

Review of Deer Surveys and Studies at Saguaro National Park

Melanie Bucci
December 13, 2007

Prepared for:

Saguaro National Park
and
Western National Parks Association (Grant#06-06)



Table of Contents

List of Tables.....	2
List of Figures.....	4
Introduction.....	5
Rincon Mountain District.....	10
Saguaro National Park Internal Reports.....	10
Sumner Study.....	15
Day Study.....	15
Other Studies.....	16
Nocturnal Rodent Survey.....	16
Douglas Gilbert (Colorado State University).....	17
William Cooper (Park Technician-Naturalist).....	17
Bob Barsch (University of Arizona).....	18
Douglas Duncan, University of Arizona Mammalogy Project.....	18
Bellantoni and Krausman Study.....	19
Helicopter Surveys.....	22
Tucson Mountain District.....	24
Clark Study.....	26
Elder Study.....	32
Kline, Swann, and Hubbard Study.....	34
Helicopter Survey.....	35
Conclusions.....	35
Literature Cited.....	39

List of Tables

Table 1. Identifying characteristics to distinguish between mule deer (<i>Odocoileus hemionus</i>) and white-tailed deer (<i>Odocoileus virginianus</i>) (Heffelfinger 2006).....	43
Table 2. Numbers of white-tailed deer (<i>Odocoileus virginianus</i>) and mule deer (<i>Odocoileus hemionus</i>) reported in annual wildlife reports for Saguaro National Monument Tucson, Arizona.....	45
Table 3. Numbers of mule deer (<i>Odocoileus hemionus</i>) counted during Gerald Day's javelina (<i>Pecari tajacu</i>) survey routes from 1961 to 1974, Saguaro National Park, Rincon Mountain District, Tucson, Arizona.....	47
Table 4. Numbers of white-tailed deer (<i>Odocoileus virginianus</i>) counted during Gerald Day's javelina (<i>Pecari tajacu</i>) survey routes from 1961 to 1974, Saguaro National Park, Rincon Mountain District, Tucson, Arizona.....	48
Table 5. Survey routes used by Gerald Day during a javelina (<i>Pecari tajacu</i>) study from 1961 to 1974 to count deer, Saguaro National Park, Rincon Mountain District, Tucson, Arizona.....	49
Table 6. Mule deer use of vegetation associations by sex (M indicates male and F indicates female) and season in relation to availability (+ indicates used significantly more than available, - indicates used significantly less than available, and 0 indicates not used at all) at Rincon Mountain District, Saguaro National Park, Tucson, Arizona 1988-1989 (Bellantoni and Krausman 1991).....	50
Table 7. Mule deer use of vegetation associations by sex (M indicates male and F indicates female) and season in relation to availability (+ indicates used significantly more than available, - indicates used significantly less than available, and 0 indicates not used at all) for foraging at Rincon Mountain District, Saguaro National Park, Tucson, Arizona 1988-1989 (Bellantoni and Krausman 1991).....	51
Table 8. Mule deer use of vegetation associations by sex (M indicates male and F indicates female) and season in relation to availability (+ indicates used significantly more than available, - indicates used significantly less than available, and 0 indicates not used at all) for bedding at Rincon Mountain District, Saguaro National Park, Tucson, Arizona 1988-1989 (Bellantoni and Krausman 1991).....	52
Table 9. Dates and times of helicopter surveys for deer at Saguaro National Park, Rincon Mountain District, Tucson, Arizona.....	53
Table 10. Number of mule deer (<i>Odocoileus hemionus</i>) counted during helicopter surveys in 1989 and from 2000 to 2006 at the Rincon Mountain District, Saguaro National Park, Tucson, Arizona.....	54

List of Tables

Table 11. Number of white-tailed deer (*Odocoileus virginianus*) counted during helicopter surveys in 1989 and from 2000 to 2006 at the Rincon Mountain District, Saguaro National Park, Tucson, Arizona.....55

Table 12. Comparison of mule deer (*Odocoileus hemionus*) (bucks/100 does and fawns/100 does) between Saguaro National Park, Rincon Mountain District (SNP) and Arizona Game and Fish, Game Management Unit 33 (GMU33), Tucson, Arizona.....56

Table 13. Comparison of white-tailed deer (*Odocoileus virginianus*) (bucks/100 does and fawns/100 does) between Saguaro National Park, Rincon Mountain District (SNP) and Arizona Game and Fish Game Management Unit 33 (GMU33), Tucson, Arizona.....57

List of Figures

Figure 1. Mule deer (<i>Odocoileus hemionus</i>) trends from survey data by Gerald Day during a javelina (<i>Pecari tajacu</i>) study from 1961 to 1974, Saguaro National Park, Rincon Mountain District, Tucson, Arizona.....	58
Figure 2. Nocturnal data collected on Cactus Forest Drive for mule deer (<i>Odocoileus hemionus</i>) from December 1964 to July 1965 by park staff at Saguaro National Park, Rincon Mountain District, Tucson, Arizona.....	59
Figure 3. Helicopter survey route for deer on 6 January 2001, Rincon Mountain District, Saguaro National Park, Tucson, Arizona.....	60
Figure 4. Helicopter survey route for deer on 5 January 2002, Rincon Mountain District, Saguaro National Park, Tucson, Arizona.....	61
Figure 5. Helicopter survey route for deer on 4 January 2003, Rincon Mountain District, Saguaro National Park, Tucson, Arizona.....	62
Figure 6. Helicopter survey route for deer on 4 January 2004, Rincon Mountain District, Saguaro National Park, Tucson, Arizona.....	63
Figure 7. Helicopter survey route for deer on 19 January 2006, Rincon Mountain District, Saguaro National Park, Tucson, Arizona.....	64
Figure 8. Mule deer (<i>Odocoileus hemionus</i>) trends from helicopter surveys from 2000 to 2006 at the Rincon Mountain District, Saguaro National Park, Tucson, Arizona.....	65
Figure 9. White-tailed deer (<i>Odocoileus virginianus</i>) trends from helicopter surveys from 2000 to 2006 at the Rincon Mountain District, Saguaro National Park, Tucson, Arizona.....	66
Figure 10. Helicopter survey route for deer on 20 January 2006, Tucson Mountain District, Saguaro National Park, Tucson, Arizona.....	67

Introduction

Mule deer (*Odocoileus hemionus*) and white-tailed (*Odocoileus virginianus*) deer are the only two species of deer occurring in the southwest (Hoffmeister 1962). Mule deer occur throughout most of western North America and into southern Mexico (Anderson and Wallmo 1984). Ten subspecies of mule deer are recognized throughout the species' range (Anderson and Wallmo 1984). The subspecies of mule deer occurring in southeastern Arizona is the desert mule deer (*Odocoileus hemionus eremicus*, previously referred to as *Odocoileus hemionus crooki*; Hoffmeister 1986, Heffelfinger 2006). White-tailed deer occur from southern Canada throughout most of the contiguous United States, except Utah, south to northern South America (Smith 1991). Thirty-eight subspecies of white-tailed deer are recognized throughout its range (Smith 1991). The subspecies of white-tailed deer occurring in southeastern Arizona is the Coues white-tailed deer (*Odocoileus virginianus couesi*; Hoffmeister 1986).

In the southwestern United States mule deer are found from 200 to 7,300 foot elevation, most being found below 4,500 feet (Heffelfinger 2006). They inhabit a number of vegetation associations, including palo verde (*Cercidium spp.*)-saguaro (*Carnegiea gigantea*) communities, upper desert grasslands, pinyon (*Pinus spp.*)-juniper (*Juniperus spp.*) woodlands, dense chapparral, and oak (*Quercus spp.*) woodlands in southern Arizona (Heffelfinger 2006). Mesquite (*Prosopis spp.*) bordered washes are important for forage and cover in the Sonoran Desert (Heffelfinger 2006). White-tailed deer are usually found above 4,000 feet elevation in the southwest (Heffelfinger 2006). They mainly inhabit woodland communities but can be found in ponderosa pine (*Pinus ponderosa*), desert scrub, and deciduous forests (Hoffmeister 1986). At lower elevations

where mule deer and white-tailed deer overlap there may be competition for forage, especially when resources are scarce (Anthony and Smith 1977).

Mule deer and white-tailed deer have similar diets in areas where they coexist (Anthony and Smith 1977, Heffelfinger 2006). Both species depend heavily on browse (i.e., woody plants and shrubs) throughout much of the year and along elevational gradients (Heffelfinger 2006). After seasonal rains, forbs (i.e., broad-leaved weeds) make up an important component of the diet of both species (Heffelfinger 2006). Tree and shrub fruits are utilized when available, while grass makes up a small portion of the diet (Heffelfinger 2006).

Deer get water from 2 sources: free standing water (e.g., springs, rivers, cattle tanks, etc.) and preformed water (i.e., water contained in food). Both species of deer in the southwest depend on freestanding water, especially during the hot, dry summer months (Heffelfinger 2006). Desert mule deer moved closer to water sources during the dry season in the King Valley, Yuma County, Arizona (Rautenstrauch and Krausman 1989) while white-tailed deer were densest around water sources in the Santa Rita Mountains, Pima County, Arizona (Ockenfels et al. 1991).

Desert mule deer breed from December to February in southeastern Arizona, and fawn from July to August (Clark 1953, Truett 1971, and Rodgers 1977). Coues white-tailed deer breed from December to February and fawn from July to September (White 1957). Deer gestation lasts approximately 200 to 207 days. High reproductive and fawn survival rates are dependent on good nutrition (Heffelfinger 2006). Rainfall affects the amount and quality of forage available; therefore, it also can affect deer populations (Heffelfinger 2006).

Deer populations are also affected by mortality. The main agents of mortality for deer are malnutrition, hunting, predation, disease, parasites, and accidents (Heffelfinger 2006). Although most deer do not die directly from starvation, other agents of mortality can become important when deer are weakened due to malnutrition (Heffelfinger 2006). Hunting is the direct take of animals by humans; however, game laws attempt to prevent serious declines in deer populations due to over-kill (Heffelfinger 2006). Unfortunately, poaching (i.e., illegal take of deer and other animals) can adversely affect populations when it occurs (Heffelfinger 2006). Diseases and parasites tend to most seriously affect nutritionally deficient and stressed animals (e.g., during times of drought; Heffelfinger 2006). Collisions with motor vehicles do not seem to be a major source of mortality in deer populations in Arizona because high deer densities are usually not centered near commuter traffic (Heffelfinger 2006).

Deer populations are usually measured as density (i.e., deer/sq. mile). In the southwest deer densities do not usually exceed 15 deer per square mile; however, deer densities, as well as home range, can fluctuate because due to resource availability, time of year, and age and sex of animals (Heffelfinger 2006). Males tend to have larger home ranges than females, which tend to travel in groups (Heffelfinger 2006). Home ranges are generally larger in areas that are less productive (e.g., southwestern deserts; Heffelfinger 2006). Mule deer and white-tailed deer in the southwest make seasonal movements in response to food, cover, and water availability rather than true migrations (Clark 1953, Welch 1960, Rautenstrauch and Krausman 1989, Ordway and Krausman 1986).

Estimating deer density can be prohibitive because of the time and expense involved, and is usually done only on a small scale (Heffelfinger 2006). Indices of abundance (number of deer/unit effort) using standardized methods over time can be done more frequently and cost less than calculating density (Heffelfinger 2006). As with all scientific techniques, there are advantages and disadvantages with each type of survey methodology (Aldous 1956, Eberhardt and Van Etten 1956, Progulske and Duerre 1964, Van Etten and Bennett 1965, Lewis 1970, Mooty et al. 1984, DeYoung 1985, Pollock and Kendall 1987). Regardless of survey type, it is important for observers to be able to accurately distinguish between mule and white-tailed deer (Table 1).

Foot or horseback surveys are conducted on predetermined routes in deer habitat using binoculars or spotting scopes to record the number of deer observed. On the ground researchers are able to count and classify all animals, as well as assess field conditions (i.e., forage, water availability, deer concentrations, and behavior).

Driving surveys are conducted along roadways in a similar manner to walking/horseback surveys. Density can potentially be estimated with line transects using spotlights during driving surveys at night. Some disadvantages to walking/horseback and driving surveys is that they are time intensive, and driving surveys are restricted to roads.

Aerial surveys (i.e., helicopter and fixed-wing aircraft) have the advantage of being able to cover large areas in a relatively short amount of time and are particular good in areas of rough terrain. However, they can be dangerous, expensive, and make deer classification difficult. In addition, low-flying aircraft may be prohibited over designated Wilderness, as at Saguaro National Park.

Pellet plots are a relatively inexpensive method for determining deer abundance but because of the variability in defecation rates for deer they may not yield accurate indices.

Harvest data is important in the management of deer populations; however, it is illegal to hunt within national park boundaries so would not serve as a survey method for deer populations at Saguaro National Park (Heffelfinger 2006).

There has been concern that the number of mule deer at Saguaro National Park, Tucson, Arizona may be declining (personal communication, Natasha Kline). For this study, funded by the Western National Parks Association (Grant #06-06), I reviewed five major studies of deer at Saguaro National Park, two in the Rincon Mountain District and three in the Tucson Mountain District. I also report on information regarding 15 years of mule deer monitoring in Saguaro National Park's Rincon Mountain District (from 1961-1974). Most recently Saguaro National Park has conducted helicopter surveys (2000 to 2006) in conjunction with Arizona Game and Fish Department. I examined all these data and looked at overall short-term trends for mule and white-tailed deer in the park. Along with data from these studies, I included information about deer from other park records to help interpret fluctuating deer populations throughout Saguaro National Park's history. Based on this information, I make recommendations for long-term monitoring of deer at Saguaro National Park.

Rincon Mountain District

Saguaro National Park Internal Reports

All of these reports are found in NPS files at either Saguaro National Park (SNP) or the Western Archeological Conservation Center (WACC).

Annual wildlife reports (AWR) provided estimates for the deer population in the Rincon Mountain District of Saguaro National Park from 1939 to 1974, with the exception of 1952 to 1954, and 1966. Estimates ranged from 15 to 200 for white-tailed deer, and 15 to 330 for mule deer (Table 2). It is unclear how these estimates were derived until 1960 onward. During 1966-1974 for every individual deer observed opportunistically it was assumed there were 10 additional individuals not observed (Annual Wildlife Report for Saguaro National Monument 1960-1961). Although the annual wildlife reports as well as annual reports (AR), monthly reports (MR), and other reports were not of a strictly scientific nature they provide insight as to where deer were observed, general climatic conditions, range conditions, and competition with cattle over a broad time period of the park's history.

AWR 1939: Mule deer were "occasionally seen on lower part of monument during winter...and reported from higher areas...during summer." No white-tailed deer were observed in the monument "but some taken by hunters...at foot of Rincons east of monument."

Trip Report December 20, 1939 by Park Naturalist, Natt Dodge: "Disease and other factors unknown have greatly depleted...whitetail deer on the monument..."

Grazing Reconnaissance on the Saguaro National Monument March 30, 1940 by the Associate Wildlife Technician: "...only 12 deer were observed. I have ridden the

area...consistently...since 1925...it was nothing...to see twice that many deer. Without question lions have been taking a large number of the deer.”

AWR 1940 by D.W. Eggermayer: “Mule deer...frequently seen...at the lower elevations...no marked increase in recent years.” “White-tailed deer...are making a noticeable recovery from the low of two years ago reported by A.A. Nichol when so many were killed by disease or bad water...a marked increase in frequency of tracks and numbers...seen at the higher elevations between May 1 and September 15 of this year...”

November MR 1940: “Conversation with deer hunters off the monument indicates fewer deer being found in this section of the state...which...agrees...fewer deer...present on the monument than were here last fall.”

AWR 1941: “...it is thought that a slight decrease has occurred...because of an increase in number of cattle using area in which the mule deer were found previous to last January...” “A tremendous increase over last year’s population...The past winter brought unusually heavy rains, and water and food have been...plentiful...”

AWR 1942 by John Peavy: Mule deer “probably decreasing...An overabundance of rodents and rabbits area cutting down...available forage.” White-tailed deer “...probably decreasing...due to the fact that last year was an unusually good year and this year has been unusually dry.”

AWR 1943 by John Peavy: Mule deer “numbers not increasing...due to lack of food and water and...numerous predators.” White-tailed deer “specimens seen in Lower, Upper Sonoran and Transition zones...evidently numbers on decrease.”

February MR 1943 by John Peavy: “Several Mexican mule deer and white-tailed deer have been seen along the Loop.”

AWR 1946 by Don W. Egernmayer: White-tailed deer “very greatly decreased from population...noted in 1941. Tracks few, sign sparse” (Table 2).

AWR 1947 by Don W. Egernmayer: Mule deer “...tracks few all year...Feed poorest since 1938.” There were no white-tailed deer “fawns, or tracks, encountered...Water on Rincon Mts. almost nil for past 6 months” (May to September).

AR 1947: “...no Desert Mule Deer having been seen, or reported, within the cactus section of the monument since last September. A few white-tail deer are reported...but their numbers are so far below the population of pre-war years that it is estimated the present census would be less than 10 percent of the figure reported in 1941” (Table 2).

Special Report on the Wildlife of Saguaro National Monument June 11, 1947: “White-tailed deer “population estimated at over 75% does, most of which are barren.”

AWR 1948 by Samuel A. King: No mule deer fawns reported. White-tailed deer were found only in forested areas.

AWR 1949 by Samuel A. King: Mule deer and white-tailed deer in good condition.

AR 1949: “The sex ratio of both species of deer is below normal, especially among the Mexican Mule Deer...predators are not overly numerous...”

AR 1951: There was “a substantial increase in white-tailed deer...It is probable that previous census estimates were in error...Good deer forage is available throughout the area of the 1943 burn, which constitutes a major portion of their range.”

AR 1952 by the Superintendent, Saguaro National Monument: White-tailed deer “appear to be more numerous in both the Upper Sonoran and Transition Life

Zones....They appear to be utilizing available browse in the rougher sections of the Tanque Verde Mountains, not frequented by cattle.”

AWR 1955: “Improved browse and water conditions...are making the Monument an attractive habitat...” for mule deer. White-tailed deer “erroneously listed as common in 1953 report. Continued fringe hunting... has made serious inroads in the population.”

AWR 1956-1957: Mule deer “appear to be in excellent condition.” The same comments about browse and water appear in this report as they did in the 1955 report. There was “no apparent increase” in white-tailed deer and continued concern about fringe hunting.

AWR 1958-1959: Mule deer “...seem to be on the increase as browse conditions improve in the desert section.” There was “no apparent increase” in the white-tailed deer but some concern about fringe hunting, however, it was not affecting the population in the monument.

AWR 1960-1961: “There seems to be a distinct low reproduction as compared to similar areas outside the Monument” for mule deer. “The white-tailed deer range within the Monument is believed to consist of about 38,400 acres. The greatest concentration seems to be in the Spudrock Cabin area where past burns have brought about an abundant food supply.”

AWR 1962 by Leslie W. Cammack: The “earlier report on the white-tail deer was based primarily on the formula given...by the Arizona State Game and Fish biologist...however, because of the more or less gregarious nature of the species, and the heavy concentration in certain given areas, we have chosen to decrease the original estimate considerable to conform more closely with past records” (Table 2).

AWR 1963 by Chief Park Ranger: Mule deer “inhabit the desert floor and adjacent foothills up to...5,000 feet...must share the higher, semi-desert foothill country with livestock. This probably results in considerable forage competition throughout the better part of their range...” “White-tailed deer range is restricted to...higher elevations...the bulk of the population...inhabits the timber and brushlands above 6,000 feet...range is also intensively grazed by cattle...”

July MR 1964 by Acting Superintendent, Saguaro: “Due to dry weather...some of the larger mammals began frequenting the water hole at the Visitor Center...Several observations were made of mule deer....Foust observed two whitetail deer at a low elevation of 4,500 feet near a water tank.”

Mammal Notes January 1966 by Barbara Lund: Superintendent Giles observed “...three whitetail deer...on the Cactus Forest Drive between stops 4 and 5. This is a low elevation, about 3,200 feet, for this species.”

The overall trend in the park is that white-tailed deer inhabit the upper elevations of the park, however, they are known to move to lower elevations when range conditions are poor or they are in search of water. Mule deer tend to remain in the lower elevations of the park and have been frequently observed by visitors and park staff drinking from the water hole behind the Visitor’s Center, and from sources in park neighbors’ yards (Bellantoni 1991). Seasonal and annual rainfall are both important to deer populations. Evidence indicates that rainfall can cause dramatic increases and decreases in the deer population in the park. The other main factors apparently affecting deer populations throughout the park’s history were competition for forage with cattle and hunting along the park boundary.

Sumner Study

From January to February 1951 Lowell Sumner (1951) examined predator/prey relationships at Saguaro National Monument to provide information to support including Saguaro National Monument into the Rincon-Tanque Verde Mountain Game Management Unit (GMU). He conducted intensive track surveys in the upper elevations for ~21 days and spent the remaining portion surveying the lower elevations. He found that white-tailed deer were concentrated above 7,000 feet, mainly from Cowhead Saddle to Mica Mountain and in smaller numbers towards Rincon Peak. He estimated 80 white-tailed deer in the park. Sumner felt that the white-tailed deer population was low and they were restricted to the higher elevations because drought conditions reduced the quality of forage at the lower elevations. Sumner found that mule deer were mainly found below 5,000 feet; however, because of the lack of snow in which to count tracks he was not able to provide an estimate for the population in the park. He felt there were fewer mule deer per acre than white-tailed deer but overall there were more mule deer in the park because there were more acres of low desert and foothills. He could not determine whether the mule deer population was stable or decreasing. He felt the range could support more deer, however, he also noted cattle were heavily grazing Happy Valley and Rincon Valley.

Day Study

As part of a study by Gerald Day (1977), to determine if there was a correlation between climate and javelina (*Pecari tajacu*) range, 15 years (1961-1974) of data on deer at Saguaro National Park were collected during his javelina surveys in the Rincon

Mountains (SNP files). Species of deer, along with number of bucks, does, fawns, and unknown individuals were counted (Table 3 and 4) using binoculars along 18 specified survey routes (Table 5) which covered much of the lower elevations. Surveys were conducted in November, December, or January (Table 3 and 4) from sunrise to ~1000 hours by walking along established routes that were no more than four air miles long and at least one air mile apart. Mule deer numbers fluctuated dramatically in the 15 years the surveys were conducted (Figure 1). Mule deer numbers were lowest in 1969 with 52 individuals counted during the survey, and highest in 1970 with 132 individuals counted (Figure 1 and Table 3). Buck/doe ratios varied from a low of 0.11 in 1972 to a high in February 1961 of 1.40 (Figure 1 and Table 3). Because Day's surveys were not in prime white-tailed deer habitat, the numbers of white-tailed deer counted were very low to non-existent. No white-tailed deer were observed from 1962 to 1966 or from 1971 to 1973 (Table 4). The highest number of white-tailed deer counted was in February 1961 with eight deer observed during the survey (Table 4).

Other Studies

Nocturnal Rodent Survey

As part of a nocturnal rodent survey conducted by park staff from December 1964 to July 1966 on Cactus Forest Drive, all wildlife species were recorded, including mule deer (Figure 2). Numbers of mule deer observed ranged from a low of 0 in August 1965 to a high of 45 in May 1965 (NPS files; Daily Sight Record, Nocturnal Data December 1964 to July 1966).

Douglas Gilbert (Colorado State University)

Douglas Gilbert from Colorado State University proposed to study the ecology of mule and white-tailed deer in 1968 at Saguaro National Monument. He wanted to study population dynamics; competition for food, water, and space between individual deer and between deer species, and with other animals; determine movements and distribution; and examine the effects of fire and plant succession on population size for each species (NPS files; letter to Douglas Gilbert from Stanley Broman September 26, 1968). On April 17, 1969 a letter was sent from Warren Steenbergh questioning whether to proceed with the study for three reasons: it did not set out to answer specific management problems, it was designed to remove one white-tailed deer/year from the population, and it did not involve working with the Cooperative Wildlife Research Unit. Harold Jones further felt that the park could not house the research staff and that the money, if funded, would go further not having to pay for the costs of transportation if the study was done by the Cooperative Wildlife Research Unit (NPS files; letter to the Regional Director, April 18, 1970). There is no evidence or reports to indicate the study occurred.

William Cooper (Park Technician-Naturalist)

William Cooper, Park Technician-Naturalist, conducted a track census in the Rincon Mountains to estimate the population of white-tailed deer from 11-13 March 1970 in a similar manner as the survey conducted by Lowell Sumner in 1951 (NPS files; Natural Sciences Resource Studies Problem December 13, 1969). Cooper surveyed 29 linear miles, 13 of them above 7,000 feet, which were assumed to be in white-tailed deer habitat. He found 26 sets of deer tracks on approximately four miles of trail surveyed

above 7,000 feet. Below 7,000 feet he found numerous sign of mule deer but did not give any numerical data on the tracks or sign observed (White-tailed deer track census Saguaro National Park, 1970).

Bob Barsch (University of Arizona)

In 1974 Bob Barsch visited the park to determine whether data could be collected on the value of burned areas to white-tailed deer. He visited the east slope of Mica Mountain, where a 600-acre burn occurred during the summer of 1972, but determined it to be unusable for his study because of the inaccessibility, the variety of vegetation types not corresponding to unburned vegetation types, and lack of permanent water in a control area. During his visit he saw seven white-tailed deer on the burn and two in the “oak woods” adjacent to the burned area (NPS files; letter to Dr. Roger Hungerford, 2 February 1974).

Douglas Duncan, University of Arizona Mammalogy Project

Douglas Duncan (1986) conducted a study to obtain an index of deer numbers along the western boundary of the park and to determine movement of deer across the western park boundary in August to September 1986. He used pellet plot transects to estimate the number of deer along the western boundary and track plots placed in washes, along game trails, and gates to determine movement into and out of the park. Duncan estimated that there were 49 deer/mile² in the northwest corner and 85 deer/mile² in the southwest corner. He felt these estimates were extremely high because of the short time period of the study, the small area surveyed, plot size, and pellet group distribution. He

found <1 deer track/10 days crossing into and out of the park, however, Duncan also noted that deer commonly crossed the boundary fence at places where he did not place track plots.

Bellantoni and Krausman Study

A study on habitat use by desert mule deer and javelina was conducted in the Rincon Mountain District of Saguaro National Park from February 1988 to September 1989 by University of Arizona graduate student Elizabeth Bellantoni (1991). An official report for the study was submitted to the National Park Service (Bellantoni and Krausman 1991). The objectives of the study, in relation to mule deer and Saguaro National Park, were to:

1. describe movements for mule deer along the monument boundaries and adjacent private lands.
2. describe habitat use in regard to sex, season, activity, vegetation association, aspect, slope class, and slope position

Bellantoni (1991) radio-collared 10 mule deer (five males and five females) that were located 596 times. Her major results were:

Movement: There was individual variation in movements of mule deer into and out of the park during different times of the year and different times of day.

Home range: Both males and females increased their home range sizes during late summer (16 July to 31 October).

Habitat use: Females used available vegetation associations differently during spring (1 February to 30 April), early summer (1 May to 15 July), and late summer; and males used available vegetation associations differently for all seasons (Table 6).

Activity and use of vegetation associations: Foraging and bedded observations made up 51% and 25%, respectively, of all observations reported. Use of vegetation associations for foraging and bedding did not differ between sexes. Foraging use of available vegetation associations differed for females during early and late summer and differed during all seasons for males (Table 7). Bedding use of available vegetation associations differed from availability for females during early summer and differed during all seasons for males (Table 8).

Seasonal use of aspect: Use of aspect did not differ between sexes during any season. During late summer males and females used north slopes more often and level ground less often than available. Females did not use east slopes in winter (1 November to 31 January). Males used south slopes less often in spring and late summer and west slopes less often in winter than available.

Activity and use of aspect: Use of aspect for foraging and bedding did not differ between sexes. Females did not forage on east slopes during winter or south slopes during spring, early summer, and winter. Males did not forage on east slopes during early and late summer or west slopes during winter. Females did not bed on east or west slopes in spring, north or south slopes during early summer, or east slopes in winter. They bedded on north slopes more often in late summer and flat ground less often than available. Males did not bed on south slopes in spring, east or south slopes in early

summer, and only bedded on flat ground during winter. They also bedded on flat ground less often than available during late summer.

Seasonal use of slope and slope position: Use of slope did not differ between sexes during any seasons. Females did not use steep slopes (>40%) during early summer and males did not use steep slopes during spring and winter. Both males and females used available moderately steep slopes (10-40%) more often in late summer and available less steep slopes (<10%) less often. Use of slope position differed between sexes during late summer. Females did not use the top of slope during spring and ridgelines during early summer and winter. Males did not use ridgelines during late summer and winter. Both sexes used available mid-slopes more often in late summer and available flats/benches less often.

Activity and use of slope and slope position: Use of slope did not differ between sexes during any season for foraging or bedding. Females did not forage on steep slopes during spring, early and late summer. Males did not forage on steep slopes. Males foraged on available moderately steep slopes more often in spring and late summer. They also foraged on available less steep slopes less often in late summer. Females did not bed on steep slopes and males did not bed on steep slopes in spring, early summer, and winter. Both males and females used available moderately steep slopes (10-40%) more often in late summer and available less steep slopes (<10%) less often for bedding. Males solely bedded on less steep slopes in winter. Use of slope position for foraging and bedding did not differ between sexes during any season. Females did not forage on the tops of slopes during spring or ridgelines during early summer and winter. They foraged less often on available flats/benches in late summer. Males did not forage on

tops of slopes during early summer and winter or on ridgelines during late summer and winter. They foraged more often on available mid-slope during late summer. Females did not bed on tops of slopes during spring or ridgelines during early summer and winter. They bedded less often on available flats/benches during late summer. Males did not bed on mid-slope during winter, tops of slope during early summer, or ridgelines during spring, late summer, and winter. They bedded on available mid-slope more often and less on available flats/benches.

Two other papers (DelGiudice et al. 1989, DelGiudice et al. 1990) were published as a result of capturing deer during Bellantoni's (1991) study.

Helicopter Surveys

In 1989 the first helicopter survey for deer was conducted in the park in conjunction with the Arizona Game and Fish Department. Helicopter surveys for deer resumed in 2000 and have continued through 2006 in conjunction with Arizona Game and Fish Department (Figures 3-7; Arizona Game and Fish Department only had maps for 2001-2004 and 2006). Surveys for deer were conducted to compare deer populations in the park between years as well as to compare populations adjacent to the park, in Arizona Game and Fish Department Game Management Unit 33 (GMU 33), by comparing bucks/100 doe and fawns/100 doe ratios (i.e., standardized ratios, used by Arizona Game and Fish, to compare deer populations across different areas). Provided survey routes are similar on a yearly basis, some comparisons can be made. However, the helicopter surveys should be used to indicate trend data rather than statistically significant population data.

Surveys were flown in the mornings when deer activity was highest and the angle of the sun low (Heffelfinger 2006). Surveys began between 0800 and 0840 hours and lasted between 1.3 and 1.9 hours (Table 9). Survey routes were similar from 2000 to 2006 (Figures 3-7). Surveys were conducted in the winter (Table 9) at the peak of breeding season while bucks still had antlers and the fawns were still small. Observers recorded weather conditions, names of the observers, method of survey (in this instance helicopter survey), odometer readings at the start and finish of the survey, and time the survey began and ended. Numbers of individual deer (as well as javelina) along with demographic information [bucks, does, fawns, or unknown (i.e. could not be classified)] were recorded on data sheets provided by the Arizona Game and Fish Department and locations noted with a Global Positioning System. Other information, such as the number of antler points, vegetation, size of the animal, predators, etc., was noted in the remarks column.

Deer observations were low for both mule and white-tailed deer in the park compared to 1989 (Tables 10 and 11); however, mule deer numbers were notably lower from 2000 to 2006 than 1989 (Table 10). Mule deer numbers fluctuated from 2000 to 2006 (Figure 8). There was an increase from 2000 to 2002, a decline until 2005, and an increase in 2006 (Figure 8). Mule deer numbers were lowest in 2000 with no deer being observed during the survey and highest in 2002 but only 12 individuals were observed (Figure 8 and Table 10). Buck/doe ratios, which ideally would equal 1.00, varied from a low of 0.00 in 2003 when no bucks were observed, to a high in 2006 of 0.67 (Table 10). Overall there has been a steady increase in the number of white-tailed deer from 2000 to 2006 (Figure 9 and Table 11). In 2005 there was a slight decrease but numbers increased

to the highest number recorded (49) in 2006 (Figure 9 and Table 11). From 2000 to 2006 white-tailed deer numbers were lowest in 2000 with only eight deer being observed during the survey (Figure 9 and Table 11). Buck/doe ratios varied from a low of 0.35 in 2002 to a high in 2000 of 1.67 (Table 11). Variability among years could reflect differences during the flight (e.g., observer bias), flight routes, and length of flights; however, the routes and lengths of flights were similar (Figures 3-7).

The number of bucks/100 does (i.e., a standard used by Arizona Game and Fish to compare different areas) were consistently higher for both mule and white-tailed deer in the park than in GMU 33 (Table 12 and 13). There was greater variability in methodologies to derive population estimates between the park and GMU33 because various methods of counting deer were used in GMU33 (i.e., ground surveys, fixed-wing aerial surveys, as well as helicopter surveys). However, deer populations within park boundaries are not hunted nor under competitive pressure by cattle grazing, and this could account for higher numbers as well.

Tucson Mountain District

Unlike the Rincon Mountain District, there are few records of deer in monthly and other miscellaneous reports in park files. There were two major studies concerning deer from the early 1950's before part of Tucson Mountain Park was officially established as the Tucson Mountain District of Saguaro National Park (see below) and one study in the early 1990's. There is only a single record of white-tailed deer having occurred in Tucson Mountain District at the seep in under the catchment dam in Kings Canyon.

Transcript of Taped Conversation (NPS files) with Mr. C.B. Brown, June 5, 1970:

“Oh, no, mule deer was the only deer that was ever in there until the white tails were introduced. Then, of course in the Thirties we introduced the Kaibab mule deer. There was only about....we estimated 25 head of mule deer in the area when we started the Park idea.”

However, white-tailed deer may have been present in the Tucson Mountains before 1970 (Brown and Henry 1981).

A proposal was made by the United States Department of the Interior National Park Service State Park Division to build dams, walls, a museum, trails etc. in Tucson Mountain Park in 1936 because the park was important for providing “...refuge for the rapidly diminishing forms of interesting desert animal life, such as mule deer...” (Camp Application).

In October 1936 it was proposed to erect 1-2 windmills to pump water from mineshafts for wildlife. A. Borell concluded that Tucson Mountain Park served as an important wildlife refuge. During his two-day visit he noted four mule deer (NPS files; Technical Comment from A.E. Borell, October 15, 1936).

In early 1938 a wildlife count was conducted at Tucson Mountain Park. Unfortunately no information was found on the number or locations of deer counted (NPS files; letter from Cecil Clark to Herbert Maier on February 3, 1938).

On June 5, 1970 a taped conversation with Mr. Brown C.B., “Father” of the Tucson Mountain Park (NPS files), revealed that he once counted about 1,000 deer in the Tucson Mountains with the CCC perhaps in the late 1920’s or early 1930’s. Brown also

stated that he “can’t even find deer out there on hiking trips and you never see one along the road anymore.” In the Mam-A-Gah area he noted that the game population “...has been down” over the last 10 years.

Clark Study

A study of the behavior and movements of mule deer was conducted in the Tucson Mountains from January 1952 to January 1953 (Clark 1953). The objectives of the study were:

1. to study the behavior and movements of a mule deer herd in southwestern Arizona
2. to compile data on life history and ecology of mule deer

Clark observed deer throughout the year from daylight to 1000 hours and from 1700 hours until dark by stalking, observations at water holes, and observation points where large areas could be observed. Clark’s (1953) major results were:

Description of Deer:

Taxonomy: In 1931 two bucks and five does were transplanted from Kaibab because it was estimated that 25 mule deer remained in Tucson Mountain Park because of overgrazing and hunting prior to 1929. Clark considered the deer herd in the Tucson Mountains to be genetically influenced by the northern subspecies *Odocoileus hemionus hemionus*.

Physical Characteristics:

- **Size:** Data was collected from the special hunt from 6-9 November 1952.
The average weight of mule deer was 118 pounds, average hind foot length 18.6 inches, average ear length 8.3 inches, and average tail length 7.4 inches.
- **Physical Condition:** Sight records from 1952 showed that condition was lowest in the summer and improved in the fall.
- **Antlers:** Antler development and shedding occurred later in the Tucson Mountains than other areas. Clark noted relatively high numbers of deformed antlers, however, he also believed that among the male population in the Tucson Mountains there were record numbers of trophy mounting animals.
- **Pelage:** Pelage coloration varied with season and age. Molt occurred in the spring and fall.
- **Voice:** There were three main call types, a bark, a snort, and a bleat. The bark and snort were warning calls to other deer and the bleat was a call between does and their fawns.
- **Senses:** The deer depended on scent, hearing, and sight, respectively according to importance.

Abnormalities: Ten abnormalities were observed with split ears being the most numerous followed by bobtails and deformed antlers.

Herd Composition: Throughout the year buck:doe varied because of behaviors inherent to the sexes.

Yearly Cycle:

Rut: The rut occurred from mid-December to mid-March and peaked in the beginning of February. Large bucks were the main breeders commencing the rut with young males entering the rut later. Breeding groups averaged 7.5 individuals (1 buck, 4.8 does, and 1.7 young).

Gestation: The first signs of pregnancy were noted in late June. Seventy-five percent of the Tucson Mountain deer were observed to be pregnant. The minimum breeding age was 18 months and fawning age two years.

Fawning: The first fawning observation was mid-July. Fawning occurred from mid-July to early October and peaked in early August. Females with fawns remained within ½ mile of water. Medium density vegetation on northern slopes in medium elevation saddles and ridges provided shade for bedding during the hottest part of the day.

Antler drop and development: Males shed their antlers from late March to mid-April (after the end of the rut) except in extraordinary cases. Older males were the first to shed their antlers while younger males shed them 15 to 20 days later. Antler growth began during early May (occurring first in older males), full growth was reached in late August, and velvet shedding started in late September and ended by late October.

Behavior:

Bucks: Following the breeding season adult males gathered in groups of 2-4 individuals. Older males became very secretive after shedding their antlers; spending most of the time bedded down in the best available cover and drinking and feeding only during darkness. As antler growth progressed, older males fed, watered, and bedded with

groups of females until fawning. Younger males joined female groups after shedding their antlers and remained until fawning when they formed groups of their own or joined groups of older males. After antler growth ended males were seen bedded and exposing antlers to the sun and spent time polishing their antlers when they started to shed velvet. In mid-November most males developed swollen necks indicating the beginning of the breeding season. By early December male groups disbanded and males started moving long distances. Males spent much time gathering females into harems until they became cooperative as the rut advanced. Harems intermingled while feeding provided the male showed no interest in a particular female. If the male showed interest in a female no other individual (including females of the group) would be tolerated near them. During the rut males lost body condition because of constant combat and efforts needed gather and guard females.

Does: Following the breeding season females gathered in groups of 4-8 individuals including fawns from the previous year. During late pregnancy females remained within $\frac{1}{2}$ mile of water and drank throughout the day. They moved slowly and only moved faster than a walk when severely startled but would move only a few hundred feet. Females left their groups and previous year's fawns going into seclusion during fawning. Females used a variety of cover from dense mesquite thickets to open ridges mostly on northern slopes to fawn but were always within $\frac{1}{4}$ mile of water. Females gathered in groups when fawns could move with their mothers. During pregnancy and fawning females lost body condition but regained it within a few weeks of weaning their fawns. At the beginning of breeding season females were uncooperative to male attempts to form harems but became more cooperative after constant herding.

Fawns: Fawns were hidden for 2-3 days after birth then remained with their mothers only being hidden when the mother went to a drinking hole. At 2-3 weeks they ate green forage but continued to nurse until their first juvenile molt.

Cooperation: Cooperative behaviors that occurred were warning calls, same sex deer scratching one another, an individual acting as a rear guard to the herd, baby sitting of numerous fawns by a single female, and scouting of an area for possible danger by a young male for older males.

Reactions: Deer and javelina fed and bedded near each other without aggression, however, at waterholes javelina were the dominant animal. Deer had a range of reactions to humans from indifference to immediate flight.

Erratic Behavior: Behaviors described as erratic were males mounting other deer year round, deer urinating on the “heel or tarsal gland while rubbing the hocks together in quick, short strokes,” and touching another individual of the same sex with their noses.

Movements:

Summer movements: Movement during the summer was influenced by water. When a waterhole dried up deer, albeit reluctantly, moved to an available water source but returned to the original watering area when the summer rains refilled it.

Man-caused movements: Deer moved into Tucson Mountain Park during the special hunt of 6-9 November 1952, however, returned to their original range after the hunt some weeks later.

Rutting movements: During early December males extended their movements in search of females but returned to a limited range after forming harems.

Daily activity: Deer spent 50% of their time feeding and bedding during the summer, feeding in daylight until the heat of the day and bedding in the shade until late afternoon or early evening. During the winter deer spent 60% of their time feeding, mostly during the day and 40% of their time bedded down. Watering took less than 15 minutes and deer drank during darkness during the summer and required little free water during winter. Rutting activities accounted for 25% of daily movement during the breeding season.

Home range:

- Yearly: Mean home range was 4.5 square miles (range 1.3-9.3 square miles).
The maximum movement occurred during the rutting season.
- Daily: Deer moved close to five miles during the winter but moved less than one mile and remained close to water during the summer. During the summer deer moved to washes and on cold days they moved to low ridges and south facing slopes.

Movements into and out of the study area: Few deer moved in or out of the Tucson Mountains because of barriers (i.e. highways, agricultural land, fences, homes).

Food and Water:

Forage utilization: Jojoba (*Simmondsia chinensis*) was used heavily year round. Cholla (*Opuntia sp.*) and prickly pear (*Opuntia engelmannii*) fruits were used during the summer and annuals during the winter.

Water utilization: During winter deer went days without water, however, free water requirements increased during spring and summer. Except for late term pregnant

females, drinking occurred from daylight to sunrise and from sunset to dark. Deer drank an average of 6.1 quarts and spent an average of 167 seconds drinking.

Decimating Factors:

Predators: Predators in the Tucson Mountains included coyotes (*Canis latrans*), bobcats (*Lynx rufus*), domestic dogs (*Canis familiaris*), and mountain lions (*Puma concolor*).

Accidents: Four deer were killed on the highway, three fell into mineshafts or steep embankments, and two were tangled in wire fences.

Diseases: There was no evidence of mortality due to disease or parasites.

Illegal kill: There was evidence (i.e. hides, deer that had been shot, heads, etc.) that the number of deer illegally killed exceeded the number of deer legally killed during 1952 hunt in the Tucson Mountains.

Elder Study

A study of water holes by wildlife was conducted in the Tucson Mountains from June 1951 to January 1953 with most of the work being conducted from January 1952 to February 1953 (Elder 1953).

The objectives of the study were:

1. to determine species using man-made tanks
2. to determine if species using the tanks were dependent on the tanks for their water requirements
3. to study behavior at the tanks

Two water holes were observed during the study, Cam Boh (R12E, T13S, Section 7) and Deer Trap (R11E, T13S, Section 34). Daytime and nighttime observations were made at a distance of 200 feet of the tank. A circular three-foot track lane was placed 75 yards from Deer Trap to determine a daily record of use by deer and javelina. Elder's (1953) major results in relation to mule deer were:

Behavior: Most observations were recorded at Deer Trap in the spring and summer of 1952 and only a few observations were made at Cam Boh tank in late summer and early fall of 1951. Deer rarely drank alone and usually came in groups (same or mixed sex), however, groups showed no sign of organization and there were few instances of aggressive behavior towards one another. Individual variation in the way deer approached and drank were recorded, with some deer being bold and unconcerned while others easily frightened. Deer tended to be less sensitive and easily frightened in large groups than when alone or in groups of 2-3. It was noted that during the rainy season few deer approached the tank and when they did they were easily startled while during hot dry weather deer became bolder when approaching and drinking from the tank. On moonless nights deer were more nervous to drink than during daylight and moonlit nights. Males emitted a snort followed by them pawing the ground alarmed. At waterholes javelina were yielded to as well as bobcats, but gray foxes (*Urocyon cinereoargenteus*) were ignored.

Daily and seasonal patterns of waterhole use: Mule deer drank mainly at night, from sunset until midnight and an hour before dawn to shortly after dawn except during the summer when they arrived earlier in the evening and remained longer after sunrise. Deer drank erratically during the daylight hours. Use of the tanks was minimal from

February to April and increased from May to June peaking in July. They almost never drank from tanks in August but resumed again in September to October and decreased use in November to December.

Kline, Swann, and Hubbard Study

A study to monitor wildlife use of two water catchments (Red Hills catchment and Dobe House catchment) using infrared-triggered cameras was conducted in the Tucson Mountain District, Saguaro National Park from 1989-1993 (Kline et al. 1998).

The objectives of the study (in relation to deer) were:

1. to describe wildlife use at each catchment
2. describe diurnal and seasonal differences in wildlife use at each catchment
3. determine if the presence of a fence, or shared use of the catchments by horses and humans has an effect on wildlife use of these areas

There were 451 visits by mule deer to the Dobe House catchment and 88 visits to the Red Hills catchment from November 1989 to September 1993. Mule deer showed a bimodal visitation pattern, mainly visiting from pre-dawn to early morning and late in the afternoon. Seasonal visitation, also, showed a bimodal pattern with deer visiting catchments mainly from June through September and from November through January, except in 1992 when peak visitation occurred from May through June and September through November. After the fence was removed from the Red Hills site in 1992 deer use remained low indicating the fence was not a deterrent.

Helicopter Survey

In 2006 the first helicopter survey for deer was conducted in the Tucson Mountain District of Saguaro National Park in conjunction with the Arizona Game and Fish Department (NPS files; Figure 10). The survey was flown in the morning when deer activity was highest and the angle of the sun was low (Heffelfinger 2006). The survey began between 0805 hours, lasted for 2.0 hours. The survey was conducted on 20 January 2006 during winter at the peak of breeding season while the bucks still had antlers and the fawns were still small. Observers recorded weather conditions, names of the observers, method of survey (in this instance helicopter survey), odometer readings at the start and finish of the survey, and time the survey began and ended. Numbers of individual deer along with demographic information [bucks, does, fawns, or unknown (i.e. could not be classified)] were recorded on data sheets provided by the Arizona Game and Fish Department and locations noted with a Global Positioning System. Other information such as the number of antler points, vegetation, size of the animal, predators, etc. was noted in the remarks column. Sixteen mule deer were counted in 2006, six bucks, six does, and four fawns. The buck/doe ratio was 1.00. No white-tailed deer were observed.

Conclusions

During nearly three quarters of a century Saguaro National Park has recognized the importance of long-term monitoring trends for deer. Initiation of helicopter surveys and a meeting with Gerald Day in early 2007, to reestablish his survey routes and protocol, shows that the park is making a commitment to determine an index of

abundance that can be used to track long-term. Over its history the park has failed to recognize previous efforts and has never developed a consistent monitoring program.

In the late 1960's it was recommended by Douglas Gilbert from Colorado State University to study the ecology of white-tailed deer in the park. I support this idea. Saguaro's white-tailed deer population is unique in that it is under no pressure from hunting and the park acts like an outdoor laboratory. With easier access into the high country (i.e. pack mules and helicopters) and exceptional modern technology (i.e. Global Positioning Collars) studying white-tailed deer movements, life history, response to plant succession from fire, and competition with mule deer could not be more opportune. Potentially the Desert Southwest Cooperative Ecosystem Studies Unit may be interested in funding this project.

I believe that continuing the helicopter surveys for tracking trends would be beneficial in determining long-term trends. Currently these surveys have provided beneficial baseline data for the status of deer populations, and also, has the added benefit of establishing a good working relationship with the Arizona Game and Fish Department. Although people may be disturbed by noises in national parks (Mace et al. 2004), Krausman et al. (2004) found that desert ungulates were not affected by aircraft noise in the same way as humans. Furthermore, noise disturbance from a helicopter during deer surveys is probably minimal because they are so infrequent (currently once/year). It has been suggested that surveys be done on alternating years for Rincon Mountain District and Tucson Mountain District (Arizona Game and Fish Department, Summary Report 2003). Depending on cost, the time period between surveys could be extended, for

instance, every 2 to 3 years/district. The main goal is to obtain information on deer in a similar manner during each survey to track long-term trends.

Along with the helicopter surveys it would be ideal to repeat Day's surveys to the best of the park's ability. Reestablishing his routes would make his 15 years of data comparable to the data that could be collected. Also, because there seems to be some question as to the effectiveness of surveying mule deer by helicopter, using a different method may help clarify the status of the population in the park. There is concern that the population is on the decline and numbers from the past seven years in comparison to the survey done in 1989 indicate a declining trend. It would be prudent to rule out a survey bias before making conclusions about the overall status of the population. Trained volunteers could potentially do ground surveys, thereby, keeping cost down. Deer are large mammals that can be exciting to watch and encourage people to want to become involved. Furthermore, ground surveys also provide an opportunity to start tracking all animals observed so that trend data can be collected for many species.

Over the course of the park's history it has been important to try to estimate the status of the population of deer as evidenced by the annual wildlife reports. Many attempts have been made at estimating numbers (Sumner, Gilbert, Cooper). Unfortunately, with the exception of Sumner (1951), the attempts have not adhered to a standardized methodology. By conducting systematic surveys over time a clearer picture of deer populations will arise. It is difficult to know whether the populations are experiencing a downswing in their cycle or if the population is in danger of becoming locally extinct. Drought and poor range conditions have been purported to affect deer populations in the park throughout its history. Long-term trends correlated to climate

data collected by the park could be helpful in understanding how deer populations operate.

It is my recommendation to continue the helicopter surveys in a manner that is cost effective for the park. I also recommend that Day's survey routes be reestablished to survey for mule deer especially. It is unfortunate that there is no other baseline data on deer for Tucson Mountain District other than that collected during the helicopter survey for 2006. Continued helicopter surveys for deer at Tucson Mountain District will help establish a baseline to work from.

Literature Cited

- Aldous, C.M. 1956. Conducting deer studies with the use of a helicopter. *Journal of Wildlife Management* 20:327-328.
- Anderson, A. E. and O. C. Wallmo. 1984. *Odocoileus hemionus*. Mammalian Species Special Publication No. 219. American Society of Mammalogists.
- Anthony, R. and N. S. Smith. 1977. Ecological relationships between mule deer and white-tailed deer in southeastern Arizona. *Ecological Monographs* 47:255-277.
- Bellantoni, E. S. 1991. Habitat use by desert mule deer and collared peccary in an urban environment. Master's Thesis, University of Arizona, Tucson, Arizona.
- Bellantoni, E.S. and P.R. Krausman. 1991. Habitat use by desert mule deer and collared peccary in an urban environment, 39 p. Tech. Report #42.
- Brown, D. E. and R. S. Henry. 1981. On relict occurrences of white-tailed deer within the Sonoran Desert in Arizona. *Southwestern Naturalist* 26:147-152.
- Clark, E. D. 1953. A study of the behavior and movements of the Tucson Mountain mule deer. Master's Thesis, University of Arizona, Tucson, Arizona.
- Day, G.I. 1977. Climate and its relationship to survival of young javelina. Federal Aid in Wildlife Restoration Project W-78-R. Arizona Game and Fish Department. Phoenix, AZ 12pp.
- DelGiudice G.D., P.R. Krausman, E.S. Bellantoni, R.C. Etchberger, and U.S. Seal. 1989. Reversal by tolazoline hydrochloride of xylazine hydrochloride-ketamine hydrochloride immobilizations in free-ranging desert mule deer. *Journal of Wildlife Diseases* 25:347-352.

- DelGiudice G.D., P.R. Krausman, E.S. Bellantoni, M.C. Wallace, R.C. Etchberger, and U.S. Seal. 1990. Blood and urinary profiles of free-ranging desert mule deer in Arizona. *Journal of Wildlife Diseases* 26:83-89.
- DeYoung, C.A. 1985. Accuracy of helicopter surveys of deer in south Texas. *Wildlife Society Bulletin* 13:146-148.
- Duncan, D.K. 1986. Deer and javelina along Rincon Mountain Unit's western boundary. In-house report to Saguaro National Park. 9pp + figures.
- Eberhardt, L.L. and R.C. Van Etten. 1956. Evaluation of the pellet-group count as a deer census method. *Journal of Wildlife Management* 20:70-74.
- Elder, J. B. 1953. Utilization of man-made waterholes by wildlife in southern Arizona. Master's Thesis, University of Arizona, Tucson, Arizona.
- Heffelfinger, J. 2006. Deer of the southwest. A complete guide to the natural history, biology, and management of southwestern mule deer and whit-tailed deer. Texas A&M University Press. College Station, Texas.
- Hoffmeister, D. F. 1962. The kinds of deer, *Odocoileus*, in Arizona. *American Midland Naturalist* 67:45-64.
- Hoffmeister, D. F. 1986. Mammals of Arizona. University of Arizona and Arizona Game and Fish Department, Tucson, Arizona.
- Kline, N.C., D.E. Swann, and T. Hubbard. 1998. Results of wildlife monitoring at two water catchments in the Tucson Mountain District of Saguaro National Park from 1989-1993. Intra-Agency Agreement Report 7-AA-05720 between U.S. Bureau of Reclamation and National Park Service, 45 p.

- Krausman, P.R., L.K. Harris, C.T. Blasch, K.K.G. Koenen, and J. Francine. 2004. Effects of military operations on behavior and hearing of endangered Sonoran pronghorn. *Wildlife Monographs* 157:1-41.
- Lewis, J.C. 1970. Wildlife census methods: a resume. *Journal of Wildlife Diseases* 6:356-364.
- Mace, B.L., P.A. Bell, and R.J. Loomis. 2004. Visibility and natural quiet in national parks and wilderness areas-Psychological considerations. *Environment and Behavior* 36:5-31.
- Mooty, J.J., P.D. Karns, and D.M. Heisley. 1984. The relationship between white-tailed deer track counts and pellet group surveys. *Journal of Wildlife Management* 48:275-279.
- Ockenfels, R. A., D. E. Brooks, and C. H. Lewis. 1991. General ecology of Coues white-tailed deer in the Santa Rita Mountains. Technical Report No.6. Arizona Game and Fish Department, Phoenix, Arizona.
- Ordway, L. L. and P. R. Krausman. 1986. Habitat use by desert mule deer. *Journal of Wildlife Management* 50:677-683.
- Pollock, K.H. and W.H. Kendall. 1987. Visibility bias in aerial surveys: a review of estimation procedures. *Journal of Wildlife Management* 51:502-510.
- Progulske, D.R. and D.C. Duerre. 1964. Factors influencing spotlighting counts of deer. *Journal of Wildlife Management* 28:27-34.
- Rautenstrauch, K. R. and P. R. Krausman. 1989. Influence of water availability and rainfall on movements of desert mule deer. *Journal of Mammalogy* 70:197-201.

- Rodgers, K. J. 1977. Seasonal movement of mule deer on the Santa Rita Experimental Range. Master's Thesis, University of Arizona, Tucson, Arizona.
- Smith, W. P. 1991. *Odocoileus virginianus*. Mammalian Species Special Publication No. 388. American Society of Mammalogists.
- Sumner, L. 1951. A biological survey of Saguaro National Monument. NPS In-house report. 50 p.
- Truett, J. C. 1971. Ecology of the desert mule deer, *Odocoileus hemionus crooki* Mearns, in southeastern Arizona. Ph.D. Dissertation, University of Arizona, Tucson, Arizona.
- Van Etten, R.C. and C.L. Bennett Jr. 1965. Some sources of error in using pellet-group counts for censusing deer. *Journal of Wildlife Management* 29:723-729.
- Welch, J. M. 1960. A study of seasonal movements of white-tailed deer (*Odocoileus virginianus couesi*) in the Cave Creek Basin of the Chiricahua Mountains. Master's Thesis, University of Arizona, Tucson, Arizona.
- White, R. W. 1957. An evaluation of white-tailed deer (*Odocoileus virginianus couesi*) habitats and foods in Southern Arizona. Master's Thesis, University of Arizona, Tucson, Arizona.

Table 1. Identifying characteristics to distinguish between mule deer (*Odocoileus hemionus*) and white-tailed deer (*Odocoileus virginianus*) (Heffelfinger 2006).

Characteristic	Mule Deer	White-tailed Deer
Tails	▪ Cylindrical ▪ Usually white on dorsal side with distinctive black tip surrounded by large white rump ▪ <7 ½ inches	▪ Wide, flattened tail that is broad at base and narrow at tip ▪ White underside contrasts with dark dorsal side ▪ Edged with white fringe hairs ▪ Large white rump patch ▪ > 7 ½ inches long
Antlers (least informative characteristic to distinguish deer because of the amount of variation that can be present)	▪ Small brow tines if present ▪ Main beams sweep out and upward forking once with each fork dividing again ▪ 8 points or 10 if brow tines present	▪ Several antler tines rising independently off the main beam that sweeping outward and forward from the base ▪ Brow tines nearly always present and usually prominent ▪ 8 points including the brow tines
Facial Markings	▪ Distinctive black forehead contrasting with light gray face ▪ Less obvious eye rings and nose	▪ Forehead same color as rest of face ▪ White eye rings and nose markings prominent
Ears	▪ ~9 ½ inches ▪ ¾ length of head	▪ ~7 inches ▪ ⅔ length of head
Flight Behavior	▪ Does not throw tail up ▪ Bounds by pushing off with all 4 hooves at the same time	▪ Throws up tail ▪ Runs directly away from source of danger

Table 1. Identifying characteristics to distinguish between mule deer (*Odocoileus hemionus*) and white-tailed deer (*Odocoileus virginianus*) (Heffelfinger 2006)

(Continued).

Characteristic	Mule Deer	White-tailed Deer
Metatarsal Glands	3-7 inches (desert mule deer ~5 inches) - Starts at ankle joint and extends downward toward hoof	1 inch or less and encircled by white hairs (Coues deer ~½ inch) - At midpoint or below midpoint on the lower shank of leg
Preorbital Glands	Substantial pocket with a depth ~¾ inch	Small slit with a maximum depth of ⅜ inch

Table 2. Numbers of white-tailed deer (*Odocoileus virginianus*) and mule deer (*Odocoileus hemionus*) reported in annual wildlife reports for Saguaro National Park, Rincon Mountain District, Tucson, Arizona.

Year	White-tailed deer	Mule deer
1939	15	35
1940	20	35-40
1941	200	25-30
1942	200	25-30
1943	200	25-30
1944	200	25
1945	150	25
1946	40-50	15
1947	25-30	8
1948	30-40	20
1949	30	30
1950	20	30-40
1951	87	30-40
1955	rare, reduced	common
1956-1957	reduced, rare	uncommon
1958-1959	50	50-75
1960-1961	330	100
1962	80	100

Table 2. Numbers of white-tailed deer (*Odocoileus virginianus*) and mule deer (*Odocoileus hemionus*) reported in annual wildlife reports for Saguaro National Park, Rincon Mountain District, Tucson, Arizona (Continued).

Year	White-tailed deer	Mule deer
1963	100	150
1964	100	300
1965	100	300
1967	100	300
1968	100	300
1969	100	200
1970	100	300
1971	100	300
1972	100	300
1973	100	300
1974	100	300

Table 3. Numbers of mule deer (*Odocoileus hemionus*) counted during Gerald Day's javelina (*Pecari tajacu*) survey routes from 1961 to 1974, Saguaro National Park, Rincon Mountain District, Tucson, Arizona.

Date	Bucks	Does	Fawns	Unknown	Total	Buck:Doe
February 1961	35	25	11	10	81	1.40
December 1961	29	46	9	5	89	0.63
December 1962	18	38	8	29	93	0.47
January 1964	36	81	6	0	123	0.44
January 1965	21	28	8	2	59	0.75
December 1965	17	31	5	12	65	0.55
November 1966	14	69	15	0	98	0.20
November 1967	7	46	6	28	87	0.15
November 1968	12	65	10	9	96	0.18
November 1969	6	35	6	5	52	0.17
November 1970	13	67	9	43	132	0.19
December 1971	16	35	5	11	67	0.45
December 1972	5	47	12	3	67	0.11
November 1973	17	51	18	1	87	0.33
December 1974	15	35	18	5	73	0.43

Table 4. Numbers of white-tailed deer (*Odocoileus virginianus*) counted during Gerald Day's javelina (*Pecari tajacu*) survey routes from 1961 to 1974, Saguaro National Park, Rincon Mountain District, Tucson, Arizona.

Date	Bucks	Does	Fawns	Unknown	Total	Buck:Doe
February 1961	2	2	1	3	8	1
December 1961	0	4	0	0	4	0
December 1962	0	0	0	0	0	
January 1964	0	0	0	0	0	
January 1965	0	0	0	0	0	
December 1965	0	0	0	0	0	
November 1966	0	0	0	0	0	
November 1967	1	0	0	0	1	
November 1968	2	2	0	0	4	1
November 1969	0	1	0	0	1	0
November 1970	0	1	0	0	1	0
December 1971	0	0	0	0	0	
December 1972	0	0	0	0	0	
November 1973	0	0	0	0	0	
December 1974	0	1	1	0	2	0

Table 5. Survey routes used by Gerald Day during a javelina (*Pecari tajacu*) study from 1961 to 1974 to count deer, Saguaro National Park, Rincon Mountain District, Tucson, Arizona.

Route	Route
Inside Cactus Forest Loop Road-West	West of Madrona
Inside Cactus Forest Loop Road-East	Deer Camp- East
South of Cactus Forest Loop Road	Deer Camp- West
Box Canyon	Deer Camp- North
North of Cactus Forest Loop Road	South of Rincon Peak Trail
East of Cactus Forest Loop Road	East of Madrona
East of Tina Larga Tank	Miller Creek Trail (proper)
Tina Larga Tank	North of Miller Creek Trail
North of Madrona	South of Miller Creek Trail

Table 6. Mule deer use of vegetation associations by sex (M indicates male and F indicates female) and season in relation to availability (+ indicates used significantly more than available, - indicates used significantly less than available, and 0 indicates not used at all) at Rincon Mountain District, Saguaro National Park, Tucson, Arizona 1988-1989 (Bellantoni and Krausman 1991).

Vegetation associations	Spring		Early summer		Late summer		Winter	
	F	M	F	M	F	M	F	M
Creosote-acacia-palo verde ocotillo-zinnia			-		-	-		
Palo verde-mixed shrub-mixed cacti-zinnia/burroweed	-	0			-	-		-
Palo verde-saguaro-mixed cacti-mixed scrub		-		0		-		
Jojoba-mixed scrub	0	+	0		0		0	
Palo verde-creosote-desert broom-brittlebush-ocotillo				+	0		0	+
Palo verde-saguaro-brittlebush								
Palo verde-acacia-mixed cacti-mixed scrub-grass			+		+	+		+
Mesquite-acacia-palo verde-mixed cacti-mixed scrub				+		+		
Mesquite-mixed short tree and mesquite-wolfberry-mixed scrub			+					

Table 7. Mule deer use of vegetation associations by sex (M indicates male and F indicates female) and season in relation to availability (+ indicates used significantly more than available, - indicates used significantly less than available, and 0 indicates not used at all) for foraging at Rincon Mountain District, Saguaro National Park, Tucson, Arizona 1988-1989 (Bellantoni and Krausman 1991).

Vegetation associations	Spring		Early summer		Late summer		Winter	
	F	M	F	M	F	M	F	M
Creosote-acacia-palo verde ocotillo-zinnia		-	-		0	-	0	
Palo verde-mixed shrub-mixed cacti-zinnia/burroweed		0			-	-		0
Palo verde-saguaro-mixed cacti-mixed scrub		-		0		-		
Jojoba-mixed scrub	0	+	0		0		0	
Palo verde-creosote-desert broom-brittlebush-ocotillo					0		0	
Palo verde-saguaro-brittlebush								
Palo verde-acacia-mixed cacti-mixed scrub-grass					+			
Mesquite-acacia-palo verde-mixed cacti-mixed scrub				+				
Mesquite-mixed short tree and mesquite-wolfberry-mixed scrub			+					0

Table 8. Mule deer use of vegetation associations by sex (M indicates male and F indicates female) and season in relation to availability (+ indicates used significantly more than available, - indicates used significantly less than available, and 0 indicates not used at all) for bedding at Rincon Mountain District, Saguaro National Park, Tucson, Arizona 1988-1989 (Bellantoni and Krausman 1991).

Vegetation associations	Spring		Early summer		Late summer		Winter	
	F	M	F	M	F	M	F	M
Creosote-acacia-palo verde ocotillo-zinnia						-		
Palo verde-mixed shrub-mixed cacti-zinnia/burroweed		0	-			0		0
Palo verde-saguaro-mixed cacti-mixed scrub				0		0		
Jojoba-mixed scrub	0		0		0		0	0
Palo verde-creosote-desert broom-brittlebush-ocotillo	0		0		0		0	
Palo verde-saguaro-brittlebush								
Palo verde-acacia-mixed cacti-mixed scrub-grass								
Mesquite-acacia-palo verde-mixed cacti-mixed scrub							0	
Mesquite-mixed short tree and mesquite-wolfberry-mixed scrub					0			0

Table 9. Dates and times of helicopter surveys for deer at Saguaro National Park, Rincon Mountain District, Tucson, Arizona.

Date	Time survey began	Time survey ended	Total hours of flight
6 February 1989	0840 hours	1115 hours	1.90
26 January 2000	0800 hours	0935 hours	1.35
6 January 2001	0810 hours	1124 hours	1.48
5 January 2002	0812 hours	1012 hours	2.00
4 January 2003	0823 hours	1050 hours	1.57
4 January 2004	0827 hours	1020 hours	1.43
20 January 2005	0817 hours	1002 hours	1.80
19 January 2006	0832 hours	1002 hours	1.30

Table 10. Number of mule deer (*Odocoileus hemionus*) counted during helicopter surveys in 1989 and from 2000 to 2006 at the Rincon Mountain District, Saguaro National Park, Tucson, Arizona.

Date	Bucks	Does	Fawns	Unknown	Total	Buck:Doe
6 February 1989	20	48	26	0	94	0.42
26 January 2000	0	0	0	0	0	
6 January 2001	1	2	0	0	3	0.50
5 January 2002	2	5	5	0	12	0.40
4 January 2003	0	6	0	0	6	0.00
4 January 2004	3	3	1	0	7	1.00
20 January 2005	1	1	0	0	2	1.00
19 January 2006	4	6	0	0	10	0.67

Table 11. Number of white-tailed deer (*Odocoileus virginianus*) counted during helicopter surveys in 1989 and from 2000 to 2006 at the Rincon Mountain District, Saguaro National Park, Tucson, Arizona.

Date	Bucks	Does	Fawns	Unknown	Total	Buck:Doe
6 February 1989	19	21	8	0	48	0.90
26 January 2000	5	3	0	0	8	1.67
6 January 2001	7	11	1	0	19	0.64
5 January 2002	6	17	3	0	26	0.35
4 January 2003	17	13	2	0	32	1.31
4 January 2004	15	24	1	0	40	0.63
20 January 2005	6	10	8	2	26	0.60
19 January 2006	24	22	3	0	49	1.09

Table 12. Comparison of mule deer (*Odocoileus hemionus*) (bucks/100 does and fawns/100 does) between Saguaro National Park, Rincon Mountain District (SNP) and Arizona Game and Fish, Game Management Unit 33 (GMU33), Tucson, Arizona.

Year	Mule Deer			
	Bucks/100 does ¹		Fawns/100 does ²	
	SNP	GMU33	SNP	GMU33
1989	42	9	54	26
2000	-	21	-	39
2001	50	11	0	36
2002	40	21	100	72
2003	0	11	0	44
2004	100	11	33	23
2005	100	24	0	62
2006	67	20	0	52

¹ Standardized ratio used by Arizona Game and Fish to compare populations across different areas:

$$\frac{\text{number of bucks observed/number of does observed}}{\text{standardized number of bucks/100 does}}$$

² Standardized ratio used by Arizona Game and Fish to compare populations across different areas:

$$\frac{\text{number of fawns observed/number of does observed}}{\text{standardized number of fawns/100 does}}$$

Table 13. Comparison of white-tailed deer (*Odocoileus virginianus*) (bucks/100 does and fawns/100 does) between Saguaro National Park, Rincon Mountain District (SNP) and Arizona Game and Fish Game Management Unit 33 (GMU33), Tucson, Arizona.

Year	White-tailed Deer			
	Bucks/100 does ¹		Fawns/100 does ²	
	SNP	GMU33	SNP	GMU33
1989	90	27	38	29
2000	167	36	0	35
2001	64	22	9	38
2002	35	22	18	35
2003	131	17	15	13
2004	63	21	4	25
2005	60	22	80	40
2006	109	31	64	24

¹ Standardized ratio used by Arizona Game and Fish to compare populations across different areas:

number of bucks observed/number of does observed
standardized number of bucks/100 does

² Standardized ratio used by Arizona Game and Fish to compare populations across different areas:

number of fawns observed/number of does observed
standardized number of fawns/100 does

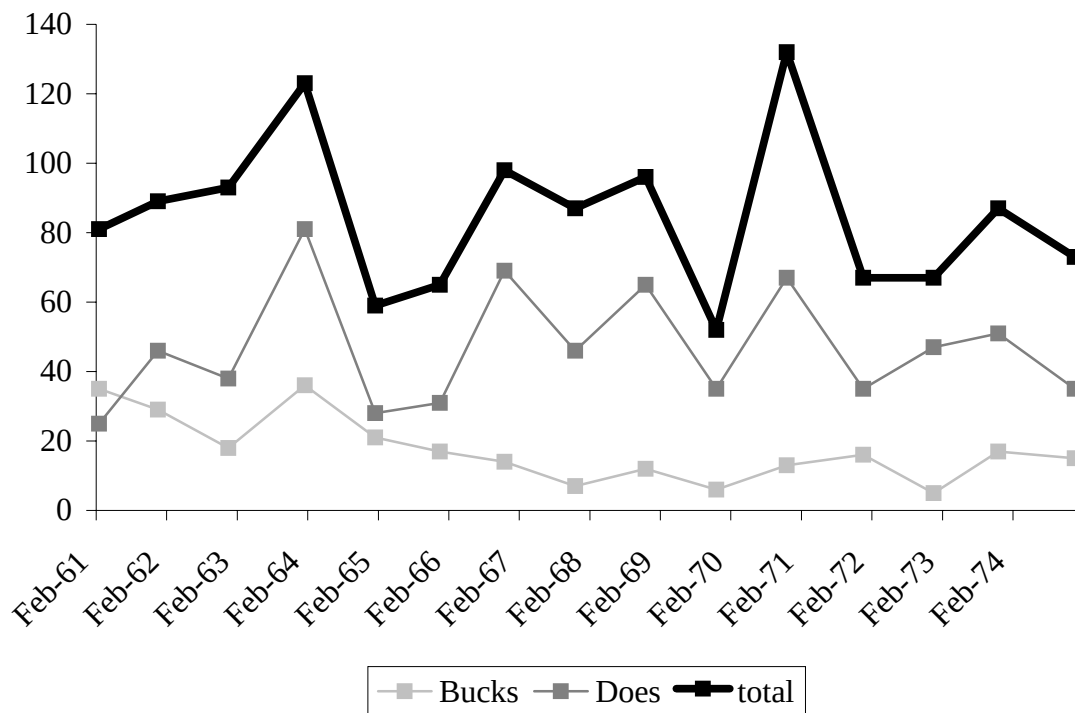


Figure 1. Mule deer (*Odocoileus hemionus*) trends from survey data by Gerald Day during a javelina (*Pecari tajacu*) study from 1961 to 1974, Saguaro National Park, Rincon Mountain District, Tucson, Arizona.

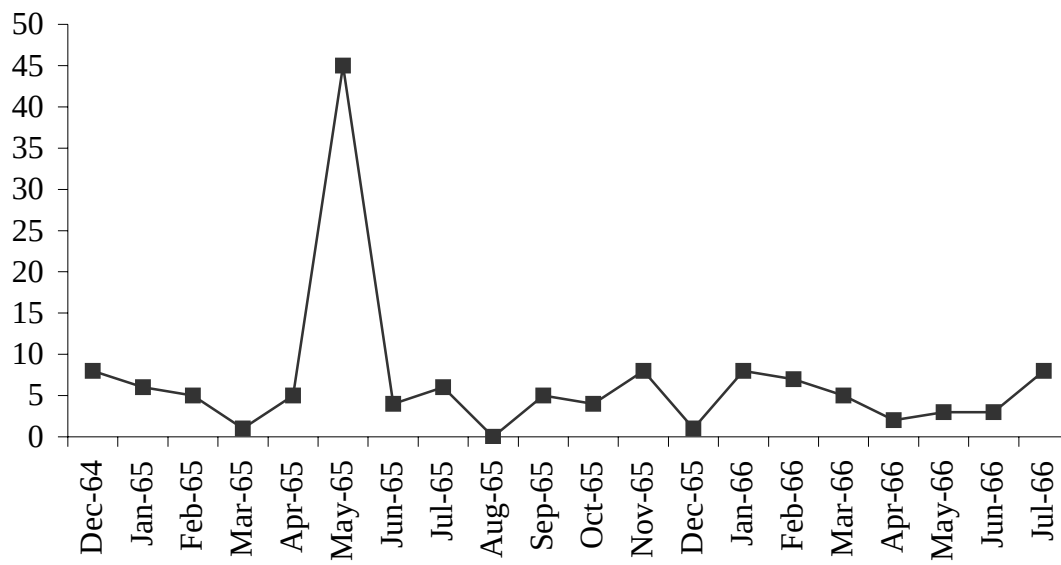


Figure 2. Nocturnal data collected on Cactus Forest Drive for mule deer (*Odocoileus hemionus*) from December 1964 to July 1965 by park staff at Saguaro National Park, Rincon Mountain District, Tucson, Arizona.

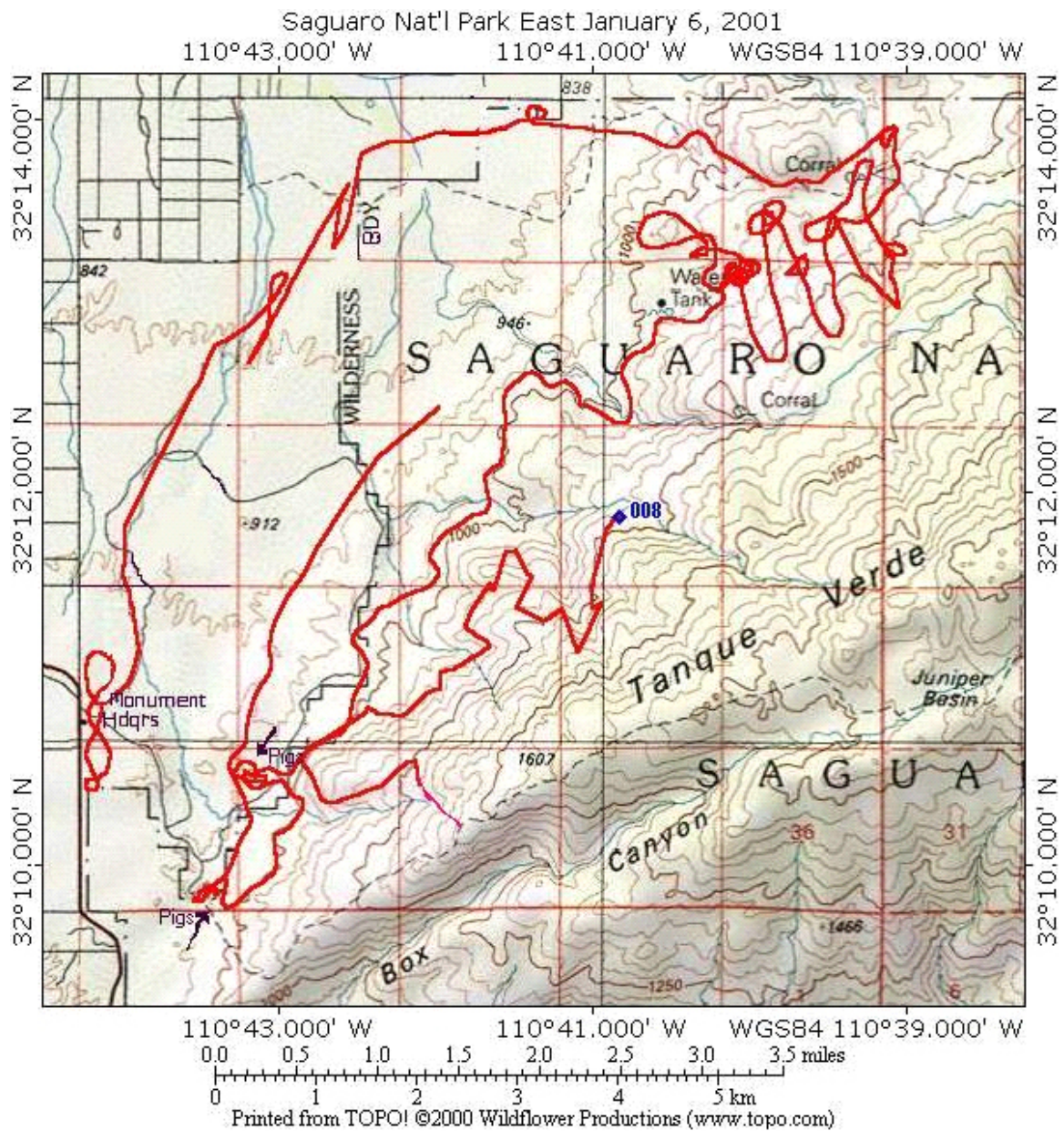


Figure 3. Helicopter survey route for deer on 6 January 2001, Rincon Mountain District, Saguaro National Park, Tucson, Arizona.

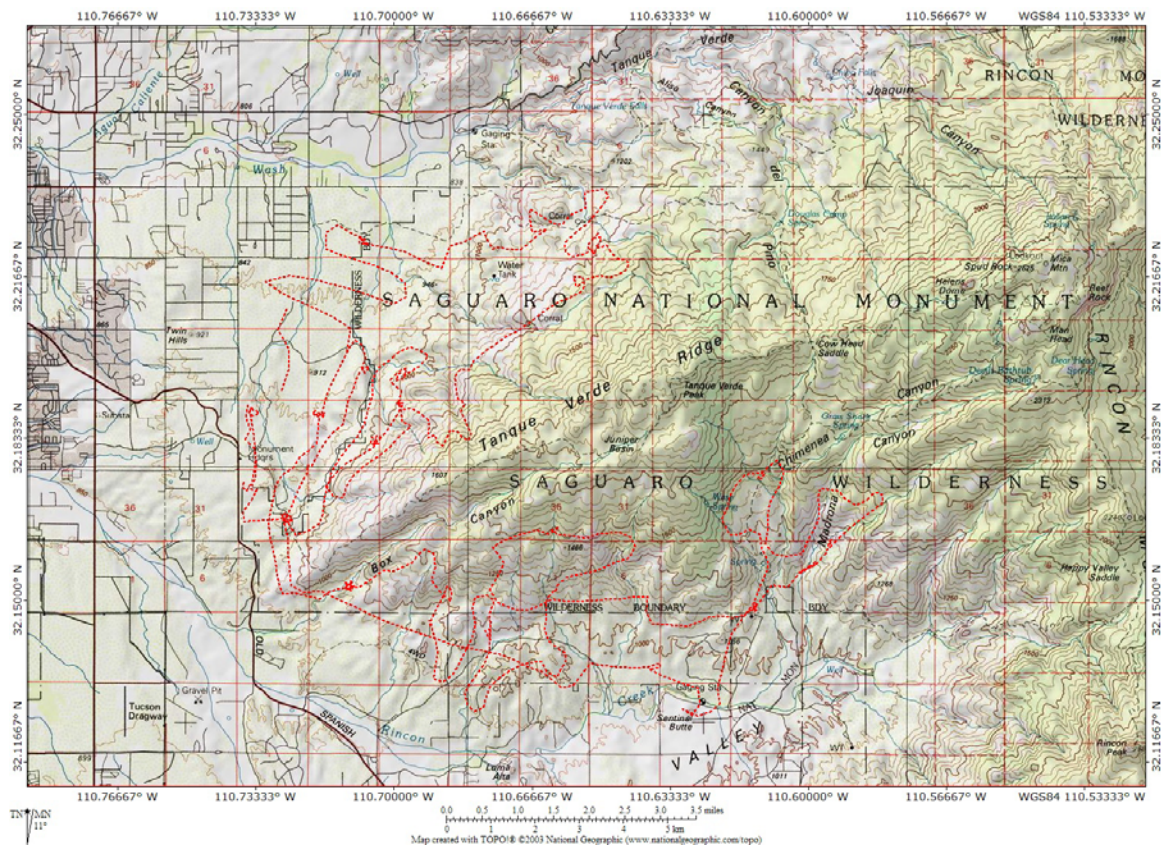


Figure 4. Helicopter survey route for deer on 5 January 2002, Rincon Mountain District, Saguaro National Park, Tucson, Arizona.

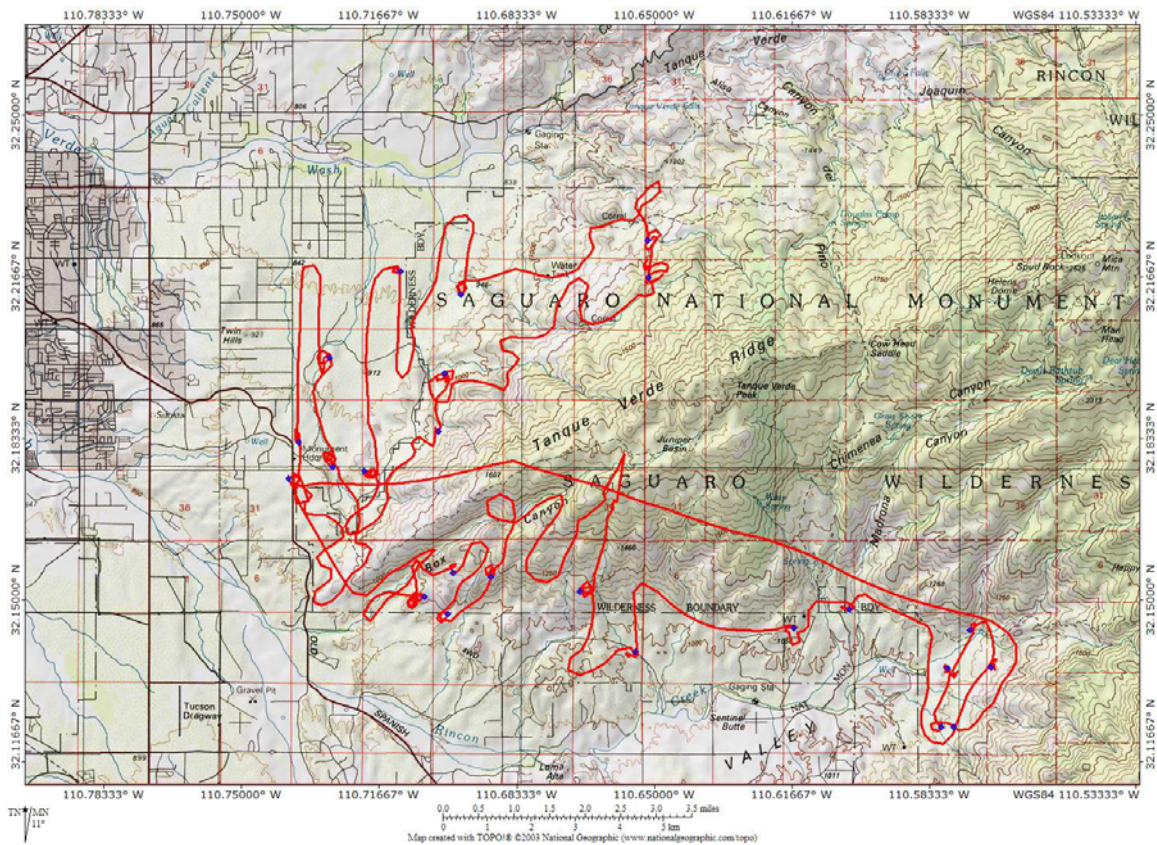


Figure 5. Helicopter survey route for deer on 4 January 2003, Rincon Mountain District, Saguaro National Park, Tucson, Arizona.

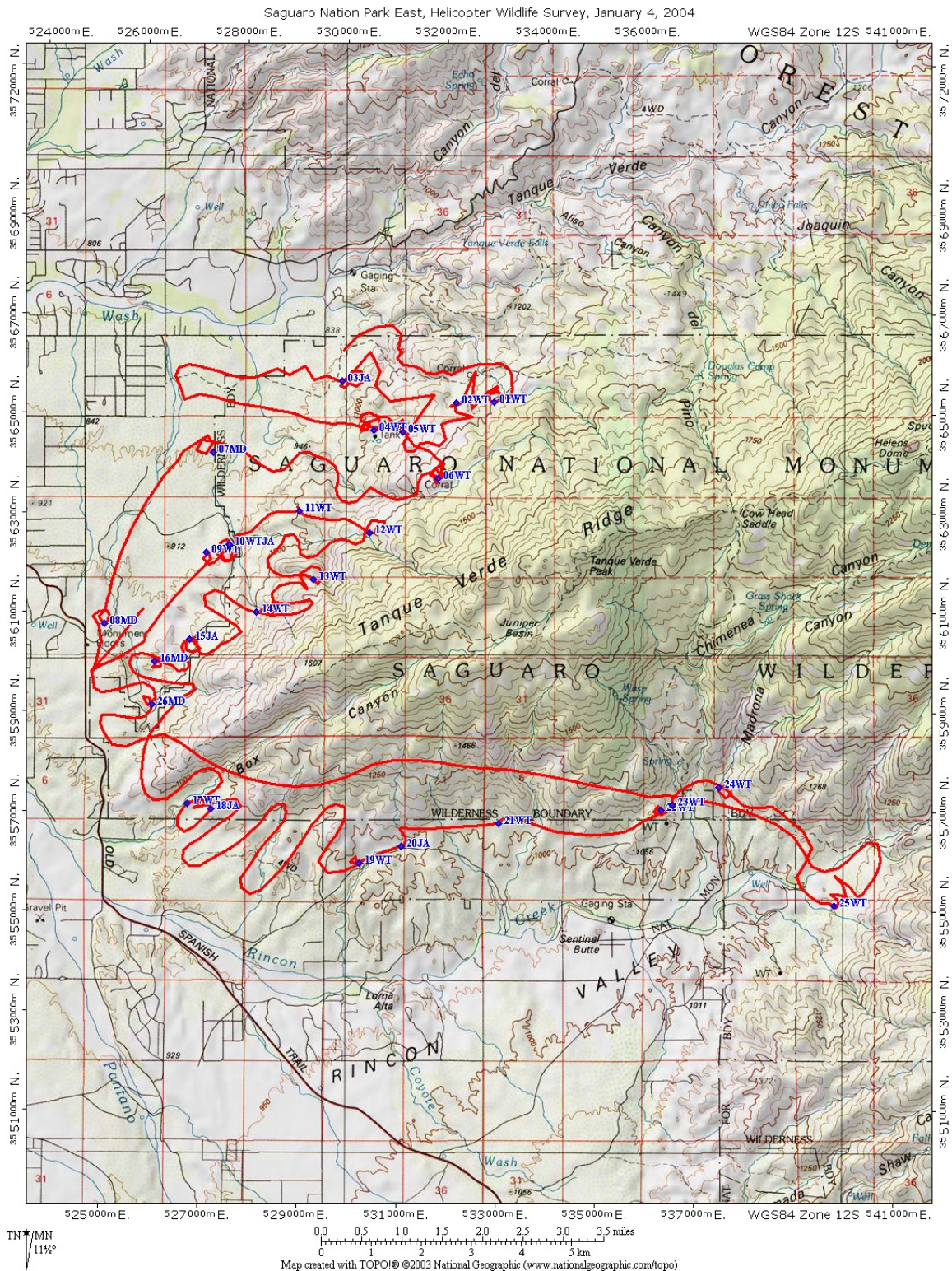


Figure 6. Helicopter survey route for deer on 4 January 2004, Rincon Mountain District, Saguaro National Park, Tucson, Arizona.

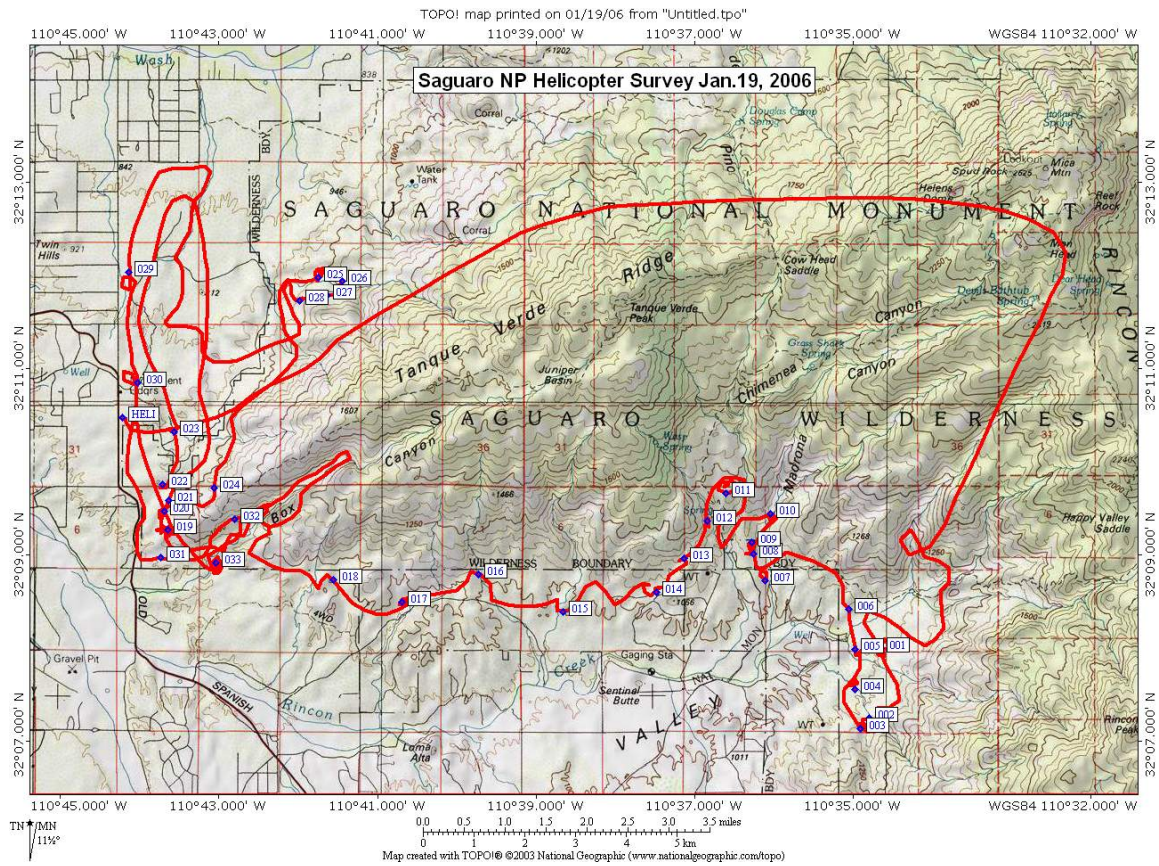


Figure 7. Helicopter survey route for deer on 19 January 2006, Rincon Mountain District, Saguaro National Park, Tucson, Arizona.

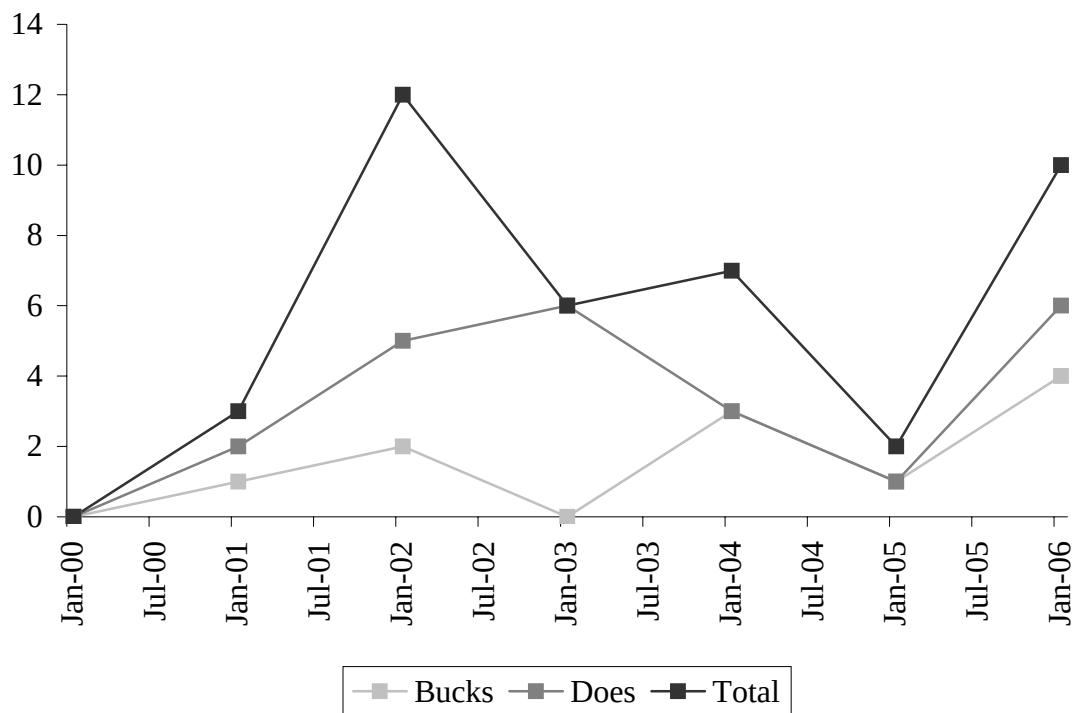


Figure 8. Mule deer (*Odocoileus hemionus*) trends from helicopter surveys from 2000 to 2006 at the Rincon Mountain District, Saguaro National Park, Tucson, Arizona.

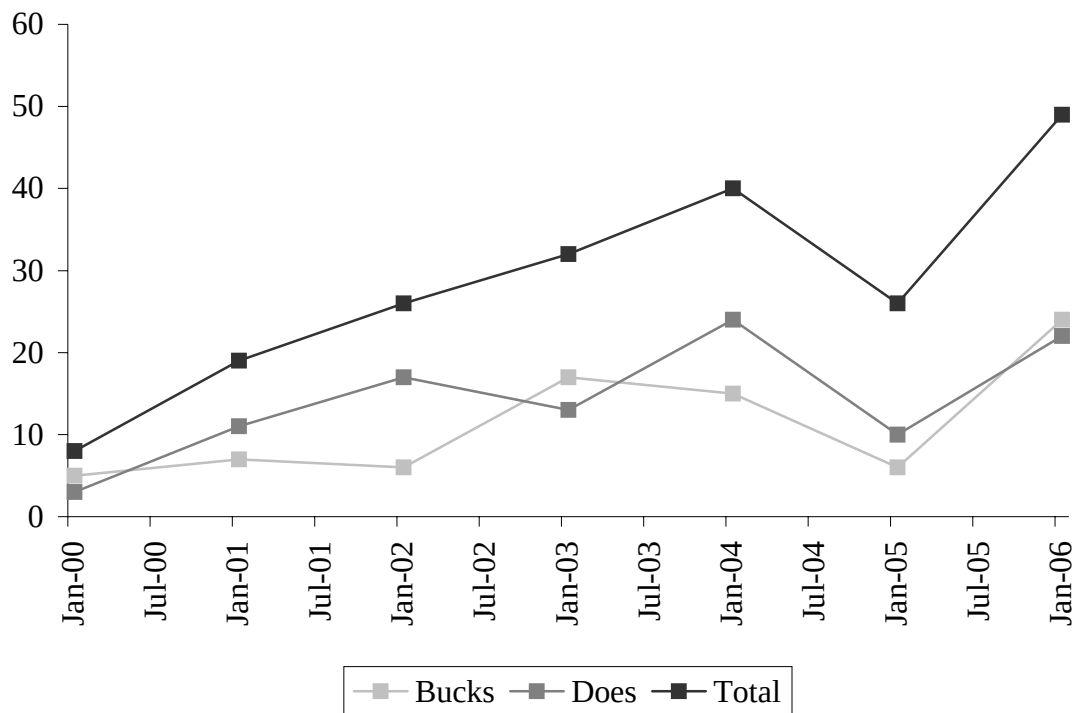


Figure 9. White-tailed deer (*Odocoileus virginianus*) trends from helicopter surveys from 2000 to 2006 at the Rincon Mountain District, Saguaro National Park, Tucson, Arizona.

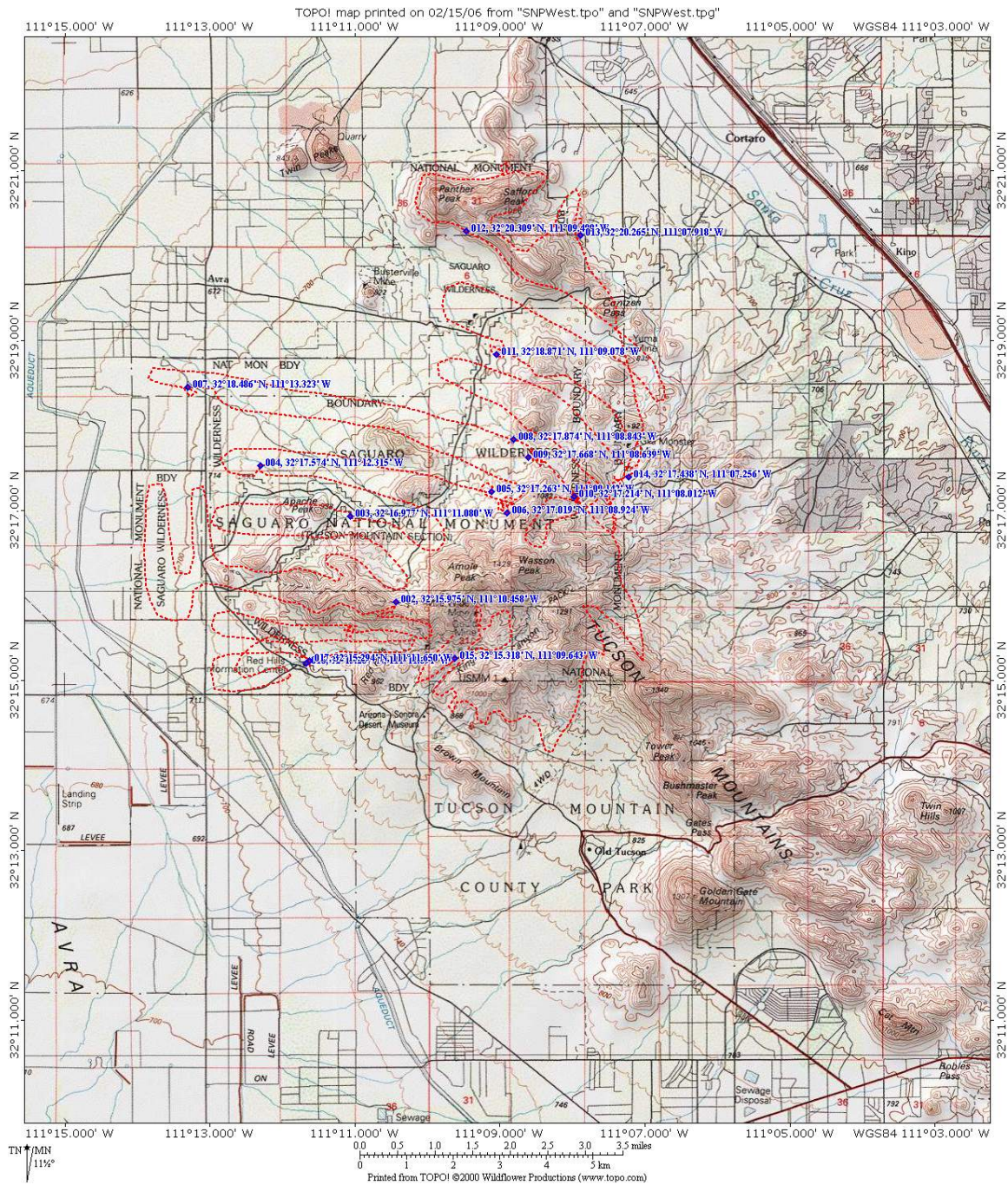


Figure 10. Helicopter survey route for deer on 20 January 2006, Tucson Mountain District, Saguaro National Park, Tucson, Arizona.