEAR	1981	1977	1978	1979	1980
3 BAR COTTONTAILS	0.42	0.50	0.51	0.60	0.66

YEAR	1981	1978	1980	1979	1977
TONTO LAGOMORPHS	0.38	0.68	0.76	0.84	1.04

YEAR	1981	1978	1980	1979	1977
TONTO COTTONTAILS	0.32	0.54	0.57	0.68	0.87

[1]Indices underlined by same line are not significantly different at $\alpha=0.10$.

For the Tonto Basin area, the AOV for lagomorphs did show significant variation among years ($P \leq 0.004$) also reflected more specifically by the Duncan's test. Likewise for cottontails the AOV was significant ($P \leq 0.007$), the differences being confirmed by the Duncan's test.

An AOV was also performed to test for significant differences in total lagomorph and cottontail-only population indices between areas during the same year. Only the data for total lagomorph and cottontail-only population indices between the Three Bar and Tonto areas in 1977 were significantly different. Results are shown in Table 6.

Table 6: AOV results for total Lagomorphs population index between areas during the same year.

YEAR	3 BAR	TONTO	P[1]
1977	0.55	0.87	0.04
1978	0.50	0.62	0.38
1979	0.73	0.84	0.45
1980	0.67	0.76	0.40
1981	0.43	0.38	0.67

[1]Probability of Type I error.

2. <u>Cover, frequency, and density of trees, shrubs and half shrubs:</u>

The line intercept survey for cover and cover height and belt transect survey for frequency and density of trees, shrubs and half shrubs were run in May 1977 and 1982. Density estimates for the various species in each habitat type were computed along with total cover and cover by height category. Cover height categories were developed for a measure of hiding cover for rodents, rabbits and fawns, and included categories: I (0-6"), II (6-12"), III (12-24"), IV (24-48"), and V (> 48"). Line intercept and belt transect surveys were not rerun in the riparian woodland habitats in 1982 because of extensive modification and scouring of the flood plains by large floods during 3 years of the study period. A conspicuous difference between the grazed and ungrazed areas was noted in the amount of ground cover present in 0 to 24" height categories, the cover height assumed most important for newborn fawn protection. In both survey years the ungrazed Three Bar had a significantly higher percentage of ground cover in this height category than did the grazed Tonto Basin area. The difference between areas was greatest in 1977 which was considered a drought year with poor vegetative growth. During 1982 the differences were less but reflected the same trend in a year considered above average in vegetative production. In both years the desert grassland habitat had the greatest variation between areas in the 0 to 24' category while the desertscrub type showed the 2nd largest variation between areas. The interior chaparral habitat showed the least variation between areas. Table 7 provides a comparison of areas for the 0 to 24" vegetation height categories while Figures 3-8 provide comparisons of all vegetative height categories for the desert-scrub, desert grassland, and interior chaparral habitat types.

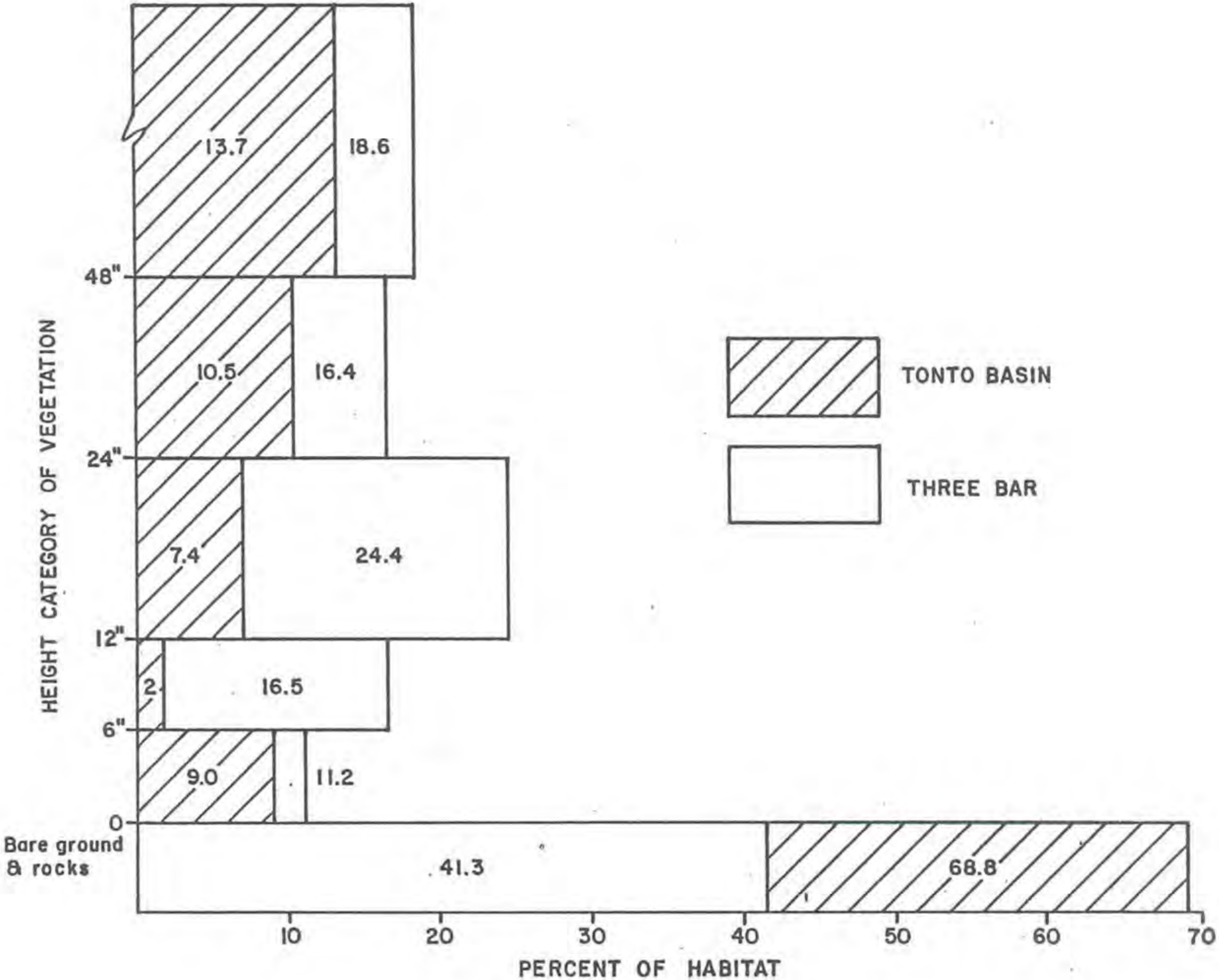

Figure 3. Sonoran desertscrub

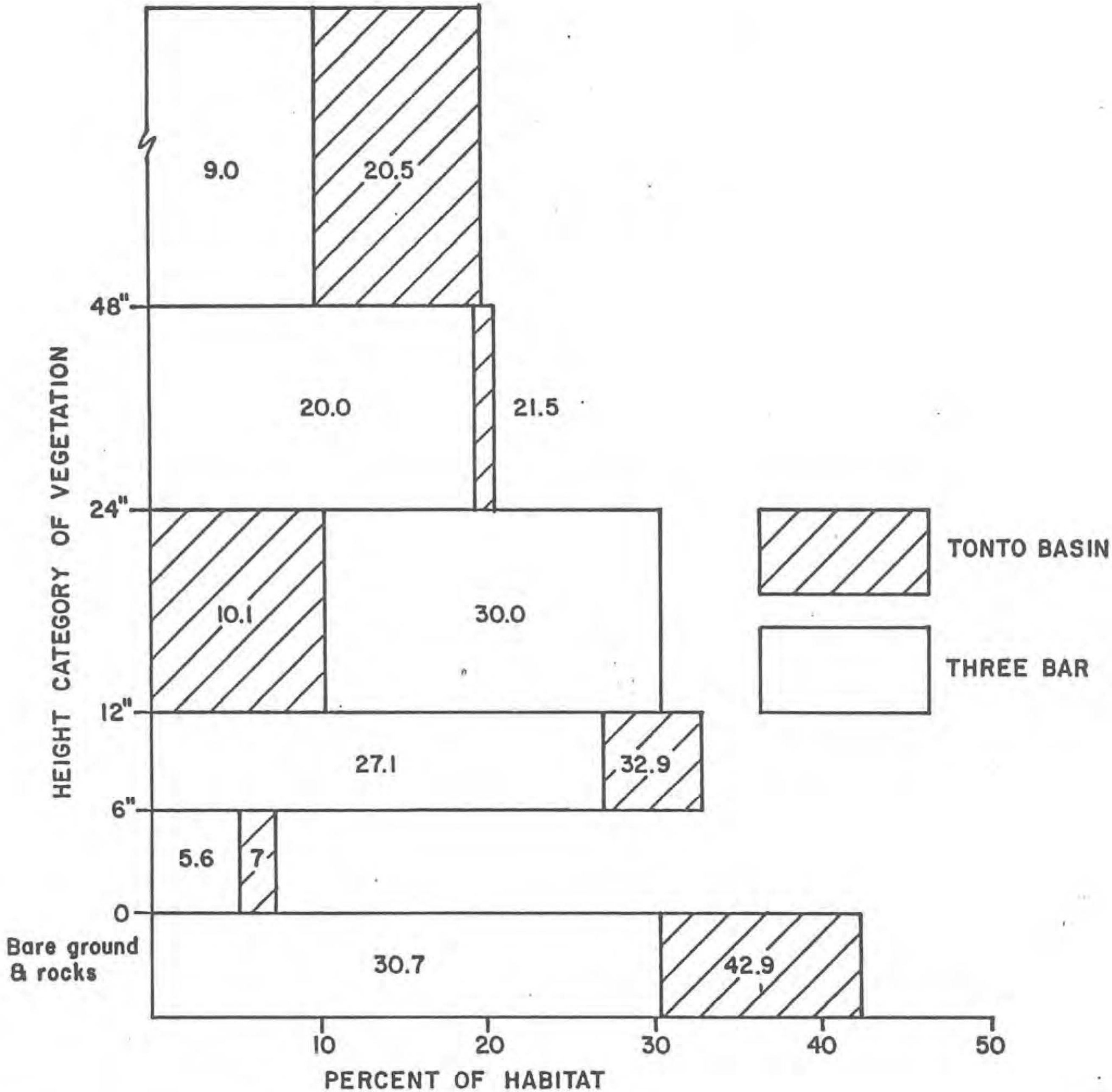

Figure 4. Sonoran desertscrub vegetation and ground cover (May 1982).

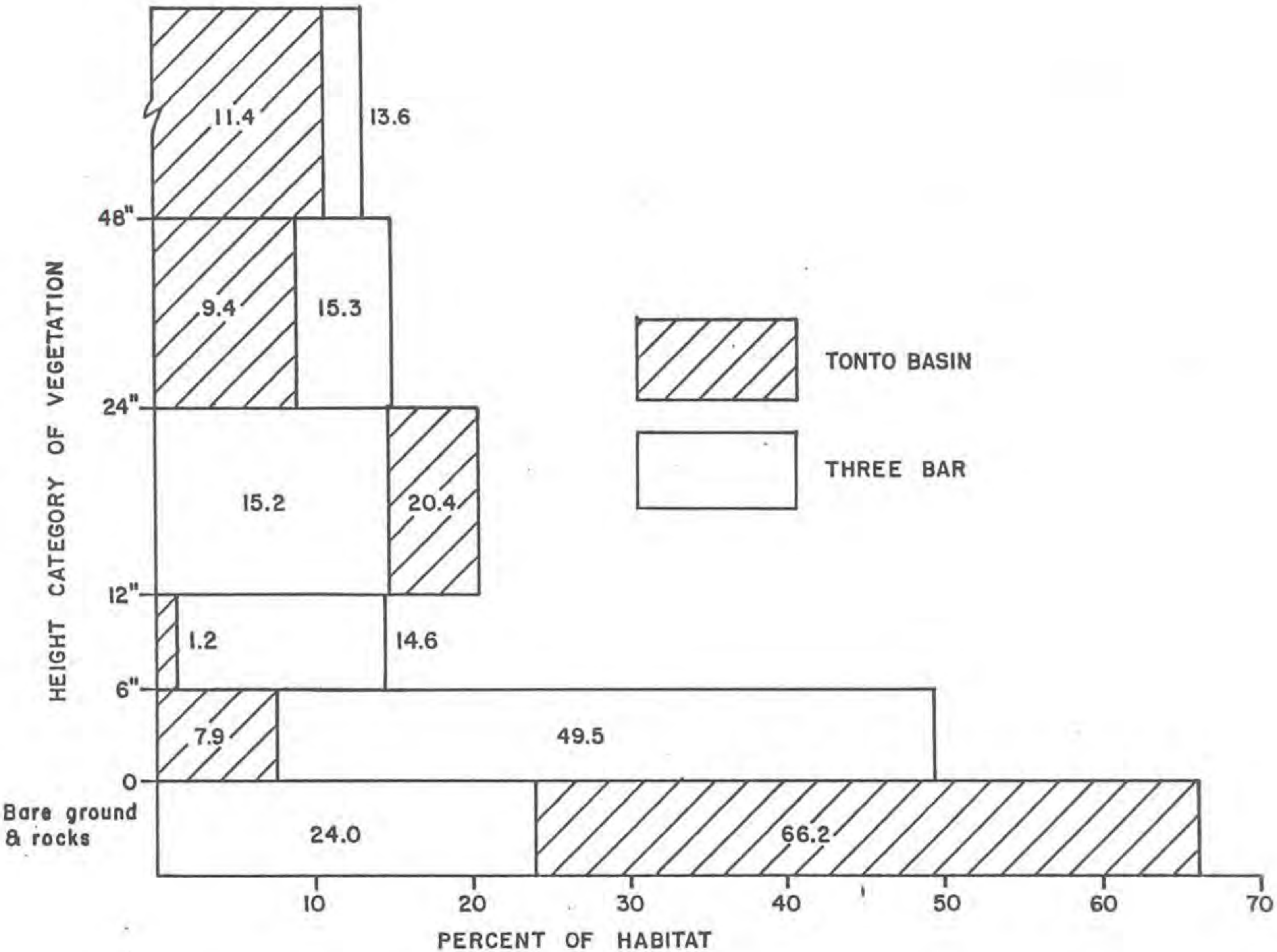

Figure 5. Desert grassland
vegetation and ground cover

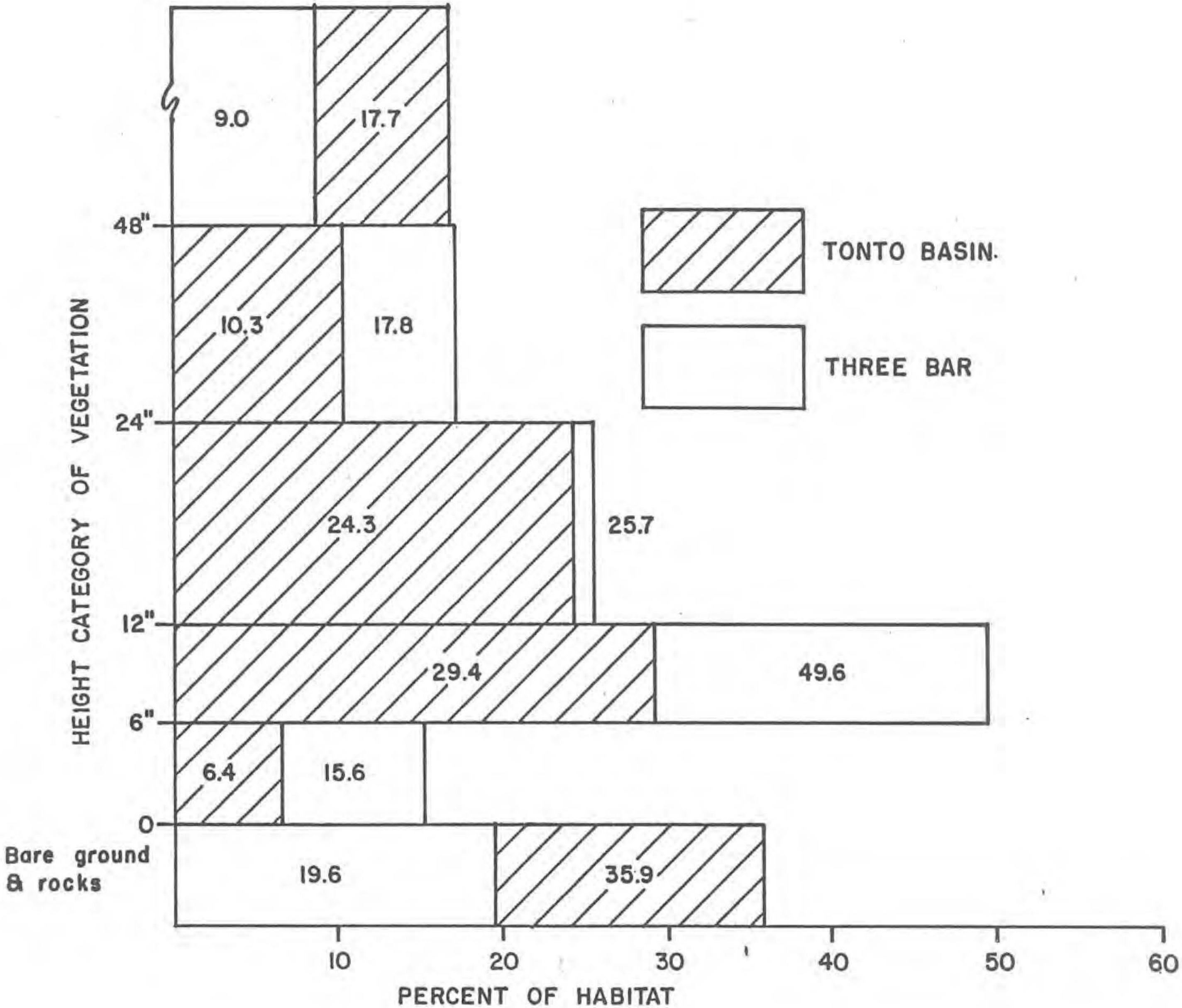

Figure 6. Desert grassland vegetation and ground cover (May 1982).

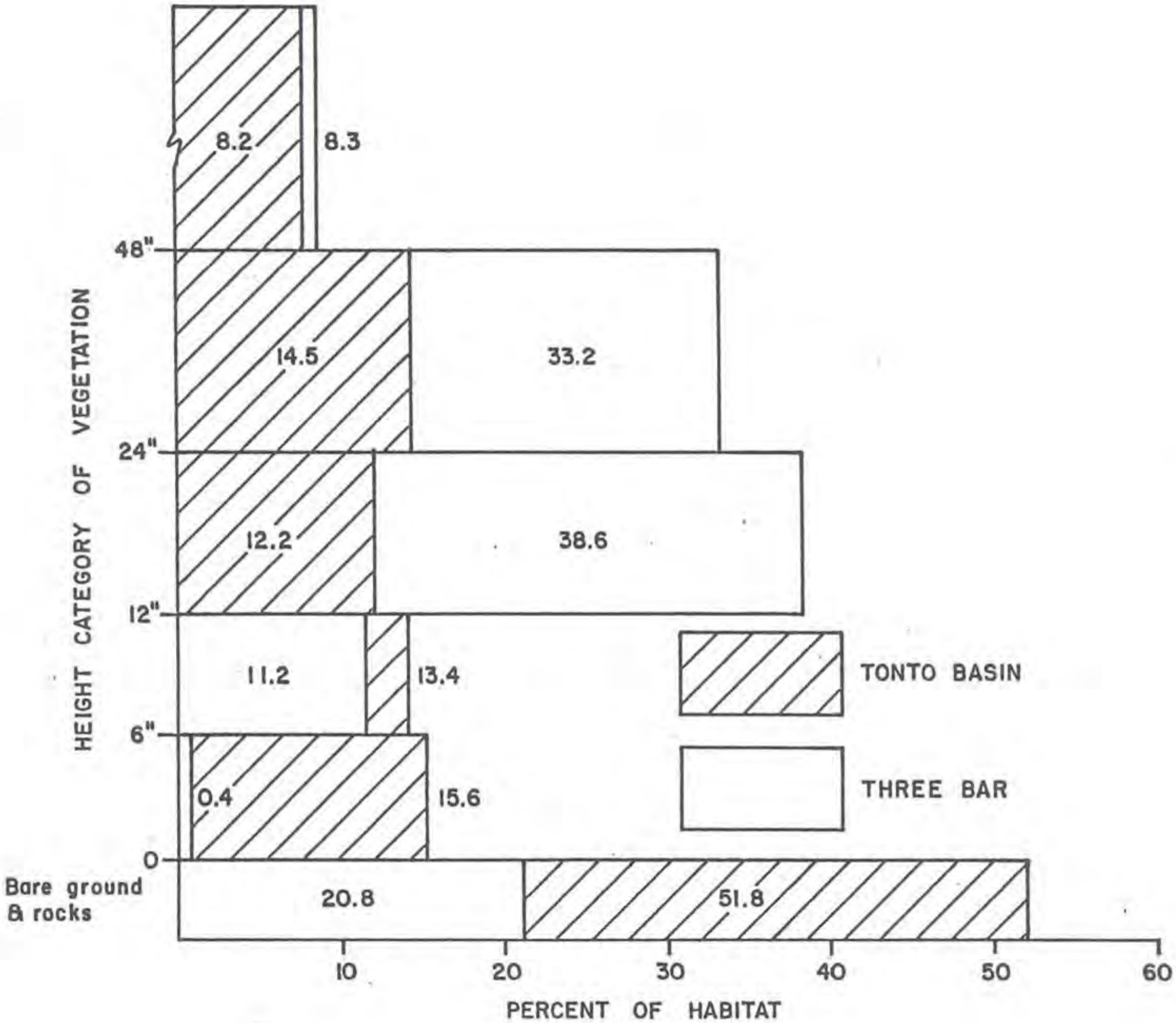

Figure 7. Interior chaparral vegetation and ground cover (May 1977)

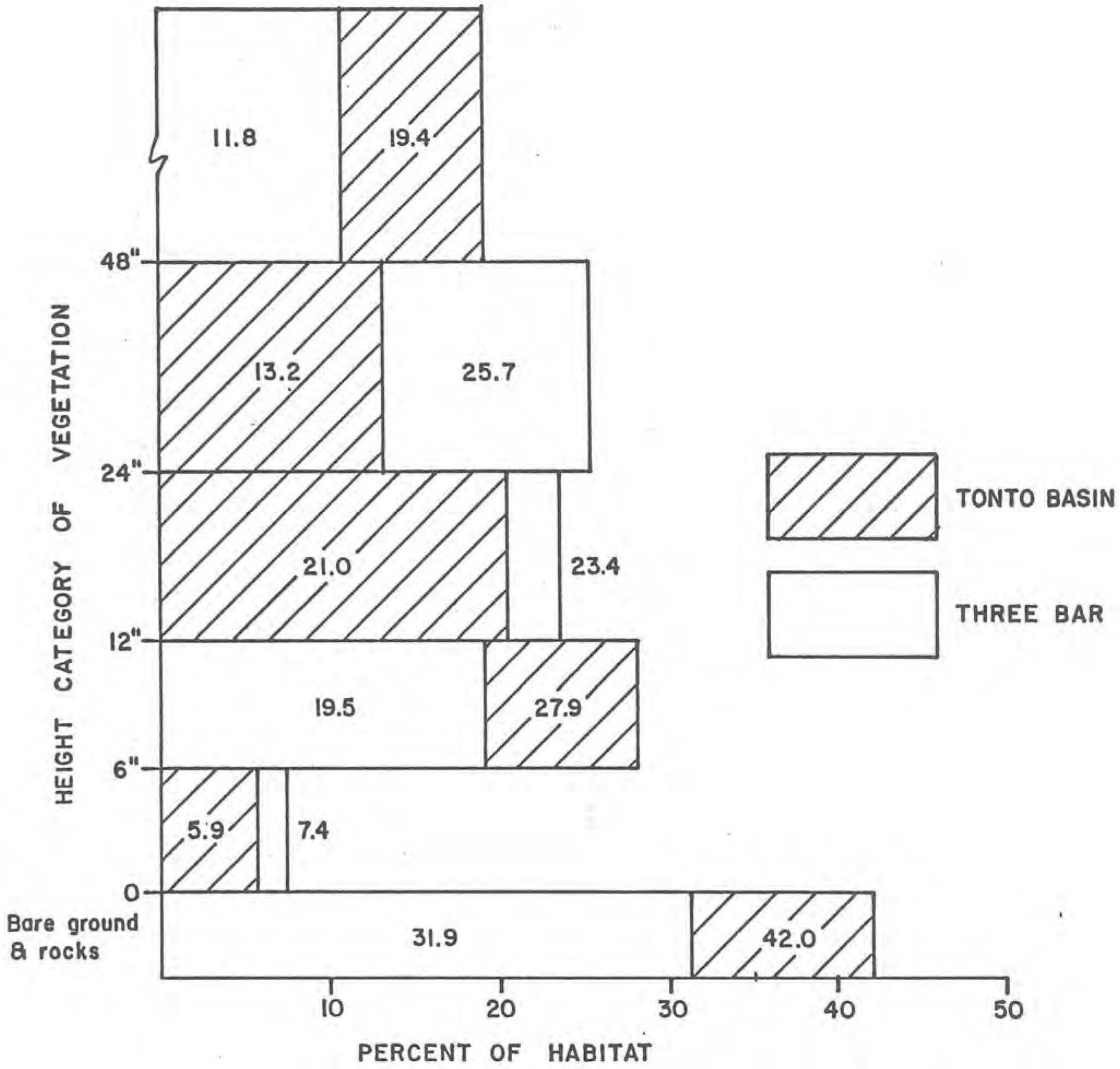

Figure 8. Interior chaparral vegetation and ground cover (May 1982).

Table 7. Percent ground cover (0 to 24" categories) from line intercept surveys.

HABITAT TYPE	MAY 1977 THREE BAR	MAY 1977 TONTO BASIN	MAY 1982 THREE BAR	MAY 1982 TONTO BASIN
Desert Grassland	79.2	29.5	90.8	71.8
Desert Scrub	48.2	18.4	62.7	50.1
Interior Chaparral	50.2	41.2	52.0	54.8
Riparian Woodland	44.3	25.2	Not Surveyed-Flooded	

3. Fruit, nut and berry production:

The harvesting technique used for fruit, nut and berry production estimates reflected a large amount of variation among individual plants, sites, and treatments. The method was extremely time-consuming and resulted in small sample sizes and corresponding large variations. The occular production ranking system utilized the last 2 years also proved unreliable again due to limited sample size and observer biases. Neither method provided sufficient information to make any conclusions about production of these food sources. Until more reliable and efficient techniques can be developed, information on such forage production will continue to be an elusive data point.

4. Green forage production in spring:

Spring forage production estimates were made on both treatments during all 5 years of the study. Total green forage production (both grasses and forbs) was greater on the ungrazed Three Bar during 4 of the 5 years. Grass production was greater on the ungrazed area during all years while forb production was greater on the ungrazed area in 3 of the 5 years (Table 8). Results again suggest that forage conditions are probably not a directly limiting factor on fawn survival but are interacting with predator and alternate prey species populations in some manner (possibly cover conditions) and thus affecting fawn survival.

Table 8. Spring forage production on grazed and ungrazed desert ranges, (pounds/acre).

YEAR	FORBS		GRASSES		TOTAL FORAGE	
	3 BAR	TONTO	3 BAR	TONTO	3 BAR	TONTO
1977	204	194	155	85	359	279
1978	389	471	179	150	568	621
1979	563	610	328	231	891	841
1980	617	554	524	348	1141	902
1981	501	434	250	203	751	637

5. Nutritional quality of key vegetative species:

Examination of the nutritional quality of major forage species (jojoba, turbinella oak, mesquite, catclaw acacia, prickly pear, calliandra, and saguaro cactus) was undertaken since deficiencies in certain essential components can influence the productivity of female herbivores. One such example is the relatively high level of phosphorous required by does during gestation for normal development of the fetus and for extensive quantities of milk during lactation (Short 1969). Short (1981) further states that phosphorous levels should be about 0.20-0.25% of the diet and calcium should be no more than 1 to 5 times the phosphorous level.

While nutritional components of the browse species analyzed were virtually identical between treatments the phosphorous:calcium ratios missed the optimum levels substantially and ranged from 1:8 for oak acorns up to 1:28 for calliandra foliage. Only jojoba nuts and catclaw acacia beans (1:2) and mesquite beans (1:5) fell within the limits mentioned. The average phosphorous content of the 7 browse species analyzed was 0.14%. Forb components of the diet were not analyzed, however, and may have made up for shortages noted in the browse.

6. Mule deer densities:

Mule deer densities were estimated from pellet group counts for both treatments during all 5 years of the study. Deer density estimates were considered an important element in evaluating the impact of livestock grazing on the deer population. Previous to the initiation of this study, the grazed Tonto Basin area had been open to buck-only mule deer hunting while the Three Bar area had been closed to mule deer hunting since 1972.

Despite the differences in deer management between the 2 areas previous to this study, population density estimates for the 2 treatments were quite similar except for the final year, 1981. Confidence intervals indicate there was no difference between areas in any year. The deer density estimates for both areas are presented in Table 9. Background data from pellet group counts on the Three Bar since the 1950's shows that the deer herd has increased from a low in 1969-70 of 6 deer/mi^2 to the present 10 deer/mi^2. The population appears to have remained stable at 10 deer/mi^2 since 1979. An expected lower deer density on the grazed and previously hunted Tonto Basin area was not observed at the beginning of the work.

Table 9. Deer population density estimates on grazed and ungrazed desert ranges.

YEAR	DEER/MI^2 (pellet group counts) TONTO BASIN (grazed)	THREE BAR (ungrazed)
1977	7.4±2.8[1]	7.2±3.1
1978	8.8±3.3	8.9±3.2
1979	9.9±3.9	9.7±3.0
1980	11.5±5.6	12.8±3.6
1981	7.8±2.8	9.5±2.8

[1]Percent confidence interval (0.05)

In July 1980 approximately 25% of the Tonto study area was burned by a lightning-caused wildlife. Subsequent pellet group and winter classification surveys showed increased deer use in this area following the fire. Groups of deer as large as 40 individuals were surveyed on the area, indicating a preference for the vegetative regrowth on this area.

The 1981 surveys and fawning period were preceeded by an extremely dry winter period (3.92", Oct.-Feb.) which is well below the 27 year average of 8.14". This drought resulted in a below average vegetative production year and may be a causative factor for the reduced deer population densities estimated in December 1981 pellet group counts.

If grazing is detrimental to a desert deer herd, it seems most likely it would have its greatest impact during the most stressful years - the drought years. The spreading density estimates, though not significant, between grazed and ungrazed areas in 1981 may reflect the impact that grazing has on the deer population. Both herds (grazed and ungrazed) showed declines during the drought year but the grazed area had a decrease of greater magnitude. The decline in deer numbers on both areas in 1981 is probably real, although our sampling rate did not have enough power to detect or verify the estimated differential in the decline between the 2 areas. Thus the foregoing statement is very speculative.

7. Buck, doe and fawn classifictions in mid-winter:

Mid-winter classification surveys were completed on both areas during all 5 years of the study. Surveys were run in early January at the peak of breeding activity and should therefore represent the best estimate of herd composition since animal activity is considered at its peak.

The fawn/doe ratios are assumed to be a maximum index to fawn survival at 5-6 months after birth. Table 10 presents the buck/doe and fawn/doe ratio estimates for both study areas plus the Walnut Canyon enclosure herd (control area: ungrazed, unhunted, and predator-free).

Table 10. Buck/doe and fawn/doe ratio estimates from mid-winter surveys.

YEAR*	TONTO BASIN (GRAZED)		THREE BAR (UNGRAZED)		WALNUT CANYON ENCLOSURE CONTROL	
	♂:100♀	FAWNS:100♀	♂:100♀	FAWNS:100♀	♂:100♀	FAWNS:100♀
1978[1]	33	29	50	33	114	14[2]
1979	49	45	66	39	200	75
1980	37	53	48	51	145	82
1981	51	34	51	49	111	59
1982[1]	51	21	46	31	50[3]	29

[1]Survey followed a drought year condition.

[2]Drought year conditions coupled with severe water supply problems in enclosure.

[3]Enclosure herd was reduced by 19 animals (13 bucks and 6 does) to make population size more compatible with available habitat.

The number of animals surveyed varied from year to year on both areas and averaged 142 (range 91-185) on the Tonto and 161 (range 132-184) on the Three Bar. Buck/doe ratios were compared between areas and showed no significant difference. A comparison was also made of buck size class frequencies based on antler size and point counts. Chi-square analysis showed no significant differences in the frequency distribution of bucks by antler size and point classes between areas. Though not statistically valid, department personnel working on the 2 areas expressed a "gut-feeling" that the frequency of older age class bucks (based on antler size and points) increased over the duration of the study on the grazed Tonto area. This would be expected as elimination of deer hunting reduced the loss of bucks and thus allowed an increase in numbers of older age bucks.

Fawn/doe ratios were also compared between areas and among years within the same area.

There were no significant differences in fawn/doe ratios between areas during the same year. A significant difference at the 0.10 level (X^2=9.182) was noted, however, among years on the Tonto Basin area this difference occurred between 1980 and 1982. No significant difference was noted in fawn/doe ratios among years on the Three Bar.

8. Predator population surveys:

The index of predator populations from scats/mile of road was abandoned during the 4th year due to inconsistent results. The inconsistencies were believed due to scat losses from heavy weekend vehicle traffic, road maintenance and rains.

The results of the U.S. Fish & Wildlife Service's predator scent post surveys for the 5 study years are presented in Table 11. Problems inherent to the technique were discussed by Roughton (1982). These limitations of the method were recognized but in lieu of a more precise system the technique was maintained for our work.

Table 11. Predator population indices on Three Bar and Tonto Basin study areas.

	PREDATOR INDEX[1]			
	COYOTE		BOBCAT	
YEAR	THREE BAR	TONTO BASIN	THREE BAR	TONTO BASIN
1977	184	60	16	0
1978[2]	35	49	49	21
1979	240	112	0	12
1980	194	71	41	6
1981[2]	66	40	0	0

[1]Predator Index = $\frac{\text{animal visits}}{\text{station nights}}$ X 1,000

[2]Surveys severely hampered by rains.

High predator impact on these desert mule deer herds was strongly implicated by Smith and LeCount (1979) in their comparison of fawn survival in a predator-free area vs. an adjacent herd subject to predation. The coyote has been considered the most significant predator of fawns on the study areas. Mountain lions are also present on the study areas and must be considered in assessing fawn and adult mortality. Tracks and scratches of mountain lions have indicated that on any given day 5 individuals are present on the Three Bar area and 4 individuals may be found on the Tonto Basin area. Shaw's lion:sq. mile ratio estimator (personal communication) indicate lion populations of 4-5 individuals on the Three Bar and 4-5 on the Tonto area.

Bobcats are present on both study areas and are listed in Table 11 but are not considered to have a significant impact on fawn survival. Jones and Smith (1979) in their bobcat dietary work found that deer remains occurred in only 3% of 176 scats collected over a 1 year period.

Coyote indices developed from the surveys indicated a consistently higher number on the Three Bar area, except for 1978 when surveys were severely hampered by heavy rains. Although both areas were closed to the taking of predatory mammals, the Tonto Basin area was closed for the first time at the onset of this study, while the Three Bar had been closed since 1971. The longer period of legal trapping of coyotes on the Tonto Basin area may account in part for the lower coyote index on Tonto during the 1st year or 2 of the study.

9. Coyote food habits:

Coyote food habits as determined by the analysis of over 1,800 scats were developed for both treatments for the period August 1976 through December 1981.

Rabbit was found to be the most frequently consumed animal food followed by rodents. Together these 2 classes of animal foods made up approximately 35% and 28%, respectively, of the yearly diet on the Three Bar and Tonto areas, respectively. Deer and insects were the next 2 most often used animal foods on both areas. Use of deer by coyotes averaged less than 10% year-long but peaked in fall and winter on both areas. Animal foods made up 63% (seasonal ranges 55-79%) and 58% (seasonal ranges 51-74%) of the yearly Three Bar and Tonto coyote diets, respectively.

Plant foods, taken as seasonally available, composed 37% (seasonal ranges 21-45%) and 42% (seasonal ranges 26-49%) of the yearly Three Bar and Tonto coyote diets, respectively. Manzanita berries and mesquite beans were the most important plant foods consumed. Prickly pear fruits and grass where the next 2 most heavily used plant foods. Grass is probably consumed as a digestive aid.

The seasonal and year-long diet compositions of coyotes on the 2 treatments are listed in Table 12. Diet composition and rabbit and rodent population indices do not appear to be correlated.

Table 12. Coyote food habits from SCAT analysis.

	SEASONAL DIETS: % RELATIVE FREQUENCY OF DIET								YEARLONG DIETS: % REL. FREQ.	
	SPRING		SUMMER		FALL		WINTER			
ANIMAL MATTER	3 BAR	TONTO	3 BAR	TONTO	3 BAR	TONTO	3 BAR	TONTO	3 BAR	TONTO
Deer	2.8	3.0	7.6	5.8	8.4	10.0	15.9	8.5	8.5	7.1
Javelina	1.9	0	1.4	0.2	0.4	0.4	0.6	0	1.0	0.2
Rabbit	32.0	21.9	12.6	10.7	19.8	15.6	35.6	26.0	23.1	16.5
Rodent	17.5	19.8	9.0	7.3	9.3	10.6	13.0	16.1	11.5	11.8
Livestock	0.4	4.6	0.1	2.9	0	3.1	2.3	8.5	0.6	4.1
Unk mammals	1.5	2.1	2.5	3.1	1.8	1.5	0.4	0.9	1.7	2.1
Birds	4.3	5.9	4.9	4.8	5.7	4.0	7.9	7.6	5.6	5.1
Eggs	4.7	5.5	3.5	2.7	0.2	0.2	0	0	2.0	1.9
Reptiles	3.6	5.9	2.4	1.7	0.9	0.8	0.4	0	1.7	1.8
Insects	5.1	4.6	10.7	11.9	7.9	4.8	2.5	2.7	7.1	7.0
Other animals	0.4	0.4	0.1	0	0.4	0.4	0	0	-	-
ANIMAL SUB TOTAL	(74.2)	(73.7)	(54.8)	(51.1)	(54.8)	(51.4)	(78.6)	(70.3)	(62.8)	(57.6)
VEGETATIVE MATTER										
Manzanita berries	5.5	1.7	12.1	8.1	17.2	3.5	6.9	1.3	11.5	4.5
Mesquite beans	0.6	0	6.2	17.1	5.8	22.1	1.0	7.6	4.0	14.5
Grass	11.1	10.1	5.8	4.6	6.0	5.0	7.7	9.0	7.2	6.3
Prickly pear fruit	0	0	14.7	4.4	13.4	9.0	0.6	0	8.7	4.5
Graythorn fruit	0.6	3.4	0.3	6.5	0.1	0.2	0	0	0.2	2.9
Juniper berries	0.2	0.4	0	0.2	0.1	2.3	0	3.6	0.1	1.4
Hackberry fruit	0.4	0	0	0.6	0	1.7	0.2	3.1	0.1	1.2
Turbinella oak	1.7	2.5	0.6	1.0	0.5	0.6	1.3	0.9	-	-
Other vegetation	2.9	1.0	3.7	1.8	1.0	1.7	1.0	2.0	3.5	3.1
Unk vegetation	2.8	7.2	1.8	4.6	1.1	2.5	2.7	2.2	1.9	4.0
VEG. SUB TOTAL	(25.8)	(26.3)	(45.2)	(48.9)	(45.2)	(48.6)	(21.4)	(29.7)	(37.2)	(42.2)
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

10. Deer and cattle food habits:

Deer and cattle diets were analyzed on a seasonal basis by the micro-histological examination of fecal material. Mule deer were found to use 73 plant species on the Three Bar and 63 species on the Tonto study areas, while cattle on the Tonto area utilized 82 species. Appendix 1 lists the common and scientific names of all plant species identified in deer and cattle fecal samples. Table 13 presents both deer and cattle seasonal diets developed from the fecal analysis. The seasonal diets are a composite of 3 year's data.

Table 13. Mule deer and cattle seasonal diets (1978-1980).

SPECIES	% OF RELATIVE FREQUENCY OF FORAGE PLANTS IN DIETS		
	MULE DEER		CATTLE
	3 BAR	TONTO BASIN	TONTO BASIN ONLY
	SPRING PERIOD (APRIL)		
GRASSES			
Bromus rubens	0.0	0.2	15.7
Panicum sp.	0.0	0.1	1.4
Other grasses combined	0.0	0.0	3.1
Total grasses	0.0	0.3	20.2
FORBS			
Eriogornum spp.	6.7	8.6	8.5
Erodium cicutarium	0.6	1.7	1.5
Franseria confertiflora	0.3	0.0	2.5
Krameria parvifolia	3.7	2.9	3.2
Lotus rigidus	0.0	5.9	3.1
L. tomentellus	10.4	3.1	0.2
Lupinus concinnus	4.9	4.3	4.8
L. sparsiflora	0.8	8.0	0.5
Phorandendron californicum	0.2	0.3	1.2
Plantago spp.	0.6	0.4	2.2
Sphaeralcea spp.	3.0	2.6	9.8
Verbena ciliata	0.0	0.1	1.2
Other forbs	2.1	4.5	2.6
Total forbs	33.3	42.4	41.3
SHRUBS			
Acacia greggii	0.0	0.1	2.6
Calliandra eriophylla	33.8	20.7	5.6
Ceanothus greggii	4.7	5.0	0.5
Cercocarpus betuloides	0.0	6.3	0.7
Opuntia engelmannii	0.0	0.0	4.1
Prosopis juniflora	0.1	0.0	3.3
Quercus turbinella	10.9	17.9	0.1
Simmondsia chinensis	12.7	5.9	20.0
Other shrubs	2.5	1.3	1.6
Total shrubs	64.7	57.2	38.5

SPECIES	% OF RELATIVE FREQUENCY OF FORAGE PLANTS IN DIETS		
	MULE DEER		CATTLE
	3 BAR	TONTO BASIN	TONTO BASIN ONLY
	SUMMER PERIOD (JUNE)		
GRASSES			
Bromus rubens	2.0	0.3	9.8
Cynodon dactylon	0.0	0.0	1.3
Eragrostis spp.	0.0	0.0	2.2
Sporabolus spp.	0.0	0.0	1.0
Other grasses combined	0.2	0.1	4.5
Total grasses	2.2	0.4	18.7
FORBS			
Abutilon spp.	0.3	3.4	0.2
Astragalus nuttallianus	2.0	4.9	0.03
Eriogonum spp.	4.1	3.5	5.2
Erodium cicutarium	0.7	10.5	0.4
Erysium capitatum	3.0	0.2	0.0
Krameria parvifolia	2.3	0.7	0.7
Lotus rigdus	1.1	1.5	1.3
L. tomentellus	0.5	0.03	1.4
Phoradendron californicum	0.3	0.7	3.3
Senecio douglasii	0.0	5.5	0.1
Sphaeralcea spp.	2.2	3.1	6.1
Other forbs combined	2.8	2.9	6.7
Total forbs	18.9	36.7	25.1
SHRUBS			
Acacia greggii	1.1	1.5	4.2
Calliandra eriophylla	31.6	22.1	10.1
Ceanothus greggii	2.2	6.1	7.4
Cercidium microphyllum	1.2	0.5	0.8
Cercocarpus betuloides	0.2	1.0	0.3
Prosopis juliflora	2.4	1.5	12.9
Quercus turbinella	22.5	19.0	1.7
Rhus trilobata	2.3	2.6	0.3
Simmondsia chinensis	13.8	7.7	17.5
Other shrubs combined	1.6	0.8	1.0
Total shrubs	78.9	62.9	56.1

SPECIES	% OF RELATIVE FREQUENCY OF FORAGE PLANTS IN DIETS		
	MULE DEER		CATTLE
	3 BAR	TONTO BASIN	TONTO BASIN ONLY
FALL PERIOD (OCTOBER-NOVEMBER)			
GRASSES			
Aristida spp.	≤0.1	0.0	5.3
Bouteloua spp.	<0.1	0.0	2.2
Bromus rubens	0.6	0.1	1.7
Eragrostis spp.	0.0	0.0	1.7
Hilaria spp.	0.1	0.0	1.8
Poa spp.	0.0	0.0	1.5
Other grasses combined	0.0	0.0	3.9
Total grasses	0.8	0.1	18.1
FORBS			
Artemisia ludoviciana	0.9	1.0	0.2
Ayenia spp.	0.3	1.9	0.9
Eriogonum spp.	5.6	12.2	5.6
Erodium texanum	0.9	4.2	0.4
Erysimum spp.	9.8	7.2	0.8
Franseria confertiflora	8.4	4.9	3.7
Phoradendron californicum	0.1	0.3	2.2
Sphaeralcea spp.	7.3	8.2	7.8
Other forbs combined	1.7	5.1	3.0
Total forbs	35.0	45.0	24.6
SHRUBS			
Acacia greggii	2.1	0.8	3.6
Calliandra eriophylla	27.5	18.3	7.2
Ceanothus greggii	5.2	8.5	14.2
Cercidium microphyllum	2.3	6.9	1.1
Cercocorpus betuloides	2.4	7.0	6.0
Opuntia engelmannii	0.1	<0.1	1.1
Prosopis juliflora	0.4	0.6	4.6
Quercus turbinella	3.9	3.7	0.3
Simmondsia chinenis	20.0	8.3	18.4
Other shrubs combined	0.4	0.8	0.8
Total shrubs	64.3	54.9	57.3

SPECIES	% OF RELATIVE FREQUENCY OF FORAGE PLANTS IN DIETS MULE DEER		CATTLE
	3 BAR	TONTO BASIN	TONTO BASIN ONLY
	WINTER PERIOD (FEBRUARY)		
GRASSES			
Bromus rubens	1.9	0.9	12.9
Panicum spp.	0.1	0.1	3.5
Other grasses combined	0.1	0.0	4.0
Total grasses	2.1	1.0	20.4
FORBS			
Arabis perennans	1.8	1.1	0.2
Artemisia ludoviciana	5.0	3.3	0.0
Dichelostemma pulchellum	1.1	0.8	0.1
Eriogonum spp.	20.9	18.4	8.1
Erodium cicutarium	1.5	3.9	1.3
Franseria confertiflora	1.4	0.8	0.4
Lotus rigidus	10.6	12.7	0.3
Lygodesmia juncea	0.1	1.3	0.0
Phoradendron californicum	0.6	0.3	2.3
Sphaeralcea spp.	6.4	5.5	6.3
Other forbs combined	5.9	1.5	5.0
Total forbs	55.3	49.6	24.0
SHRUBS			
Acacia greggii	0.1	0.1	1.3
Calliandra eriophylla	4.1	5.3	0.7
Ceanothus greggii	2.5	5.6	3.8
Cercocarpus betuloides	1.6	0.6	11.4
Opuntia engelmannii	0.0	0.1	1.3
Prosopis juliflora	0.0	0.03	11.8
Quercus turbinella	1.1	5.2	0.6
Simmondsia chinesis	31.5	31.0	22.1
Other shrubs combined	0.7	1.5	1.6
Total	41.6	49.4	54.6

A general synopsis of the results indicates that deer utilized grass 2% or less in their diet while it averaged 20% for cattle diets. Forb usage by cattle and deer was much less distinct. Forb use overlap between cattle and deer was greatest during the spring period. Shrub use also showed a large amount of overlap between deer and cattle with the highest overlap occurring in the fall and winter periods.

Two calculations were made to evaluate the degree of diet overlap between Three Bar and Tonto deer and between deer and cattle. Kulczynski's index of similarity (Oosting 1956) expresses the ratio of percentage shared to total percentages. This index is calculated by the following formula:

$$\text{Similarity Index} = \frac{(2W)}{(A+B)} \times 100$$

Where: W = sum of smaller number of occurrences found in both diets.
A = sum of number of occurrences of all species in diet A which are shared with diet B.
B = sum of number of occurrences of all species in diet B which are shared with diet A.

A value of "0" indicates no dietary overlap while a value of "100" indicates identical diets. Tables 14 and 15 are provided to show Three Bar and Tonto deer diet overlaps and deer/cattle diet overlaps, respectively. As was expected, the Three Bar and Tonto deer had very similar dietary habits.

Table 14. Similarity indices[1] for Three Bar and Tonto Basin deer diets (percents).

FORAGE CLASS	SPRING	SUMMER	FALL	WINTER
Grass	no use	32	29	63
Forbs	68	48	73	84
Shrubs	75	81	70	88
Overall	73	72	71	86

[1]0=no diet overlap: 100=complete diet overlap.

Table 15. Similarity indices[1] for deer and cattle diets (percent).

FORAGE CLASS	SPRING	SUMMER	FALL	WINTER
Grass	4	19	8	16
Forbs	66	47	67	53
Shrubs	35	50	63	60
Overall	45	47	61	53

[1]0=no diet overlap: 100=complete overlap.

Greatest competitive use of forbs between cattle and deer was for the Eriogonum sp., Lotus rigidus and Sphaeralcea sp. Competitive use of shrubs was focused on Calliandra, Ceanothus and Simmondsia. These species accounted for the majority of dietary overlap indicated by the similarity indices.

The Kendall rank order correlation analysis was also used to evaluate Three Bar/Tonto deer and deer/cattle diet similarities. This analysis uses a comparison of the ranking of plant species shared by the 2 animal species. The correlation coefficients developed for the Three Bar/Tonto deer and deer/cattle are presented in Tables 16 and 17, respectively. A high positive coefficient indicates a strong correlation for the orders in which different food items are selected. A strong negative coefficient shows a low potential for food competition.

Table 16. Three Bar and Tonto mule deer diet correlations (P=0.05).

	SPRING	SUMMER	FALL	WINTER
CORRELATION COEFFICIENT	0.57	0.61	0.74	0.75

Table 17. Deer and cattle diet correlations (P=0.05).

	SPRING	SUMMER	FALL	WINTER
CORRELATON COEFFICIENT	0.26*	0.38	0.53	0.15*

*Not significant.

CONCLUSIONS

A multitude of data on different factors was collected during the course of this study. Individually each factor can be of value, but the most important evaluation comes from analysis of the combined factors. The basis for collecting the data presented was to evaluate the effects each factor has singularly and in-combination with others on mule deer fawn survival and herd production in relation to livestock grazing.

Rodent population indices

Results of the rodent population surveys indicate that rodent populations alone have no apparent relationship to fawn survival either on the Three Bar or Tonto areas under conditions encountered in this study. Rodents are an important component in coyote diets and might influence fawn survival through predation if they were substantially reduced or eliminated. Livestock grazing in this study does not appear to have reduced rodent population. The opposite, in fact, appears to be true; grazing may have increased rodent numbers. Rodent population indices were greater on the grazed area during all years; during 2 of those years that difference was statistically significant.

Rabbit population indices

Results of the rabbit population surveys also indicated a greater rabbit population on the grazed Tonto area during 4 of the 5 years. Unlike the rodent indices, a strong positive correlation was observed between total lagomorph population indices and fawn survival on the Three Bar ($r=0.919$) and moderate correlation ($r=0.506$, n.s.) on the Tonto area.

Forage and cover production

The cover and height surveys showed large differences in the amount of ground cover (0-24" categories) between the grazed and ungrazed areas. These differences, as noted, were greatest between treatments within the desert grassland and desertscrub habitat types. These two habitats are considered the most important for desert mule deer and lagomorph/rodent populations.

Our original hypothesis concerning ground cover, grazing and fawn survival was that livestock grazing may reduce protective cover for newborn fawns to the extent that predation may be significantly increased. The amount of ground cover did appear to be reduced on the grazed area but the fawn survival rates between treatments were not substantially different except during the last 2 years (1981 and 1982) when fawn survival rates were lower on the grazed area. Lagomorph population indices during the summer periods corresponding to these fawning seasons also showed decreases. The 1981 fawning period was preceeded by a severe drought as previously noted.

The implication from these facts is that if grazing is negatively impacting fawn survival the most noticeable results will occur during the drought year. This impact appears to be related to decreased ground cover. Livestock grazing appears to have little, if any, impact on fawn survival during normal precipitation and vegetation production years.

Carrying the increase in vulnerability of fawns 1 step further, we can add in nutritional problems. As discussed earlier, nutritional analysis of deer forage in this area indicated below optimum levels of phosphorous. Poor physical condition of does and fawns due to poor nutirtion coupled with reduced cover and decreased rabbit populations may further increase fawn vulnerability to predation.

Fawn survival was correlated with total October-March precipitation for the ungrazed Three Bar (Table 18: $r = 0.538$, $P \leq .05$) and the grazed Tonto (Table 19: $r = 0.860$, $P \leq .10$). A comparison of these correlations is not appropriate since the correlation for Three Bar was for 13 years of data and the Tonto only 5. Despite the statistical significance for the correlation on Three Bar, only 29% ($r^2 = 0.29$) of the variation in fawn:doe ratios was accounted for by October-March rainfall. Kie (1977) also found that fawn survival was strongly associated with precipitation.

Table 18. Simple linear correlation coeffecients for relationships between listed variables and Three Bar fawn:doe ratios.

VARIABLE	r	n	p
October-March rainfall	0.538	13	0.05
Forb production (lbs/A.)	0.677	13	0.05
Grass production (lbs/A.)	0.625	13	0.05
Total forage production (lbs/A.)	0.740	13	0.01
Rabbit population index	0.920	5	0.05
Rodent population index	-0.323	5	n.s.

Table 19. Simple linear correlation coefficients for relationships between listed variables and Tonto Basin fawn:doe ratios.

VARIABLE	r	n	p
October-March rainfall	0.860	5	0.10
Forb production (lbs/A.)	0.585	5	n.s.
Grass production (lbs/A.)	0.121	5	n.s.
Total forage production (lbs/A.)	0.432	5	n.s.
Rabbit population index	0.520	5	n.s.
Rodent population index	0.038	5	n.s. -

The current study also provided 5 additional years of data to further confirm the relationship shown by Smith and LeCount (1976) between fawn survival and total forage production on the 3 Bar ($r = 0.740$, $P \leq .01$)

These analyses indicate that October-March precipitation is strongly influencing spring forage production and subsequent ground cover. The manner in which this forage and cover ultimately affects fawn survival through the following winter is much less clear. On Three Bar there was a significant relationship ($r = 0.920$, $P \leq 0.10$) between the fawn survival index and the rabbit index. Though the same relationship ($r = 0.520$, n.s.) on the Tonto was not significant, the relationship of rabbits to fawns appeared to be worth further investigation. Consequently, 2 series of multiple regression analyses were performed, 1 for Three Bar and the other for Tonto. In these analyses, the rabbit index was chosen as 1st independent variable, forb production as the 2nd independent variable and fawn survival as the dependent variable.

On Three Bar, the 2 independent variables combined to account for a estimated 93 % of the variation in fawn survival ($F = 13.78$, $P \leq 0.10$). On Tonto, these variables accounted for 67 % of the variation in fawn survival ($F = 2.05$, n.s.). In both cases there appears to be a very important contribution by the rabbit index in explaining a large portion of the variation in fawn survival.

Obviously, rabbits do not have any direct effect on the survival of fawns. Rabbit populations, however, probably fluctuate in response to a complex of environmental variables, being only partially influenced by current vegetative conditions. Their influence on fawn survival is probably indirect through their mediating effect on the degree to which coyotes and other large predators prey on fawns. As shown in Table 12, rabbits are the single most important item in the diet of coyotes on both Three Bar and Tonto. The implication of the results presented here is that during years when rabbit populations are low, predation on fawns may increase. This increased predation factor would work independent of the relative effect that vegetative forage and cover has on fawn survival. If years of drought, and consequently poor forage and cover, happen to coincide with reduced rabbit populations, predation on fawns would likely be extreme.

The foregoing conclusions must be regarded as somewhat speculative since they are based at least partly on coefficients (r values) that lack statistical significance because of the short span of years for which data were available.

Trouts (1978) suggestions, however, that the abundance and distirbution of small mammals may have an important influence on the predator/prey relationship between coyotes and deer, support our conclusion.

Fawn survival in the predator-free enclosure for the 11 years of available data appears to fluctuate independently of spring forb production ($r = 0.057$) and October-March precipitation ($r = 0.0220$). During this period this small deer herd averaged 68 fawns per 100 does and had an average density of about 32 deer/square mile within the 602-acre enclosure. In 1972, following a winter rainfall period of only 5.6 inches of precipitation, the herd of 17 deer had a fawn:doe ratio of 117:100. Again, in 1974, with a herd of 25, the ratio was 111:100.

The history of this enclosure herd strongly supports the contention that desert mule deer herds are well adapted to the extremes of variable forage and will maintain high rates of recruitment in the absence of predation except in years of extreme winter drought. The relationships of fawn survival to forb production demonstrated on the Three Bar and Tonto areas subject to predation suggests that the forage factor in some way mediates the effect of predation. Predation may be the primary factor that keeps fawn:doe ratios depressed.

A look at the predator-free Walnut Canyon enclosure herd may be beneficial in assessing the growth potential of a desert deer herd. The 603-acre enclosure was completed in early 1971 and contained 2 bucks and 6 adult doe mule deer. By November 1976 the herd numbered 45 individuals. In 1977, 14 deer were removed. By January 1981 the herd had again climbed to 47 individuals at which time 20 additional animals were removed. To date 34 individuals have been removed from the enclosure with an additional 8-10 animals known to have died inside, for a total of about 45 animals removed in a 10-year period. In 1977 and 1981, the deer densities approached 50 deer/section. Over this 10 year period the fawn:doe ratio has averaged about 38% higher for the herd inside the enclosure than the adjacent outside herd, except during the severe drought years. This enclosure herd expansion indicates that desert mule deer herds have the potential to increase substantially.

It appears that a double-barreled impact is affecting desert mule deer herds during drought years. First, there is a reduction in fawn survival relating to the drought directly and indirectly through heat and water stress, decreased cover, and alternate prey populations. Secondly, with little or no fawn recruitment into the population, the loss of adult animals further reduces the population. Adult losses can be manifested in several forms including disease, nutrition, heat stress and impact of predators. Lion predation on deer has been termed a significant factor in regulating deer numbers according to Shaw (personal communication). He further theorizes that the presence of livestock helps prop up a lion population during periods of prey population decline so that the classic predator/prey cycle is "short-ciricuited."

This work indicates that livestock grazing of the aforementioned intensity on these ranges has little impact on desert mule deer fawn survival and population densities during normal precipitation and forage/cover production years. Only during severe drought years does grazing seem to impact the deer herd and then only slightly more than impacts observed on nongrazed areas. Any impact observed appears related to reduction of the vegetative cover which provides post-natal protection for fawns and associated effects on rabbit and rodent populations. There does appear to be some dietary competition between cattle and deer but there is no evidence from this study that this competitive overlap is limiting deer populations or fawn survival during normal rainfall years. If grazing does reduce fawning cover it may also counteract this negative aspect by benefiting rabbit and rodent populations which are primary coyote foods. Though the nutritional quality of desert forage may be seasonally poor, it appears that desert soils rather than present grazing intensity is the cause of the poor nutrition.

The Walnut Canyon predator-free enclosure herd shows us that during all but severe drought years these desert mule deer herds have the capability to increase rapidly. The herds subject to predation, however, are not fulfilling this capability. In order to increase the densities of these outside herds we must reduce losses of both juvenile and adult deer.

There are several management recommendations to be made from this study.

<u>Management Recommendations:</u>

The long range goal for mule deer management in Arizona as defined in the Big Game Strategic Plan (Anon. 1980) is to increase mule deer numbers so as to increase deer harvests by 10% while stablizing hunter success. Since increasing deer numbers is our primary objective, our management efforts must be directed toward this end.

Information gathered in this study points to several possible paths for increasing deer populations on desert ranges. Fawn and adult mortality are clearly factors affecting populaton densities. Management efforts which would reduce fawn mortality and thus increase recruitment into the herd and which would reduce adult mortality yearlong would be especially beneficial. This study suggests that during severe drought years, forage and cover conditions may influence the survival rates of new born fawns. Shaw (personal comm.) has also suggested that cover conditions may influence adult mortality by modifying the rate of predation.

A range management plan which would allow immediate and substantial reductions in stocking rates of cattle during severe drought years might alleviate some fawn mortality by increasing cover. When climatic and vegetation conditions become more favorable stocking rates would again be adjusted. Such changes should be available on a year to year basis since winter precipitation measurements can predict the coming spring and summer forage/cover conditions reasonably well.

Another factor associated with forage/cover conditions is that of fire suppression on the desert scrub and chaparral habitats. Fire suppression has allowed over-mature stands of chaparral to develop which results in reduced use of these areas by both wildlife and livestock. These reductions appear to be related to decreased forage, access to favorable forage and nutritional value of available forage. Brady and Phelps (1975) state that fire appears to have a beneficial effect on the habitat and resulting use of that habitat by wildlife. Increases in the amount and availability of succulent forage and the nutritional value of forage all appear important to deer. Mule deer and javelina use of an area in the vicinity of Mills Ridge on Three Bar increased substantially following a wildfire on that area. Shaw (personal comm.) also has concluded that dense brush favors the mountain lion in preying on deer with a subsequent impact on the deer herd.

A fire management policy which would allow periodic controlled burning or "let burn" policy in the chaparral habitat would help alleviate most of these problems. Some restrictions would have to be retained to limit the size of burns since large continuous tracts of chaparral conversion are also detrimental to wildlife. Rather, a mosaic of openings and chaparral would be most beneficial.

Periodic burning would help open the dense stands and increase access. It would also increase the amount of new and succulent forage. In addition burning would release many nutrients which are normally tied up in old growth vegetation. This could help eliminate nutritional deficiencies presently noted in desert mule deer forage. By opening up the dense cover the deer would also gain an advantage over the mountain lion and predation could be decreased.

Other possible management efforts could include predator control programs. The enclosure deer herd points to the fact that fawn loss to predation may be substantial. Improved range conditions may, however, decrease predation problems.

Research Recommendations:

Although this study has covered many facets of desert mule deer ecology, it has also raised new questions. Many of the relationships found among the variables studied have not been substantiated because of the short span of years for which they were measured. Some of these measurements should be continued and certain new data should be obtained. What follows is a list of objectives that could be met on the present study areas and would be important extensions to our knowledge about factors limiting desert mule deer populations:

1. Determine the causes of adult deer mortality through the study of radio instrumented deer.

2. Determine the relationship between rabbit population levels and fawn survival rates.

3. Determine the rate of illegal kill of does during buck only desert mule deer hunting.

4. Continue measurements of forage production, rainfall, and certain deer population variables so as to provide long term series of records to evaluate interrelationships among deer, climate, and habitat.

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Appendix 1: Plant species identified in deer and cattle diets.

SCIENTIFIC NAME	COMMON NAME
Grasses	
Andropogon sp.	bluestem
Aristida sp.	threeawn
Bouteloua curtipendula	sideoats grama
Bromus rubens	red brome
Chloris sp.	
Cynodon dactylon	bermudagrass
Cyperus sp.	flatsedge
Eragrostis sp.	lovegrass
Hilaria belangeri	curly mesquite-grass
Hordeum sp.	barley
Koeleria cristata	prairie junegrass
Leptochloa sp.	sprangletop
Panicum sp.	
Poa	bluegrass
Setaria sp.	bristlegrass
Sporobolus cryptandrus	dropseed
Stipa sp.	needle grass
Tridens sp.	
Forbs	
Abutilon incanum	indian-mallow
Ambrosia psilostachya	ragweed
Amsinckia intermedia	fiddleneck
Anemone tuberosa	
Aplopappus sp.	turpentine bush
Arabis perennans	rockcress
Artemisia ludoviciana	sandsage
Astragalus nuttallianus	Locoweed
Ayenia filiformis	
Baeria chrysostoma	goldfields
Baileya multiradiata	
Bowlesia incana	
Brickellia californica	
Calochortus kennedyi	desert mariposa
Castillija sp.	indian paintbrush
Cirsium neomexicana	mexican thistle
Cryptantha nevaclensis	hidden flower
Daucus puxillux	wild carrot
Descurainia sophia	tansy mustard
Dichelostemma pulchellum	grassnut
Eriogonum wrightii	buckwheat
Erodium cicutarium	filaree
Erodium capitatum	filaree
Erysimum capitatum	
Euphorbia sp.	spurge
Franseria confertiflora	bur-sage
Galium sp.	bed straw
Gutierrezia sarothrae	snakeweed
Krameria parvifolia	ratany

APPENDIX 1 - cont'd

SCIENTIFIC NAME	COMMON NAME
Forbs	
Lepidium medium	pepper grass
Lomatium sp.	indian root
Lotus humistratus	deer vetch
Lotus rigidus	deer vetch
Lotus tomentellus	deer vetch
Lupinus concinnus	Lupine
Lupinus sp.	Lupine
Lygodesmia juncea	skeleton plant
Malva sp.	mallow
Melampodium leucanthum	plains blackfoot
Menodora scabra	
Mimulus sp.	monkey flower
Mirabilis sp.	four o'clock
Orthocarpus purpurascens	owl-clover
Parietaria sp.	
Pellaea longimucronata	cliff bake
Penstemon sp.	
Phacelia distans	
Phlox tenuifolia	
Phoradendron californicum	mistletoe
Plantago sp.	indian wheat
Pseudocymopterus montanus	
Psoralea sp.	scruff pea
Senecio douglasii	groundsel
Senecio sp.	groundsel
Solanum sp.	night shade
Sphaeralcea sp.	globe mallow
Stellaria nitens	starwort
Thysanocarpus amplectens	lacepod
Verbena ciliata	
Shrubs	
Acacia greggii	catclaw acacia
Berberis sp.	algerita
Calliandra eriophylla	false mesquite
Carnegiea gigantea	saguaro
Ceanothus greggii	
Celtis pallida	desert hackberry
Celtis recticulata	netleaf hackberry
Cercidium microphyllum	palo verde
Cercocarpus betuloides	mountain mahogany
Juglans major	walnut
Lycizim sp.	wolfberry
Mimosa biuncifera	catclaw mimosa
Opuntia sp.	prickly pear
Platanus wrightii	sycamore
Prosopis juliflora	mesquite
Quercus emoryi	emoryi oak
Quercus turbinella	turbinella oak

APPENDIX 1 - cont'd

SCIENTIFIC NAME	COMMON NAME
Shrubs	
Rhamnus crocra	holly-leaf buckhorn
Rhus ovata	sugar sumac
Rhus trilobata	skunk bush
Salix sp.	willow
Sambucus mexicana	elder berry
Simmondsia chinesis	jojoba
Yucca baccata	yucca