
ARIZONA GAME AND FISH DEPARTMENT

RESEARCH BRANCH
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GENERAL
ECOLOGY OF COUES
WHITE-TAILED DEER
IN THE SANTA RITA
MOUNTAINS
A Final Report

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August 1991

FEDERAL AID IN WILDLIFE
RESTORATION PROJECT



Arizona Game and Fish Department Mission

To conserve, enhance, and restore Arizona's diverse wildlife resources and habitats through aggressive protection and management programs, and to provide wildlife resources and safe watercraft recreation for the enjoyment, appreciation, and use of present and future generations

Arizona Game and Fish Department
Research Branch

Technical Report Number 6

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In The Santa Rita Mountains**

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Federal Aid in Wildlife Restoration
Project W-78-R

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General Ecology of Coues White-tailed Deer in the Santa Rita Mountains

Richard A. Ockenfels, Daniel E. Brooks, and Charles H. Lewis

Abstract: We investigated Coues white-tailed deer (*Odocoileus virginianus couesi*) home range sizes, habitat use patterns and selection of habitat components, water requirements, diet, and dietary overlap with cattle. Also studied were competition with mule deer (*O. hemionus*), reproductive phenology, mortality, and effects of roads on their distribution. The study occurred in the southeastern foothills of the Santa Rita Mountains, from 1987-1990. Female core areas and home ranges averaged 1.89 and 5.18 km², respectively. Male core areas and home ranges were larger ($P < 0.001$), at 4.47 and 10.57 km². Coues white-tailed deer used habitat components out of proportion ($P < 0.001$) to availability. Females heavily used oak-mesquite thickets on northern slopes in foothills. Males favored mesquite-shrub areas in lowlands for much of the year. Habitat use patterns by deer depended largely upon location of their home range and sex of the animal. Northern aspects, on which oak-mesquite thickets occurred, were heavily favored ($P = 0.003$) over southern exposures, where grassy conditions prevailed. Coues white-tailed deer selected ($P < 0.001$) the first 800 m around water sources. Most deer had more than 1 water source within their core area and home range, as many water sources were seasonal in nature. Coues white-tailed deer diets fluctuated seasonally from 1987-1989, mainly between high shrub and high forb use. Seasonal forb availability seemed to determine percentage of shrubs, trees, and forbs used. Shrubs (50.8%) accounted for most of the overall diet, while forbs (29.8%) were heavily used. Velvet-pod mimosa (*Mimosa dysocarpa*) was the most commonly consumed plant. Cattle diets were dominated by grasses (greater than 70%) for most seasons. High shrub and forb use by cattle during late summers (July-August) of 1988 and 1989 increased dietary overlap between Coues white-tailed deer and cattle. However, dietary overlap was generally less than 20%, and not a problem for climatic and range conditions encountered. We speculate that possibility of competition between Coues white-tailed deer and mule deer is very high, particularly in areas where habitat conditions favor neither species. Nutritional needs and diet are similar, but habitat use patterns are generally different. The reproductive cycle of Coues white-tailed deer is delayed approximately 2 months compared to northern and eastern subspecies. The average date bucks polished antlers was October 9. Rutting behavior started in earnest in late December-early January, peaked in mid-January, and lasted into February - early March. Bucks typically cast antlers in late April-early May (\bar{x} = May 7). Peak fawn drop occurred in mid - to late August. Early fawns were seen in late July, and some neonatal fawns were still observed as late as September. Fawn mortality generally occurred within the first month of life. Adult survival rates were different ($P < 0.001$) by sex. Annual female survivability was 81.0-85.4%, while male survivorship was 53.3-54.0%. Mountain lions (*Felis concolor*; 40%) and coyotes (*Canis latrans*; 40%) were major mortality factors on does, while legal hunting (58.3%) and mountain lions (33.3%) reduced the buck population. Few bucks lived longer than 3 years. More bucks were harvested than expected, based on percentage area within GMU 34A. Coues white-tailed deer avoided ($P < 0.001$) the first 400 m of habitat along graded dirt roads. Unimproved roads were not avoided. Deer harvest was not affected ($0.250 > P > 0.100$) by presence of graded roads. Lowland habitats, favored by bucks, but not does, were privately owned. Bucks became more vulnerable during hunting season, as they moved onto national forest lands for the start of the rut.

INTRODUCTION

White-tailed deer are widely distributed across North, Central, and South America, adapting to many different sets of environmental conditions (Hesselton and Hesselton 1982, Baker 1984). They are found in 45 of 48 contiguous states, not having been identified in California, Nevada, and Utah (Hesselton and Hesselton 1982).

White-tailed deer are adapted to habitats where abundant ground cover, shrub cover, and low trees are major components of the environment (Baker 1984). In the Southwest, distribution of white-tailed deer is largely discontinuous, following an island configuration, occurring in isolated pockets of adequate habitat

(Evans 1984). Evans (1984) considered the species to be uncommon, but not rare in the Southwest, and noted that little is known about the Coues subspecies of white-tailed deer.

A single subspecies, Coues, occurs in Arizona (Hoffmeister 1986). It inhabits most southeastern and central mountain ranges below the Mogollon Rim (Fig. 1), primarily in mixed oak woodlands and higher elevation semidesert grasslands (Knipe 1977). Coues white-tailed deer also occur locally in high desert scrublands, along riparian corridors, and in pine forests (Hoffmeister 1986). Isolated populations in Arizona occur in the Sonoran Desert, along the deer's northern and western limits, in pockets of suitable habitat (Brown and

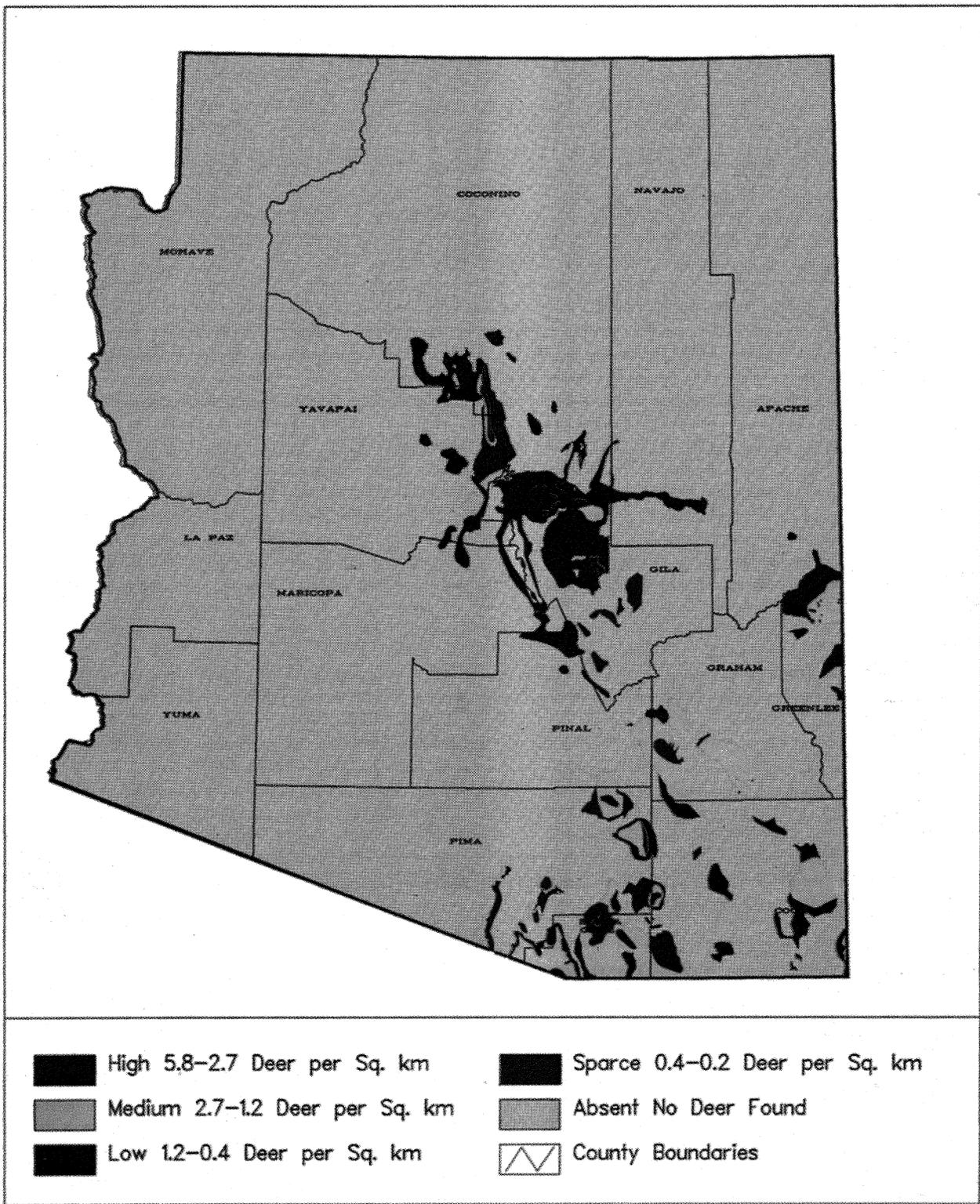


Figure 1. Estimated Coues white-tailed deer distribution in 1990. Indian reservation data not included.

Henry 1981). The range of Coues white-tailed deer extends into southwestern New Mexico and northern states of Mexico (Miller and Kellogg 1955), particularly in mountain ranges with Madrean evergreen woodland components (Evans 1984).

The white-tailed deer's vast economic influence from sport hunting (Fig. 2), recreational viewing, and agricultural conflicts has resulted in it being one of the most studied animals, if not the most studied, in wildlife management today (Hesselton and Hesselton 1982). Although Coues white-tailed deer have not been researched as thoroughly as northern and eastern subspecies, it is an important subspecies in Arizona. Annual harvest of Coues white-tailed deer in Arizona has steadily risen over the last 5 decades and in the 1980s was accounting for nearly 1 of every 4 legally taken deer (Table 1).

Because of rising popularity of Coues white-tailed deer to sportsmen in Arizona, the Department initiated a 5-year general ecology study to collect information to improve management decisions throughout the Coues white-tailed deer's range. Objectives of the study were to investigate the following items.

- Select a study area, Santa Rita Study Area (SRSA) and map the site into associated

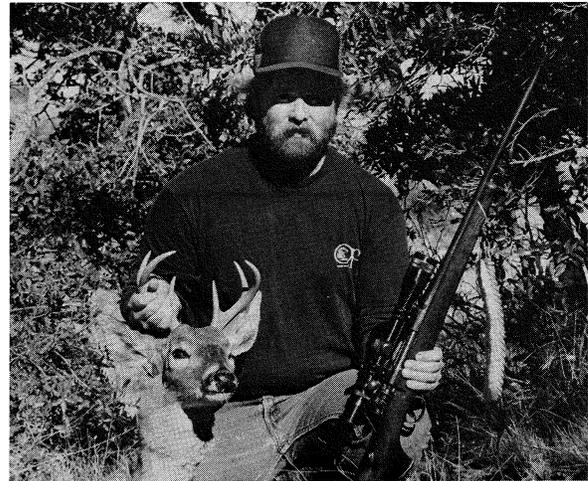


Figure 2. Coues white-tailed deer hunting is an important management tool in Arizona.

habitat types based on species composition and structure.

- Document core area and home range size of Coues white-tailed deer on SRSA.
- Investigate habitat use and habitat selection patterns of Coues white-tailed deer in relation to habitat availability.
- Investigate water requirements of Coues white-tailed deer to determine number of human-made water sources within core areas

Table 1. Coues white-tailed deer statewide harvest and survey data for each decade in Arizona from 1946-1989 (SD in parenthesis).

Decade	Average harvest	Percent of deer harvest	Average number surveyed	Bucks: 100 does	Fawns: 100 does
1940s	1173 (147)	15.3 (1.6)	198 (57)	57.5 (20.2)	42.0 (20.7)
1950s	2435 (1556)	10.9 (3.1)	916 (413)	47.8 (7.9)	45.4 (25.5)
1960s	3738 (949)	17.2 (2.9)	1042 (180)	44.4 (5.7)	39.4 (4.5)
1970s	2426 (586)	18.1 (3.3)	790 (198)	35.0 (7.2)	39.8 (6.5)
1980s	4916 (1298)	24.8 (2.5)	2032 (506)	29.3 (3.1)	40.8 (8.4)
ALL YEARS	3178 (1591)	17.5 (5.5)	1104 (643)	40.8 (11.8)	41.4 (14.1)

- and home ranges.
- Determine annual and seasonal diet of Coues white-tailed deer within SRSA.
 - Document Coues white-tailed deer dietary overlap with cattle on SRSA.
 - Investigate the likelihood of Coues white-tailed deer competition and dietary overlap with desert mule deer (*O. b. crooki*) in sympatric ranges bordering white-tailed deer habitat.
 - Document the annual reproductive cycle of Coues white-tailed deer on SRSA.
 - Determine annual mortality rates and cause-specific mortality factors of Coues white-tailed deer on SRSA.
 - Investigate effects of roads and road types on Coues white-tailed deer use patterns within SRSA.
 - Determine effects of land ownership on use patterns of Coues white-tailed deer on SRSA.

Home Range

The amount of area necessary for a white-tailed deer to live in, its home range (Burt 1943), is important. The area must be large enough to provide essential components of food, shelter, and water, but small enough to be totally familiar to deer for survival advantages (Marchinton and Hirth 1984). Home ranges of white-tailed deer have been studied in Georgia (Marshall and Whittington 1968), Minnesota (Rongstad and Tester 1969, Kohn and Mooty 1971, Mooty et al. 1989), Montana (Wood et al. 1989), Oklahoma (Ockenfels 1980), South Dakota (Sparrowe and Springer 1970), Texas (Thomas et al. 1964, Michael 1965, Inglis et al. 1979, Cohen et al. 1989), Washington (Gavin et al. 1984), and Wisconsin (Larson et al. 1978). White-tailed deer home range sizes and shapes are generally the smallest of North American deer (Marchinton and Hirth 1984) and have been found to differ because of environmental factors, deer densities, and individual characteristics. Seasonal shifts in use areas within a home range apparently are common, as are excursions for exploratory behavior (Inglis et al. 1979, Marchinton and Hirth 1984). Home ranges tend to change little annually in most areas, but white-tailed deer have been shown to exhibit low fidelity to their home range in some areas (Wood et al. 1989).

Welch (1960) found that Coues white-tailed deer did not need to migrate, but did have seasonal movements related to cover, food and

water availability. Knipe (1977) believed that Coues white-tailed deer have relatively small home ranges, but he estimated they were familiar with up to 10 km² of habitat. He also believed that home range varies with individual deer; such factors as terrain, forage, water availability, breeding and fawning activity, and hunting influenced home range size.

Habitat Use

A prime management concern has been the relationship of a species with its habitat. What habitat components are preferred, or selected for, and what components are unsuitable and avoided? Studies evaluating habitat requirements of white-tailed deer have been completed in Arkansas (Sweeney et al. 1984), Michigan (McCullough et al. 1989), Minnesota (Rongstad and Tester 1969, Kohn and Mooty 1971, Mooty et al. 1989), Montana (Compton et al. 1988, Wood et al. 1989), Oklahoma (Ockenfels 1980), Oregon (Suring and Vohs 1979, Smith 1987), South Dakota (Sparrowe and Springer 1970), Texas (Krausman and Ables 1981, Beasom and Krysl 1984, Wiggers and Beasom 1986, Rollins et al. 1988), Vermont (Williamson and Hirth 1985), Virginia (Guadette and Stauffer 1988), and Wisconsin (Larson et al. 1978).

White-tailed deer have long been considered an "edge" species (Williamson and Hirth 1985), utilizing ecotones or areas between major habitat types (Suring and Vohs 1979, Ockenfels 1980, Rollins et al. 1988, Wood et al. 1989). Availability of cover, food, and water in close proximity are the most important factors determining patterns of habitat use (Kohn and Mooty 1971, Suring and Vohs 1979, Ockenfels 1980, Guadette and Stauffer 1988, Wood et al. 1989). Other factors contributing to habitat selection are land use practices (i.e., livestock, forestry, recreation, developments), reproduction, weather, ecological competition with other species (e. g., mule deer), and hunting.

Knowledge of Coues white-tailed deer habitat requirements are mostly observational in nature (Knipe 1977). They have been investigated partially in relation to ecological overlap with mule deer (Anthony and Smith 1977), to burns (Barsch 1977), to cattle grazing (M. Brown 1984), and in relic areas (Henry and Sowls 1980). The principal areas in Arizona for Coues white-tailed deer are encinal (Mexican oak) woodlands and oak-pine woodlands (Knipe 1977), both part of

Madrean evergreen woodlands. Other areas of use are; chaparral, desert grasslands, desert scrub, montane coniferous forests, and riparian forests (Knipe 1977, Henry and Sowls 1980, M. Brown 1984, Evans 1984, Hoffmeister 1986).

Water Requirements

Although Coues white-tailed deer have adapted to exist with minimum moisture, either free-standing water or adequate succulent forage is necessary for survival (Knipe 1977, Maghini and Smith 1990). Lack of precipitation, or drought, is suspected to be the main factor limiting Coues white-tailed deer distribution in Arizona (Brown and Henry 1981). In particular, frequency of drought during summer monsoon season appears to have an effect on fawn productivity and survival (D. Brown 1984, Smith 1984). Haywood et al. (1987) demonstrated a strong relationship between summer moisture and the following winter's fawn survival. Because of Coues white-tailed deer's distributional relationship with precipitation (Brown and Henry 1981, D. Brown 1984) and effect of precipitation on reproduction (Smith 1984, Haywood et al. 1987), data on water relationships are important for management.

Temperature, water content of forage, and animal activity are important factors governing water needs of white-tailed deer (Nichol 1938, Michael 1968, Marchinton and Hirth 1984, Verme and Ullrey 1984). Distribution of water sources throughout the habitat is important (Welch 1960, Knipe 1977, Henry and Sowls 1980, Krausman and Ables 1981). Availability is especially important for pregnant and lactating does (Michael 1968, Marchinton and Hirth 1984), particularly if does stay within their home range in drought periods.

Water relationships of Coues white-tailed deer have previously been investigated in Arizona (Nichol 1938, Barsch 1977, Henry and Sowls 1980, Maghini and Smith 1990). However, the question of water needs and monetary expenses involved in water management and development dictate that a thorough understanding of effects of water placement on Coues white-tailed deer distribution is essential for proper management.

Diet

White-tailed deer are considered "browsers" because of their high consumption of plant material from woody species (Harlow 1984).

Amount of woody material consumed in the diet can range from nearly zero in some seasons (Cross 1984, Gavin et al. 1984, Verme and Ullrey 1984) to virtually all browse (Erickson et al. 1961, Allen 1968), particularly during non-growing seasons.

The diet of white-tailed deer, throughout its range, has been studied extensively (Hesselton and Hesselton 1982). Variety of vegetation eaten is high (Harlow 1984) and is related to what plants are available in the local area (Hesselton and Hesselton 1982, Verme and Ullrey 1984). White-tailed deer are adaptable enough, such that if a variety of plants is available, they are usually able to find sufficient forage. White-tailed deer can detect slight differences in palatability (Hesselton and Hesselton 1982, Sauer 1984) and select the most nutritious forage of whatever is available.

Diets of Coues white-tailed deer have been studied in the Santa Rita (Nichol 1938, White 1961), Chiricahua (Day 1964), Mazatzal (McCulloch 1972, 1973), San Cayetano and Dos Cabezas (Anthony and Smith 1977) and Ajo (Henry and Sowls 1980) mountains of Arizona, as well as the Durango region of Mexico (Gallina et al. 1981).

McCulloch (1973) concluded Coues white-tailed deer are adapted to a wide variety of food resources and that diet changes seasonally and spatially. Knipe (1977), reviewing available literature and his field observations, noted a list of 610 known and 434 suspected food sources south of the Mogollon Rim. He believed that the diet of Coues white-tailed deer was very complex and preferences for food items varied from habitat to habitat. Because of their adaptability, diets of Coues white-tailed deer, like other subspecies, must be studied locally.

Dietary Overlap with Cattle

White-tailed deer cannot digest highly lignified forage as well as cattle (Verme and Ullrey 1984), and a diet high in woody material reduces survival. Larger animals, such as cattle, are better able to utilize coarser plant materials than small subspecies of deer (Clutton-Brock and Harvey 1983). White-tailed deer are classed as selective foragers (Verme and Ullrey 1984), eating the most palatable parts of plants first, while cattle are considered a non-selective grass-roughage feeding type (Henke et al. 1988).

Diet overlap between Coues white-tailed deer

and cattle has been studied in Arizona (Day 1964) and Mexico (Gallina et al. 1981), as well as for other subspecies in Louisiana (Thill 1984, Thill and Martin 1990) and Montana (Allen 1968).

Of primary concern is the potential for high overlap during periods of drought (Knipe 1977). Cattle, being larger animals and requiring more forage volume than deer, are more strongly influenced by seasonal forage availability (Clutton-Brock and Harvey 1983), possibly resulting in direct competition with white-tailed deer for browse and forbs in dry periods.

Competition with Mule Deer

White-tailed deer are expanding their range westward and in many areas are encroaching into mule deer habitat (Baker 1984, Beasom and Krysl 1984). Habitat changes favoring white-tailed deer are suspected to be the cause. This expansion is of concern in areas where mule deer are limited in numbers.

In southern and central Arizona, white-tailed deer and mule deer ranges overlap extensively. Mule deer are much more numerous and widespread than white-tailed deer in Arizona and concern is reversed. Many wildlife managers believe that mule deer are displacing populations of white-tailed deer, particularly those that are somewhat isolated (Brown and Henry 1981, D. Brown 1984).

Habitat and diet similarity between Coues white-tailed deer and mule deer have been evaluated (Urness et al. 1971, McCulloch 1972, Anthony 1976, Anthony and Smith 1977), as has forage competition with bighorn sheep (*Ovis canadensis*) (Henry and Sowls 1980). Habitat and diet overlap of other subspecies of white-tailed deer with mule deer have also been studied (Kramer 1973, Krausman 1978, Beasom and Krysl 1984, Wood et al. 1989).

Reproduction

Local fluctuations in white-tailed deer populations, seasonally and annually, are related to reproductive phenology and success (Sauer 1984). Reproductive phenology consists of antler development, rutting behavior, and antler cast (i.e., drop) for males, while rutting season, fawn drop, and lactation are important time periods for females.

Rutting season for white-tailed deer is partially related to photoperiod, the ratio of

diminishing daylight to darkness (Verme and Ullrey 1984). Over most of North America, active rutting begins in September with sparring between males, extends 3-4 months, and terminates in January (Marchinton and Hirth 1984). Variation is found in timing of rut in relation to latitude (Verme and Ullrey 1984), with rut in southern areas occurring up to 2 months later than northern areas (Marchinton and Hirth 1984). The rut for Coues white-tailed deer is normally from mid-December into March, with a peak in January (McCabe and Leopold 1951, Welles 1959, Welch 1960, Knipe 1977).

Antler cast for most northern and eastern white-tailed deer populations starts in late December and peaks in January (Sauer 1984, Verme and Ullrey 1984). Antler cast generally occurs after breeding season and is based on decreasing levels of testosterone in males (Sauer 1984). Antler cast can be delayed by poor nutrition (Verme and Ullrey 1984). Coues white-tailed deer bucks typically cast their antlers in mid-March to late May (Welles 1959, Knipe 1977, Hoffmeister 1986).

Female white-tailed deer are receptive to bucks for breeding only 2-3 days during each estrus cycle (Knox et al. 1988). Does may cycle 2-7 times on an average of every 26 days, if conception does not occur (Knox et al. 1988). Age and condition of does are related to conception rate (Verme 1969). Fawns and yearlings generally do not conceive under normal conditions, but may on high conditioning diets (Verme 1969, Munding 1981, Reid and Carrol 1984, Kie and White 1985). Verme (1969) found that diets low in energy and protein restricted the ability of yearlings to cycle into estrus and be receptive for breeding. In Michigan, he estimated that peak of estrus, which coincided with peak of rut, was November 17 ($SD = 4.4$ days). For Coues white-tailed deer, peak of estrus should occur in mid-January to coincide with rut. Nichol (1938) found the earliest breeding date was January 10 for Coues white-tailed deer.

Verme (1969) found that on a moderate diet, white-tailed deer have an average gestation period of 202.1 days ($SD = 4.1$). Nichol (1938) believed that Coues white-tailed deer have a gestation period of 200-210 days, as did McCabe and Leopold (1951) and Knipe (1977). Fawn drop for Coues white-tailed deer tends to peak in mid-August (McCabe and Leopold 1951, Welles 1959,

Knipe 1977). Fawning dates seem to be related to age of female (Butts et al. 1978) and her nutritional condition (McGinnes and Downing 1977).

Mortality

Accurate estimates of mortality are necessary to effectively manage white-tailed deer populations (DeYoung 1989). Mortality factors commonly affecting most wildlife species are accidents, disease, poaching, legal hunting, predation, and weather (Heisey and Fuller 1985). Coues white-tailed deer populations can be susceptible to many of these mortality factors.

Natural predators such as coyotes, wolves (*Lupus* spp.), bobcats (*Felis rufus*) or lynx (*F. lynx*), mountain lions (Fig. 3), and black bear (*Ursus americanus*) prey on white-tailed deer (McCabe and Leopold 1951, Knipe 1977, Krausman and Ables 1981, Mech 1984, DeYoung 1989). Domestic or feral dogs can also be a problem in local areas (Lowry and McArthur 1978, Causey and Cude 1980).

Hunting white-tailed deer, particularly the male segment, is a common management tool (Matschke et al. 1984). In most areas, hunting is assumed to be compensatory rather than additive to male mortality rates, but this may not always be the case (Wood et al. 1989). Vulnerability of males can be influenced by habitat availability, road networks, and hunt structure.

Mortality tends to be naturally higher for males than females; even in wild, un hunted populations (McCabe and Leopold 1951, Krausman and Ables 1981). Harvest of the antlerless segment (i.e., females and fawns) can be used as a means of effectively controlling population size (Matschke et al. 1984). Hunting of Coues white-tailed deer has been noted in the southern end of the Santa Rita Mountains since the mid-1800s, when mining started in the area (Knipe 1977, Davis 1982).

Effects of Roads

Although Coues white-tailed deer thrive in terrain typically too rugged for much human disturbance (Evans 1984), the amount and placement of roads into available habitat could have an effect on management strategies, particularly as they pertain to greater access during hunting seasons. Also of concern is the level of disturbance caused by roads on white-



Figure 3. Mountain lions are primary natural predators on Coues white-tailed deer.

tailed deer during critical periods of the year. This concern is particularly important during drought conditions and fawning season.

The location of roads in Coues white-tailed deer habitat may significantly reduce habitat use close to roads. Avoidance of areas close to roads could effectively reduce amount of habitat available to deer, possibly resulting in lower deer densities.

Quality of roads is an indication of traffic volume. Deer may respond differently to unimproved "2-tracker" or 4-wheel drive roads than to higher traffic volume graded or paved roads.

Land Ownership

Land ownership of Coues white-tailed deer habitat could affect distribution of deer because of different land management practices. Also hunters, campers, and other recreationalists, who may impact deer through disturbances, are influenced by land ownership.

Differences in land management activities, such as housing developments, fuelwood cutting, grazing practices, and water availability, between various land owners may result in differences in quality of habitat available to Coues white-tailed deer.

The inability of hunters to gain access to many private land holdings may decrease vulnerability of bucks for harvest. This could impact age structure of the herd through inclusion of refuges in white-tailed deer habitat. The

amount of private land holdings tends to reduce area available for hunting and may increase hunter densities on nearby public lands.

STUDY AREA

The Santa Rita Study Area is located in the southeastern foothills of the Santa Rita Mountains in southeastern Arizona (Fig. 4). The northern boundary follows United States Geological Survey (USGS) section lines approximately 5.8 km north of old Fort Buchanan. State Route 82, from Fort Buchanan southwesterly to the town of Patagonia, as it follows Sonoita Creek, forms the eastern boundary. Following USGS section lines westward from Patagonia to Josephine Road forms the southern end of SRSA, while a jagged line following USGS section lines northward to the northern boundary is the western edge. SRSA encompasses 123 km² of Coronado National Forest, State Trust, private, and township lands. Elevation ranges from 1,200 m along Sonoita Creek in the southeast portion to 1,675 m in foothills in the northeast corner. Topography is a series of moderately steep long ridges dissected by small canyons, with many minor ridges and gullies intersecting major ridges. Numerous canyons drain southeasterly into Sonoita Creek. Major canyons include Hog, Adobe, Wood, Dry, Big Casa Blanca, Little Casa Blanca, Smith, Stevens, Gringo, Temporal, Goat, and Squaw Gulch (Fig. 5).

Climate (Fig. 6) is characterized as mild, with Patagonia lying in an average temperature belt ranging from 4-7 C in January to 21-24 C in July (Sellers and Hill 1974). May and June tend to be hot and dry, accounting for only 2.8% (0.49 cm) of annual precipitation. Summer monsoons in July and August provide nearly half the annual rainfall (43.9 cm for Patagonia). Snowfall (3.0 cm annually) is generally ephemeral on SRSA, with most winter precipitation in the form of gentle rains. All creeks flow intermittently, typically drying up during early summer. Temporal Canyon had flowing water or isolated pools for most of the study period.

Vegetation on SRSA is classified overall as Madrean evergreen woodland (Brown 1982), but is diverse due to elevation, broken topography, and uneven precipitation. Communities studied ranged from desert grasslands to evergreen shrubs.

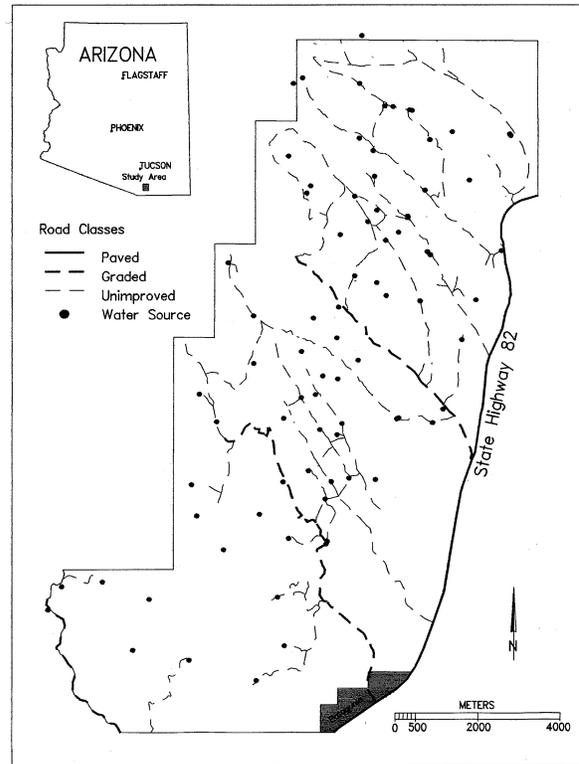


Figure 4. Location of Santa Rita Study Area (SRSA), Santa Rita Mountains, Arizona, and distribution of known water sources and roads.

The Santa Rita Mountains are rich in species diversity because of biseasonal rainfall, variety of geological features, and elevation changes (McLaughlin and Bowers 1990). McLaughlin and Bowers (1990) identified over 600 species in 89 families and 370 genera in the northern end of the mountain range. There is a sequence of overstory dominance in southwestern mountain ranges that changes altitudinally (Brady and Bonham 1976). Dominate upland overstory species at the elevation of SRSA are Mexican blue oak (*Quercus oblongifolia*), Emory oak (*Q. emoryi*), single-seeded juniper (*Juniperus monosperma*), and mesquite (*Prosopis juliflora*). Cottonwood (*Populus fremontii*), willows (*Salix* spp.), sycamore (*Platanus wrightii*), velvet ash (*Fraxinus velutina*), and walnut (*Juglans major*) line major drainages. Shrub species are very diverse, particularly the legumes. Wait-a-minute bush (*Mimosa biuncifera*), velvet-pod mimosa, false mesquite (*Calliandra eriophylla*) and range ratany (*Krameria parvifolia*) are abundant in lower elevations, while chaparral species like manzanita (*Arctostaphylos pungens*), skunkbush (*Rhus trilobata*), and silk tassel (*Garrya wrightii*)

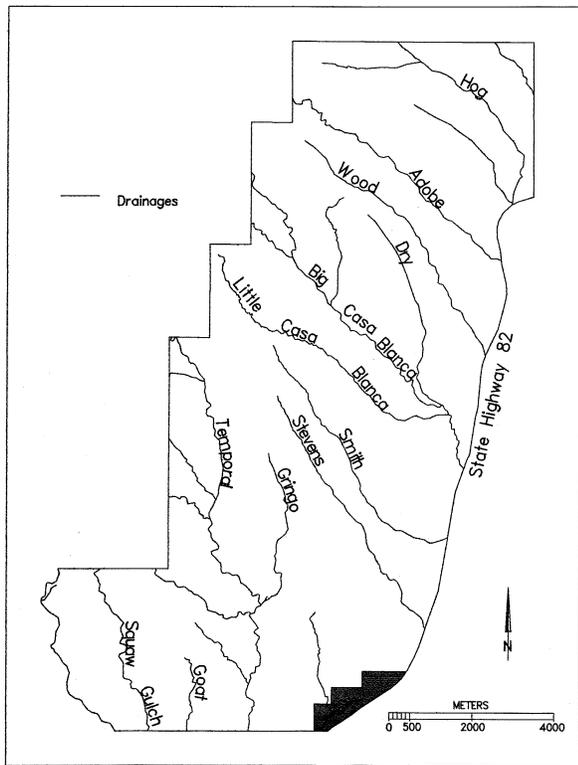


Figure 5. Location of major drainages in the SRSA, Santa Rita Mountains, Arizona.

dominate higher elevations. Grasses are predominately side-oats grama (*Bouteloua curtipendula*), hairy grama (*B. hirsuta*), and curly mesquite (*Hilaria belangeri*), however, a wide variety of grasses are present. Forbs are seasonally abundant and diverse.

There is a north versus south-facing slope vegetative dichotomy on much of SRSA. North-facing slopes are dominated by trees and shrubs, while grasses, succulents, and forbs are plentiful on drier south-facing slopes.

Portions of 3 grazing allotments, all cattle rest-rotation systems, make up SRSA. Range analysis of the area (USFS unpub. documents) showed ridge tops and drainage bottoms to be typically in fair to poor condition, with slopes generally in good condition. All 3 allotments were grazed below specified carrying capacity under current management plans. Temporal allotment, more than 50% of SRSA, took a 20% non-use reduction in forage animal unit months (AUMs) to help historically heavily grazed areas improve faster. Allotment managers maintained water distribution systems in conjunction with the rest-rotation schedules.

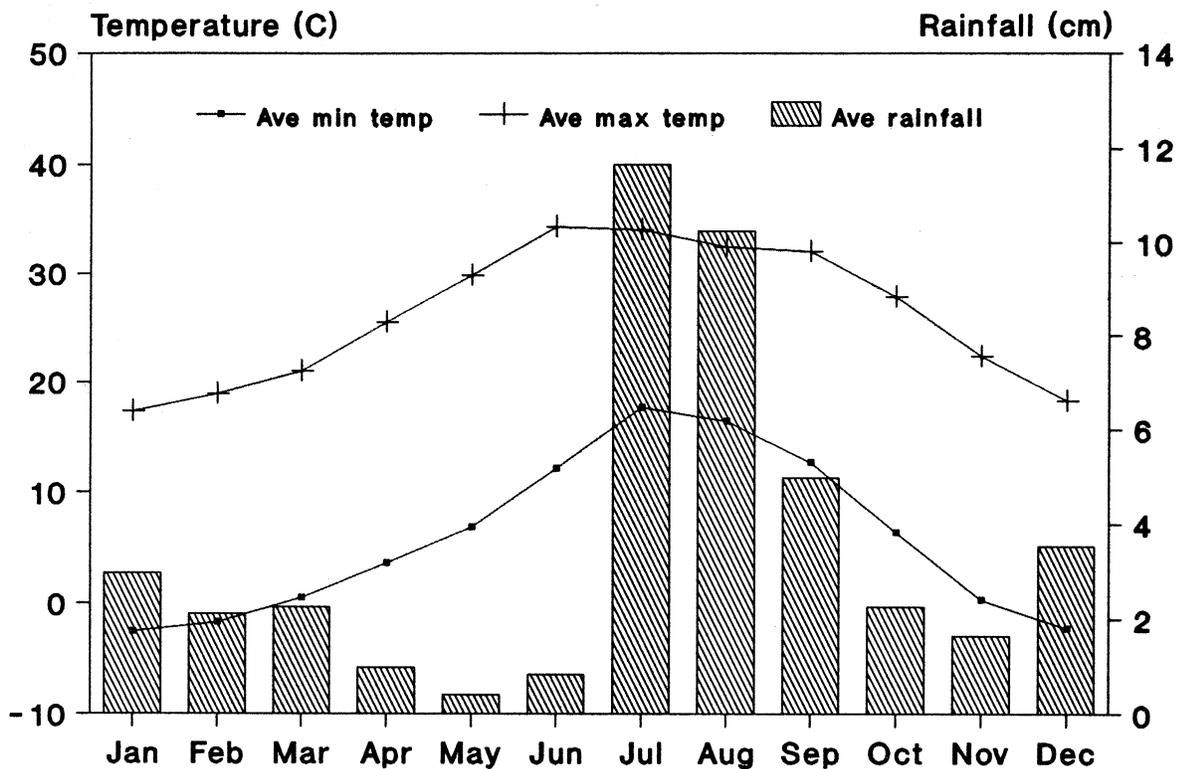


Figure 6. Long-term (1941-1970) average temperature and precipitation data from the Nogales-Patagonia, Arizona area.



METHODS

Habitat Mapping

Initial mapping of vegetative components was completed under contract with the Office of Arid Lands Studies at University of Arizona. Classification was based on *Biotic Communities of the American Southwest - United States and Mexico* (Brown 1982). Vegetative components were delineated on color infra-red aerial photographs (1:15,840) taken in October 1977. Boundaries were transferred via transfer stereoscope onto a mylar base map. Selected areas were then field verified. We digitized the base map into a geographical information system (GIS; ARC/INFO) and checked the overlay against the base map. Overlay maps of 4 USGS 7.5' topographic maps were produced and field verified again. A final GIS vegetative overlay was then completed for SRSA (Fig. 7, *a-b*). Because of management needs, we used a classification based primarily on tree and shrub dominance. Classification was completed by rank order of decreasing percentage canopy cover.

Capture and Telemetry

Coues white-tailed deer were captured with a net-gun fired from a helicopter (Smith and Horejsi 1982, Krausman et al. 1985, DeYoung 1988). Capture dates were scheduled after hunts, but before the critical hot, dry summer season. We attached radio transmitter collars, put colored ear-tags in both ears, and took blood samples. Prior to release, each deer was administered 200-400 mg of tetracycline for tooth cementum labeling and as an antibiotic.

We located telemetered Coues white-tailed deer 1-2 times per week from the ground and as needed from the air. Disturbance of animals was minimized by camouflaging personnel and using spotting scopes. Visual observations or triangulations were recorded. Weather, vegetation, physical landscape, and deer behavior characteristics were recorded. We plotted locations on USGS 7.5' maps, sequentially numbered to correspond with data cards. Locations were then entered directly into the GIS while other data were entered via computer files.

We summed daily rainfall by week and averaged values over a 7-year period (1981-1987) to establish seasonal rainfall patterns. Weekly

rainfall was graphed and examined for breakpoints. Five seasons (Winter: Dec-Feb, Spring: Mar-Apr, Early summer: May-Jun, Late summer: Jul-Sep, Fall: Oct-Nov) were established using this technique.

Home Range

Home ranges of Coues white-tailed deer were calculated using a 90% harmonic mean contour with software program HOME RANGE (Ackerman et al. 1990). Core areas (Samuel et al. 1985) were also calculated with HOME RANGE. Regression analysis was used to test if home range size was related to number of locations taken for each deer during the study. Overall home ranges were determined for each deer. Home ranges for selected deer, those with an adequate number of locations, were calculated annually.

Differences in home range and core area size by sex were tested by non-parametric Mann-Whitney tests (Zar 1974). Average home range and core area sizes were calculated for males and females and percentage differences determined. Kruskal-Wallis ANOVA (Zar 1974) was used to test for differences in core area and home range size between years for a subsample of 5 female deer that were located for 4 years of study.

Habitat Use

We identified and used 10 major vegetative habitat types, plus 1 category for miscellaneous types, for overall habitat use and selection testing. Condensed categories (type and digital classification) were as follows: 1) mixed oaks=123.3111; 2) oak-mesquite=123.3112; 3) oak-juniper=123.3113; 4) other oaks=123.3114 thru 124.0; 5) mixed grasses=143.1510; 6) grass-mesquite=143.1520 thru 143.1529; 7) grass-other=143.1530 thru 143.1560; 8) mesquite-shrub=143.1610 thru 143.1619; 9) juniper=143.1620 thru 143.1629; 10) riparian=223.2210 thru 224.0; and 11) all other types, including chaparral, development, and bare ground.

We overlaid all deer locations with the GIS vegetative map to determine habitat type each location was in. A frequency distribution of major types used by Coues white-tailed deer was then tabulated for SRSA. Overall selection and avoidance of major habitat types by Coues white-tailed deer was estimated by comparing frequency

Santa Rita Study Area
Santa Rita Mountains
Vegetation Map

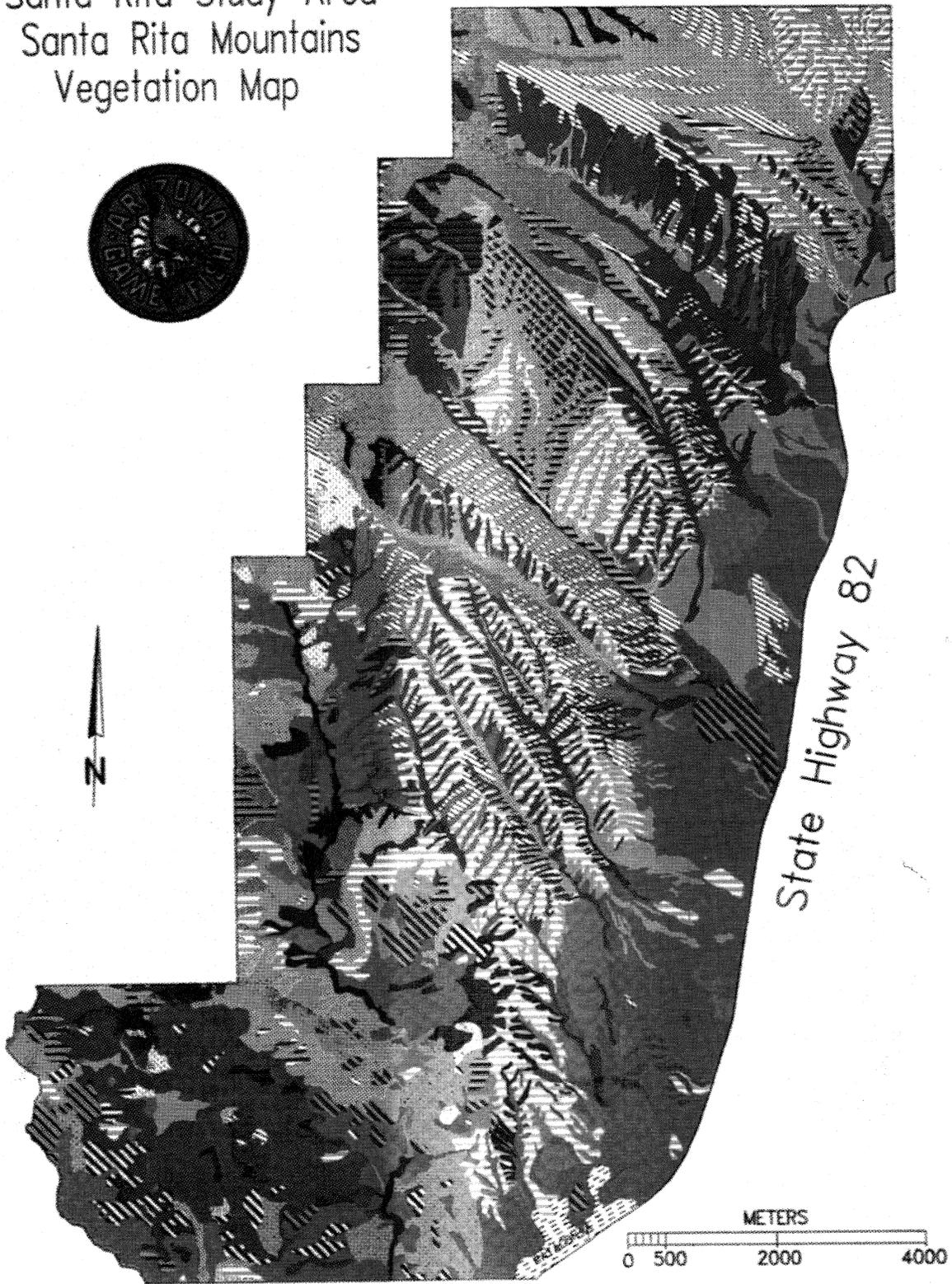


Figure 7, a.
SRSA, Santa Rita Mountains, Arizona, Vegetation Map

Key to Vegetation Types

	123.3111 Q.SPP		223.221 PLWR-FRVE-JUMA-PRJU-Q.SPP
	123.3112 Q.SPP-PRJU		223.223 FRVE-PLWR-Q.SPP/JUMA-POFR
	123.3113 Q.SPP-J.SPP		000.1 BARE GROUND
	123.3114 Q.SPP-ARPU-J.SPP		000.2 ROCK
	123.3115 Q.SPP-J.SPP-ARPU-PICE		000.3 TOWN
	123.3116 Q.SPP/J.SPP-ARPU-PRJU		143.151 MIXED GRASSES
	123.3117 Q.SPP-ARPU		143.152 GRASSES WITH PRJU
	123.3191 PICE-J.SPP-Q.SPP-ARPU		143.1521 GRASSES WITH PRJU AND JUNIPERUS
	133.3111 QUTO-ARPU-Q.SPP		143.1522 GRASSES WITH PRJU AND QUERCUS
	133.323 ARPU-PRJU		143.1523 GRASSES WITH PRJU AND SHRUBS
	133.3231 ARPU-PRJU-J.SPP		143.1524 GRASSES WITH PRJU AND CHLI
	133.3251 ARPU-Q.SPP		143.153 GRASSES WITH QUERCUS
	133.3252 ARPU-Q.SPP-PRJU		143.1531 GRASSES WITH QUERCUS AND JUNIPERUS
	133.3253 ARPU-Q.SPP-J.SPP		143.1532 GRASSES WITH QUERCUS AND SHRUBS
	133.327 ARPU-J.SPP-Q.SPP		143.154 GRASSES WITH JUNIPERUS
	143.1611 PRJU-J.SPP		143.1543 GRASSES WITH JUNIPERUS AND SHRUBS
	143.1613 PRJU-Q.SPP		143.155 GRASSES WITH SHRUBS
	143.1614 PRJU/CHLI		
	143.1616 PRJU-ARPU		
	143.1618 PRJU		
	143.1619 PRJU-FOSP		
	143.1621 J.SPP-Q.SPP-PRJU		
	143.1622 J.SPP-Q.SPP-PRJU-ARPU		
	143.1623 J.SPP-FRVE		
	143.1624 J.SPP-PRJU		
	143.1625 J.SPP-PICE-Q.SPP		

Key to Plant Code Names

ARPU	Arctostaphylos pungens	Mexican manzanita
CHLI	Chilopsis linearis	Desert willow
FOSP	Fouquieria splendens	Ocotillo
FRVE	Fraxinus velutina	Velvet ash
J.Spp	Juniperus spp.	Mixed juniper species
SUDE	Juniperus deppeana	Alligator juniper
JUMA	Juniperus monosperma	One-seed juniper
PICE	Juglans major	Arizona walnut
PLWR	Pinus cembroides	Mexican pinyon
POFR	Platanus wrightii	Arizona sycamore
PRJU	Populus fremontii	Fremont cottonwood
Q.Spp	Prosopis juliflora	Honey mesquite
QUAR	Quercus spp.	Mixed oak species
QUEM	Quercus arizonica	Arizona white oak
QUOB	Quercus emoryi	Emory oak
QUTO	Quercus oblongifolia	Mexican blue oak
	Quercus toumeyii	Toumey oak

Figure 7, b.
SRSA, Santa Rita Mountains, Arizona, Vegetation Map Legend

distribution of locations with study area distribution using Chi-square analysis. Bonferroni confidence intervals for habitat use values (Neu et al. 1974) were calculated and Jacobs' D (Jacobs 1974) was used as the criteria for selection and avoidance. Proportion of each habitat type within each deer's core area was calculated and differences in composition of core areas by sex was tested with ANOVA. Proportions were first transformed by use of an arcsine square root function to normalize data (Zar 1974).

Proportion of use of each habitat type was estimated for 4 temperature classes (0-9, 10-19, 20-29, and 30-39 C). Effects of temperature on use of habitat types were tested by Chi-square analysis for each 10 C temperature class.

To evaluate if habitat types were used differently in relation to a deer's activity, we tested 3 activity patterns (feeding, bedding, and other activities) against proportion of habitat types used for each activity. An 11x3 Chi-square contingency table was used to determine if significant differences in use of habitat types was due to activity patterns.

Aspect (8 categories) was also tested against activity classes by a Chi-square contingency table (8x3). Each deer location that had an activity code and estimated aspect was used in the analysis.

Differences in use of slope by deer gender was tested by Chi-square contingency tables (7x2). Slope was grouped into 10° intervals for analysis. We also tested slope class (10° intervals) by activity class with a 7x3 Chi-square contingency table.

A GIS cover map of major drainages (Fig. 5) within SRSA was taken from an Arizona State Land Department database. A series of 400 m contour intervals were delineated on the cover and proportion of SRSA within each interval was calculated. Deer locations were overlaid with drainage cover and distance to major drainage was calculated. Frequency distribution of proportion area in each 400 m interval was compared to distribution of deer locations by Chi-square, Bonferroni confidence intervals, and Jacobs' D.

Water Requirements

All known water sources (stock tanks, troughs, springs, stream pools) found on SRSA were mapped and digitized into a GIS cover (Fig. 4). Contour lines (400 m intervals) were generated to create buffers around each water

source and to calculate percentage of SRSA in selected distance classes. We overlaid deer locations with GIS water cover and distance to water was estimated for each location.

A frequency distribution of distance classes from water was compared to expected distribution (i.e., total locations times proportion of area in each distance interval) with Chi-square Goodness of Fit test, Bonferroni confidence interval, and Jacobs' D selectivity index. Selection or avoidance of habitats within a distance contour interval was concluded if the Bonferroni confidence interval did not contain the availability value for that contour interval. Jacobs' D indicated relative amount of selection-avoidance if availability was outside the Bonferroni confidence interval.

We overlaid home range boundaries of each deer on the GIS water cover and determined number of water sources within each core area and home range. Differences in number of water sources between females and males, within their core areas and home ranges, were tested with a Mann-Whitney test.

Arizona Game and Fish Department also partially funded a concurrent graduate research project on summer water requirements (Maghini and Smith 1990) to estimate daily use of water sources, shifts in home range size by summer season, and determine forage moisture relationships with use of free-standing water.

Diet

We collected fecal samples from white-tailed deer during 5 seasons (winter Dec-Feb; spring Mar-Apr; early summer May-Jun; late summer Jul-Sep; fall Oct-Nov) from each of 5 different habitat types scattered throughout SRSA. We collected a minimum of 5 pellets from 15 different deer pellet groups during each season and labeled and froze samples for future analysis.

Frozen samples were transferred to the Range Analysis Lab of University of Arizona for microhistological examination (Sparks and Malechek 1968). Density data by plant and plant groupings (grasses, forbs, shrubs, trees, cacti, and other) were summarized and relative percentage use for species and plant grouping was calculated. Plant names follow Soil Conservation Service reference (USDA 1982) and Kearney and Peebles (1973).

We attempted to normalize percentages by arcsine square root transformations (Zar 1974).

We tested for difference in annual deer diet composition by oneway ANOVA. Plant category and seasonal diet interaction were tested by two-way ANOVA.

Dietary Overlap with Cattle

Small pieces of 20-25 cattle droppings were collected in the same sampling scheme as were deer pellets. Cattle droppings were also sent to the Range Analysis Lab for examination. Percentage diet was calculated the same as for Coues white-tailed deer.

We computed deer dietary overlap with cattle by niche overlap index of Morista (1959), following review by Smith and Zaret (1982). Diet overlap values range from 0 to 1, with 0 indicating no overlap by composition grouping and 1 reflecting total dietary overlap by plant grouping.

Competition with Mule Deer

No field work was done on this objective of the study, other than general observations when Coues white-tailed deer were located, during surveys, and when fecal samples were collected. A review of pertinent literature was undertaken to compile information on diet, habitat, and reproductive similarities between mule deer and white-tailed deer. Evaluation of potential for competition was based on information collected and a review of the biology of both species.

Reproduction

We noted evidence of velvet polishing, rutting behavior, and antler cast of males during location periods. Rutting behavior, pregnancy status, and fawning data were recorded for females. We observed pregnant females as often as possible in late summer in an attempt to document fawning dates. Females no longer looking pregnant were observed undisturbed for extended periods to determine if they had fawns. Fawn survival was determined by monthly observations of telemetered females and their fawns.

Winter (January) survey routes (Fig. 8) were run each year to determine buck:doe and fawn:doe ratios. We completed predetermined foot or vehicle routes in early morning hours and used binoculars and spotting scopes to obtain estimates of group size, composition by sex and age classification, and group behavior.

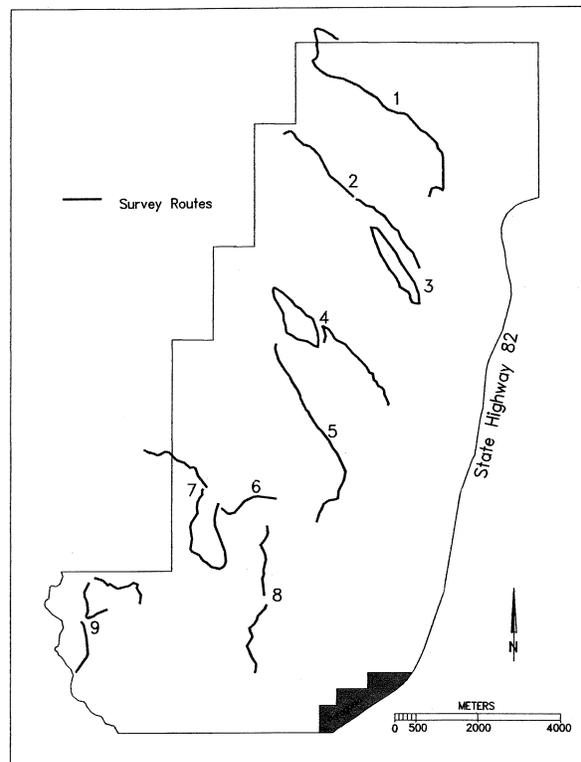


Figure 8.
Winter survey routes on the SRSA, Santa Rita Mountains, Arizona.

Mortality

We used mortality-pulse transmitters on telemetered deer to assist in determining Coues white-tailed deer mortality factors and rates. Mortality pulsing modes were investigated immediately and sites were examined for cause of death. We took photos at sites and collected physical evidence. Predator tracks were identified and measured and carcasses were inspected for clues of predation (Shaw 1983, Woolsey 1985, LeCount 1986). We collected skulls or lower jaws of carcasses to obtain teeth for dental cementum aging.

We investigated attrition rates of collared deer by calculating number of years each animal survived after capture. We also calculated survival and cause-specific mortality probabilities using version 1.1 of MICROMORT (Heisey and Fuller 1985). Causes of mortality were classified as; 1) mountain lion, 2) coyote, 3) hunter, and 4) other/unknown. Differences in survival were estimated by sex. Survival probabilities were calculated by sex for each year and seasonally.

We ran hunter check stations during deer seasons to field age, weigh, and measure harvested

Coues white-tailed deer from SRSA. An incisor from mature (>1.5 years) bucks was collected for cementum aging. Questionnaire boxes were located along major roads within SRSA to obtain information from hunters who did not come through check stations.

Locations of bucks harvested on SRSA were compared to the water GIS cover. Distance contours (400 m) were buffered around waters and frequency distributions of area versus harvest were tested for differences by Chi-square, Bonferroni confidence intervals, and Jacobs' D.

Harvest of white-tailed deer from SRSA was compared to harvest of Game Management Unit 34A to see if number of deer harvested on the 123 km² study area was higher or lower than expected, based on percentage of area on SRSA in comparison to available white-tailed deer habitat in 34A. Harvest data for SRSA was collected at the check station and through card stations at major entrance points. Data for 34A was taken from the hunter mail questionnaire program, which had been used to estimate harvest by GMU since 1958-1959.

Effects of Roads

We mapped currently used roads available to the general public on SRSA and digitized them into a GIS cover by road type (Fig. 4). These roads included the paved highway (State Route 82) at the east boundary, 3 graded dirt roads, and any four-wheel drive trail passable by motorized vehicle. Contour buffers (400 m intervals) were generated along each road to determine amount of area on SRSA close to each road type. We overlaid deer locations on the road buffer cover and estimated distance class for each location. A frequency distribution of deer locations by distance interval was tabulated and compared for selection-avoidance to distribution of area near roads with a Chi-square Goodness of Fit test, Bonferroni confidence interval, and Jacobs' D. Selection or avoidance at a particular contour interval was concluded if the Bonferroni confidence interval did not contain the area available on SRSA at that contour.

Major access roads to SRSA were monitored in 1987, 1988, and 1989 with road traffic counters to determine intensity of use. We read counters at weekly intervals. We calculated number of vehicle crossings per day as an index to intensity of use.

Locations of bucks harvested during hunting seasons were estimated by hunters from topographic maps at check stations and by hunter checks in field. Kill locations on SRSA were plotted on GIS maps, distance from roads calculated, and compared to road distance distribution in the same manner as described above.

Land Ownership

A land ownership GIS cover was created for SRSA from data available statewide at Arizona State Land Department. Deer locations were overlaid with ownership cover and a frequency distribution of deer locations by ownership was produced. Selection and avoidance of ownership by deer was determined by Chi-square analysis, Bonferroni confidence intervals, and Jacobs' D. Differences in percent use of national forest lands by sex was tested by Mann-Whitney two-sample test. Male use of national forest lands was compared by a paired *t*-test for hunting versus non-hunting periods.

Hunter kills of Coues white-tailed deer were also overlaid with ownership cover. Testing of ownership distribution was as above.



Radio-tagged Coues white-tailed buck, in early stage of antler development.

*Following Page:
Retreating Coues white-tailed deer.*



RESULTS

Capture and Telemetry

We captured Coues white-tailed deer in February-March 1987, January 1988, and January-February 1989 (Table 2). During capture operations, we had 1 F mortality in 1987, 2 M mortalities in 1988, and 1 M mortality in 1989. Capture related mortality was 11.9% (5 of 42 attempts) during operations. The net-gun capture method proved to be an effective, but difficult and dangerous, means of capturing Coues white-tailed deer in Arizona. We located each deer on a weekly basis to obtain an adequate number of locations for home range and habitat use analyses (Table 3). The majority of locations, 4,007 (87.8%), were from the ground, with 556 (12.2%) taken from aerial telemetry flights. More locations were completed in 1988 (32.4%) and 1989 (36.8%) than in 1987 (15.3%) or 1990 (15.5%), because of aerial flights and additional resource commitments associated with the concurrent water requirements graduate study.

Locations were completed from before 0600 to after 2000 MST to document diurnal home ranges and habitat use patterns. More ground

locations were taken in morning hours (Fig. 9), while all aerial locations were completed in the morning hours, due to safety considerations.

Home Ranges

We found no significant relationship between home range ($r^2 = 0.054$, $n = 35$, $P = 0.180$) or core area size ($r^2 = 0.000$, $n = 32$, $P = 0.949$) and number of locations taken per animal. Therefore, we used all 90% harmonic mean contour home ranges and core areas (Table 4) in further analyses. Female home ranges ($\bar{x} = 5.18 \text{ km}^2$) were significantly ($U = 50.0$, $n = 14M$, $21F$, $P < 0.001$) smaller than male ($\bar{x} = 10.57 \text{ km}^2$) home ranges, averaging only 49% of males. Several males had split seasonal core areas within their home ranges (Fig. 10) and incorporated only a travel corridor between areas. Core areas for females ($\bar{x} = 1.89 \text{ km}^2$) and males ($\bar{x} = 4.47 \text{ km}^2$) were also significantly ($U = 24.0$, $n = 13M$, $19F$, $P < 0.001$) different. Females (Fig. 11) used a core area averaging only 42% as large as males.

Annual variation in home range and core area size for females was tested for 5 females that had 4

Table 2. Capture and mortality data for Coues white-tailed deer in the SRSA, Santa Rita Mountains, Arizona, 1987-1991.

Animal/ Sex	Date captured	Mortality date	Mortality cause	Animal/ Sex	Date captured	Mortality date	Mortality cause
3/F	3/20/87	3/2/89	Unknown	21/F	2/5/87		
4/F	3/21/87	8/1/87	Unknown	22/F	2/5/87	3/4/90	Mtn. lion
5/M	2/4/87	9/30/87	Mtn. lion	23/M	1/23/88	2/18/88	Mtn. lion
6/F	3/21/87	6/30/88	Coyotes	24/F	1/23/88		
7/F	3/21/87	9/9/87	Coyotes	25/F	1/23/88	7/8/88	Mtn. lion
8/F	3/21/87	2/11/91	Coyotes	26/M	1/24/88	4/29/90	Unknown
9/M	3/21/87			27/M	1/24/88	11/29/89	Hunter
10/F	3/21/87			28/M	1/24/88	11/9/90	Hunter
11/F	2/4/87			29/M	1/24/88	11/13/88	Hunter
12/M	2/4/87	11/21/87	Hunter	30/M	1/24/88		
13/F	2/4/87			33/M	2/11/89	2/21/90	Mtn. lion
14/F	2/4/87			34/F	2/12/89		
15/M	2/4/87	11/10/87	Mtn. lion	35/M	2/12/89	10/26/90	Hunter
16/F	2/4/87	1/24/89	Mtn. lion	36/F	2/11/89		
17/F	2/4/87	7/23/88	Coyotes	37/F	2/11/89		
18/F	3/21/87	3/31/90	Mtn. lion	38/F	2/11/89	10/28/89	Hunter
19/M	3/21/87	11/20/87	Hunter	40/M	2/11/89		
20/F	2/5/87			41/M	2/12/89		

Table 3. Number of locations of Coues white-tailed deer from the SRSA, Santa Rita Mountains, Arizona, 1987- 1990.

Animal	1987	1988	1989	1990	Total
3	28	56	2		86
4	10				10
5	26				26
6	37	39			76
7	17				17
8	45	83	69	53	250
9	33	69	54	17	173
10	37	62	54	37	190
11	45	92	109	48	294
12	48				48
13	52	114	127	51	344
14	42	100	121	51	314
15	34				34
16	32	55	1		88
17	45	77			122
18	30	54	47	10	141
19	39				39
20	27	49	52	37	165
21	34	59	52	48	193
22	37	57	50	8	152
23		2			2
24		111	121	45	277
25		49			49
26		77	70	17	164
27		70	50		120
28		87	47		134
29		53			53
30		64	63	45	172
33			52	6	58
34			50	48	98
35			47	36	83
36			109	47	156
37			106	7	113
38			116	50	166
40			39		39
41			58	48	106
Yearly Totals	698	1479	1677	709	4563
% Totals	15.3	32.4	36.8	15.5	100.0

Table 4. Home range^a and core area size^b (km²) of Coues white-tailed deer in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Males			Females		
Animal number	Home range	Core area	Animal number	Home range	Core Area
5	5.64		3	0.93	0.40
9	14.10	5.70	4	0.89	
12	14.58	4.51	6	2.46	1.14
15	11.05	4.58	7	0.60	
19	4.51	1.71	8	11.20	3.56
26	12.97	5.83	10	7.39	2.25
27	10.41	4.08	11	18.11	5.39
28	5.51	2.44	13	5.92	2.15
29	7.80	3.74	14	3.98	1.45
30	15.11	7.29	16	3.61	1.35
33	14.71	6.32	17	7.89	2.81
35	9.53	4.14	18	3.10	1.19
40	5.19	2.26	20	2.13	0.84
41	16.92	5.56	21	6.18	1.98
			22	3.53	1.35
			24	10.04	3.03
			25	2.01	0.89
			34	7.86	2.61
			36	4.15	1.14
			37	2.66	1.00
			38	4.16	1.44

^a Home range based on 90% harmonic mean contour area, program HOME RANGE.

^b Core area based on program HOME RANGE, use exceeds availability area.

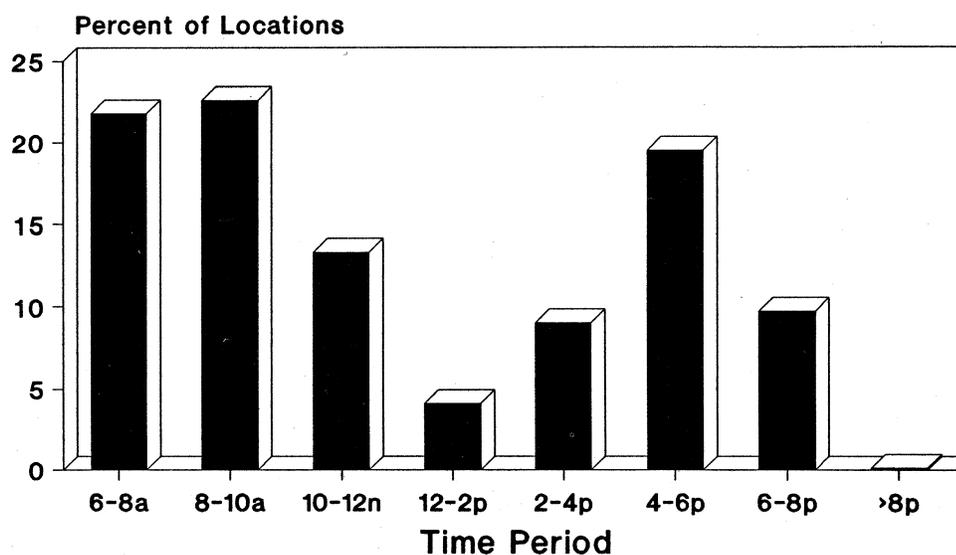


Figure 9. Percent of ground locations by time period for Coues white-tailed deer in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

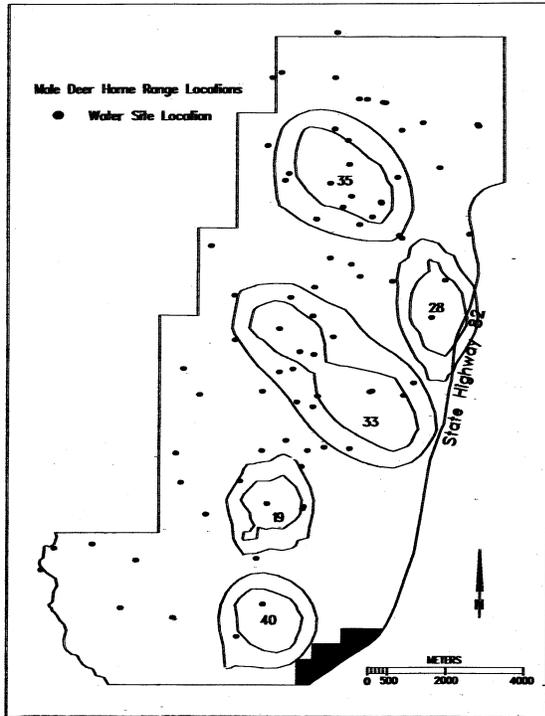


Figure 10.
Selected home ranges of male Coues white-tailed deer in the SRSA, 1987-1990 in relation to water sources.

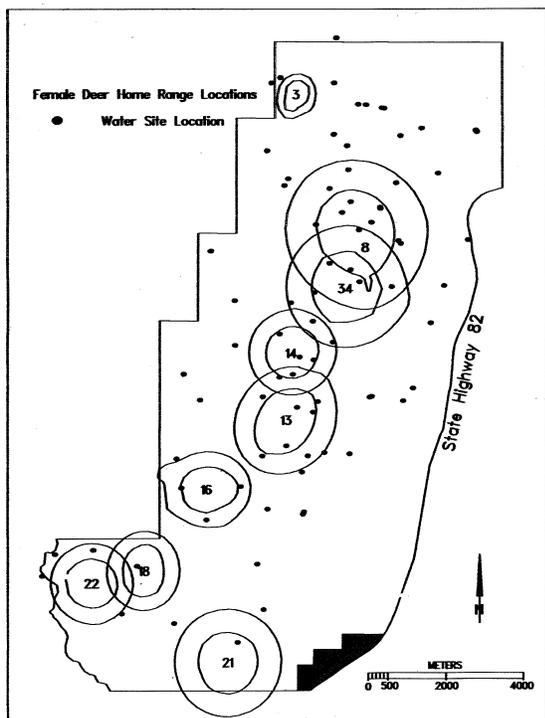


Figure 11.
Selected home ranges of female Coues white-tailed deer in the SRSA, 1987-1990 in relation to water sources.

years of sufficient (>30 per year) locations. Kruskal-Wallis ANOVA indicated no significant ($\chi^2 = 1.75, n = 20, P = 0.625$) difference in size of home range due to year during 1987-1990. Core area size also was not significantly ($\chi^2 = 1.68, n = 20, P = 0.641$) different by year. Variation in use area (core area) was more a function of which animal it was ($\chi^2 = 8.08, n = 20, P = 0.081$) than what year it was.

Habitat Use

Coues white-tailed deer used 11 major habitat types in a manner significantly ($\chi^2 = 1147.11, 10 df, P < 0.001$) different from availability (Table 5). Bonferroni confidence intervals and Jacobs' D values suggested that 2 habitat types, oak-mesquite thickets on hillsides and mesquite-shrub invaded grasslands in flats, accounted for the majority of differences in use versus availability.

Oak types in bottoms and dense thickets of oaks in either tree or shrub form were used by collared deer as available, as were grass-mesquite types. Pure stands of grass were avoided, as were grass-other tree types.

Composition of habitat types used by sex (Table 6) differed significantly for only 3 of 11 comparisons. Mesquite-shrub invaded grasslands, those areas bordering lowlands of major drainages as they empty into Sonoita Creek, were heavily favored by males, as were mixed grass openings. Females made little use of these 2 types, relative to males. High variability of use of each habitat component was observed for females and males. Each habitat component ranged from 0 to large proportions, depending on location of core areas within SRSA and sex of animal. All habitat types were found within at least some core areas, none were totally avoided.

Temperature, by 10 C classes, had a significant ($\chi^2 = 41.38, 30 df, P = 0.081$) impact on use of 11 habitat components (Table 7). Too few locations were made at temperatures less than 0 C to use for testing, therefore, we only tested classes 0-9 thru 30-39 C. We found that use of mixed oaks, those areas in drainage bottoms and minor ridge drainages, and oak-juniper decreased as temperature increased. Conversely, use of mesquite-shrub invaded grassland increased for each 10 C class, even though the type was avoided overall. Neither could be considered major shifts in use by temperature. No other trends in use by temperature were documented during this study.

Table 5. Distribution of Coues white-tailed deer locations in relation to habitat types in the SRSA, Santa Rita Mountains, Arizona, 1987-1990. CI refers to Bonferroni test (Neu et al. 1974).

Habitats	No. deer	Percent deer	90% CI		Expected ^a deer	Percent area	Overlap CI	Jacobs' D
			lower	upper				
Mixed oak	514	11.3	10.1	12.5	557	12.2	Yes	
Oak-mesquite	1272	27.9	26.2	29.6	593	13.0	No	0.44
Oak-juniper	320	7.0	6.0	8.0	274	6.0	Yes	
Other oak	290	6.4	5.5	7.3	315	6.9	Yes	
Mixed grass	176	3.9	3.2	4.6	224	4.9	No	-0.12
Grass-mesquite	812	17.8	16.3	19.3	762	16.7	Yes	
Grass-other	96	2.1	1.6	2.6	142	3.1	No	-0.20
Mesquite-shrub	827	18.1	16.6	19.6	1420	31.1	No	-0.34
Juniper	195	4.3	3.5	5.1	132	2.9	No	0.20
Riparian	16	0.4	0.2	0.6	32	0.7	No	-0.27
Other	47	1.0	0.6	1.4	119	2.6	No	-0.45

^a Based on percent area.

Habitat use patterns of Coues white-tailed deer were significantly ($\chi^2 = 44.90$, 20 *df*, $P = 0.001$) affected by activity patterns (Table 8). Grassy areas invaded with either trees or shrubs seemed to provide feeding sites, but were used less for bedding sites. Pure stands of grass (mixed-grass types) were not used for feeding, but edges were used for bedding. Oak types provided bedding and feeding sites. Activity patterns (feeding, bedding, and other/unknown) were not significantly ($\chi^2 = 6.89$, 6 *df*, $P = 0.330$) affected by changes in temperature.

Coues white-tailed deer significantly ($\chi^2 =$

33.24, 14 *df*, $P = 0.003$) used slope aspects differently for foraging and bedding (Table 9). Northerly (N, NE, NW = 49.2%) aspects were used more extensively than southerly (S, SE, SW = 22.7%) areas for bedding. The use of southerly (27.5%) aspects increased for foraging, but northerly (42.1%) aspects were still used more. We found that all exposures were used by Coues white-tailed deer for each activity class. No aspect was totally avoided or selected for any activity class.

Coues white-tailed deer tended to use slopes less than 40° (Fig. 12), with males using

Table 6. Distribution of habitat types by sex within Coues white-tailed deer core areas^a for the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Habitat	Female Percent (SD)		Male Percent (SD)		<i>F</i> ^b	Probability
Mixed oaks	10.5	(11.6)	10.2	(12.1)	0.007	0.935
Oak-mesquite	24.4	(20.2)	17.2	(14.6)	1.174	0.287
Oak-juniper	9.6	(13.0)	6.1	(7.6)	0.753	0.393
Other oaks	4.5	(12.1)	2.0	(5.2)	0.527	0.474
Mixed grass	3.4	(4.0)	7.0	(5.5)	4.472	0.043
Grass-mesquite	27.9	(15.5)	19.5	(10.0)	3.069	0.090
Grass-other	3.6	(6.9)	1.9	(3.4)	0.660	0.423
Mesquite-shrub	11.4	(16.4)	33.9	(28.2)	7.816	0.009
Juniper	3.0	(6.4)	1.7	(4.7)	0.351	0.558
Riparian	0.8	(2.1)	0.3	(1.0)	0.685	0.415
Other	1.0	(2.1)	0.3	(0.7)	1.295	0.264

^a Core areas calculated by HOME RANGE (Ackerman et al. 1990). Sample based on 19 females and 13 males.

^b *F* statistic and probability from ANOVA using Arcsine square root transformation.

Table 7. Percentage use of habitat types by temperature class for Coues white-tailed deer in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Habitat	Temperature class (C)				
	<0	0-9	10-19	20-29	30-39
Mixed oaks	7.7	13.1	12.4	11.3	8.8
Oak-mesquite	15.4	26.3	27.3	25.7	30.6
Oak-juniper	23.1	11.2	6.6	6.5	5.4
Other oak	0.0	8.0	6.0	6.1	6.5
Mixed grass	23.1	5.6	3.8	3.4	4.4
Grass-mesquite	15.4	15.1	18.4	18.6	15.5
Grass-other	7.7	2.0	2.0	2.8	1.3
Mesquite-shrub	7.7	14.7	17.7	19.9	23.3
Juniper		2.8	4.2	4.4	2.6
Riparian		0.4	0.3	0.4	0.8
Other		0.8	1.4	0.9	0.8
<i>n</i>	13	251	102	1634	386

Table 8. Percentage use of habitat types by activity for Coues white-tailed deer in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Habitat	Percent activity		
	Feeding	Bedding	Other ^a
Mixed oaks	39.2	45.5	15.3
Oak-mesquite	41.3	40.6	18.2
Oak-juniper	41.8	44.7	13.5
Other oak	48.3	41.1	10.6
Mixed grass	36.8	45.3	17.9
Grass-mesquite	52.5	28.6	18.9
Grass-other	44.2	29.3	15.5
Mesquite-shrub	45.8	36.3	17.9
Juniper	51.6	35.5	12.9
Riparian	55.6	33.3	11.1
Other	42.9	42.9	14.3
Total	45.1	38.1	16.9

^a Category includes watering, flight, rutting, travel, sentry, and unknown.

Table 9. Distribution (percentages) of Coues white-tailed deer locations^a by aspect (for different activities) in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Aspect	Percent Activity			
	Feeding	Bedding	Other	Total
E	17.2	13.3	16.2	15.6
N	16.1	21.5	14.0	17.7
NE	16.7	14.7	15.1	15.7
NW	9.3	13.0	10.7	10.9
S	10.8	8.3	11.8	10.1
SE	7.9	6.0	6.0	6.9
SW	8.8	8.4	11.0	9.0
W	13.1	14.8	15.3	14.1
<i>n</i>	1045	818	365	2228

^a Only those locations that had both aspect and activity recorded were used in the analysis.

gentler terrain significantly ($\chi^2 = 85.21, 6 \text{ df}, P < 0.001$) more than females. Over one-half of female locations were in the 20-29° class, which is moderate to steep in nature. Males used gentle, rolling areas – areas less than 20° – but also used the 20-29° class most.

Use of slope for feeding and bedding activities by Coues white-tailed deer was similar (Table 10), but activities such as watering and travel tended to be on gentler slopes, which caused significant ($\chi^2 = 54.42, 12 \text{ df}, P < 0.001$) differences in use of slope classes. Again, the 20-29° class was the most used class for all activities.

We found that deer locations were distributed significantly ($\chi^2 = 166.42, 2 \text{ df}, P < 0.001$) closer to drainages than expected (Table 11). Bonferroni confidence intervals and Jacobs' D indicated that the first 400 m from a drainage were selected for, the next 400 m slightly avoided, and the rest of SRSA heavily avoided by telemetered deer.

Water Requirements

We identified and mapped 82 permanent or semi-permanent water sources, of which 79 were

on and 3 were adjacent to SRSA. The majority, 50 (61.0%), occurred in semi-desert grassland habitats; of which 31 (37.8%) were in mixed grass-shrub, 15 (18.3%) occurred in disclimax shrub-shrub invaded, and 4 (4.9%) were in disclimax juniper-dominated types. Thirty (36.6%) were in Madrean evergreen woodland and 2 (2.4%) were in riparian areas.

A significant ($\chi^2 = 1429, 3 \text{ df}, P < 0.001$) relationship was found between distribution of area around water sources and number of locations found within each 400 m distance intervals (Table 12). Bonferroni confidence intervals and Jacobs' D values indicated selection for the first 800 m around a water source, and a lower likelihood of deer using areas greater than 800 m from a water source on SRSA. Strongest selection was for the first 400 m around a water source. We located few deer greater than 1,200 m from water, and Jacobs' D indicated a nearly total avoidance of those areas.

We found an average of 7.5 ($SD = 5.5$) water sources within 90% harmonic mean contour home ranges of 32 Coues white-tailed deer (Table 13).

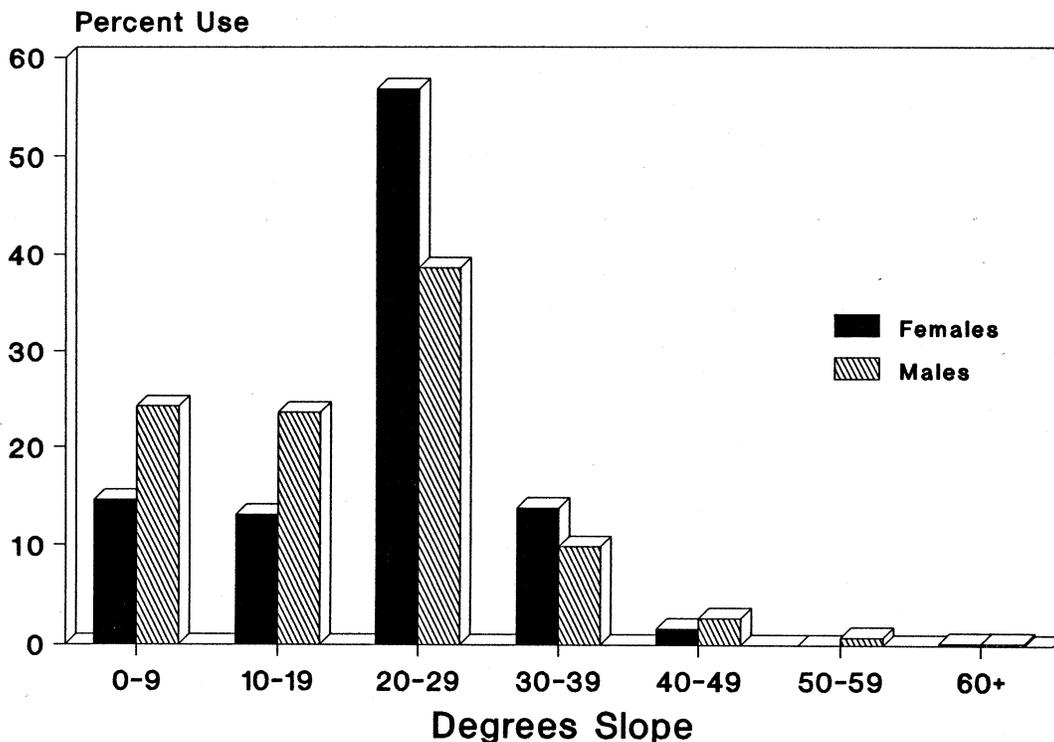


Figure 12. Percentage use of slope classes (by sex) of Coues white-tailed deer in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Table 10. Use of slope classes (by activity) for Coues white-tailed deer in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Degrees Slope	Feeding	Bedding	Other ^a
0-9	13.7	12.5	23.8
10-19	14.8	15.1	17.8
20-29	55.5	58.8	43.2
30-39	12.6	11.8	13.4
40-49	3.0	1.7	1.4
50-59	0.4	0.0	0.3
60+	0.2	0.2	0.1
<i>n</i>	541	536	718

^a Other includes watering, flight, breeding, sentry, unknown.

Table 11. Distribution of Coues white-tailed deer in relation to drainage bottoms in the SRSA, Santa Rita Mountains, Arizona, 1987-1990. CI refers to Bonferroni test (Neu et al. 1974).

Distance class (m)	Number of locations	Percentage locations	90% CI		Expected ^a locations	Percentage area	Overlay CI	Jacobs' D
			lower	upper				
0-400	3224	70.9	69.5	72.3	2891	63.6	No	0.16
401-800	1219	26.8	25.4	28.2	1368	30.1	No	-0.08
801-1200	101	2.2	1.7	2.7	277	6.1	No	-0.49
1201 +	1	0.0			9	0.2		

^a Based on percentage of area.

Table 12. Distribution of Coues white-tailed deer locations in relation to water sources in the SRSA, Santa Rita Mountains, Arizona, 1987-1990. CI refers to Bonferroni test (Neu et al. 1974).

Distance class (m)	Number of locations	Percentage locations	90% CI		Expected ^a locations	Percentage area	Overlay CI	Jacobs' D
			lower	upper				
0-400	1870	41.1	39.5	42.7	1182	26.0	No	0.33
401-800	2246	49.4	47.7	51.1	1791	39.4	No	0.20
801-1200	401	8.8	7.9	9.7	809	17.8	No	-0.38
1201 +	29	0.6	0.3	0.9	764	16.8	No	-0.94

^a Based on percentage of area.

This was over twice the number found in core areas ($\bar{x} = 3.3$, $SD = 2.5$). We found that males ($\bar{x} = 9.8$, $SD = 5.1$, $n = 13$) had significantly ($U = 72.0$, $P = 0.049$) more water sources within their home ranges than females ($\bar{x} = 6.0$, $SD = 5.1$, $n = 19$). Males ($\bar{x} = 4.5$, $SD = 2.5$, $n = 13$) also had significantly ($U = 64.0$, $P = 0.022$) more waters within their core areas than females ($\bar{x} = 2.4$, $SD = 2.2$, $n = 19$).

Diet

We collected fecal samples for white-tailed deer in 1987, 1988, and 1989 for 5 different seasons. We calculated percentage composition of diet for deer by plant grouping for each season (Table 14). White-tailed deer dietary composition varied by season. Major components of deer diet shifted between forbs, shrubs, and trees; with

Table 13. Number of identified water sources within Coues white-tailed deer home ranges^a and core areas in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Females			Males		
ID no.	Core area	Home range	ID no.	Core area	Home range
3	0	0	5		
4			9	7	16
6	0	2	12	4	10
7			15	3	8
8	7	16	19	1	4
10	3	5	26	5	6
11	4	16	27	9	15
13	3	10	28	2	2
14	5	7	29	4	9
16	1	3	30	4	12
17	4	12	33	7	16
18	1	1	35	7	15
20	1	1	40	1	2
21	1	1	41	4	12
22	1	1			
24	7	13			
25	1	1			
34	4	9			
36	1	4			
37	0	4			
38	2	7			

^a Home ranges and core area from program HOME RANGE (Ackerman et al. 1990).

grasses, cacti, and other species of relatively minor importance in all seasons and years. High percentages of forb use were identified in spring of 1987 and 1988. Shrub use was high when forb use was low.

We identified a total of 11 grasses, 22 forbs, 21 shrubs, and 4 trees used by Coues white-tailed deer during the 3 years studied (Table 15). Only 1 cactus, prickly pear (*Opuntia* spp.), was identified, as was 1 fern (*Notholaena parryi*), in fecal samples. Oak trees were identified only to genus level. Relatively few species dominated the diet of Coues white-tailed deer. We documented only 6 species that accounted for more than 5% individually in overall diet. Shrubs accounted for over half the overall diet (50.8%). Forbs and trees comprised 29.8 and 14.7% of overall diet. Grasses (1.1), cacti (1.5), and ferns (2.2%) were relatively minor components of diet.

We combined data from grasses, cacti, and other for ANOVA tests, because of problems with zero data. We found no significant ($F = 0.01, 12 \text{ df}, P = 0.989$) effect on deer diets due to annual variation. Coues white-tailed deer diets were influenced significantly ($F = 73.49, 3 \text{ df}, P < 0.001$) by plant category (i.e., forb, shrub, tree, or other). We also found a significant ($F = 10.92, 12 \text{ df}, P < 0.001$) interaction between percentage use of a plant category by deer and season collected.

Table 14. Percentage diet composition by season of Coues white-tailed deer in the SRSA, Santa Rita Mountains, Arizona, 1987-1989.

Category	Year	Winter	Spring	Early summer	Late summer	Fall
Grasses	1987	0.8	7.3	0.2	0.6	0.6
Forbs		11.0	56.7	26.9	8.2	12.1
Shrubs		47.4	14.4	70.6	83.1	73.4
Trees		29.4	20.5	2.2	4.4	7.3
Cacti		1.6	1.1	0.0	0.0	0.0
Other		10.4	0.0	0.0	3.6	6.5
Grasses	1988	0.0	1.4	0.0	0.3	2.0
Forbs		24.7	66.3	36.9	26.9	28.8
Shrubs		30.8	11.5	53.5	65.5	48.6
Trees		41.3	20.7	9.4	6.9	17.6
Cacti		3.2	0.0	0.3	0.3	3.0
Other		0.0	0.0	0.0	0.0	0.0
Grasses	1989	1.8	1.0	0.3	0.2	0.2
Forbs		28.1	37.1	34.4	24.6	32.1
Shrubs		40.8	23.8	50.0	63.5	57.3
Trees		26.7	36.7	15.1	7.2	7.0
Cacti		2.6	1.4	0.3	4.3	2.8
Other		0.0	0.0	0.0	0.2	0.6

Table 15. Plant species identified in Coues white-tailed deer fecal samples from the SRSA, Santa Rita Mountains, Arizona, 1987-1989. Percentage composition in parenthesis.

Grasses	Forbs (continued)	Shrubs (continued)
<i>Aristida</i> spp (T)	<i>Heliomeris longifolia</i> (1.2)	<i>Psilostrophe cooperi</i> (T)
<i>Bouteloua</i> spp (T)	<i>Lotus</i> spp (1.1)	<i>Rhus trilobata</i> (T)
<i>Bromus rubens</i> (T)	<i>Lupinus</i> spp (1.8)	<i>Simmondsia chinensis</i> (T)
<i>Eragrostis</i> spp (T)	<i>Melilotus officinalis</i> (T)	<i>Viguiera deltoidea</i> (1.6)
<i>Heteropogon contortus</i> (T)	<i>Mentzelia multiflora</i> (T)	Unknowns (1.8)
<i>Hilaria belangeri</i> (T)	<i>Nyctaginaceae</i> spp (T)	
<i>Hilaria</i> spp (T)	<i>Plantago insularis</i> (T)	Trees
<i>Lycurus phleoides</i> (T)	<i>Sphaeralcea</i> spp (6.1)	<i>Juglans major</i> (T)
<i>Muhlenbergia porteri</i> (T)	Unknowns (3.2)	<i>Juniperus</i> spp (1.2)
<i>Sporobolus</i> spp (T)		<i>Prosopis juliflora</i> (5.4)
<i>Tridens muticus</i> (T)	Shrubs	<i>Quercus</i> spp. (8.0)
Unknowns	<i>Acacia greggii</i> (T)	Unknowns (T)
	<i>Artemisia</i> spp (1.0)	
Forbs	<i>Calliandra eriophylla</i> (4.3)	Cacti
<i>Arabis perennans</i> (T)	<i>Ceanothus Greggii</i> (1.4)	<i>Optuntia</i> spp (1.5)
<i>Artemisia ludoviciana</i> (T)	<i>Cercarpus</i> spp (1.5)	
<i>Astragalus</i> spp (1.0)	<i>Cowania mexicana</i> (T)	Other
<i>Baileya multiradiata</i> (T)	<i>Ephedra</i> spp (T)	<i>Notholaena parryi</i> (2.2)
<i>Boraginaceae</i> spp (1.0)	<i>Eriogonum</i> spp (T)	
<i>Camissonia</i> spp (T)	<i>Eriogonum wrightii</i> (T)	
<i>Dalea</i> spp (6.1)	<i>Eurotia lanata</i> (T)	
<i>Descurainia pinnata</i> (T)	<i>Garrya wrightii</i> (T)	
<i>Erigeron divergens</i> (1.8)	<i>Hyptis Emoryi</i> (T)	
<i>Eriogonum fasciculatum</i> (T)	<i>Janusia gracilis</i> (T)	
<i>Eriogonum</i> spp (2.7)	<i>Krameria</i> spp (9.8)	
<i>Erodium cicutarium</i> (1.2)	<i>Mimosa biuncifera</i> (T)	
<i>Euphorbia</i> spp (T)	<i>Mimosa dysocarpa</i> (29.2)	
<i>Evolvulus</i> spp (T)	<i>Nolina microcarpa</i> (T)	

Dietary Overlap with Cattle

Samples of cattle diet for fall of 1989 were unusable, because slide identifying information was lost at the lab. Several other slides for both deer and cattle were also unusable because seasonal data were lost.

Cattle dietary composition (Table 16) was dominated (>70%) by grasses, except during late summer of 1988 and 1989. Forb and shrub use increased during this season. Trees were used more by cattle than shrubs, except during late summer periods.

Calculated dietary overlap between white-tailed deer and cattle was generally low (Table 17). Values were less than 0.20 (i.e., 20%), except during late summers of 1988 and 1989. No overlap value for fall of 1989 could be calculated, because of missing cattle data.

Competition with Mule Deer

Articles pertaining to ecological relationships, such as diet, habitat, and reproduction, of mule and white-tailed deer throughout the Western Hemisphere were compiled. Information on white-tailed and mule deer biological requirements, independent of the other species, was also investigated.

SRSA had few mule deer living within the boundary. Some mule deer were commonly seen along Route 82 in mesquite invaded lowlands. East of Route 82, along Sonoita Creek, mule deer seemed to be more numerous, at least our observations of them were more common. Mule deer also were sometimes seen on open ridgelines in hilly areas of SRSA, whereas white-tailed deer tended to use northern slopes within their core areas.

Table 16. Percentage diet composition by season of domestic cattle in the SRSA, Santa Rita Mountains, Arizona, 1987-1989.

Category	Year	Winter	Spring	Early summer	Late summer	Fall
Grasses	1987	74.3	92.1	83.4	91.0	78.7
Forbs		2.4	3.5	5.0	0.9	10.7
Shrubs		2.4	0.9	1.5	4.8	3.2
Trees		16.0	2.2	9.8	3.0	7.0
Cacti		3.6	1.3	0.4	0.3	0.4
Other		1.2	0.0	0.0	0.0	0.0
Grasses	1988	75.9	86.0	74.1	34.7	90.2
Forbs		2.7	7.0	3.5	54.1	4.0
Shrubs		1.3	1.1	0.9	7.8	0.9
Trees		8.0	4.9	17.6	3.5	4.0
Cacti		12.1	1.1	3.9	0.0	0.9
Other		0.0	0.0	0.0	0.0	0.0
Grasses	1989	85.8	91.2	81.8	45.0	
Forbs		2.8	4.6	3.2	19.7	
Shrubs		0.3	1.3	0.0	31.3	
Trees		10.9	2.8	12.4	3.2	
Cacti		0.3	0.2	2.7	0.8	
Other		0.0	0.0	0.0	0.0	

Table 17. Dietary overlap values for Coues white-tailed deer and cattle from the SRSA, Santa Rita Mountains, Arizona, 1987-1989.

Year	Winter	Spring	Early summer	Late summer	Fall
1987	.15	.15	.04	.07	.08
1988	.10	.11	.07	.43	.08
1989	.10	.06	.06	.62	

Reproduction

Antler Polish. We were able to collect antler polishing data on 11 of 16 males during the study (Table 18). Antler polishing on SRSA typically started in late September and was generally completed by mid-October. The average date we first observed males on SRSA with polished antlers was on October 9 ($n = 17$, $SD = 8.2$ days). Observations of several males suggested that polishing was started and completed in a short time, typically less than a week. On September 21, 1987 male #19 was observed in velvet and polished by September 28. Velvet rubbing was observed for male #15 on October 1, 1987 and he was observed on October 6 with polished antlers. Animal #30 was observed in velvet on October 3, 1988 and polished the next day. During 1990, we observed animals #35, 40,

and 41 with antler velvet on October 3 and completely polished by October 10.

Rutting Period. Swollen necks on males were noted by November and some rutting behavior by bucks was observed as early as November 7 during the study. On November 8, 1989, we observed male #26 chasing a doe. An uncollared spike displaying typical rutting behavior was seen following 2 does on November 9, 1989. Early rutting activity by bucks and does was seen in December 1988 and 1989. On December 30, 1988, we located male #26 bedded with a doe, but saw no indication of chasing activity. In 1989, a spike buck was seen displaying rutting behavior toward female #38 on December 6, while on December 28 male #33 and another buck were seen chasing 2 does. Rutting behavior by Coues white-tailed deer was observed through January during location efforts and surveys (Table 19).

Table 18. Dates (1987-1990) that radio-instrumented Coues white-tailed bucks were first observed without velvet in the SRSA, Santa Rita Mountains, Arizona.

Animal no.	1987	1988	1989	1990
5				
9	10/06	10/04		
12	09/29			
15	10/06			
19	09/28			
23				
26		10/18	10/18	
27		10/09	10/18	
28		09/29		
29				
30		10/04	10/19	
33				
35			10/18	10/09
39				
40				10/09
41			09/27	10/10

Males were trailing does, displaying typical rutting behavior (i.e., sniffing bed sites, lip curls, neck extended, nose to ground, trotting). On mid- to late January locations and survey routes, observed rutting behavior tended to peak. Observed rutting behavior dropped off drastically in February, compared to the peak in January. During 1988, we observed an uncollared buck chasing female #20 on February 18, while in 1989 we observed rutting behavior on February 28. Some rutting behavior was noted as late as mid-March (March 16, 1988), when we observed a spike buck chasing female #25.

Antler Cast. We collected antler cast or shedding data on 13 of 16 instrumented bucks (Table 20). Average date we first observed males without antlers was on May 7 ($n = 22$, $SD = 10.9$ days). Variability of antler cast was greater than for antler polishing, as bucks were seen either shed or antlered throughout April and May.

Fawn Drop. Fawn drop tended to occur in mid- to late August on SRSA. Female pregnancy status seemed a more reliable gauge than observation of neonatal fawns. White-tailed deer females hide their fawns at birth and few neonatal fawns were observed during 1987-1990. We observed neonatal fawns as early as August 1 and 3 for collared does, and July 27 for uncollared does. The fawn of an uncollared doe seen on

Table 19. January occurrence (day by year) of rutting behavior by Coues white-tailed deer on the SRSA, Santa Rita Mountains, Arizona.

Day	1988 ^a	1989	1990	1991
1				
2				
3			R	
4		R		
5	R			
6				
7				
8				S
9				
10		SR	S	S
11		SR	S	S
12		S	S	
13	R			
14	R			
15				S
16				
17			S	
18		SR	R	
19				
20	SR			
21	S			
22	S			
23			S	
24	R			
25				
26	S			
27				
28	S			
29				
30			R	
31				

^a R = Radiotracking data/S = Survey data.

August 1, 1990 was judged to be less than a week old. Neonatal fawns were seen only 9 times for collared does in August.

Fawns of collared does were first observed more typically in September (Table 21), after their activity patterns changed and does, rather than hiding fawns, kept fawns with them. Fawns typically seen in late August or early September were judged to be at least 2-3 weeks old. Fawn drop in early to mid-August should occur with peak of rut/estrus in mid-January and a 200-day gestation period. A few neonatal fawns were also observed in September, corresponding to a late or second estrus cycle for some does.

Mortality

Fawn Survival. We observed collared does in July-August for changes in home range size, visible signs of pregnancy, and number of fawns in an attempt to determine a fawning rate. We noted presence of fawns by month for estimating monthly fawn survival. Unfortunately, we could not locate does daily and many times, fawns were probably lost before we had a chance to observe evidence of them.

In general, fawn survival seemed to be very good, after an initial 3-4 week period of high mortality. For example, during 1990, 10 of 11 fawns observed with 11 collared does survived the first month, and on into January 1991. Conversely, only 33% (5 of 15) of the collared does in 1987 were even observed with fawns, and only 1 of 6 fawns survived until January surveys, with all 5 fawns lost almost immediately.

January survey data for routes in 1987-1991 (Table 22) indicated uneven fawn survival by year on SRSA. The study period started in 1987 during a downswing phase of an excellent period of recruitment in GMU 34A (Fig. 13).

Table 20. Date that radio-instrumented Coues white-tailed bucks were first observed without antlers in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Animal no.	1987	1988	1989	1990
5	4/28			
9	4/28	5/5	4/25	5/1
12	4/17			
15	4/28			
19	4/28			
23				
26		5/11	5/11	
27		5/24	5/25	
28		5/13	5/11	
29		5/14		
30		5/06		5/17
33			5/23	
35			5/9	5/01
39				
40			4/19	
41			5/18	

Table 21. Date (and estimated weeks old) radio-instrumented Coues white-tailed does were first observed with fawns in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Animal No.	1987	1988	1989	1990
3		11/5		
4	M ^a			
6		M		
7	M			
8	8/14			
10		9/28	9/20	9/12 (2)
11		10/29	8/8 (<1)	9/4 (2)
13				
14		9/27		9/10 (2)
16	9/1 (3)	8/9		9/25 (>4)
17		M		
18		9/20		
20	9/10	10/3		8/31 (>3)
21	9/2	8/3 (>1)	8/9	8/31 (2)
22	9/7	9/7 (1)	8/1 (<1)	
24			9/9	9/26 (3)
25		Y	M	
34				9/10 (3)
36			9/26	9/25 (>4)
37	R			
38				8/29 (>1)

^a M = Mortality near fawning
 Y = Yearling
 R = Radio failure near fawning.

Table 22. Mid-winter^a (January) Coues white-tailed deer survey data in the SRSA, Santa Rita Mountains, Arizona, 1987-1991.

Survey Year	Bucks	Does	Fawns	Unknown	Total	Bucks:100 does	Fawns:100 does
86/87	26	80	27	32	165	33	34
87/88	18	115	15	2	150	16	13
88/89	24	139	38	14	215	17	27
89/90	25	165	64	14	268	15	39
90/91	40	156	71	13	280	26	46

^a Winter period: December-February.

Recruitment of fawns started back into an upswing phase as the study progressed. Survey results on SRSA tended to be less than ratio data for 34A (Fig. 14). The second and third year of the study period deviated over 20% less than 34A data. Survey data by route (Fig. 15) indicated fairly even recruitment over SRSA, with only Route 6 showing poor recruitment.

In 1988-89, total deer seen during surveys increased to nearly double that of the first 2 years. The increase in deer observed was partially related to increased fawn survival ($r^2 = 0.669, n = 5, P = 0.091$). However, although we had the same routes for each year, we also increased survey effort (i.e., personnel and hours surveyed) and these factors likely contributed to total deer seen.

Adult Mortality. We investigated 22 mortalities for 36 collared deer from 1987-1991 (Table 2). Mountain lions (36.4%), hunting (3.8%), coyotes (22.7%), and unknown-cause (9.1%) were mortality factors on SRSA. Legal hunting (58.3%) and mountain lion predation (33.3%) were major mortality factors for males, while mountain lion (40.0%) and coyote (40.0%) predation were predominate factors for females.

Attrition (i.e., loss) rate after capture of collared Coues white-tailed deer (Fig. 16) was greater for males than for females. Nearly half the collared males were lost to some mortality factor within a year of capture, whereas less than 20% of females were lost in 1 year or less. Because of small sample sizes of males and short

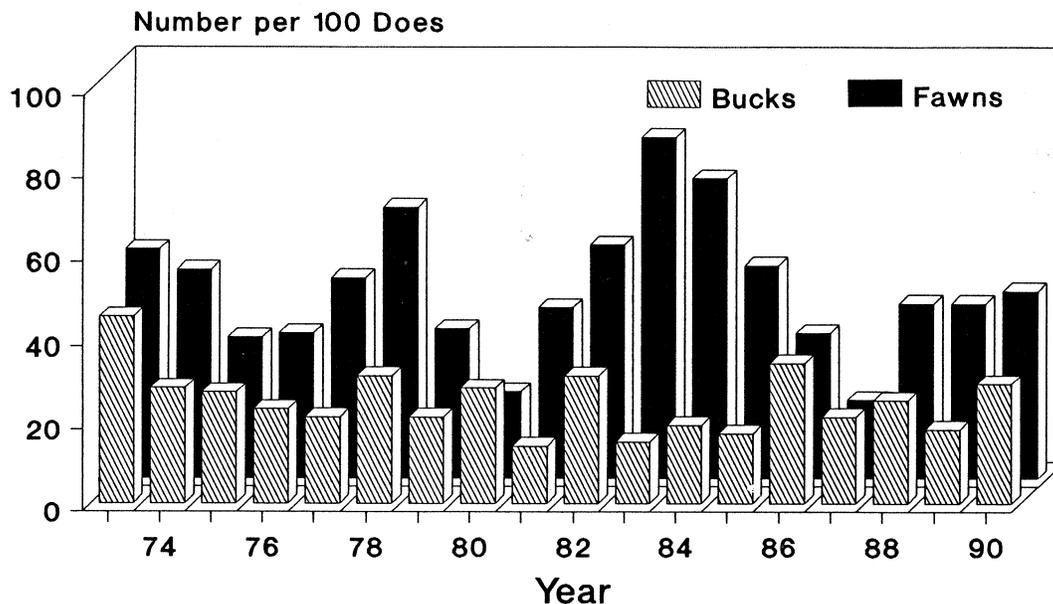


Figure 13. Mid-winter Coues white-tailed deer survey data for Game Management Unit 34A, which includes the Santa Rita Mountains, Arizona.

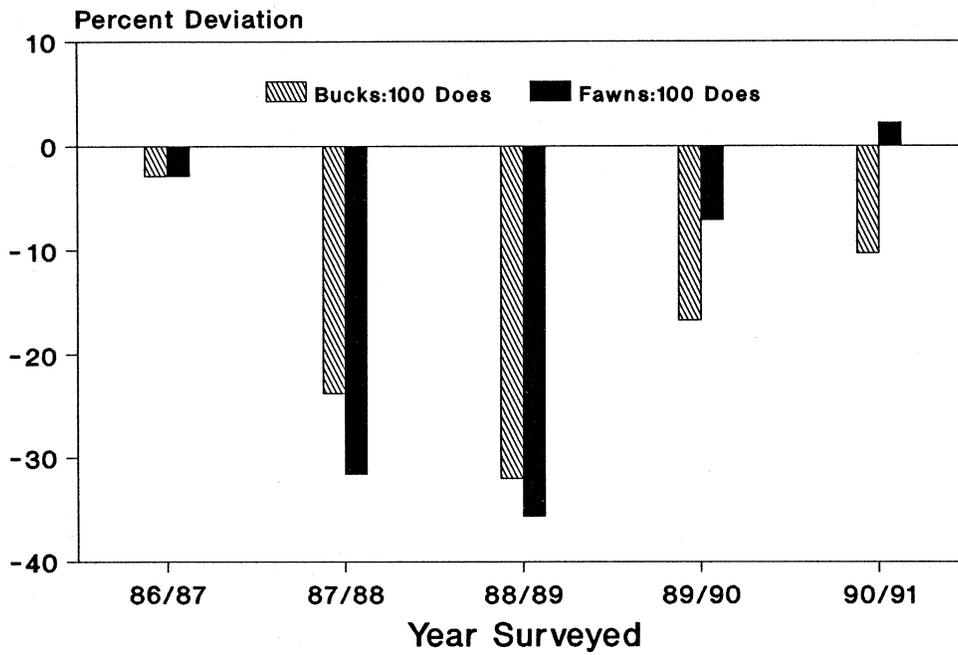


Figure 14. Percentage difference between Coues white-tailed deer mid-winter survey data for Game Management Unit 34A and the SRSA, Santa Rita Mountains, Arizona, 1987-1991.

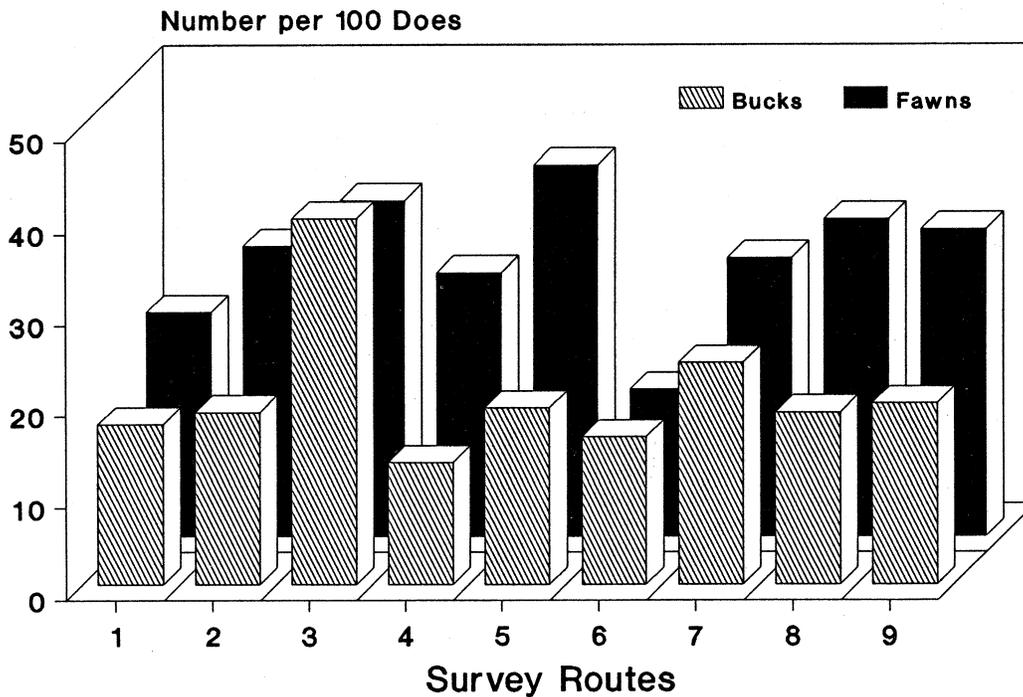


Figure 15. Coues white-tailed deer survey data by route in the SRSA, Santa Rita Mountains, Arizona, 1987-1991.

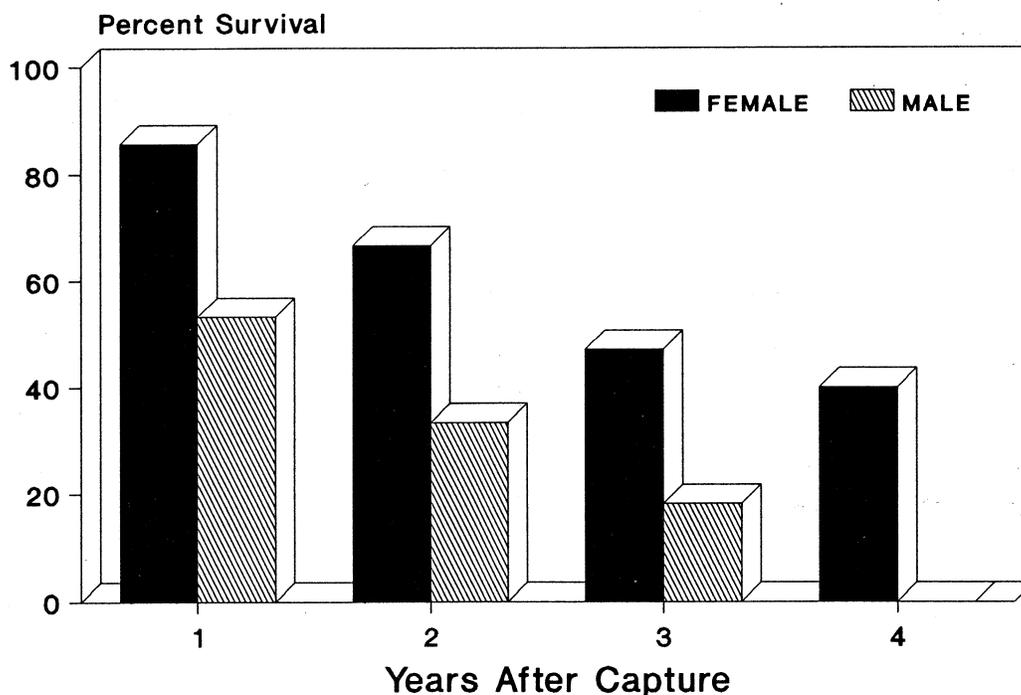


Figure 16. Attrition rate (by sex) of collared Coues white-tailed deer in the SRSA, Santa Rita Mountains, Arizona, 1987-1991.

transmitter battery life, we had to assume that 10% of males collared would be alive in the fourth year after capture to complete the data set to 4 years. The attrition rate is nearly linear for both males ($r^2 = 0.968$, $n = 4$, $P = 0.016$, $Y = 64.95 - 14.50X$) and for females ($r^2 = 0.965$, $n = 4$, $P = 0.017$, $Y = 99.05 - 15.67X$). There was a nearly constant 30 percentage point difference between male and female attrition rates.

Using estimated mortality rate from attrition data for females of 0.146 and the mortality factors from investigated kills, we found that a doe had a 0.058 ($0.146 * 0.40 = 0.058$ or 5.8%) probability of being killed by a mountain lion, 0.058 from coyotes, and only 0.029 from other causes. Male mortality (0.467 or 46.7%) was much higher, as bucks had a 0.272 probability of dying during a hunt, 0.156 from mountain lions, and 0.039 from other causes. Non-hunting male mortality was 0.195 (19.5%) on an annual basis.

We next calculated survival probabilities (overall 1987-1990), using MICROMORT, for individual males and females. Probability of surviving to the next year was significantly ($Z = 20.439$, $P < 0.001$) less for males (0.540, 95%CI = 0.374-0.780) than females (0.810, 95%CI = 0.711-

0.923). However, we found that neither male nor female rates remained the same on an annual basis (Table 23).

We also found survival probabilities for males and females to vary significantly by season (Table 24). Losses to the male segment of the population tended to occur mainly during fall hunting seasons (October-November) and just after rutting (from predation), resulting in lower survival probabilities during those periods. Female losses generally occurred in mid-summer (July-August) before fawning (from predation), or scattered throughout the winter and early spring (from predation). Cause-specific mortality probabilities (Table 25) indicated that female mortality factors vary and tend to be relatively low, while males are vulnerable mainly to hunting.

We checked 938 hunters at weekend check stations and from questionnaire boxes in 1987-1990 (Table 26). Hunters checked at Temporal Road station tended to camp on SRSA and hunt SRSA and nearby areas. Some hunters drove through SRSA and camped west of SRSA. Hunter numbers from the check station and questionnaire boxes were positively related ($r^2 = 0.688$, $n = 13$, $P < 0.001$) to number of hunters

Table 23. Annual (May 1 - April 30) survival probability^a of Coues white-tailed deer in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Sex	Year	Survival probability	95% Confidence Interval	
			lower	upper
F	1987	0.866	0.709	1.000
	1988	0.652	0.447	0.950
	1989	0.923	0.789	1.000
	1990	0.803	0.592	1.000
M	1989	0.333	0.112	0.991
	1988	0.839	0.596	1.000
	1989	0.443	0.215	0.912
	1990	0.685	0.327	1.000

^a Using MICROMORT (Heisey and Fuller 1985).

Table 24. Seasonal survival probability^a of Coues white-tailed deer in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Sex	Season	Survival probability	95% Confidence Interval	
			lower	upper
F	Jan-Feb	0.957	0.900	1.000
	Mar-Apr	0.978	0.935	1.000
	May-Jun	0.981	0.945	1.000
	Jul-Aug	0.902	0.824	0.987
	Sep	0.979	0.938	1.000
	Oct-Nov	1.000	1.000	1.000
	Dec	1.000	1.000	1.000
M	Jan-Feb	0.925	0.794	1.000
	Mar-Apr	1.000	1.000	1.000
	May-Jun	0.956	0.874	1.000
	Jul-Aug	1.000	1.000	1.000
	Sep	0.956	0.874	1.000
	Oct-Nov	0.639	0.469	0.870
	Dec	1.000	1.000	1.000

^a Using MICROMORT (Heisey and Fuller 1985).

in GMU 34A, as well as to number of permits issued in the respective area block (i.e., multiple GMUs) hunts ($r^2 = 0.597$, $n = 13$, $P = 0.002$). Rough estimates of hunter densities (Fig. 17) tended to be fairly stable by year, except during December, which decreased each year as drought conditions dictated that the Department reduce hunter opportunities. Hunter densities were greatest during November hunts.

We checked hunters from 1987-1990 and documented 189 white-tailed deer harvested (Table 27) either on SRSA or just off roads that cut

through SRSA. Most of the harvest was equally divided between October and November hunts. Only 5.8% of bucks were taken during December hunts. Fewer bucks were harvested in 1988 than in other years, which corresponded to the year with highest estimated male survival rate.

We found no significant ($r^2 = 0.087$, $n = 14$, $P = 0.305$) relationship between hunt success and number of hunters checked at stations. Hunters who hunted SRSA also tended to hunt off SRSA, and kill location data (Fig. 18) indicated many harvested a white-tailed deer in rougher country

Table 25. Estimated annual cause-specific mortality probability^a for Coues white-tailed deer in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Sex	Cause	Mortality probability	95% Confidence Interval	
			lower	upper
F	Mountain lion	0.076	0.004	0.148
	Coyote	0.076	0.004	0.148
	Hunting	0.000		
	Other/Unknown	0.038	0.000	0.089
M	Mountain lion	0.127	0.000	0.262
	Coyote	0.000		
	Hunting	0.288	0.109	0.467
	Other/Unknown	0.044	0.000	0.130

^a Using MICROMORT (Heisey and Fuller 1985).

Table 26. Hunter check station and harvest questionnaire data for the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

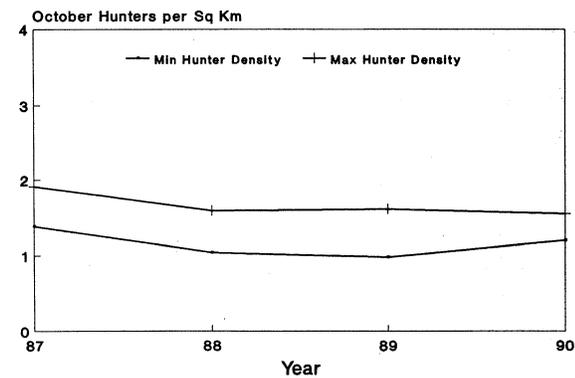
Year	Month	Permits available ^a	Hunters checked out	Cards returned ^b	Cards not returned	Minimum estimated hunters	Percent success	Unit 34A hunters
1987	Oct	3000	129	41	65	170	14	531
	Nov	520	107	186	112	293	16	912
	Dec	3000	35	97	120	132	19	605
1988	Oct	3000	68	60	68	128	19	499
	Nov	4700	123	124	156	247	13	1009
	Dec	1500	35	69	85	104	13	301
1989	Oct	3000	91	30	77	121	26	491
	Nov	3850	128	130	166	258	20	1733
	Dec							
1990	Oct	3600	101	47	43	148	11	763
	Nov	5200	121	137	194	258	17	1659
	Dec	200		49	70	49	17	183

^a Data from Department's Data Summary books (Hunter Questionnaire Program).

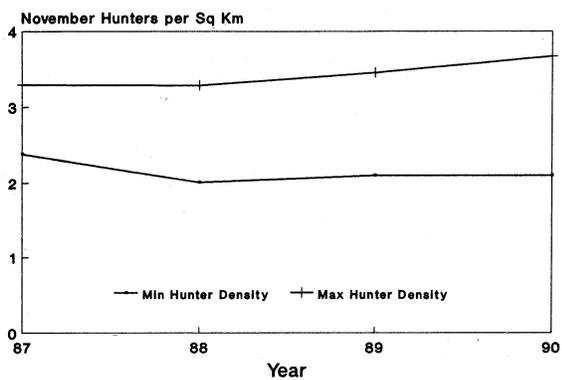
^b Data from card stations at main road entrances to SRSA.

Table 27. Harvest (by month) of Coues white-tailed deer in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

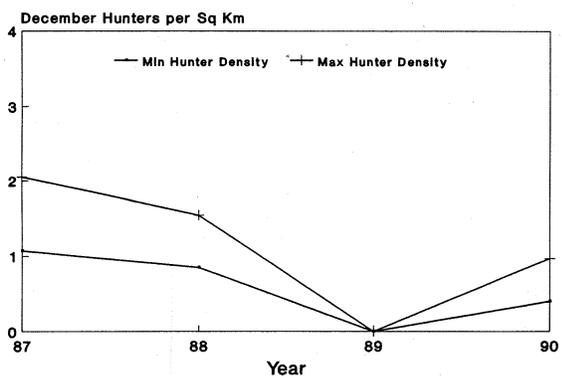
Month	1987	1988	1989	1990	Total
October	19	19	33	15	86
November	23	15	24	30	92
December	6	2		3	11
Total	48	36	57	48	189



(A)



(B)



(C)

Figure 17. Estimated monthly minimum and maximum hunter densities in the SRSA, Santa Rita Mountains, Arizona, 1987-1990. (A) October; (B) November; (C) December.

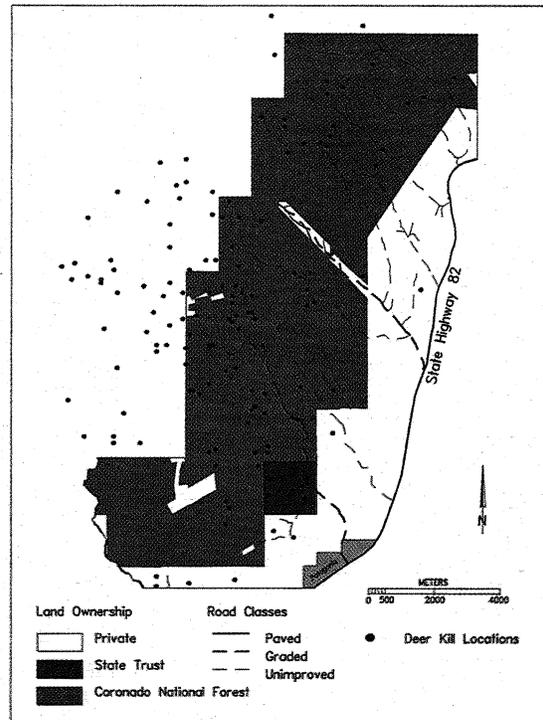


Figure 18. Distribution of Coues white-tailed deer harvest in relation to land ownership and roads in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

to the west. Only 55.6% (105 of 189) of harvested bucks by checked hunters were taken on SRSA. Private land on the eastern edge of SRSA reduced hunting opportunities and few legally taken bucks came from this strip along Route 82. Hunters either moved into rougher country to the west or moved to another area of white-tailed deer habitat to hunt.

We found no significant ($\chi^2 = 6.845, 6 df, P = 0.335$) relationship between the field age of a buck and the number of days before it was harvested. Most (74.1%) hunters harvesting a buck did so in only 1 or 2 days (Table 28). Dental cementum aging of the bucks (Fig. 19) indicated few bucks greater than 3 years of age were in the harvest.

Based on 98 deer that we had accurate kill locations for, hunters tended to harvest bucks closer to water than expected (Table 29). The first 400 m was selected for, the area from 401-1,200 m harvested as expected, and areas greater than 1,200 m had fewer bucks than expected.

Table 28. Number of days after season opening Coues white-tailed deer were harvested in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Days	1987	1988	1989	1990	Total
1	26	15	17	18	76
2	11	14	20	19	64
3	8	6	14	10	38
4+	1	1	6		8
Unknown	2	0	0	1	3

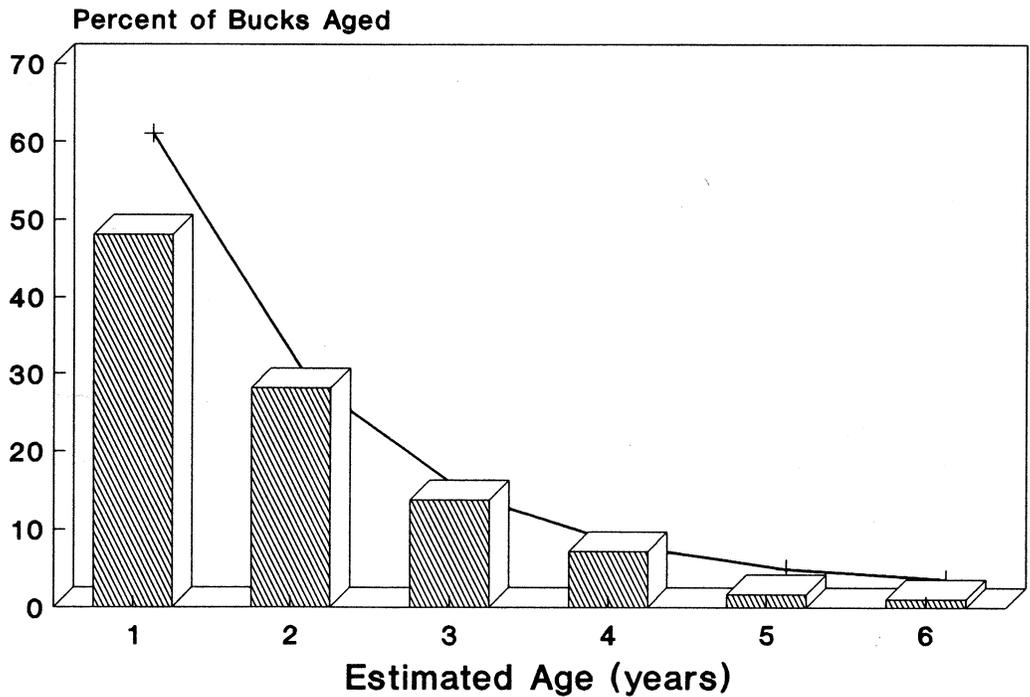


Figure 19. Estimated dental cementum age of Coues white-tailed deer harvest in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Table 29. Distribution of Coues white-tailed deer harvest in relation to water sources in the SRSA, Santa Rita Mountains, Arizona, 1987-1990 (CI refers to Bonferroni test, Neu et al. 1974).

Distance class (m)	# deer	% deer	90% CI		Expected deer ^a	% area	Overlap CI	Jacobs' D
			lower	upper				
0-400	37	37.8	26.8	48.8	25	26.0	No	0.27
401-800	37	37.8	26.8	48.8	39	39.4	Yes	
801-1200	20	20.4	11.3	29.5	17	17.8	Yes	
1201+	4	4.1	0	0.9	16	16.8	No	-0.65

^a Based on percentage area.

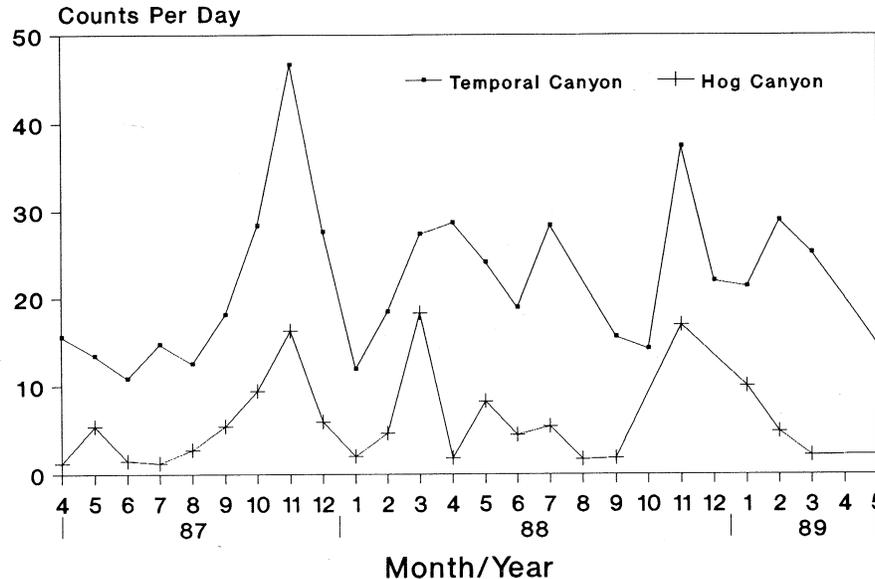


Figure 20. Estimated vehicle traffic (crossings per day) on 2 road types in the SRSA, Santa Rita Mountains, Arizona, 1987-1989.

Based on available Department data, we estimated that GMU 34A had 2,150 km² of white-tailed deer habitat, of which 123 km² (5.7%) was SRSA. During 4 years of hunts, we could account for the approximate location of 98 harvested bucks within SRSA. We also accounted for 7 other bucks on SRSA, in which hunters checking out did not know their exact kill location on SRSA. Hunter mail questionnaire data estimated that 1,579 white-tailed deer were taken from 34A during the same time period. Based on questionnaire testing from the Department, we assumed that mail results were 10% high, which resulted in an estimated 34A harvest of 1,421 instead of 1,579. We then found a significantly ($\chi^2 = 7.54, 1 \text{ df}, P < 0.01$) higher than expected harvest from SRSA (Table 30) during the 4 year period of our study.

Effects of Roads

Three classes of roads were identified (Fig. 4) on SRSA. Fifteen km of State Route 82 bordered the eastern edge, while 21.5 km of graded dirt roads (Josephine, Temporal, and Big Casa Blanca roads), and 140.2 km of passable unimproved (2-track) roads were within the study area. Within SRSA, disregarding boundary roads, road density was 0.17 km per km² for graded and 1.1 km per km² for unimproved roads.

Traffic counters were placed at entrances of Hog, Adobe, Wood, Dry, Little Casa Blanca, Smith/Stevens, Temporal, Josephine, and Squaw drainages. Number of vehicle crossings per day indicated at least a doubling of crossings during months in which hunting seasons were underway (Fig. 20). Most of normal background crossings could be accounted for by research personnel working in the area, or from ranch personnel maintaining allotments. The busiest days were in fall during opening weekends of deer hunts. Javelina (*Tayassu tajacu*) seasons in February and March also were busy periods of vehicular traffic. Traffic on graded roads (Josephine, Temporal, and Big Casa Blanca) was twice as heavy as for unimproved roads.

Testing of distribution of deer locations by 400 m contour intervals from all types of roads (Table 31) indicated a significant ($\chi^2 = 321, 3 \text{ df}, P < 0.001$) relationship. The first 400 m interval was highly selected for, while all other distance intervals were avoided. But, over 86% of the interior roads were unimproved roads, typically along major ridgelines and leading to water.

Because of this finding we also tested for relationship between graded roads (Table 32) and deer locations by 400 m contour intervals. A significant ($\chi^2 = 741.57, 6 \text{ df}, P < 0.001$) deviation from expected was found, with deer avoiding the first 400 m distance interval from a graded road,

Table 30. Distribution of Coues white-tailed deer harvest (1987-1990) in relation to percentage area of SRSA, Santa Rita Mountains, Arizona, and available harvest in Unit 34A.

Site	# deer ^a	% deer	90% CI		Expected deer ^b	% area	Overlap CI	Jacobs' D
			lower	upper				
SRSA	105	7.4	6.0	8.8	81	5.7	No	0.14
34A	1316	92.6	91.2	94.0	1340	94.3	No	-0.14

^a Based on number checked out of SRSA and 4-year harvest from Department hunter harvest mail questionnaire program.

^b Based on percentage area.

Table 31. Distribution of Coues white-tailed deer locations in relation to all road types in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Distance class (m)	# locations	% locations	90% CI		Expected locations ^a	% area	Overlap CI	Jacobs' D
			lower	upper				
0-400	3476	76.5	75.1	77.9	2928	64.4	No	0.29
401-800	801	17.6	16.3	18.9	1082	23.8	No	-0.19
801-1200	152	3.3	2.7	3.9	377	8.3	No	-0.45
1201+	117	2.6	2.1	3.1	159	3.5	No	-0.15

^a Based on percentage of area.

Table 32. Distribution of Coues white-tailed deer locations in relation to graded roads in the SRSA, Santa Rita Mountains, Arizona, 1987-1990.

Distance class (m)	# locations	% locations	90% CI		Expected locations ^a	% area	Overlap CI	Jacobs' D
			lower	upper				
0-400	303	6.6	5.7	7.5	566	12.4	No	-0.33
401-800	661	14.5	13.2	15.8	579	12.7	No	0.08
801-1200	665	14.6	13.3	15.9	602	13.2	No	0.59
1201-1600	880	19.3	17.9	20.7	598	13.1	No	0.23
1601-2000	842	18.4	17.0	19.8	534	11.7	No	0.26
2001-2400	495	10.8	9.7	11.9	383	8.4	No	0.14
2401+	718	15.7	14.4	17.0	1296	28.4	No	-0.36

^a Based on percentage of area.

and selecting the rest of the distance intervals. Areas greater than 2,400 m also were not selected for.

The majority of hunters tended to harvest deer less than 400 m from a road. However, harvest distribution did not differ significantly ($\chi^2 = 0.543$; 3 *df*, $0.980 > P > 0.950$) from amount of area available from all road types. Few hunters on SRSA killed a deer more than 800 m from a passable road. Many of the deer harvested off SRSA were in rough areas to the west with fewer roads. Those areas also contained some passable 4-wheel drive roads, but not as many as on SRSA.

We then looked at distribution of harvest versus distribution of graded roads on SRSA to see if traffic volume was important to harvest. We found no significant ($\chi^2 = 9.53$, 6 *df*, $0.250 > P > 0.10$) relationship between where a deer was harvested and the available area from graded roads.

Deer harvested far ($> 1,200$ m) from a passable road were generally within 800 m of a water source. In these cases, there normally was an old roadbed in the area, that was impassable, and led to a water source.

Land Ownership

We found a significant relationship ($\chi^2 = 648.65$, 2 *df*, $P < 0.001$) between distribution of land ownership and areas used by Coues white-tailed deer (Table 33). Examination of Bonferroni confidence intervals and Jacobs' D values indicated selection of national forest land holdings by telemetered deer, and strong avoidance of private and State Trust areas on SRSA. However, land ownership in Arizona is generally related to habitat types, and is not random, thus we expected to observe this difference.

Males had significantly ($U = 51.0$, $n = 21$ F, 14 M, $P < 0.001$) less national forest land within their home ranges than females. Male home ranges averaged 69.9% ($SD = 34.75$) national forest lands, while females averaged 95.7% ($SD = 11.4\%$). During fall hunting seasons, percentage national forest lands for males increased significantly ($t = -1.98$, 13 *df*, $P = 0.069$). The mean difference between use of overall home range and use during hunting season was 13.11%.

Harvest of Coues white-tailed deer on SRSA was significantly ($\chi^2 = 24.1$, 2 *df*, $P < 0.001$) related to ownership of land (Table 34). Most

private land holdings were closed to hunting, or at least trespass was controlled. This action resulted in private land holdings being highly avoided by hunters, while national forest lands were highly selected for hunting and harvesting within SRSA. State Trust lands, which occupied only a small percentage of SRSA, were used as expected. Deer harvested off SRSA followed a similar pattern, as 7 (12.1%) were taken from private holdings and 51 (87.9%) were harvested on national forest lands.

Table 33. Distribution of Coues white-tailed deer locations in relation to land-ownership in the SRSA, Santa Rita Mountains, Arizona, 1987-1990 (CI refers to Bonferroni test, Neu et al. 1974).

Ownership	# locations	% locations	90% CI		Expected locations ^a	% area	Overlap CI	Jacobs' D
			lower	upper				
Private	688	15.1	14.0	16.2	1391	30.6	No	-0.43
State Trust	3	0.1	0.0	0.2	95	2.1	No	-0.92
National Forest	3854	84.4	83.3	85.5	3063	67.4	No	0.34

^a Based on percentage of area.

Table 34. Distribution of Coues white-tailed deer harvest in relation to land-ownership in the SRSA, Santa Rita Mountains, Arizona, 1987-1990 (CI refers to Bonferroni test, Neu et al. 1974).

Ownership	# deer	% deer	90% CI		Expected deer ^a	% area	Overlap CI	Jacobs' D
			lower	upper				
Private	9	9.2	3.0	15.4	30	30.6	No	-0.63
State Trust	5	5.1	0.0	10.0	2	2.1	Yes	
National Forest	84	85.7	78.2	93.2	66	67.4	No	0.49

^a Based on percentage of area.



DISCUSSION

Home Range

Many of the deer we followed had less than 100 locations over the length of study. Use of harmonic means to calculate home ranges necessitates large sample sizes (Ackerman et al. 1990), approaching 100 locations per time interval tested, and ground locations on SRSA for the number of deer involved proved to be inadequate and costly. Number of locations necessary for yearly or seasonal home ranges dictated effective use of aerial radio-tracking, combined with ground locations. Aerial flights were an effective way of increasing number of locations within a time interval. However, aerial flights only provided diurnal, and typically morning hour, data and probably would not adequately estimate a home range or habitat use pattern (Miller et al. 1984).

Distribution of ground locations for our study suggested a bias toward the morning and evening hours. White-tailed deer are most active at these hours (Halls 1978, Hesselton and Hesselton 1982) and are more easily observed. We do not believe lack of locations in afternoon hours greatly affected diurnal home range or habitat use data. Many times, we observed deer bedding in mid-morning and staying in the general vicinity until evening, when they moved toward a feeding area. However, lack of nighttime locations probably biased our data toward more percentage use of cover than deer really used over a 24-hour period. Rongstad and Tester (1969), Kohn and Mooty (1971), Larson et al. (1978), and Ockenfels (1980) all found significantly different habitat use patterns by time of day in the midwest. We suspect that white-tailed deer in the Southwest also use more open areas during nighttime hours than our diurnal data show. None of this, we suspect, greatly influenced home range size estimates.

That we found no significant relationship between number of locations for a deer and size of home range estimated was not expected, because of the normal inability of harmonic mean contours to remove the common problem of sample size in location studies (Ackerman et al. 1990). For example, Michael (1965) found his results to be strongly influenced by number of visual observations per deer. Because of lack of a measured relationship during the study, we were able to make use of all animals we captured for

home range estimation.

Home range sizes for both male and female Coues white-tailed deer tended to be quite variable. The range of female home ranges was very large, such that the largest home range of 18.1 km² was over 30 times larger than the smallest at 0.6 km². Even though our analysis suggested no relationship between number of locations and home range size, we still speculate that a minimum sample size over a long period of time is necessary for an accurate estimate. For example, animal #7, the smallest home range, was only located 17 times over a short period of the year and we suspect she could have had a larger home range had we located her over more seasons and years. In contrast, animal #11, the largest female home range, was followed for 4 years and had numerous short-term movements in that period that expanded the 90% contour. Wood et al. (1989) found nearly a 22X difference in the range of summer home ranges in Montana, so this type of situation has been observed before.

Neither of these situations (i.e., the smallest and largest home ranges) should be considered normal. Each animal develops a home range pattern based on availability of resources (i.e., food, water, cover) and arrangement of those resources (Michael 1965, Kohn and Mooty 1971, Larson et al. 1978, Ockenfels 1980, Wood et al. 1989). Average home range sizes we found for males and females seem to be a representative reflection of amount of area a Coues white-tailed deer needs in normal Madrean evergreen woodland habitat. Foothills such as in the Santa Rita Mountains tend to be very diverse in topography, vegetative composition, and structure over a local area. Size of area necessary for Coues white-tailed deer existence also seems to be diverse.

Standard deviations are generally high compared to home range averages in home range studies. Sparrowe and Springer (1970) had *SD* data ranging from 43% to 63% of average, Larson et al. (1978) found the *SD* to be 57% of the average, Ockenfels (1980) had 48% for fawning and 57% for the rut, while Mooty et al. (1989) data were 56% in the spring and 47% in winter. Our data for males (40%) were similar, but 81% for females was much higher.

Knipe (1977) speculated that home ranges would be very individualistic and he seemed to be correct. Numerous factors can modify size of a

home range, including forage base, water distribution, cover arrangement, season of year, hunting, or other human-related activities.

Many reported home range sizes for white-tailed deer in other areas tended to be smaller in size than what we observed. We cannot support Knipe's (1977) speculation that Coues white-tailed deer home range size should be considered in terms of hectares as in other parts of the country, but rather, we found that they must be viewed in terms of km². Knipe's (1977) concept of home range is probably closer to today's concept of core areas. That is, an area where a deer spends most of its time. Amount of forage per ha and water in the arid Southwest are not as abundant as in other areas of white-tailed deer range and using generalized data of home range size from other areas for Coues white-tailed deer will not work without considering differences in habitat quality.

Home range sizes for males, double the size of females for our study, have been reported as larger than those for females in most studies (Michael 1965, Ockenfels 1980, Gavin et al. 1984, Marchinton and Hirth 1984). With the breeding system of white-tailed deer and unbalanced sex ratio, males must use larger areas to locate does during rut. Year-round use of a larger home range area would familiarize bucks with locations of numerous does. Inglis et al. (1979) also reported male home ranges as larger than females (females only 60% of males), but they did not show a significant difference like we did. That males had twice the home range size as females seems to be normal for white-tailed deer in general.

White-tailed deer, particularly does, are very sedentary animals and live the majority of their life in a small area. Gavin et al. (1984) found that female Columbian white-tailed deer had a high degree of home range stability, and home range size did not increase or decrease with age. We did not find a difference in amount of area (core or home range) a Coues white-tailed doe needs on a yearly basis. We did find that each animal needed its own amount of area, based on location of its home range on SRSA.

Conversely, Wood et al. (1989) found that home range fidelity only occurred during fawning season. They concluded that each white-tailed doe in Montana develops her own unique home range due to distribution of resources available to her at that time and that the large area needed was a

result of poor interspersed cover and forage areas. Again, white-tailed deer are very adaptable, and are able to adjust their behavioral patterns to match many situations. From very small home ranges in the Southeast (Marshall and Whittington 1968) to large non-permanent use areas in the Northwest (Wood et al. 1989), amount of area a white-tailed deer needs to survive varies due to resources available (Marchinton and Hirth 1984).

Unfortunately, we did not obtain a sufficient number of locations to look at seasonal changes in core area or home range size. However, during the summer period, because of the concurrent water requirements study, Maghini and Smith (1990) found that home range size decreased after summer monsoons commenced in July and new growth of vegetation started. Other subspecies (Sparrowe and Springer 1970, Kohn and Mooty 1971, Ockenfels 1980, Wood et al. 1989) have been found to shift their core areas seasonally and use different size areas.

It has been speculated that good uniform habitat should result in home ranges being less linear in shape (Marchinton and Hirth 1984). Most Coues white-tailed deer core areas and home ranges, using the harmonic mean methodology, were non-linear. However, simply plotting the actual locations suggests linearity of some of the deer for the vast majority of locations. That linearity typically followed the ridge area along a major drainage.

Had we used the ellipse methodology, we would have seen larger areas that were more linear in nature for home range estimation (Ackerman et al. 1990). We used harmonic means because it is probabilistic in nature and can adjust home range shape for major deviations in shape. Unfortunately, no single method of home range estimation can account for all the unique situations animals present (Ackerman et al. 1990). Because of problems involved in methodology, we believe that our core area measurements better reflect the "real" amount of area a Coues white-tailed deer needs for its daily survival. The 90% contour tended to include areas not used by white-tailed deer and seemed to inflate home range estimates.

White-tailed deer typically have movements, or excursions, outside of their normal use area (Inglis et al. 1979, Marchinton and Hirth 1984) and harmonic means home range is less affected by these outliers (Ackerman et al. 1990). Outliers,

movements outside the home range, may have major significance to a deer's survival. Water requirements may force a deer to leave its area temporarily (Maghini and Smith 1990), or hunt pressure (Welch 1960) or breeding activity (Thomas et al. 1964) could result in movements outside the home range. Large-scale movements can present a hazard. Most of the time on SRSA, if a deer moved outside its home range too far, we subsequently had to investigate a mortality.

Habitat Use

Coues white-tailed deer have been found to use a wide variety of habitat components (Day 1964, Anthony and Smith 1977, Knipe 1977, Hoffmeister 1986), ranging from nearly open terrain to dense canopy areas (Evans 1984). However, density of deer in these types varied tremendously (Day 1964). In this study, all major habitat types were used; however, use was not equal to availability (i.e., not random).

Areas of greatest use were oak-mesquite thickets on sides of minor and major ridges (Fig. 21). Number of locations found in this habitat type was over twice the expected number, based on percentage of area available. These slope exposures provided both forage and cover (thermal and escape) for white-tailed deer. Many locations were of feeding or bedded deer along the upper one-third of numerous minor ridges leading out of drainage bottoms.

Grassy areas, which tended to occur either on south-facing exposures of ridges, on flat mesa tops, or in lower flats along Sonoita Creek, were largely avoided. Avoidance of openings, either grassy or low-crop agricultural fields, is common for white-tailed deer (Kohn and Mooty 1971, Ockenfels 1980, Compton et al. 1988, Wood et al. 1989). Size of grassy openings is important (Ockenfels 1980, Rollins et al. 1988) to whether or not a Coues white-tailed deer would use an entire area as available or just the edges. Sweeney et al. (1984) found that white-tailed deer will use small (<25 ha) clearcuts as expected, and not just the edge. However, distance to edge in grassy situations is important if the size of the openings is large (Barsch 1977, Suring and Vohs 1979, Ockenfels 1980). Basically, white-tailed deer do not like to use middles of big openings. Some use is seen at night, but it is typically less than one would expect at random. White-tailed deer densities increase as percentage woody cover

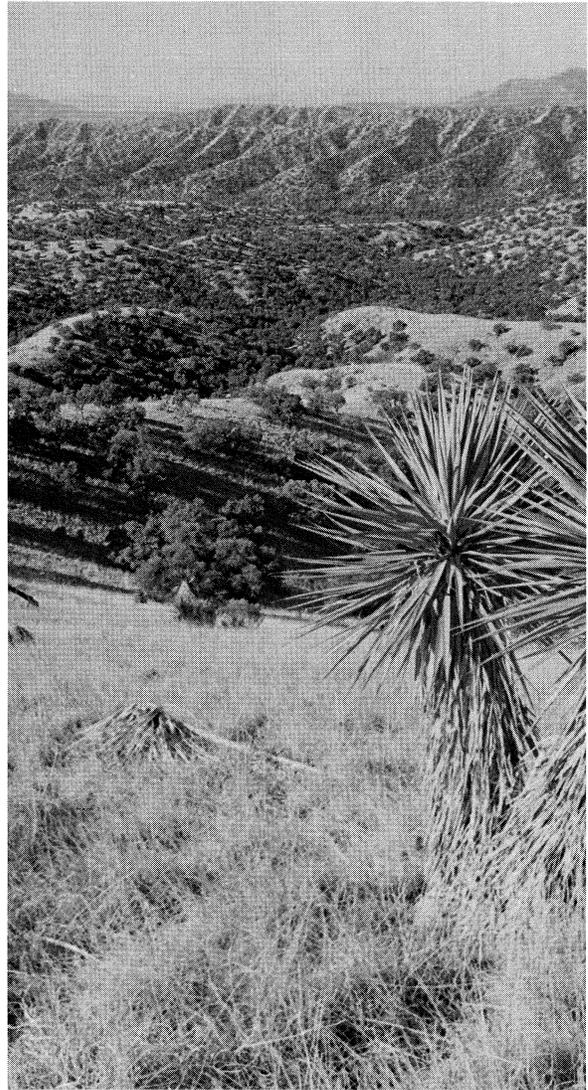


Figure 21. Oak-mesquite thickets on hillsides were selected by Coues white-tailed deer, whereas open, grassy stands were avoided on SRSA, Santa Rita Mountains, Arizona.

increases (Wiggers and Beasom 1986, Smith 1987). Either tree or brush encroachment of open areas improves thermal and escape cover, and forage diversity, for white-tailed deer.

Temperatures in the Southwest, particularly high temperatures, can affect deer behavior. Changes in habitat use patterns due to temperature shifts have been found for white-tailed deer (Ockenfels and Bissonette 1984). As temperatures increase, white-tailed deer likely need more thermal cover to maintain their body core temperature. Ockenfels and Bissonette (1984) documented major shifts in use of oak uplands

and riparian areas at temperature extremes (< 0 C or > 30 C), while only minor shifts occurred at moderate temperatures. Most locations (80.2%) on SRSA occurred during moderate temperature periods. Climate at the south end of the Santa Rita Mountains is normally very mild and periods of adverse temperature are uncommon and short in duration. Large sample sizes we obtained may have caused a statistical difference in use of habitats by temperature, in this study, that may not have been as biologically important as in the humid Southeast.

Selection of habitat types by activity is common for white-tailed deer. Areas for feeding are largely determined by availability of preferred forage species (Kohn and Mooty 1971, Ockenfels 1980, Williamson and Hirth 1985, Wood et al. 1989). These areas are normally adjacent to habitats providing cover (Wood et al. 1989). Bedding areas for white-tailed deer provide both thermal cover (low and high temperatures) and security cover.

All habitat types provided both feeding and bedding areas on SRSA. Apparently, selection for feeding and bedding mainly occurs at a structural or species composition level, rather than a broad habitat level. Ockenfels and Brooks (*in prep*) documented that summer diurnal bedsite selection was based on tree density, tree size, tree species, and vegetative structure within a habitat type. However, even at the habitat category level, we were able to see measurable differences. Areas with oaks tended to be used for bedding more than foraging, whereas grasslands, if used at all, were used as feeding areas more than bedding areas.

Coues white-tailed deer are able to use a wide and diverse variety of habitat types. Home ranges of some deer on SRSA did not contain the same mapped categorical habitat types as other deer only 5 km away. Coues white-tailed deer may prefer certain habitat types if they are available, but they are able to live under different conditions, even if "preferred" habitat types are not present.

Structure (i.e., % woody cover, shrub density, etc.) and plant species diversity are likely more important factors than plant species composition in determining if white-tailed deer can survive in an area. Whether the overstory is Mexican blue oak or Gambel oak (*Q. gambeli*), or the understory is manzanita or buckbrush (*Rhamnus*

crocea), probably is not as important to a white-tailed deer as having canopy cover greater than 40% (Wiggers and Beasom 1986), or having 5 or more tree and shrub species present in an area.

Males tended to use "less desirable" habitat types more than females. McCullough et al. (1989) noted that resource partitioning by sex in ungulates (i.e., hoofed animals) is well known. They found that females used better areas and concluded that male use of other areas tended to reduce competition between sexes for limited forage or cover resources. They also noted that mean overlap was greatest in winter and least in the fawning period. Wood et al. (1989) found a negative relationship between presence of females, particularly those with fawns, and mature males in summer or autumn use areas.

Sexual segregation was also observed on SRSA. We found that males tended to live in lowland areas during non-rutting periods, typically separated from females, who mainly used oak areas in rolling hills. In fall, as mesquite leaves dropped off and the visibility improved, bucks moved out of mesquite areas into oak areas for the start of the rut period. During the extended rut period (pre-, rut, post-) of November through March, spatial and habitat segregation was much reduced.

Northerly aspects, heavily favored for bedding and foraging, were generally oak thickets, mixed with shrubs and other tree species. Ockenfels and Brooks (*in prep*) found that summer diurnal bedsites tended to be mainly on northern (47%) exposures, rather than on southern (26%) areas. These values compare favorably with year-round data. Southern exposures, used less frequently for all activities, typically were grassland situations mixed with more xeric adapted plants. On SRSA, dichotomy of habitat types between northern and southern aspects provided diversity for Coues white-tailed deer.

Use of slope by Coues white-tailed deer was probably a byproduct of a deer's use of habitat types, rather than independent selection for steepness. Habitat types favored by bucks for part of the year (mesquite-shrub grasslands) grow in gentle, rolling terrain along Sonoita Creek. Oak areas, mixed with some mesquite, occurred on moderately steep, minor ridgetops, with slopes averaging 20-29° for much of SRSA. Henry and Sowls (1980) found that Coues white-tailed deer in isolated areas of habitat in the Sonoran Desert also

preferred gentle to moderate slopes, as opposed to steep slopes used by bighorn sheep (*Ovis canadensis*) in the area. We suspect the key to use by white-tailed deer is more dependent on woody cover than on physical terrain characteristics.

No one factor determined what a white-tailed deer used for habitat, whether in Arizona for Coues white-tailed deer (Henry and Sowls 1980, M. Brown 1984), or in Oklahoma (Ockenfels 1980), Oregon (Smith 1987), Texas (Wiggers and Beasom 1986), Virginia (Gaudette and Stauffer 1988), or any other area with white-tailed deer (Rongstad and Tester 1969, Larson et al. 1978, Compton et al. 1988, McCullough et al. 1989, Wood et al. 1989). A principal factor seemed to be diversity of habitat types, such that foraging and bedding areas were adjacent (Suring and Vohs 1979, Gavin et al. 1984, Compton et al. 1988, Wood et al. 1989), and for Coues white-tailed deer, areas closer to permanent water (Barsch 1977, Henry and Sowls 1980).

Water Requirements

Distribution of Coues white-tailed deer around human-made water sources indicated a strong dependence on them. The first 400 m around the identified water sources on SRSA were strongly selected for and areas greater than 1,200 m virtually avoided. Barsch (1977) found greater use of areas near permanent water for foraging. He found that the first 300 m around water were heavily used and greater than 1,200 m avoided for foraging. Our data were very similar.

Verme and Ullrey (1984) concluded that use of free-standing water was inversely related to forage moisture content. Water from food sources on SRSA cannot provide all the necessary water requirements for Coues white-tailed deer during the hot-dry summers (Maghini and Smith 1990). Free-standing water seemed to be required to supply needs beyond available forage moisture (Fig. 22).

The number of water sources identified in each core area and home range varied tremendously. Only 1 animal, #3, did not show an identified water source in her home range. She was followed for over 2 years, thus her locations should have been adequate to describe her home range. It is likely that we did not identify all water sources on SRSA, and she had natural water sources we were unfamiliar with in her home range. Most deer had more than 1 water

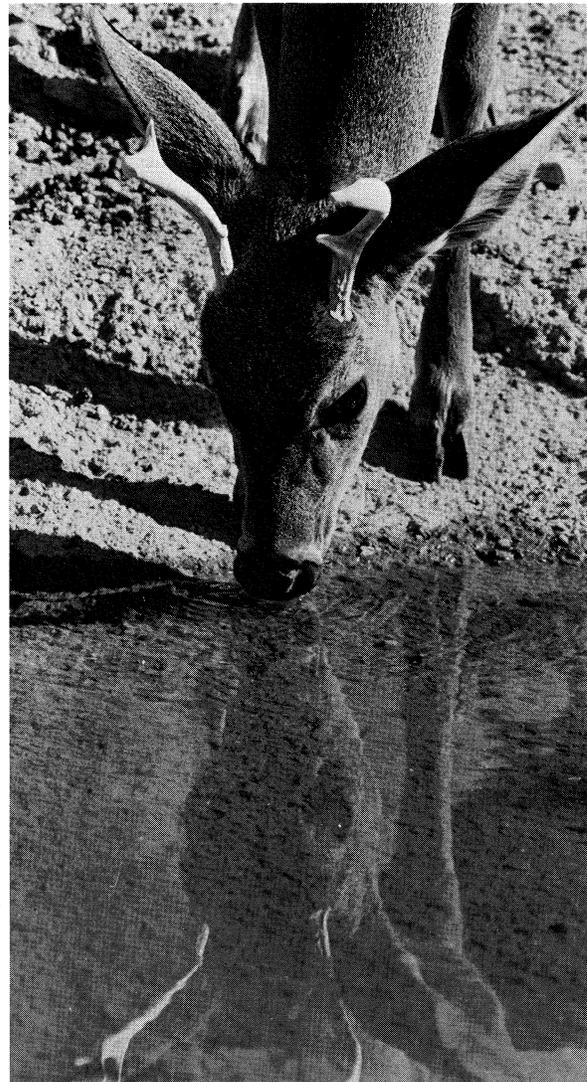


Figure 22. Coues white-tailed deer were dependent on free-standing water on the SRSA, Santa Rita Mountains, Arizona, 1987-1991.

source within their home range (Table 13). Many waters were livestock troughs and were turned off if cattle were not grazed in the pasture. Four deer had only 1 water source, and in each case it was within the core area. It seemed to be adequate for their needs. More waters did not seem to affect deer distribution. Home ranges of Coues white-tailed deer did not radiate from a water, like those of javelina (collared peccaries) found by Day (1985).

A lower density of waters in the southwestern corner of SRSA, the Squaw Gulch area and lower Temporal Canyon, did not prevent numerous deer from using the area throughout the year.

Locations and surveys indicated year-round use of the area. Maghini and Smith (1990) speculated that 1 permanent water source per km² should be sufficient for use by female Coues white-tailed deer. With an average home range size of 5.18 km² for females, that many waters should be more than adequate. One permanent water source per 2-3 km² would likely maintain a population of Coues white-tailed deer in Madrean evergreen woodland habitats.

The critical time period for Coues white-tailed deer seemed to be in June and early July (Knipe 1977), if summer monsoons started at their typical time. Rainfall in April, May, and June is normally very low (Fig. 6), and average maximum and minimum temperatures climb to their highest levels. Welch (1960) found that some deer changed their home range use patterns to move closer to water in June, then dispersed from permanent water as monsoons started. Even though he only had the ability to observe deer and not radio-track individual deer as was done on SRSA, his conclusion about white-tailed deer dependency on water seems correct.

That males had more waters in their home range is more a reflection of larger average home range size of males than greater need. In fact, need for water seems to be greater for females. Hervert and Krausman (1986) found that desert mule deer bucks watered only once every 1-4 nights, while does virtually watered nightly. Coues white-tailed deer patterns are probably similar.

If water is not adequately available, white-tailed deer will voluntarily decrease their forage consumption by the third or fourth day (Lautier et al. 1988). Lautier et al. (1988) concluded that water was critical at high temperatures, above 36 C, and during periods of summer droughts. Such conditions were common on SRSA. Four years of weather data (Fig. 23) and long-term averages for the southern end of the Santa Rita Mountains illustrate this conclusion. Nichol (1938), Michael (1968), and Marchinton and Hirth (1984) concluded that water consumption was directly tied to temperature. Other factors also are involved, but were not judged as important.

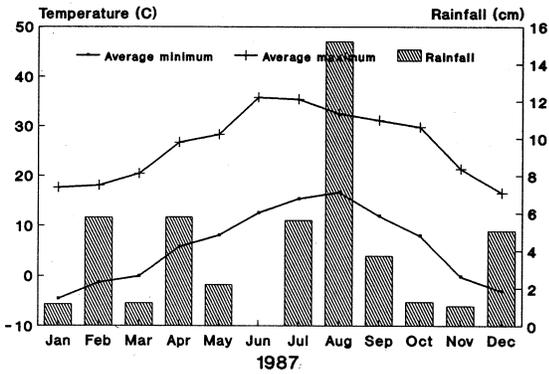
Of particular concern at this critical time is use of water by pregnant or lactating does. Pregnant does drink more frequently than other deer (Michael 1968) and lactating does probably need even more water. The month of June is late

in the gestation period for Coues white-tailed deer and water needs for pregnant does should be increasing rapidly as the fetuses mature. Maghini and Smith (1990) found that does had to increase their diurnal use areas during the hot-dry summer and concluded that it was primarily due to the need to locate available water. Available free-standing water may be a major difference between poor fawn survival at birth or good recruitment into the white-tailed deer population in areas where forage moisture is low.

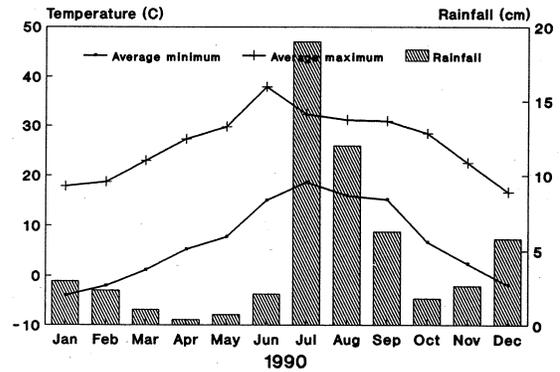
Early fawns could be extremely vulnerable, if summer monsoons were late in developing. Peak of fawn drop in early August is typically 2-3 weeks after monsoons start. If free-standing water was limited and does fawn early, or monsoons develop late, does may have insufficient water resources for growing fawns. Providing free-standing water would be a management strategy and cooperation with land managers to keep water flowing even if livestock were reduced would be important to maintain deer recruitment.

Brown (D., 1984) believed that Coues white-tailed deer tend to occur in areas of high summer rainfall. The rainfall pattern of our study area certainly fits Brown's model. His model of fawn survival for Coues white-tailed deer distribution suggested a very close tie to regularity of monsoons. Human-made waters have probably widened that distribution from earlier times. Occurrence of Coues white-tailed deer at their western limit in the Sonoran Desert is tied closely to water sources (Henry and Sows 1980). Krausman and Ables (1981) found a similar situation for Carmen Mountain white-tailed deer in Texas. Areas with free-standing water supported white-tailed deer, and areas without water had little use.

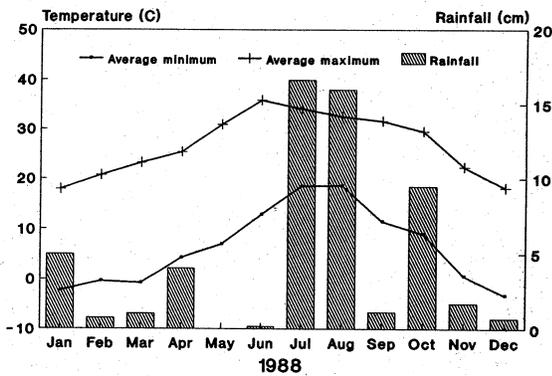
With loss of perennial streams and wetlands in Arizona, Coues white-tailed deer are now dependent upon human-made water sources to maintain their distribution. Early accounts of Coues white-tailed deer (Davis 1982) in Arizona indicated use of riparian areas. Today, Coues white-tailed deer may not be as tied to major drainages for water during the critical summer months. The seasonal distribution of Coues white-tailed deer is probably more widespread today than before placement of human-made water sources.



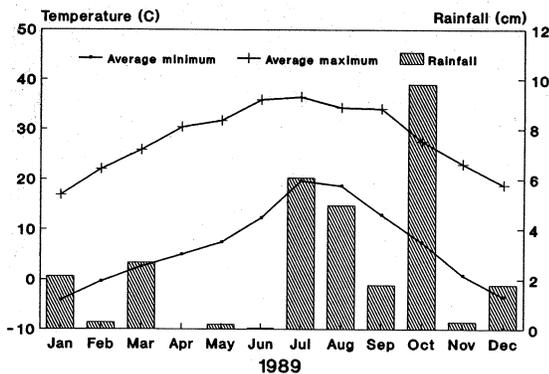
(A)



(D)



(B)



(C)

Figure 23. A,B, C, D. Climatic patterns for the SRSA, Santa Rita Mountains, Arizona, 1987-1990. Data from Nogales-Patagonia reporting stations.

If perennial streams can be reclaimed in western parts of the state, Coues white-tailed deer distribution at its western limit would probably be less fragmented. Additional water sources in suitable habitat near perennial streams could also widen their distribution.

Overall Deer Diet

Mainstay forage plants for Coues white-tailed deer appear to be shrubs, and to a lesser extent, trees (White 1961, Knipe 1977). Trees and shrub are available year-round and seasonally provide new growth. We found that well over one-half (65.7%) the diet on SRSA was accounted for by these 2 groups. Shrubs alone accounted for over half (50.8%) the yearly diet. Gallina et al. (1981) found that shrubs in the Durango area of Mexico provided a relatively high percentage (51%) of the Coues' diet year-round, and together with trees accounted for 83% of year-round diet. Browse also accounted for greater than 50% of white-tailed deer diet in Minnesota (Kohn and Mooty 1971) and Texas (Quinton and Horejsi 1977, Waid et al. 1984).

Nichol (1938) considered shrubby buckwheat (*Eriogonum* spp.) the number 1 shrub in Coues white-tailed deer diets. On SRSA, we did not find this to be the case. Welles (1959) believed that fairyduster was valuable year-round forage for Coues white-tailed deer, as it was abundant on

south-facing and lower slopes of the Coronado National Memorial in Arizona. He also noted deer ceanothus (*Ceanothus greggii*) as a key browse plant. We found fairyduster and deer ceanothus to be used, but not as heavily. White (1961) found that leguminous shrubs (mimosa, fairyduster, and ratany) were key forage plants in the Santa Rita Mountains. We verified that conclusion. Anthony (1976) concluded that these 3 species were also important in deer diets in 2 different ranges in southeastern Arizona.

Velvet-pod mimosa, 1 of 2 abundant mimosa species on SRSA, was by far the forage species most consumed on SRSA (Table 15). It accounted for nearly one-third of overall diet. Wait-a-minute bush, the other abundant mimosa, was hardly used. Wait-a-minute bush has fairly dense curved spines, while velvet pod is generally unarmed (Kearney and Peebles 1973). This may explain selection of velvet-pod mimosa over wait-a-minute. Knipe (1977) found mimosa in general was the number 1 food item in volume and in feeding minutes during his investigations. Welles (1959) did not believe that wait-a-minute bush was highly used. Ratany was the only other shrub we found to have relatively high use on the SRSA, while fairyduster received moderate use.

Oak species, particularly Mexican blue and Emory, are abundant overstory plants throughout SRSA. Oaks were used in all seasons and they constituted nearly one-tenth of overall diet. Knipe (1977) found oak use to be greatest in February through March, when forbs and new shrub growth were generally unavailable. Our data in 1988 and 1989 showed greatest oak use from January to April. Oaks also provide acorns for fall and early winter diets (Cross 1984). Oak, oak mast, and juniper provided 80% of browse components for white-tailed deer diets in Texas (Waid et al. 1984).

Mesquite was also used by Coues white-tailed deer on SRSA in all seasons for all years. Quinton and Horejsi (1977) found heaviest use of mesquite in winter and early spring, when ripened beans were abundant. Knipe (1977) believed that mesquite was not rated as high a food source as it should have been for Coues white-tailed deer. We found mesquite to be a valuable forage resource for white-tailed deer.

Grasses, cacti, and other species constituted only a minor part of overall diet on SRSA (Fig. 24). Grasses can be important in spring (Cross 1984) and year-round in certain areas (Everitt and



Figure 24. Although perennial grasses provided security cover for Coues white-tailed deer, grasses were only a minor component of diet on the SRSA, Santa Rita Mountains, Arizona

Gonzalez 1979, Gavin et al. 1984), but generally amount to less than 5% of white-tailed deer diet (Kohn and Mooty 1971, McCulloch 1973, Quinton and Horejsi 1977, Krausman 1978, Everitt and Gonzalez 1979, Henry and Sows 1980, Korschgen et al. 1980, Gallina et al. 1981). All grass species we identified contributed only trace amounts to overall diet. Prickly pear cactus can be used in relatively high amounts in some areas (Everitt and Gonzalez 1979), but we did not find this on SRSA. High percentages in diet would likely indicate serious range abuse.

We found no single forb to constitute a large proportion of Coues white-tailed deer diet on SRSA. *Sphaeralcea* spp. and *Dalea* spp. were consumed more than other species. Forb diversity was high and many (>20 species) were used, but forbs only accounted for less than 30% of overall diet. Some forb material was unidentifiable and we suspect that more species were consumed in trace amounts. We believe that forb seasonal availability was 1 of the predominate factors

influencing Coues white-tailed deer diet selection on SRSA. Forbs are the most preferred plant group for white-tailed deer when available and green (McCulloch 1973, Cross 1984, McCullough 1985), and they provide more protein and phosphorus than woody plants (Urness et al. 1971). Noticeable changes in diet are generally related to increases or decreases in forb growth (Gallina et al. 1981). Forb abundance varies year to year, and seasonally, thus it is an unstable food resource (McCulloch 1972). We did not do vegetation availability studies, but suspect that forb availability is an important trend and Coues white-tailed deer respond to that availability.

Seasonal Deer Diet

Overall diet composition of Coues white-tailed deer varies annually and by season (White 1961, Knipe 1977, Gallina et al. 1981, Evans 1984, Hoffmeister 1986). We found the seasonal effect to be important, but relatively stable over years. Seasonal variation in white-tailed deer diet has been documented in Maryland (Welch and Flyger 1977), Minnesota (Erickson et al. 1961, Kohn and Mooty 1971), Missouri (Korschgen et al. 1980), and Texas (Quinton and Horejsi 1977, Everitt and Gonzalez 1979, Cross 1984, Waid et al. 1984). Relative use of forage is influenced by availability of plants in any given area (Hesselton and Hesselton 1982, Verme and Ullrey 1984). Availability of species, particularly ephemeral grasses and forbs, can vary seasonally in white-tailed deer habitat. In Texas, Waid et al. (1984) found precipitation to be the main factor affecting availability of forage. Shrubs, trees, and cacti generally do not vary seasonally in numbers, but instead vary mainly in amount of new growth.

Relative use of species can also be affected by plant phenology (Kohn and Mooty 1971), which affects its nutritional state (Gallina et al. 1981, Verme and Ullrey 1984). White-tailed deer seem to have an innate ability to select the most nutritious forage available (Hesselton and Hesselton 1982, Verme and Ullrey 1984), be it new plants like ephemeral grasses and forbs or new growth on perennial shrubs, trees, or cacti. Sauer (1984) believed that white-tailed deer can detect differences in plant palatability or nutritional state by smell and taste. Thus, a foraging deer can select specific species of plants or only parts of a plant.

Winter. Winter is the most critical time of

year for white-tailed deer in most northern populations (White 1961). Mild winters in the arid Southwest, although probably not critical in most Coues white-tailed deer range, are, nevertheless, still important. Ephemeral plants or new plant growth are generally limited for most of the winter. Importance of browse species to white-tailed deer increases as winter progresses into early spring (Evans 1984). McCulloch (1973) documented increased use of browse, particularly of evergreen species, in mid-winter.

We documented high use of browse species (shrubs and trees) by deer (Table 14) for 3 winters, accounting for nearly 70% of winter diet. Dominant species in diet changed each year. Ratany was important in 1987, while mimosa and oaks were dominant in 1988. A variety of species were used in 1989. Nichol (1938) found fairyduster to be an important forage plant in winter and noted that deer actively sought it out. We did not find heavy winter use of fairyduster. Welles (1959) believed mountain mahogany (*Cercocarpus* spp.) was the most important winter browse. We did not find this to be the case, probably a reflection of the lower elevations on SRSA and lower availability of mahogany.

Knipe (1977) observed greatest use of oak species from February through March and into April. We also found oaks to be important in winter. In more northern areas, conifer browse can account for 75% of the white-tailed deer's diet (Erickson et al. 1961). We documented juniper use all 3 winters, but it constituted little in overall diet. Nevertheless, juniper use by Coues white-tailed deer in winter can be important (Knipe 1977). Oaks and mesquite were used more than juniper in all seasons, and were consumed more in winter relative to other seasons. By late winter, forbs and grasses are becoming available and are readily consumed by Coues white-tailed deer (McCulloch 1973). We found little use of grasses, but forbs were taken in winter.

Spring. Browse was used in fairly high amounts in early spring before ephemeral growth was abundant. Observed forb availability increased as temperatures warmed and white-tailed deer shifted their diet to forbs in 1987 and 1988. During 1989, forb use in spring was not as high, but still accounted for over one-third of the diet. Cross (1984) showed high forb use in late spring, but little use in early spring. New twig and leaf growth on browse species in spring, as well as

new grass shoots, also provide forage for white-tailed deer (Evans 1984). Active growth on most browse species is apparent by late spring and we noted moderate use of shrubs and trees by deer in 1987 and 1988 and high use in 1989.

Grasses have been found to comprise a high percentage of some spring white-tailed deer diets (Allen 1968, Cross 1984, Gavin et al. 1984, McCullough 1985). We found grasses to be only a minor dietary component on SRSA. Only in spring 1987 did we document grass use in any appreciable amount. Low grass use in spring has been noted in other areas (Quinton and Horejsi 1977, Everitt and Gonzalez 1979, Henry and Sowls 1980).

Early Summer. The hot, dry season of early summer is very critical to Coues white-tailed deer for both adult survival and fawn recruitment (Anthony 1976). Little precipitation falls in May and June on SRSA, averaging only 2.8% of the annual precipitation for Patagonia (Sellers and Hill 1974). Times of low rainfall and droughts, periods of less than 75% normal precipitation (Anthony 1976), are critical to deer (White 1961). Maghini and Smith (1990) measured decreasing forage moisture content during early summer on SRSA. We found forb use in early summer dropped off from the high values of spring, as SRSA dried out.

Both Coues white-tailed deer and desert mule deer shift their diet to more evergreen and drought-resistant species during droughts (Anthony 1976). Increased use of shrubs during this season was very evident on SRSA. Grass use continued to be low. Grasses are curing by May and are seldom used in that condition (Knipe 1977). We documented only trace amounts of grass use for this critical season.

Late Summer. By July the monsoon season has started on SRSA. Over 50% of the annual precipitation falls in this season (Sellers and Hill 1974). Forb use continued to decline, particularly in 1987. Annual growth of shrubs, as well as fruit and nut production, is generally high in late summer (McCulloch 1973) and Coues white-tailed deer on SRSA relied heavily on shrubs for forage. We documented up to 60-80% of late summer diet as shrubs. Henry and Sowls (1980) noted shrub use at 91% during this season in the Sonoran Desert. They found fairyduster to be highly used during this season. We found mimosa and ratany to be important shrubs in deer diets during late summer. Leafy green material on browse species

was also found to be consumed in late summer in Michigan (McCullough 1985) and Texas (Cross 1984).

We did not see large increases in use of forbs during rainy seasons as Gallina et al. (1981) found in Durango, Mexico for Coues white-tailed deer. They found highest species richness during the rainy season because of increased forb diversity. Forbs were readily abundant on SRSA, but still only accounted for approximately 25% of late summer diet.

Fall. Observed fall diets were very similar to late summer diets in proportions of plant groups consumed. Shrubs still dominated Coues white-tailed deer diets for the fall period, particularly in 1987. Browse also predominated fall white-tailed deer diets in Montana (Allen 1968).

We found forb use to be relatively high in fall of 1988 and 1989. McCulloch (1973) found forbs and browse to be the main items consumed by Coues white-tailed deer further north in Arizona, with fruits also taken in early fall. In Michigan, acorns and fruits were taken in high proportion (McCullough 1985). The Range Analysis Lab did not verify acorns and succulent fruits in the diet, but we observed white-tailed deer eating fruits, particularly *Yucca* spp. fruits, on numerous occasions.

Dietary Overlap with Cattle

Competition for forage resources between white-tailed deer and domestic livestock is an important concern for wildlife managers. Cattle are of particular concern because of their widespread distribution and often extremely high stocking level. Dietary overlap has been suspected to be high in Arizona (Knipe 1977), especially during dry periods. Thill and Martin (1990) found seasonal dietary overlap to be 25.8, 11.8, 26.0, and 30.7% for spring, summer, fall, and winter in Louisiana's heavily grazed pine forests. Allen (1968) found overlapping use of winter browse in Montana to be severe. Heavy snow cover of grasses and reduced supplemental hay feeding of cattle contributed to the problem.

Conversely, Day (1964) found competition for 2 key forage species, mountain mahogany and deer ceanothus, to be minimal between Coues white-tailed deer and cattle. Little dietary overlap between Coues white-tailed deer and cattle was found by Gallina et al. (1981) in Mexico and they concluded that competition for forage was

minimal. Knipe (1977) believed that competition for ratany, fairyduster, shrubby buckwheat, and mountain mahogany existed between Coues white-tailed deer and cattle. These species have high palatability to both deer and cattle. We found no noticeable overlap on SRSA, except in late summer of 1988 and 1989 (Table 17). Cattle basically consumed grasses during most seasons (Table 16).

Increased use of forbs and shrubs in the late summer by cattle, with a corresponding decrease in grass use, resulted in high overlap values. More use than normal of ratany and other shrubs by cattle in late summer of 1989 resulted in an overlap of greater than 60% by plant grouping. Even at the higher overlap values, Coues white-tailed deer and cattle typically consumed different plant species within a plant grouping. We conclude that competition for forage did not exist on SRSA, even at these overlap levels, because of different plant species used and apparently high abundance of available forage in late summer, the only season of high overlap. Also, ratany seemed to be fairly abundant on SRSA. For competition to occur, the resource in question must be limited in abundance, and either survival or reproduction of 1 of the species in question must be adversely affected (Birch 1957). We observed no definitive adverse effects on Coues white-tailed deer on SRSA that we could relate to dietary overlap with cattle. Thill (1984) believed that overlap could occur if either species was forced to use the same area during times of extreme low availability. Such a situation did not occur on SRSA, so we were unable to evaluate competition adequately.

Clutton-Brock and Harvey (1983) speculated that larger mouth parts of bigger ungulates, such as cattle, limited their ability to be as selective for more nutritious parts of a plant. Also, relative rumen volume of cattle favors a coarse diet of grasses, whereas small rumen volume for white-tailed deer favors a selective diet (Henke et al. 1988). The strategy of large ungulates is mainly to consume more plentiful, coarser forage, and to obtain nutrients via volume, not quality. White-tailed deer, being rather small ungulates, can be very selective in their foraging strategy. Combined with the structural differences in teeth (Baker 1984), differences in physical digestive structures place different foraging demands on cattle and deer. Those differences greatly reduce chances of dietary overlap under "natural"

conditions.

Competition other than through foraging could be of concern. Habitat use patterns, due to changes in relative hiding cover, or avoidance of watering or shaded areas because of cattle presence or overgrazing could have been occurring on SRSA. Unfortunately, we only investigated diet overlap between cattle and Coues white-tailed deer.

Competition with Mule Deer

For over 20 years, wildlife managers have expressed concern about white-tailed deer being displaced by mule deer in Arizona. This concern is centered on changes in climate and habitat that favor mule deer. Potential for diet overlap between Coues white-tailed deer and mule deer is a part of that concern. Mule deer and white-tailed deer have similar nutritional requirements (Urness et al. 1971) and studies have noted similarities in their diets (Allen 1968, McCulloch 1972, Anthony and Smith 1977, Krausman 1978, Beasom and Krysl 1984).

Anthony and Smith (1977) estimated seasonal dietary overlap between Coues white-tailed deer and mule deer to be as high as 67%. They found that Coues white-tailed deer used a greater diversity of plants in their diet when compared to mule deer and consumed a higher percentage of forbs and grasses. Because Coues white-tailed deer grazed more than mule deer, they speculated that overgrazing by domestic livestock would change the composition of habitats to favor mule deer. Krausman (1978) concluded that mule deer and Carmen Mountain white-tailed deer competed directly for food resources in sympatric ranges, although mule deer used succulents more and browsed less than white-tailed deer.

Concern about competition between white-tailed deer and mule deer can be in reversed order. In Texas, white-tailed deer are believed to be expanding into mule deer range. Because of this concern, Beasom and Krysl (1984) used a fenced enclosure experiment, stocked with white-tailed deer and mule deer, to document similarities between diets. At the start of the experiment, deer species segregated themselves by habitat and somewhat by diet. Dietary and habitat overlap increased the longer the experiment ran. Dietary overlap values were 56, 67, 77, and 80% for summer, fall, winter, and spring. They concluded that there were no differences in diet between the

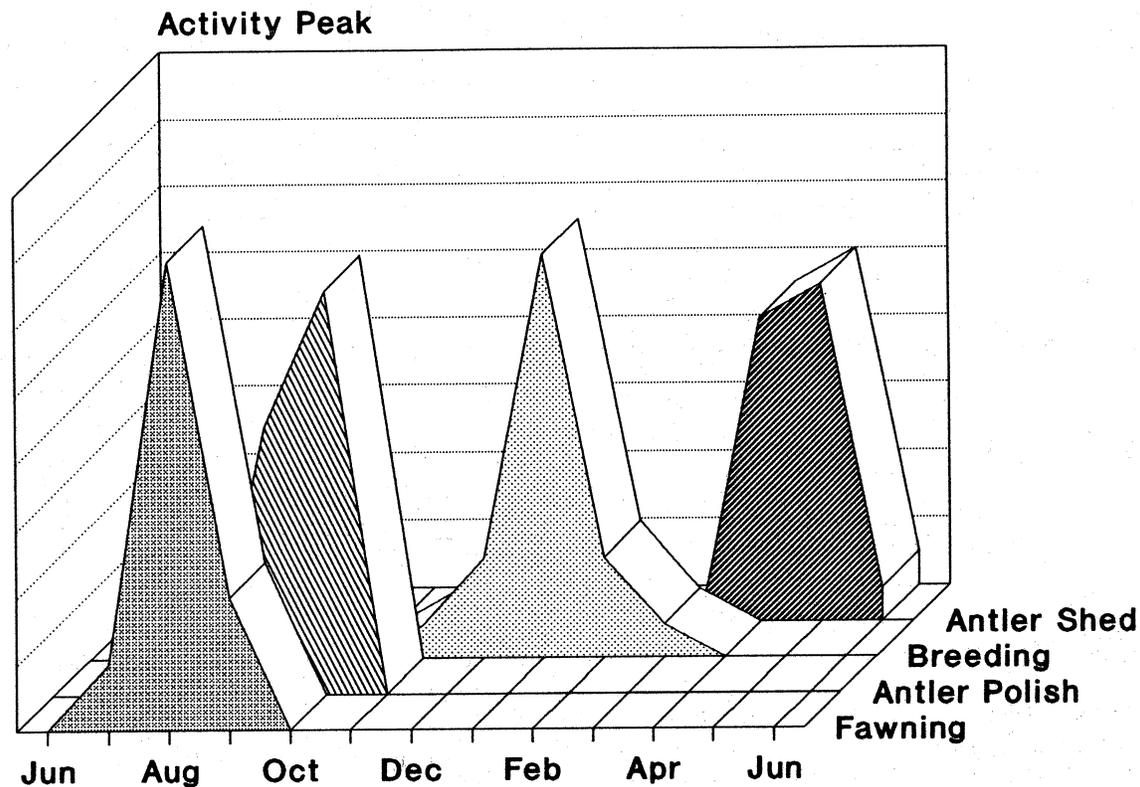


Figure 25.

Generalized annual reproductive cycle in Coues white-tailed deer in the SRSA, Santa Rita Mountains, Arizona, 1987-1991.

2 species and competition for scarce resources could exist. Unlike Anthony and Smith (1977), they found that white-tailed deer had the competitive advantage in available habitats. White-tailed deer were more adaptable in their requirements for habitat and food than mule deer.

Based on previous studies, likelihood of diet overlap is high in habitats that favor neither species over the other. On SRSA, areas of habitat overlap occurred mainly along State Route 82. All other habitats on SRSA favored white-tailed deer and interactions between the 2 species were unlikely. Although we did not attempt to measure mule deer diet patterns and white-tailed deer diet overlap with mule deer on SRSA, it is likely occurring in sympatric areas.

As long as habitats favor 1 species over the other, the 2 species maintain spatial segregation (Kramer 1973, Anthony and Smith 1977, Beasom and Krysl 1984, Wiggers and Beasom 1986, Smith 1987) and diet overlap is of little concern. White-tailed deer are favored if woody cover is greater

than 40% (Wiggers and Beasom 1986).

Competition with other native ungulates, like bighorn sheep, tends to be low (Henry and Sowls 1980). Much of that is due, we suspect, to major differences in general habitat requirements.

Reproduction

Data collected on SRSA pertaining to the period of year in which antlers were polished, velvet was shed, rutting and breeding was observed, and fawns were dropped were similar to previous information on Coues white-tailed deer (Mearns 1907, Nichol 1938, McCabe and Leopold 1951, Welles 1959, Welch 1960, Knipe 1977, Smith 1984, Hoffmeister 1986). The yearly cycle of reproductive life (Fig. 25) for Coues white-tailed deer on SRSA begins in late September or early October with antler polishing for bucks. It progresses into rut in late December, which peaks in January when most does come into estrus. Rutting behavior continues into February or March as some does recycle because of non-

breeding or failure to conceive earlier. Antler drop for bucks typically occurs in late April or early May on SRSA, however, variability was noticeable. Parturition occurs in late July, through August, and into early September to complete the cycle.

Although our data were similar to previous studies and casual observations on Coues white-tailed deer, it is not similar to most other subspecies reported in the literature (Halls 1978, Marchinton and Hirth 1984, Sauer 1984, Verme and Ullrey 1984). In as early as 1938 (McCabe and Leopold 1951), it was observed that Coues white-tailed deer breeding and fawning activities were delayed compared to northern white-tailed deer. Coues white-tailed deer polish and shed their antlers about 2 months later than northern and eastern subspecies (Sauer 1984), breed in January instead of November (Verme 1969, Klinger et al. 1985), and drop fawns in August instead of May-June or early July (Butts et al. 1978, Ockenfels 1980, Huegel et al. 1985). McCabe and Leopold (1951) concluded that the reproductive cycle was correlated to seasonal rainfall patterns and the vegetative cycle that followed it.

Timing of this cycle could be modified considerably by nutritional status of adults. Bucks on a restricted diet that does not provide adequate nutrition can have delayed antler polishing and cast (Verme and Ullrey 1984). Both antler polishing and cast are related to testosterone levels, which in turn is affected by nutritional status of bucks (Sauer 1984).

Although rutting behavior is influenced by photoperiod and weather conditions (Marchinton and Hirth 1984, Verme and Ullrey 1984), nutritional condition of bucks and does during fall and winter can also affect timing of conception (Halls 1978). Animals in poor condition, due to reduced forage availability, can widen the rut period, probably through does with delayed or repeating estrus cycles.

Female condition at conception affects date of fawning (McGinnes and Downing 1977), presumably by changing onset of estrus or by lengthening gestation period. Verme (1965) found a difference of up to 15 days earlier in breeding activity between does on a nutritious diet versus does on a substandard diet. Smith (1984) documented a delay in mean fawning date in Coues white-tailed deer by 2 weeks in what he

concluded was a poor condition year versus a good year.

Even though we had differences in rainfall patterns (Fig. 23) between years, we observed neonatal fawns around late July and early August each year. We did not have enough telemetered does in any given year to document a difference in peak fawn drop on SRSA.

Butts et al. (1978) found that age of females could also have a significant impact on average date of peak fawning. They found that mature does (3+ years) fawned earlier than either 2-year olds (nearly 3 weeks) or yearlings (nearly 6 weeks).

Age structure of females in a population also influences productivity rates. Typically, adult does have twice the productivity of yearlings, while fawns have very low productivity (Verme 1969). Klinger et al. (1985) found that does 2-years or older had higher fetus counts (2.0/female) than either yearlings (1.7/female) or fawns (1.0/female) in a population in good to excellent health.

Smith (1984) found that productivity values of Coues white-tailed deer improved as range conditions improved. Mature does with lower kidney fat indices had fewer fetuses (1.3/female) than mature does in good condition (1.9/female). Younger does, yearlings or 2-year olds, also increased their productivity in periods of improved range conditions (Smith 1984).

Mortality

Fawns. White-tailed deer fawns are "hidiers," that is hiding from predators during early life instead of fleeing, and are isolated for up to 4 weeks. Site selection can be by fawns (Marchinton and Hirth 1984) or does (Ozoga and Verme 1986). A variety of situations to choose from should increase survival by allowing fawns to select for adequate cover. Does tend to select dense vegetative cover for fawning (Ockenfels 1980), if available, and fawns could imprint on amount of cover used, or select if does do not chose the bedding site. Loft et al. (1987) found that hiding cover for mule deer fawns decreased significantly under moderate and heavy grazing. They noted that decreases coincided with the first 2 months of a fawn's life, when fawns were most vulnerable to predation. Although we did not measure hiding cover, considerable differences in hiding cover by year and pasture were apparent.

Some differences were likely related to rainfall conditions, but even moderate grazing on the pastures, without adequate rainfall, seemed to noticeably decrease grass height. Hiding fawns under such conditions would have been difficult.

Fawn mortality normally tends to be very high. Mortality rates of 72% (Cook et al. 1971), 88% (Garner et al. 1976, Garner and Morrison 1980), 59% (Mundinger 1981), 88-90% (Stout 1982), and 65% (Wood et al. 1989) have been observed. Most of this early mortality was related to coyote and bobcat predation. Heavy predation pressure lasts for up to 16 weeks postpartum (Garner et al. 1976, Kie and White 1985, Wood et al. 1989).

Fawn loss is generally quick. During the 4-year field study, we often noted doe physical and behavioral characteristics that suggested the doe was pregnant, then fawning occurred, but no fawns were observed. All of this over the span of a week or so. Cook et al. (1971) noted that 93% of their fawn loss was in the first 4 weeks (30 days), with the rest occurring in the next 4 weeks. Stout (1982) and Nelson and Woolf (1987) also saw the greatest impact in the first 4-8 weeks. Even under good recruitment conditions, most of the loss is early. Huegel et al. (1985) had a 27.2% fawn loss in the first 180 days, most of which occurred early.

Mortality of fawns can be as high as 93% for does in poor nutritional status (Verme and Ullrey 1984). Typically, fawns under such conditions were too small and poorly developed to feed properly and does were unable to produce adequate nourishment. Conversely, Verme and Ullrey (1984) found that does at high levels of nutrition may only suffer a 7% loss of fawns.

Derdeyn (1984) saw a 32% (73 to 50:100 does) loss of fawns from surveys in October to surveys in January, the typical survey period for Coues white-tailed deer. We did not see the same pattern; however, fawn loss on SRSA was generally within the first month or so, and then stabilized.

Adults. Estimating survival rates for males at less than one-half the rate for females on SRSA was no surprise. Males have nearly a 30% chance per year of being harvested during hunting seasons; which typically include hunting periods in 3 months (October-December) in 34A. This area of the Santa Rita Mountains had excellent access for hunting, provided good visibility for hunters, and had moderately easy terrain for

walking. Areas with characteristics like these traditionally receive heavy hunting pressure. Ranges of hunter density on SRSA were moderate (minimum estimate) to high (maximum estimate) for the open rolling terrain, but certainly moderate for rougher areas and those areas with dense canopy cover. High hunter densities were not necessary for higher success on SRSA, because a few hunters could adequately cover many small ridges and gullies in a day.

Accurate estimates of mortality are necessary for managing white-tailed deer populations (DeYoung 1989). The estimated yearly male mortality rate due to hunting calculated from either attrition rates (27.2% per year) and MICROMORT (28.8% per year) seem to be fairly high on SRSA. Few comparisons are available to judge our results. DeYoung (1989) found overall mortality rates in Texas for bucks in hunted populations to range from 25-29%, based on methodology used. However, many populations of white-tailed deer in Texas are managed for trophy class bucks and are hunted conservatively to increase older-age classes of deer. Other mortality factors, like mountain lion predation, likely were not operating in his study area. Our overall yearly mortality rate was considerably higher than his. Estimated hunting mortality rates on SRSA should provide a range for population modeling, at least until future generalized rates are available.

Age structure of buck harvest reflected vulnerability of deer on SRSA, with few animals older than 2 years of age taken during the seasons. Older, trophy-class bucks were taken, but in low numbers on SRSA. Arizona has, as a whole, continued to produce record book bucks for over 40 years (Fig. 26), with no indication of drop-off in overall quality. The situation for the Santa Rita Mountains is quite different. In the 1950s, the Santa Rita Mountains produced 11 Arizona record book typical Coues heads, 18 in the 60s, only 5 in the 70s, and none in the 1980s (Anon. 1990). The #6 non-typical Coues white-tailed deer was taken in the Santa Rita Mountains in 1983, but numerous trophy heads have not been produced for nearly 20 years. The fact that on a yearly basis, areas like SRSA are hunted "hard" enough such that bucks have a poor chance of surviving past 3 years of age certainly reduces the probability of mature bucks entering their trophy years. It seems likely that the whole unit (34A) is

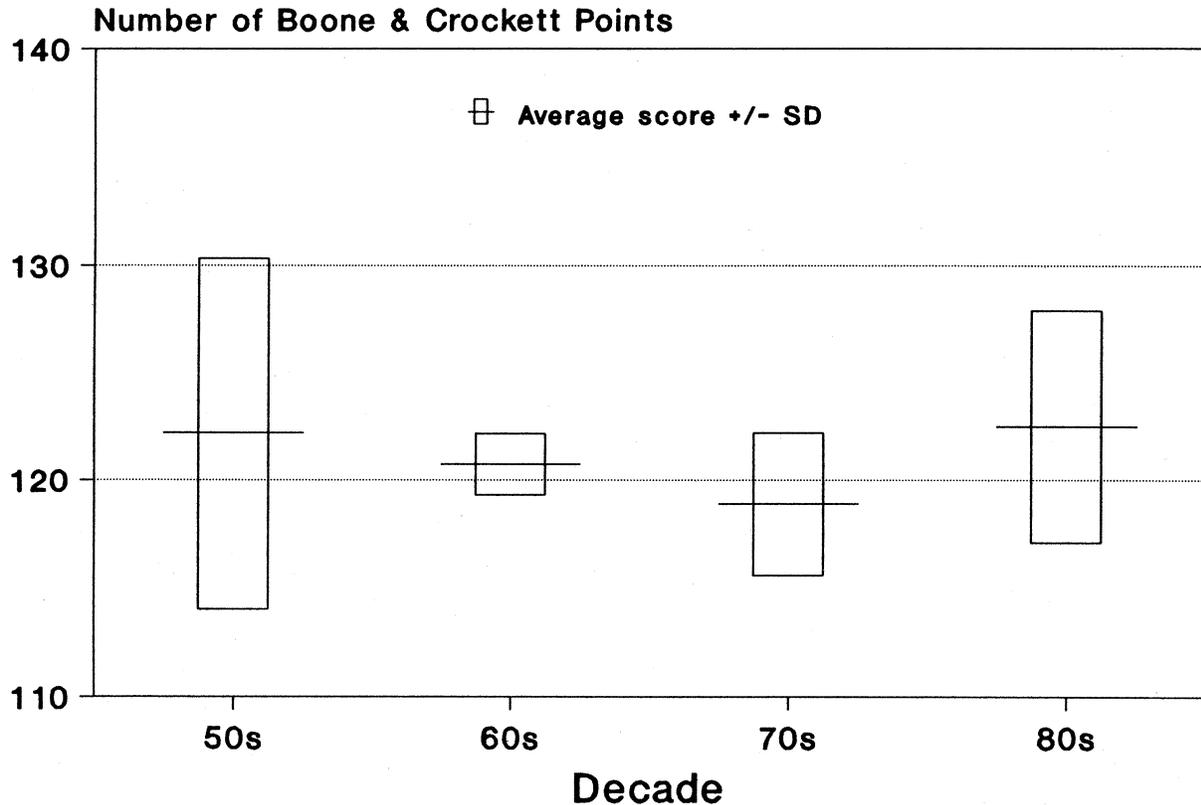


Figure 26.

Average trophy score of the top 10 Coues white-tailed deer by decade (statewide in Arizona).

hunted heavily, based on its proximity to Tucson.

Hunting is not new in the Santa Rita Mountains, as Way (1858, in Davis 1982) detailed hunting for white-tailed deer for ore mines during early settlement. The Santa Rita Mountains have provided a considerable percentage of annual statewide white-tailed deer harvest for over 40 years. Access to foothills is generally not limited by rugged terrain and lack of roads, but is controlled in areas by private lands. Localized areas like SRSA, with easy public access, provide large areas for hunter opportunity. This can result in high hunter densities at times and considerable harvest pressure.

At the same time, SRSA butts up against rough terrain that is excellent mountain lion habitat. Mountain lion predation is the major natural mortality factor affecting Coues white-tailed deer populations (Knipe 1977). Other western populations of white-tailed deer are also affected by mountain lion numbers (Krausman and Ables 1981). In Big Bend National Park, the

majority of deer killed by lions were younger (<2 years) animals (Krausman and Ables 1981). This mortality factor impacts both the male and female segments of the population, although Knipe (1977) believed males were taken in greater proportion than females. On SRSA, males were harvested in hunting seasons and this reduced male availability for predation. Still, probability of a male dying from lion predation (12.7-15.6% annually) was greater than estimates for females (5.8-7.6%). Habitat selection that favored rougher terrain after rutting, greater movements during rut, and weakened condition after rut likely increased a male's chances for lion predation.

Even in unhunted populations of Coues white-tailed deer, male mortality is higher than that for females (McCabe and Leopold 1951). Heffelfinger et al. (1990) found natural mortality rates for males to be as high as 12% for January through June. They found a difference in after-rut mortality due to coyote predation. We found no measurable probability of males dying from

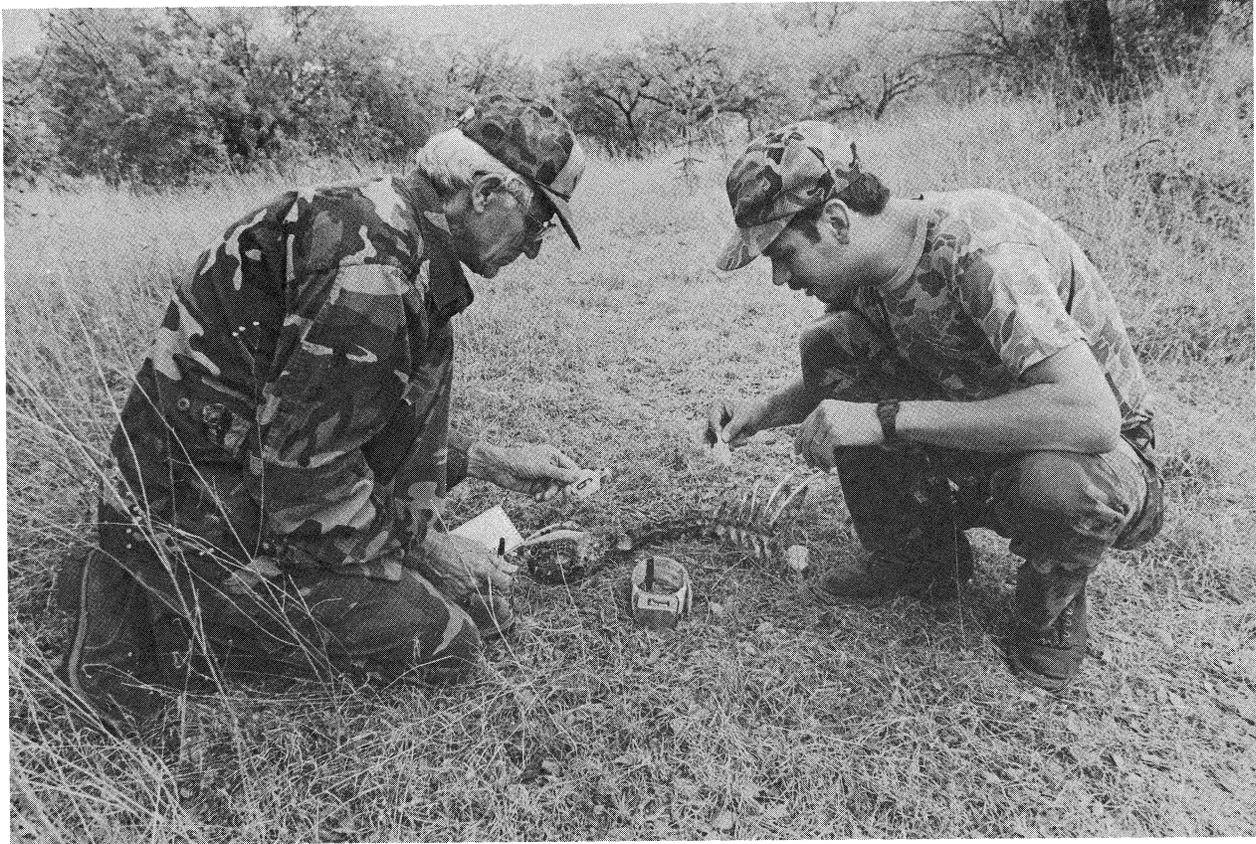


Figure 27.

Accurate estimates of Coues white-tailed deer mortality were gained through intensive field investigations on the SRSA, Santa Rita Mountains, Arizona, 1987-1991.

coyotes on SRSA. Mortality for males was due to hunting and lion kills. Coyotes did impact the female segment of the population (Fig. 27). Females were vulnerable just prior to parturition, likely through added weight and size and increased foraging demands. Both coyotes and lions preyed upon females during fawning periods.

Effects of Roads

Density of unimproved or "2-tracker" roads was quite high for most of SRSA. In addition, many more km of non-passable or lightly used unimproved roads were on SRSA that were not mapped for this study. These roads were used on an irregular basis by ranch workers and some hunters in 4-wheel drive vehicles. Access on SRSA was excellent from 3 graded roads. Most major ridges and drainages had a road of some quality within the central part of SRSA. There were many more km of roads than necessary for either ranch maintenance or hunter access.

National forest land management plans (LMPs) have road management plans associated with them. Road closures are to be included for many areas. SRSA, particularly in the Smith/Stevens area, could be considered for road closures. Areas with more than 1 km per km² of unimproved roads could be considered candidates for closure, permanent or temporarily during high-use seasons.

Data from traffic counters were not totally reliable and accurate. At most entrances, counters worked reasonably well. Several counters malfunctioned on a regular basis, and data were discarded. Still, when the majority of traffic counters were examined for vehicle crossings per day (Fig. 20), they showed a pattern that suggests hunting seasons were the major reasons for amount of traffic above background levels. Patterns were discernible. For example, traffic for Temporal, a graded road, was nearly twice that of Hog, an unimproved, but good dirt road. This pattern seemed to hold over SRSA.

This doubling of traffic likely caused reduced use of the first 400 m along a graded road by Coues white-tailed deer. Background traffic of ranch workers and research personnel on unimproved roads did not seem to cause Coues white-tailed deer to avoid areas adjacent to them.

Because of large number of unimproved roads on SRSA, hunters did not have much opportunity to hunt more than 400 m from a road. Of particular interest is lack of significance in harvest in relation to distance from graded roads. Apparently, hunter density of SRSA was such that all available habitat was covered by hunters. Even though Coues white-tailed deer naturally avoided graded roads, harvest did not reflect this situation. Either hunters were not able to locate themselves on a map properly, or the hunt pressure moved deer out of their normal areas. Based on locations of mortality sites for collared deer, some were killed outside of their core area or home range. Pressure seemed high enough to move deer out of normal areas.

Of particular concern was the number of ridgeline roads on SRSA. Water sources were installed on major ridgelines and maintenance roads for those waters were typically used by hunters. Hunter access to areas most used by Coues white-tailed deer was readily available. With these ridge roads, hunters did not have to hike up out of canyon bottoms and deer could not escape as easily by crossing over a major ridge.

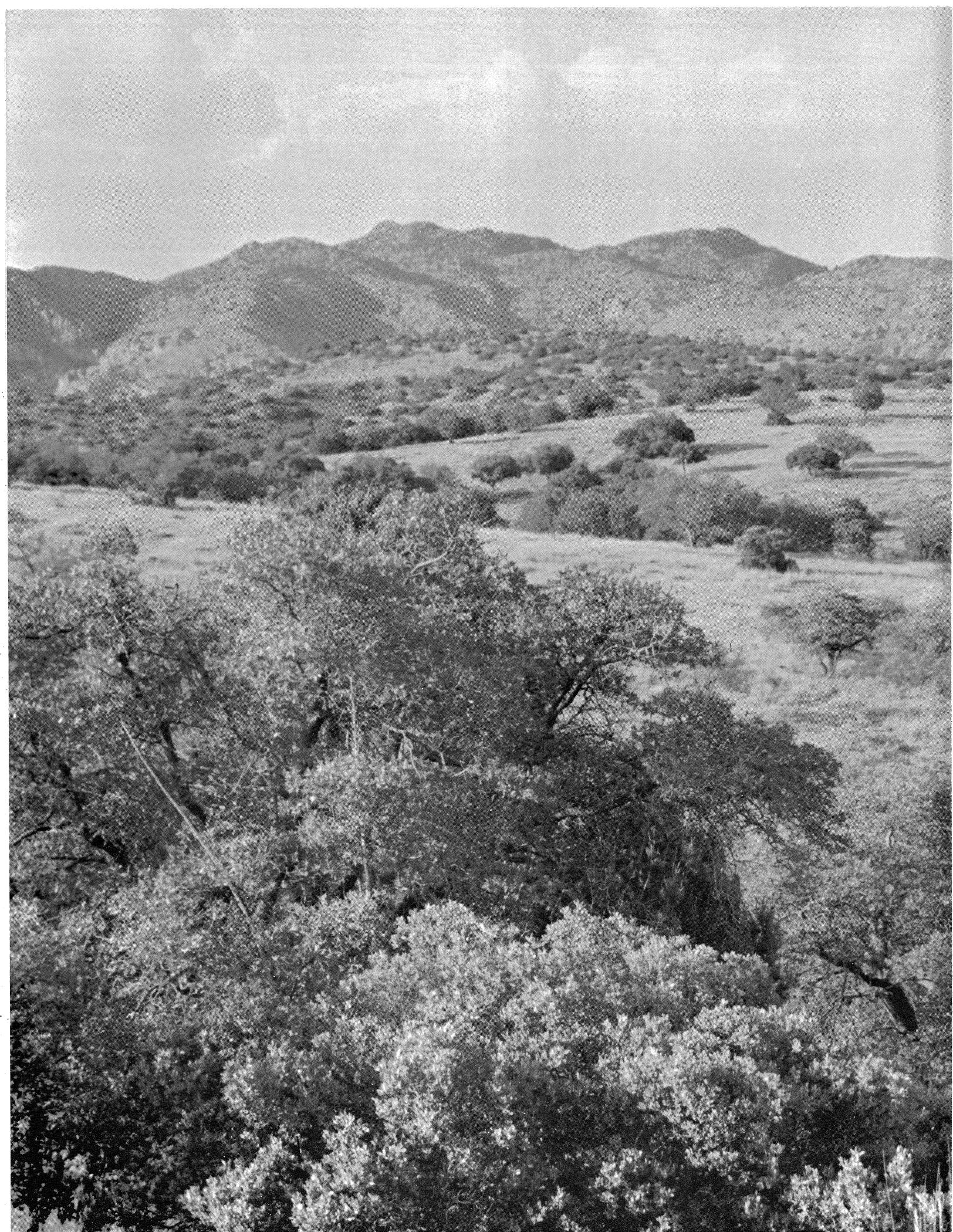
Land Ownership

Analysis of distribution of Coues white-tailed deer and land ownership was influenced by our inability to capture does on private land holdings. Deer captured on national forest lands at the edge of private land tended to use both ownership types. Most does, with their small core areas and home ranges, spend the majority of time on public lands, while bucks, with areas typically twice as large, used private lands more.

During location efforts for bucks, we also tended to see some does in private land holdings. Density of does on private land holdings was likely less than on public lands. We suspect that part of the reason for this prediction is the differences in habitat types between land owners. Private lands occupied lower flats along Sonoita Creek, which were mainly grass-mesquite or mesquite-shrub invaded grasslands. Public lands

were more in foothills than in flats and contained more areas of oak types.

Based on traffic data for road types, we suspect that part of the reason that collared deer avoided private lands was the level of disturbance. Traffic on roads for the first km or so was greater than in remote, uninhabited areas. Houses were scattered throughout private holdings, which increases number of people, dogs, and noise levels. Bucks seemed to be better able to tolerate levels of disturbance around houses than does. On numerous occasions, we located bucks bedded in brush thickets on a ridge directly above a house. Does seldom were seen in the same situation. Does also bolted quicker than bucks when located under similar conditions.



MANAGEMENT OPTIONS

Coues white-tailed deer are a valuable resource in Arizona for hunters and non-hunters alike. The subspecies has become more important each decade to hunters, as managers attempt to reduce harvest pressure on mule deer by more fully utilizing white-tailed deer recreational potential.

Based on historical statewide survey, harvest, and trophy data, management practices by the Arizona Game and Fish Department have altered statewide sex ratios of Coues white-tailed deer, as well as age structure of the buck segment of the population. Neither of these practices has resulted in a measurable change in statewide reproductive data over the last 40-50 years. Recruitment into the statewide white-tailed deer population has remained relatively stable around 40 fawns per 100 does, even as harvest pressure increased.

For strategic, regional, and operational planning processes, the Department, land management agencies (i.e., Bureau of Land Management, Forest Service, State Land Department, etc.), and private landholders need sound data on basic life history requirements for Coues white-tailed deer. Our study provided management data related to estimated area an "average" buck and doe needs over their life span, the way habitat components were used, reproductive timing, mortality estimates for computer modeling, water needs, effects of roads and vehicular traffic, and harvest-related data.

Because of widespread distribution and moderate abundance of white-tailed deer in Arizona the model estimate for 1989 was 96,000 adults (Ariz. Game and Fish, Unpub.). A reasonably secure future is likely for them. However, localized populations of Coues white-tailed deer, isolated from contiguous blocks of habitat, have been extirpated, threatened with extirpation, or reduced in density (Brown and Henry 1981, Evans 1984, Hoffmeister 1986). Management must be able to handle these small isolated, as well as large, contiguous populations. Conversely, along its northern limit, Coues white-tailed deer are continuing to expand into new habitat or increase their density as habitats improve. Continued range extensions or range improvements will better ensure future Coues white-tailed deer populations.

Department strategic planning documents

(Anon. 1987) suggest that white-tailed deer should be managed separately from mule deer, so that individual managers can control harvest of each species in areas of range overlap. Current management direction is to manage white-tailed deer in as small an area (i.e., Game Management Unit) as possible, as harvest pressure on the subspecies increases. Information on local populations of Coues white-tailed deer becomes more critical as level of management increases.

Like other white-tailed deer subspecies, Coues white-tailed deer are very adaptable (Hesselton and Hesselton 1982, Baker 1984), and use a wide range of habitats in Arizona (Day 1964, Anthony and Smith 1977, Knipe 1977, Evans 1984). Because of this plasticity managing harvest and habitat for white-tailed deer can vary considerably from local area to local area, and still maintain a population of white-tailed deer. Following are a series of possible alternative activities that could assist agencies in managing Coues white-tailed deer populations.

The reader is cautioned that the following options are for management of Coues white-tailed deer in Arizona. These options may not be suitable for managing other species of wildlife or affect them in the same way they do white-tailed deer. These options are intended to maintain or increase white-tailed deer numbers in a given area. It is likely that combinations of options will be most beneficial for managing white-tailed deer populations. Further inquiry by the reader into an individual option is suggested before undertaking any tasks.

Use Separate Core Area and Home Range Estimates for Females and Males in Modeling Exercises

Bucks tend to use at least twice the area as does for most subspecies studied. Coues white-tailed deer are no different. Average size of female core areas and home ranges are 1.9 and 5.2 km² in areas dominated by Madrean oak woodlands, the principal habitat type for Arizona. Bucks used 4.5 and 10.6 km² for their core area and home ranges. Estimates for home ranges using harmonic means tend to be inflated over what is necessary, therefore, we suggest that general core area values of 2 and 5 km² for does and bucks, respectively, should be used for future planning, instead of the home range values. These values will account for a deer's daily activities.

Adjust Core Area Size by Quality of Habitat

Model core area size estimates for female and male Coues white-tailed deer can be adjusted according to habitat type for local planning processes. Madrean oak woodland habitat areas, with a high amount of diversity of structure and interspersions with other habitats, support deer in small core areas. More arid areas likely require larger areas for supporting deer. Core area sizes of 1-1.5 km² for females and 3-4 km² for males should be adequate for localized high quality habitats, while 3-4 and 6-7 km² may be necessary in more arid habitats to support a single Coues white-tailed deer.

Maintain Current Habitat in Present Status by Coordinating with Land Management Agencies

In general, habitat needs for most subspecies of white-tailed deer, including Coues, are not a critical problem at present (Halls 1984). Agencies involved can be coordinated with to continue to operate under current management levels and maintain adequate habitat for Coues white-tailed deer on a statewide basis. Fragmented populations may be lost under this alternative and populations will continue to be highly dependent on and fluctuate widely with climatic conditions. The key to preventing or reducing widely fluctuating population "boom and bust" cycles seems to be in maintaining diversity of habitats over time (Smith and Coggin 1984). Existing management strategies create continual disturbances to maturing habitats that often indirectly benefit white-tailed deer. Unfortunately, such disturbances are unplanned as to temporal and spatial effects.

Maintain Oak Habitat on North Slopes and Open Contiguous Areas on South Slopes

That the quality of these areas is high is reflected by female white-tailed deer selecting for oak and oak-mesquite mixes on moderately steep northern exposures. Females tend to use higher quality habitats than males (McCullough et al. 1989). These areas provide good interspersions with openings (i.e., southern aspects) and much escape terrain. Creating small openings in dense oak stands on northern exposures is not necessary if natural interspersions from southern exposures is present. However, in large contiguous blocks of

dense trees, small openings from fuelwood cuts would increase habitat diversity and effectiveness. The average slope of these areas should preclude extensive fuelwood cuts. However, wildlife managers can use 10° (or 20% slope) as an upper level guideline for extensive clearcutting projects to stay below to maintain northern slope habitat.

Use Fuelwood Sales as a Tool to Improve Habitat Quality

Fuelwood cuts can be designed so that numerous small openings are made, each less than 25 ha in size (Sweeney et al. 1984). We suggest that openings be closer to 1 ha in size to maximize use. Opening widths less than 100 m across would ensure use by Coues white-tailed deer. Barsch (1977), Ockenfels (1980), and Rollins et al. (1988) noted that use of openings tended to decrease as distance to edge increased or as size of openings increased. Presence of preferred browse in clearcuts increase their use (Williamson and Hirth 1985), but size of clearcuts was still a controlling factor as to amount of use. If openings are greater than 1 ha, irregular shaped edges, which increases amount of edge cover, should be used to compensate for increased opening size.

Uneven, or selective cutting, to open up large tracts of dense trees should provide a better forage base (Smith and Coggin 1984). Opening up dense canopy covers (>50%) should allow for increased understory of shrubs and forbs, while still maintaining shelter and thermal cover.

Use Prescribed Burning as a Tool to Improve Habitat Quality

Barsch (1977) found that burned areas were used up to 7 times more than unburned areas for foraging by Coues white-tailed deer. Burning in mosaic patterns should provide better habitat interspersions and improved forage quality. Burning should increase plant diversity, and activities designed to increase forb or shrub diversity are generally beneficial to white-tailed deer (McCulloch 1972, Harlow 1984, DelGiudice et al. 1989, Barnes et al. 1990).

Increase Water Distribution in Coues White-tailed Deer Habitat

Distribution of Coues white-tailed deer, particularly in isolated areas (Barsch 1977, Henry and Sowls 1980), tends to be restricted by availability of permanent water. Water needs are partially based on physiological status (i.e., pregnant, lactating) and use of free water is inversely proportional to moisture content of forage (Michael 1968, Marchinton and Hirth 1984, Verme and Ullrey 1984). Assuring availability of free water in arid ranges should be critical for adult and fawn survival during hot, dry summer months (May-June). Coordinating with land managers to maintain water flow to established water sources during these months is especially critical.

To improve distribution of Coues white-tailed deer, a density of water sources such that no area is more than 1.2 km from a water is necessary. Maghini and Smith (1990) suggest a density of 1/km² for female use. Water source density could be higher in female use areas (oak woodlands) and less in male use areas (mesquite-shrub invaded grasslands). A permanent water source every 2-3 km², maintained during the hot, dry summer, would be sufficient for maintaining a population of white-tailed deer, but it would not maximize area used by deer.

Strategic Placement of New Water Sources in Coues White-tailed Deer Range

Water source placement on ridgelines is a common management technique to distribute livestock out of drainage bottoms. However, natural waters are found in bottoms of drainages and deer have evolved to water away from feeding areas (Michael 1968) and bedding areas. New waters built in drainages rather than on ridges, and not fenced, should benefit Coues white-tailed deer (Michael 1968). Building waters in drainages would also reduce road densities on ridges. Although deer use both troughs and tanks (Maghini and Smith 1990), smaller, more natural waters are preferred (Henry and Sowls 1980).

Control or Reduce Road Densities in Coues White-tailed Deer Habitat

Density of graded roads affects amount of area Coues white-tailed deer will regularly use during the day. An area, buffer, of 400 m on each side of

a graded road would likely be avoided by deer, at least during diurnal hours. Loss of habitat effectiveness for Coues white-tailed deer would be 0.8 km² per linear km of new graded road. Coordinating with land management agencies to keep graded road density at or below current levels would benefit white-tailed deer. Need for reducing graded roads or maintaining sufficient distance between new roads should be evaluated by placing buffers along road corridors and estimating habitat effectiveness. Traffic level on roads is likely a function of road type, rather than road density in an area.

Density of unimproved roads and locations of those roads did not seem to adversely affect overall white-tailed deer distribution on SRSA. However, the density measured (1.1 km/km²) was high enough that deer could hardly avoid them on SRSA and still have any habitat left. SRSA was far enough away from any major population center so that overall traffic volume was normally low. However, traffic volume into white-tailed deer habitat increased without restriction during high recreational demand periods. In areas close to large populations, road densities are probably more important and should be reduced to less than 1 km/km² to control traffic volumes.

Maintain or Improve the Current Harvest Strategy for White-tailed Deer

Currently, management for Coues white-tailed deer harvest ranges from the Game Management Unit level, with few permits, to large multi-unit block hunts with thousands of permits. Hunter densities in large multi-unit blocks can be uneven from unit to unit and year to year. Hunter density for GMU 34A was not solely related to number of permits issued, nor was hunter density on SRSA related 100% to number of permits issued. Under current management strategies, only about 70% of hunter numbers is predictable, based on permits issued. Closeness to metro areas, climatic conditions, and various other influences likely affect number of hunters.

Current harvest levels in SRSA and highly accessible areas in 34A preclude the possibility of a "balanced" age structure of bucks, and with it the likelihood of trophy animals. Few bucks on SRSA lived into their prime years. Similar situations may occur in other areas. Nevertheless, overall current management practices have resulted in a stable statewide harvest of trophy

Coues white-tailed deer.

Managing hunter densities by Game Management Unit or subunit, based upon deer densities and the age/sex structure of herds would improve harvest management. Issuing permits by GMU or subunit should allow wildlife managers to better control (greater than the predicted 70%) hunter densities. Localized problem areas will still occur, but fluctuations in hunter density should be reduced compared to multi-unit block hunts.

If a higher percentage of mature or trophy bucks is desired in a localized area, permit numbers can still be set on reproductive values as currently occurs. A slight narrowing of the sex ratio by decreasing harvest for several years would allow more bucks to reach their prime.

Decreasing the probability of a buck dying from legal hunting to 20-25%, instead of the current 25-30%, should be sufficient. A change in weapon type, or season date, may be sufficient to reduce harvest without a change in permits.

Season length could be reduced to decrease harvest pressure and increase older age classes. Unfortunately, the cuts necessary to significantly reduce harvest or improve age structure would likely result in only a 2-3 day hunt in heavily impacted areas. Most hunters and managers would likely find this alternative undesirable, but it could be used in critical situations as a last resort.

Use a Range of Mortality Estimates for Population Modeling

Current management practices sometimes use mortality rate estimates for computer population modeling. Our estimates of female mortality ranged, by method, from 14.6 to 19.0%. These values, measured over 4 years, are very similar to average values used on current Arizona Game and Fish Department population modeling runs (L. Piest, *pers. comm.*). Mortality rates for males were 17.1-19.5% for non-hunting and 27.2-28.8% for hunting. Again, non-hunting values are very close to current estimates, gained through simulation runs. For typical white-tailed deer habitat, these values should allow most populations to be modeled to a reasonable level.

Estimate Mortality by Area

Realistically, actual mortality should vary by area, based on predator densities, hunter density, road networking, terrain, and numerous other

factors. For those GMUs that model poorly, additional estimates of mortality are probably necessary. For example, if female mortality is lower than 15-20%, the population could be increasing and modeling "scores" would be affected. Male mortality can be adjusted by analyzing age structure of the population and harvest data.

Reduce Mortality on Bucks by Predator Control

Male mortality can be reduced by controlling the number of mountain lions in the area, when mountain lion populations are high. Sportsmen, with hounds, could be directed into heavily impacted areas through news releases.

Reduce Doe and Fawn Mortality by Predator Control

If managers identify specific areas of concern, such as fragmented populations, or a population at a depressed level, predator removal programs could be used for short periods of time to ensure deer population viability. Coyote control just prior to fawning should be of value in depressed areas, or areas with reduced hiding cover. Aerial gunning could be considered or news releases to predator calling clubs could be used to redirect hunter effort into specific areas of concern.

Modify Livestock Management Practices

Dietary overlap values and microsite analysis of summer diurnal bedsites (Ockenfels and Brooks, *in prep*) suggest little competition between Coues white-tailed deer and cattle occurred on SRSA. The rest-rotation systems of the 3 allotments on SRSA provided adequate water sources, at least seasonally, and did not adversely affect deer such that their distribution was changed. However, habitat use patterns are affected by livestock (M. Brown 1984), and heavy grazing prior to and during fawning periods reduces hiding cover.

Fawn survival is partially dependent on amount of hiding cover provided by perennial grasses (Fig. 28). Limited observations during this study suggested that grass density and height may be important in fawn survival and recruitment. This relationship is especially important during the fawns' first month(s). Unfortunately, we were not able to measure vegetational characteristics at



Figure 28.
Inadequate vegetative cover increases vulnerability of neonate Coues white-tailed fawns to predation.

neonate fawn bedsites and have no data to establish guidelines for residual cover. This information would be useful to managers and should be considered for future research.

To increase hiding cover, heavy seasonal use by cattle could be deferred during summer months (May-August). Reducing percent use of grasses by either decreasing livestock numbers or length of time in a pasture would also increase hiding cover. Based upon the approximate back height of a bedded neonate fawn, ridges or small drainage areas with residual grass greater than 25 cm in height should provide adequate hiding cover until further research is conducted.

Grazing use should be based on actual current grass production (Thill 1984), instead of a set AUM allotment or a range analysis that is not indexed to climatic conditions prior to measurement. AUM values set during wet "periods" could easily be too high for drought "periods." Coordination in monitoring grass use by livestock is necessary for better white-tailed deer management.

Coordination with ranch managers to ensure permanency of water sources across white-tailed deer habitat should be considered. Water sources are particularly critical during the hot, dry summer, and early wet summer if monsoon storms are late in arrival. The more arid the habitat, the more critical water sources become.

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Key Words: Arizona, Coues, diet, habitat selection, home range, hunting, mortality, *Odocoileus virginianus colesi*, reproduction, survival, white-tailed deer.

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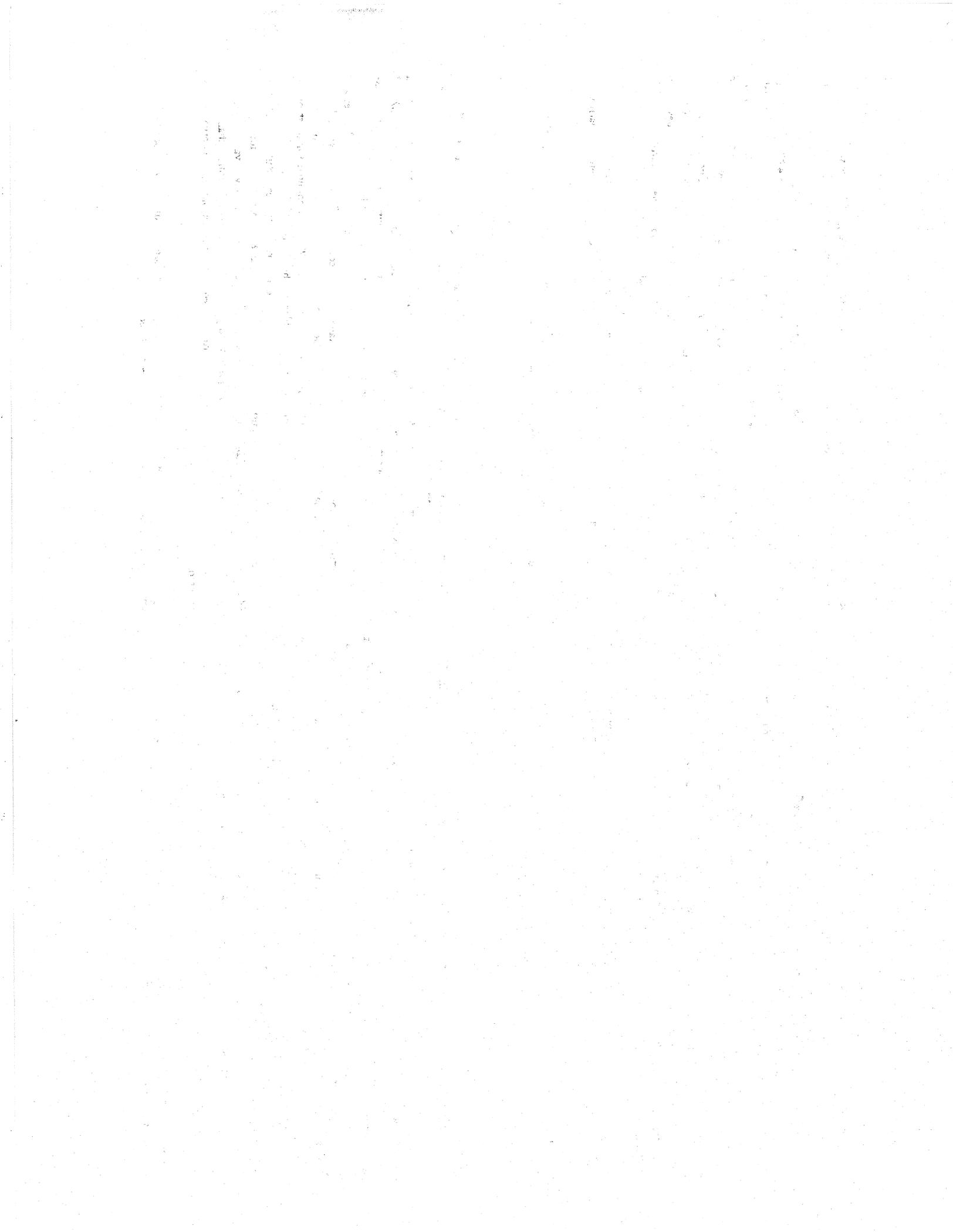
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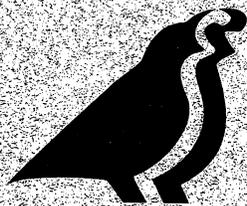
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