

**Initial Surveys to Locate Arizona Black Rattlesnakes (*Crotalus viridis cerberus*)
In Arizona National Parks and Monuments**

Final Report to Western National Parks Association (Grant # 04-14)

May 2005

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Arizona Black rattlesnake from Tonto National Monument. Photograph by Justin Schofer.

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Executive Summary

The Arizona black rattlesnake (*Crotalus viridis cerberus*) is a little-known, near-endemic species of rattlesnake found primarily at higher elevations in Arizona. To remedy a lack of information for the species, in 2004 we initiated surveys in National Parks within the range of this species, including Tonto National Monument, Saguaro National Park, and Walnut Canyon National Monument. We used visual encounter surveys and opportunistic encounters to detect the species at each park. In addition, we used natural history data from three Arizona black rattlesnakes previously telemetered at Tonto, and drew on existing capture data from each park to complete this study. We found a total of four Arizona Black rattlesnakes at the parks: two at Tonto, one at Walnut Canyon, and one at Saguaro. We found fewer Arizona black rattlesnakes than we anticipated given our survey efforts, and did not recapture any animals previously detected, thus we cannot make reliable population estimates. Data from the telemetered animals indicates that, at least at Tonto, hibernation sites tend to be in rock talus slides in washes, the active season lasts from March to October, mating occurs in late summer and early fall, babies are born in August, and prey includes rodents and birds. Based on all available data, we estimate that Arizona black rattlesnakes are rare at Tonto, potentially rare at Walnut Canyon, and relatively more common at Saguaro. Given the overall rarity of the species in Arizona National Parks and its propensity for using specific habitats at different times of the year, we make management recommendations for each park.

Introduction

The Arizona black rattlesnake (*Crotalus viridis cerberus*) is a near-endemic species of rattlesnake found primarily at higher elevations in Arizona (it ranges slightly into the mountains of far western New Mexico). Its biology has not previously been studied in any detail. Recent genetic analyses using mitochondrial DNA found that the species is genetically distinct from its former parent species, the Western Rattlesnake (*Crotalus viridis*; Pook et al. 2000, Douglas et al. 2002). This genetic distinction is supported by morphological characteristics such as color, and elevational distribution that differ significantly from other members of the Western Rattlesnake clade. Based on these differences, Douglas et al. (2002) recommended elevating the Arizona black rattlesnake subspecies to full species status as *Crotalus cerberus*; however, this suggestion has not been universally accepted by the herpetological community (e.g. Crother et al. 2003).

Basic biological information is lacking for most populations of Arizona black rattlesnakes, including growth and survival rates, longevity, recruitment, habitat requirements, activity period, behavior, and estimates of population size. Published information on the ecology of the species includes one record on diet (Schuett et al. 2002), a summary of reproductive biology gleaned from museum specimens (Golberg 2002), and generalized distribution information and species accounts (e.g. Klauber 1972, Degenhardt et al. 1996, Christman et al. 2000). A long-term mark-recapture study of the species has been underway at a few sites near Flagstaff, Arizona since 1999 (Nowak, Schofer, and Gasaway, unpublished data). Adding to this information, we initiated a radio-telemetric study of a few individual Arizona Black rattlesnakes at Tonto in 2003.

To continue to remedy the lack of scientific and management information for Arizona black rattlesnakes, in 2004 we initiated surveys in Arizona National Parks within the range of this species. We surveyed at Tonto National Monument ("Tonto") in Gila County, Saguaro National Park East ("Saguaro") in Pima County, and Walnut Canyon National Monument ("Walnut Canyon"), in Coconino County. This study, which was the implementation phase of a longer-term project, had the following objectives: 1) document the presence of Arizona black rattlesnakes in the parks and determine recapture rates to obtain an estimate of relative abundance; 2) locate winter hibernation sites and collect habitat data to be used in the future for predicting other suitable den sites; 3) permanently mark individuals and obtain measurement data to begin studies of demography and longevity; and 4) collect supplemental data on social and defensive behavior, mating period, etc. as animals are observed.

Methods

Surveys. We conducted surveys for Arizona black rattlesnakes at Walnut Canyon, Saguaro, and Tonto (Figure 1) during the snakes' expected primary active season from late March to early October. The majority of our effort was spent conducting walking surveys. These surveys are a form of "visual encounter survey" used by Campbell and Christman (1982) and defined more precisely by Crump and Scott (1994). They consisted of walking systematically through a defined sampling area, searching all reasonable areas within that habitat, and recording rattlesnakes encountered. We conducted walking searches primarily during the day, but also conducted several on warm summer nights.

We also conducted limited night road driving surveys at Walnut Canyon. Road driving at night is known to be effective for inventorying snakes during the summer rainy period in arid areas of the southwestern US (e.g., Mendelson and Jennings 1992, Drost et al. 2001). Used in conjunction with other methods, road driving provides an estimate of relative abundance and distribution of snakes (Shafer and Juterbock 1994).

In most cases, sampling areas occurred where park staff or researchers had previously seen rattlesnakes. In some cases, we surveyed areas that we suspected would be good habitat for this rattlesnake species based on our previous experience. Areas searched included both summer foraging areas and winter hibernation sites. We searched known or suspected hibernation sites in March and April to detect rattlesnakes basking at den sites. Due to logistical and time constraints, areas surveyed at Saguaro tended to be near trails.

Data Collection. During each survey, we recorded (at a minimum) start and end location coordinates, time, weather conditions, other species seen, and numbers of rattlesnakes seen. When Arizona black rattlesnakes were detected we recorded ambient temperatures and microhabitat features at the capture site. We recorded GPS locations at the start, end, midpoint and corners (if applicable) of each survey. We also recorded capture locations of individual animals. GPS coordinates were collected in Universal Transverse Mercators (UTMs) in the NAD 27 datum, using Garmin® (GPSIII Plus or 12) hand-held GPS units.

When hibernation den sites were located (by following radio-telemetered animals), we recorded slope and aspect along the slope (both in degrees), and elevation. We recorded

biotic and abiotic ground cover and canopy height within a 2-m radius of each site (after Rowlands 1995). We adapted our measurements of vegetation to be indicative of habitat features most important to rattlesnakes, rather than using pre-defined vegetation sampling methods (Reinert 1993). We used a densitometer (an optical sighting tool used to determine cover, as described by Elzinga et al. 1998) from a height of 1.5 m to determine ground and “understory” canopy cover at 10 points along a cross-shaped transect. From these ratio data, we determined the dominant cover species or category for pre-defined abiotic and vegetative cover types. Abiotic substrate types included gravel (size class 0.6-7.6 mm), rubble (>7.6-61cm), boulder (> 61cm), bare ground or sand, cryptobiotic soil, etc. (after Rosgen 1996). Vegetative cover types are classified after Rowlands 1995 and include tree, woody shrub, forb (perennial and annual), and grass (perennial and annual). Canopy height of the tallest vegetation type was also determined using pre-defined height categories (after Rowlands 1995). We identified most plant species to genus or species.



Figure 1. Location of Arizona National Parks (Walnut Canyon National Monument, Tonto National Monument, and Saguaro National Park (East) surveyed for Arizona black rattlesnakes (*Crotalus v. cerberus*) in 2004. General location of each park is indicated by a blue star and labeled with park name.

Supplemental Methods. We used data from three previously radio-telemetered Arizona Black rattlesnakes at Tonto to supplement natural history information in this report. We conducted informal, non-time recorded “surveys” while radio-tracking these and other telemetered reptile species at Tonto by watching for Arizona black rattlesnakes. We also drew on data previously collected on Saguaro Arizona black rattlesnakes during an inventory project, and incidental observations from Walnut Canyon.

Snake Capture and Processing. We or park staff captured rattlesnakes with snake tongs, and placed them in specially designed snake holding 5-gallon buckets. From the buckets, we then placed the snakes in special tubes, sexed them and determined their reproductive status, and weighed and measured them. Measurements included snout-vent length (SVL, in centimeters), tail length (cm), number of rattles, length of the rattle string (cm), and weight (in grams). We marked the three bottom rattle segments with paint pens to provide individual color combinations that permitted distance identification of marked rattlesnakes by researchers and park staff (after Brown et al. 1984).

For permanent identification of individual rattlesnakes, we injected a small (11 to 12 mm) glass-encapsulated passive integrated microchip transponder (PIT) tag into each snake (Fagerstone and Johns 1987). These tags last for the lifetime of their host animal, and may be scanned at a distance of 12 inches to produce a unique identification code. The tags are injected between the belly scales in the posterior third of the snake’s body, approximately one cm into the coelomic (gut) cavity (Jemison et al. 1995). PIT tags, when properly injected into the gut cavity, have been shown not to cause adverse effects to snakes and generally have low failure rates (0-1%) (Camper and Dixon 1988, Keck 1994). Each time a rattlesnake was captured, we or park staff scanned it with a PIT tag scanner to verify its identity. we released the snake near its original capture point no more than 48 hours after initial capture, consistent with each park’s policy.

Each capture and release of an Arizona black rattlesnake in the parks was used as an interpretive opportunity to explain to visitors the project’s objectives, funding source, and results, as well as rattlesnake biology and behavior. We also provided park staff with images and information for development of interpretive programs based on the research.

Results

Overall Effort and Detections

In 2004, we conducted 37 surveys at the three parks, or a total of 276 person-hours of effort (i.e., number of observers times the number of hours each person surveyed). We conducted 10 surveys at Walnut Canyon (60 person-hours), 13 formal surveys at Tonto (68 person-hours), and 14 surveys at Saguaro (147 person-hours). GPS coordinates for each survey are shown for each park in Figure 2a-c. The date, location, hours, weather and coordinates for each survey at each park are listed in Tables 4-6 in Appendix A. In addition, we spent about 560 hours radio-tracking other venomous species at Tonto from April to September, thereby significantly increasing our chances of encountering an Arizona black rattlesnake at this park.

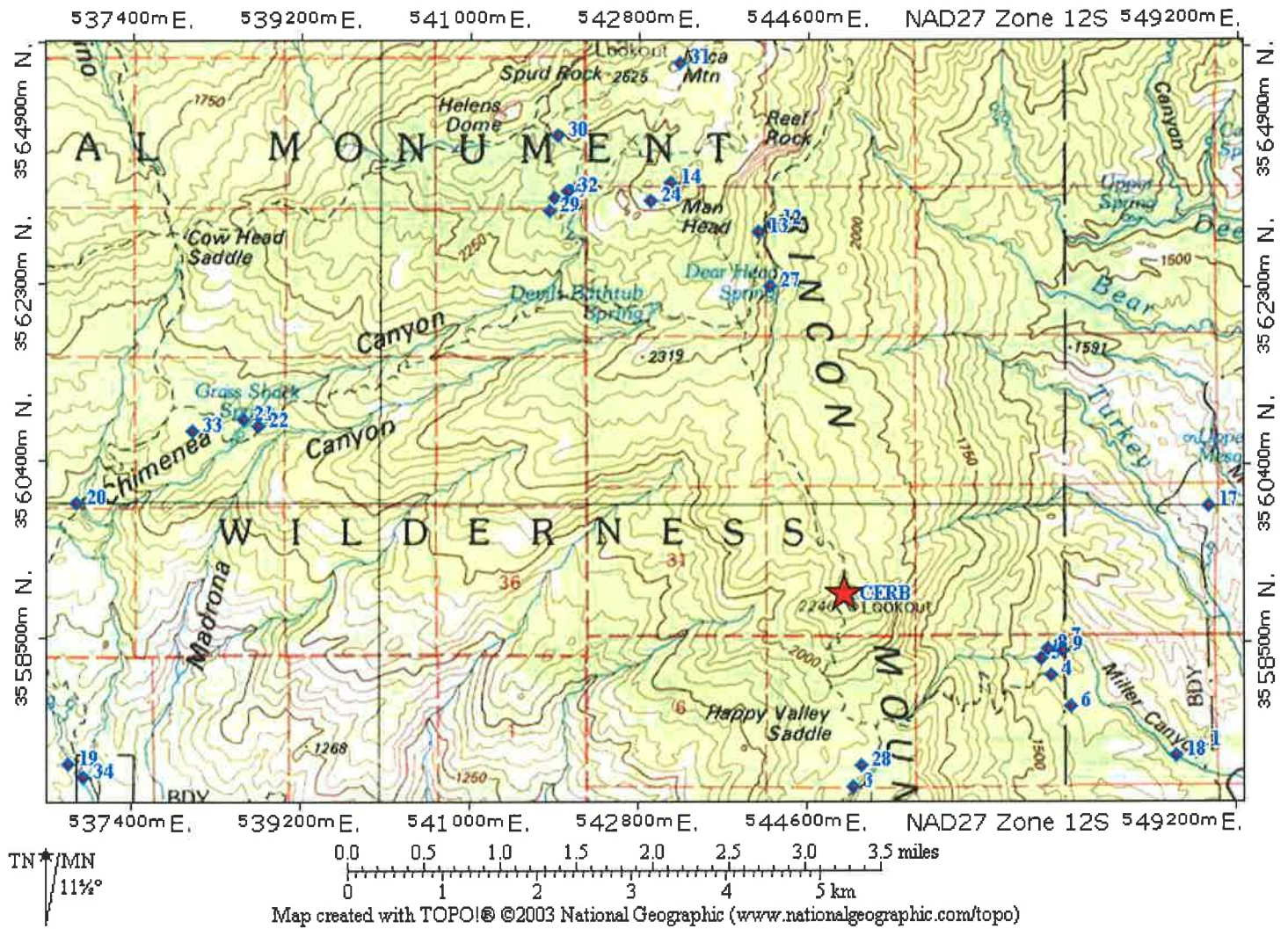


Figure 2a. Survey locations for Arizona black rattlesnakes at Saguaro National Park, Pima County, Arizona, from May to July 2004. Numbered points correspond to GPS locations given in Appendix A, Table 4. The point “CERB” indicates the capture location of male Arizona black rattlesnake #113673163A on May 28.

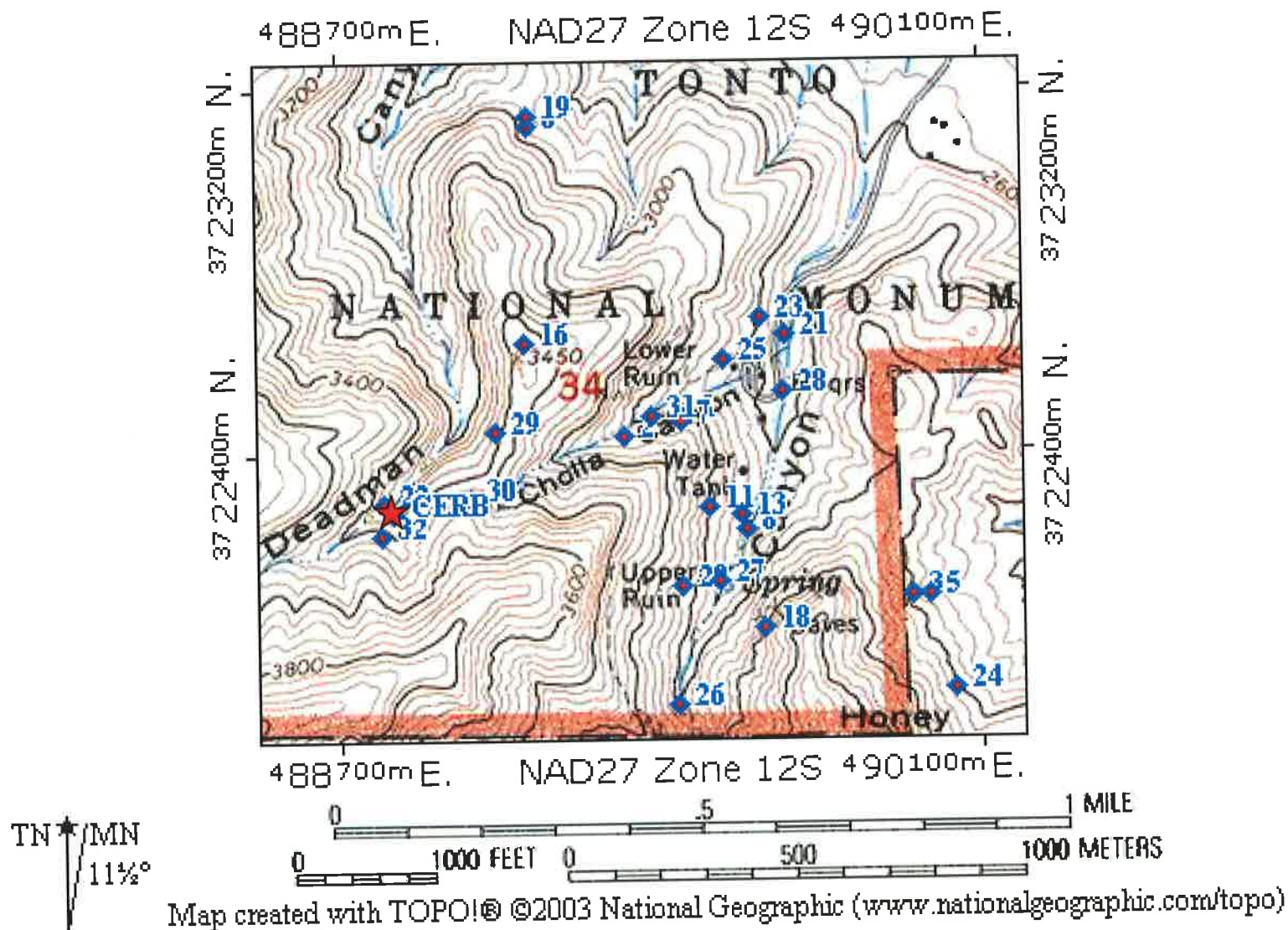


Figure 2b. Survey locations for Arizona black rattlesnakes at Tonto National Monument, Gila County, Arizona, from March to October 2004. Numbered points correspond to GPS locations given in Appendix A, Table 5. The point "CERB" indicates the capture location of female Arizona black rattlesnake Channel 40 on May 14.

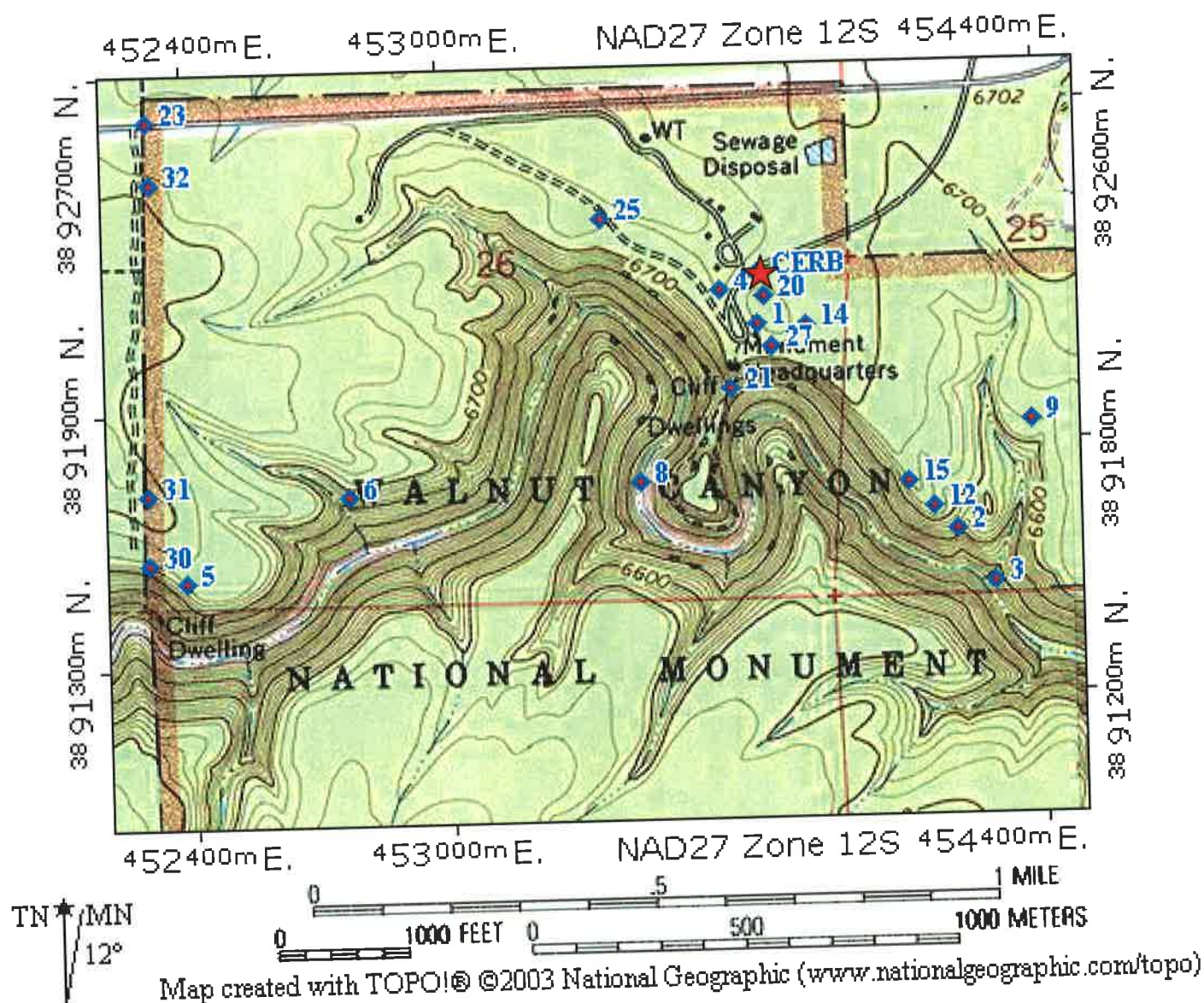


Figure 2c. Survey locations for Arizona black rattlesnakes at Walnut Canyon National Monument, Coconino County, Arizona, from May to September 2004. Numbered points correspond to GPS locations given in Appendix A, Table 6. The point "CERB" indicates the capture location of female Arizona black rattlesnake # 113662286A on August 27.

We found a total of four Arizona black rattlesnakes at the three parks in 2004: one at Saguaro, two at Tonto, and one at Walnut Canyon. All snakes were found during walking surveys, opportunistically while radio tracking (at Tonto), or by park staff (at Walnut Canyon). No snakes were found during night driving surveys. Capture data are listed for each animal in Table 1. Environmental data for each capture are given in Tables 4-6 in Appendix A.

Table 1. Capture data for Arizona black rattlesnakes detected in three Arizona National Parks in 2004. The location of each capture is given, along with date, sex (M=male; F=female), age, PIT tag and radio receiver channel number, snout-vent length (SVL) in cm, weight in g, tail in cm, and total number of rattle segments (a "0.5" indicates the rattle string was broken). UTM coordinates are in NAD 27 Datum.

Park/Location	Date	Sex	Age	PIT tag #/ Channel #	SVL	Wt	Tail	Total # Rattles	UTM Easting	UTM Northing
Saguaro Happy Valley lookout cabin area	5/28	M	adult	113673163A	84	468	5.7	9.5	545037	3558937
Tonto Deadman Wash past LCD on east slope	5/14	F	adult	113665543A 40	67	355	4.2	6.5	488815	3722270
Tonto at base of bluff overlooking Deadman Wash	8/22	F	adult?	113713335A	53.5	122	3.3	4	489039	3722445
Walnut Canyon by entrance station kiosk	8/27	F	adult	113662286A	64	302	6.4	9.5	453711	3892190

In addition to these individuals, other Arizona black rattlesnakes were detected at Saguaro in 2001 and at Tonto and Walnut Canyon in 2003. Data are provided on these animals in each park section below. Neither these nor snakes found in 2004 were recaptured again during our surveys.

Saguaro

One adult male Arizona black rattlesnake was captured at Saguaro on May 28. He was very dark and his blotch pattern was very faded compared to the other Arizona black rattlesnakes we found (Figure 3). He was captured in an area of the park where other Arizona black rattlesnakes have been detected in the park, near the Happy Valley lookout cabin.

Nineteen additional adult Arizona black rattlesnakes were detected at Saguaro in 2001 during herpetological inventories conducted by Brian Powell, Dave Prival and Dan Bell of the National Park Service's Sonoran Desert Network. Locations and capture data for these animals are listed in Table 7 of Appendix B. At least four of these animals were found in the Happy Valley area, and three others were found in areas we surveyed, including Miller Creek Trail and Chiminea Canyon.



Figure 3. Adult male Arizona black rattlesnake (#113673163A) captured at Saguaro National Park on May 28, 2004. Photograph by Justin Schofer.

Tonto

Two adult or subadult females were captured at Tonto in 2004. The first, adult #113665543A (Figure 4) was found to be gravid with approximately five enlarged follicles (ovulated eggs). We surgically implanted a radio-transmitter in this animal as part of another research project at Tonto and radio-tracked her for the rest of the season as Channel #40. Her range was very small, as expected for a gravid snake, and covered an area of less than 0.5 km² in Deadman Wash. She apparently gave birth in early to mid-August. We presume she had four or five offspring, based on initial follicle count and visual determination of the number of embryo bulges (n= 4-5) in the female's body close to parturition. This animal was almost immobile from July 29 to August 22, in a burrow or under a small boulder in a Christmas cactus (*Opuntia leptocaulis*) patch on the bottom edge of the wash. This area was apparently used as a birthing location and retreat site until the babies' first shedding of their skins (usually 1-2 weeks after birth), and the female apparently stayed with them until this shed cycle was completed, as is typical for other rattlesnake species (Klauber 1972). We did not see the babies after they were born, but we did find a shed skin from one of the babies at the birthing burrow on August 29.



Figure 4. Adult female Arizona black rattlesnake (#113665543A, Channel 40) captured at Tonto National Monument on May 14, 2004. Photograph by Justin Schofer.

The second Tonto female, #113713335A, was found apparently in courtship with a telemetered male Arizona black rattlesnake (Channel 03, see below) on August 22. Based on her body size (Figure 5), we thought that this was a juvenile or subadult snake, but the presence of an adult male actively courting her suggests that she was of reproductive age and therefore should be defined as “adult.” Channel 03 reacted protectively toward this female before and after she was captured. When the pair was initially approached, he repeatedly moved toward the technician. When the female was released after processing, the male coiled in a tight circle completely on top of her, a behavior known as “stacking” among rattlesnake biologists (S. Beaupre, pers. comm.). To our knowledge, this behavior has not been seen previously in Arizona black rattlesnakes.



Figure 5. A small adult female Arizona black rattlesnake (#113713335A) captured at Tonto National Monument on August 22, 2004. Snake was in courtship with an adult male Arizona black rattlesnake. Photograph by Amyann Madara.

In 2003, we detected three additional adult Arizona black rattlesnakes at Tonto. Of these, two males (Channels 03 and 22) were implanted with radio transmitters and Table 2 lists their capture data. A third female was found in courtship with one of the telemetered males (Channel 03) on September 7, 2003 but not captured, so we do not know if she was one of the same females found in 2004. Thus, four individual Arizona black rattlesnakes were documented at Tonto in 2003-2004. In addition, Don Swann recorded nine observations of the species at Tonto during inventory work at the park in 1994-1996 (pers. comm.).

Male #113612716A (Channel 22) was captured for transmitter implant in 2003 after he was found sitting in a hunting position next to a live trap for small mammals in 2003. When captured, he regurgitated a partially digested white-throated woodrat (*Neotoma albigula*). On June 5, 2004, the same snake was found next to a dead ash-throated flycatcher. While the technician watched him, he subsequently picked up, positioned, and swallowed the bird head-first, pausing a few times as if distracted. The entire process took 52 minutes, and then the snake moved away (A. Madara, pers. comm.).

One telemetered male Arizona black rattlesnake (Channel 03) spent over half of his active season in the riparian area at Cave Wash, while the other (Channel 22) was found in a variety of habitats in the park. The female did not leave Deadman Wash in 2004.

Table 2. Initial capture data for Arizona black rattlesnakes detected in Tonto National Monument in 2003. The location of each capture is given, along with date, sex (M=male), age, PIT tag and radio receiver channel number, snout-vent length (SVL) in cm, weight in g, tail in cm, and total number of rattle segments (a "0.5" indicates the rattle string was broken). UTM coordinates are in NAD 27 Datum.

Tonto Location	Date	Sex	Age	PIT tag #/ Channel #	SVL	Wt	Tail	Total # Rattles	UTM Easting	UTM Northing
Above the spring in Cave Creek ~2m from the Upper Ruin trail	7/14	M	adult	113612716A 03	74	300	6	7.5	489562	37722160
Above the sewage tank NW of the visitor center in small mammal trap grid S-18	7/31	M	adult	113447644A 22	78.5	361	6	8.5	489642	3722787

Walnut Canyon

The adult female found at Walnut Canyon was not obviously gravid. She was detected and captured by park staff near the entrance kiosk on August 27. Her dark background color and blotch pattern were typical for adult Arizona black rattlesnakes in northern Arizona (Figure 6).

In March 2004, we received a report and a photograph of a rattlesnake seen at Walnut Canyon from NPS interpreters Kirk Peterson and Diana Pennington (compliments of Mary Blasing, Wuptaki National Monument District Ranger). This adult animal was seen in the pit house near the visitor center on the rim of the canyon in September 2003 (Figure 7). Based on comparison of photographs of the blotch patterns on the forebody of this snake with the one we processed in 2004, it appears that these are two different individuals.



Figure 6. Adult female Arizona black rattlesnake (#113662286A) captured by rangers at Walnut Canyon National Monument on August 27, 2004. Photograph by Justin Schofer.



Figure 7. Adult Arizona black rattlesnake captured by park rangers at Walnut Canyon National Monument in September 2003. Animal was not processed or sexed. Photograph by Diana Pennington.

Hibernation Dens – parts of this section have been moved to a Confidential Appendix (Appendix D) at the request of Don Swann, Saguaro NP.

We found four individual hibernation dens for three telemetered adult Arizona black rattlesnakes at Tonto in 2004; one snake used different sites in the 2003-2004 and 2004-2005 hibernation seasons. Each den site appeared to contain only one individual rattlesnake; however it is possible that other animals using the same sites remain undetected. No hibernation sites were found at Saguaro or Walnut Canyon.

No Arizona black rattlesnake hibernation sites were found at Tonto for animals that did not have implanted radio transmitters, even though a den was found by Don Swann in the mid-1990's. This den is located... (information moved to Confidential Appendix D). We did not take environmental and habitat measurements at this site because we could not confirm it being used by Arizona black rattlesnakes, despite repeated surveys there in March, April, May, and October.

General locations for each animal's hibernation site are as follows... (moved to Confidential Appendix D).

Habitat and environmental parameters were collected around each site using 2-m radius plots in December 2004. Table 3a lists the environmental characteristics of each den site... (moved to Confidential Appendix D). Table 3b lists the percent cover of each vegetative type, the dominant vegetative cover species, and the canopy height class for each site.

The hibernation sites selected by telemetered Arizona black rattlesnakes at Tonto were striking in that all were found in rocky talus (rubble) slope areas... (Figure 8a-d, moved to Confidential Appendix D).

Table 3b. Vegetative ground cover characteristics of four hibernation sites selected by three adult Arizona black rattlesnakes at Tonto National Monument, Arizona, characterized in December 2004. Total vegetative (biotic) ground cover (determined by densitometer) is given, as well as percent cover of three pre-defined vegetative types: woody shrubs, forbs, and grasses. No trees were found in any plot. The dominant (by percent cover) plant species in each vegetative category is given, as is the height class for the canopy layer (after Rowlands 1995). See methods for additional explanation of cover class determination.

Snake Chnl	Year of Use	Total % biotic cover	% Shrub cover	Dominant shrubs	Dominant shrub height	% Forb cover	Dominant forbs	% Grass cover	Dominant grasses
03	03-04 04-05	20	5	Cholla (<i>Opuntia sp.</i>)	10 cm- 0.5m	10	Fiddlenecks (<i>Amsinckia sp.</i>)	5	annual bromes (<i>Bromus spp.</i>)
22	03-04	80	60	Wolfberry (<i>Lycium sp.</i>)	0.5-<2m	5	Fiddlenecks (<i>Amsinckia pp.</i>)	15	Gramma (<i>Bouteloua sp.</i>)
22	04-05	30	10	Jojoba (<i>Simmondsia chinensis</i>)	0.5-<2m	5	Desert senna (<i>Cassia sp.</i>)	15	Three-awn (<i>Aristida sp.</i>)
40	04-05	60	40	Soaptree yucca (<i>Yucca elata</i>)	0.5-<2m	15	Globemallow (<i>Sphaeralcea sp.</i>)	5	unknown sprouts

No trees were found within den site plots, but trees were present within 1-50 m of each plot. Nearby trees included crucifixion-thorn (*Canotia holocantha*, at the sites of Channel 03 and Channel 22 in 2003-2004), palo verde (*Parkinsonia* species, Channel 22 in 2004-2005), and velvet mesquite (*Prosopis velutina*, Channel 40). The sites were relatively open, with vegetative ground cover 60% or less at three sites and the canopy layer (shrubs) was less than 2 m tall. The shrub ground cover was also less than 50% at three sites. Forbs and grasses combined (mostly annual species) made up 20% of the ground cover at all sites. There was no pattern of dominant vegetation species at the sites.

Volunteers and Outreach

At least 17 volunteers assisted with many of the surveys at each park (see Acknowledgements). These volunteers included NPS staff, Student Conservation Association interns, professional herpetologists, graduate students, and friends and family of the researchers.

We conducted a two-hour rattlesnake handling training session for the Flagstaff Area National Monuments staff in mid-June. During the presentation, we covered goals and methods for the Arizona black rattlesnake surveys, discussed rattlesnake ecology, and supervised as the rangers practiced safe snake handling techniques.

Interpretive Ranger Mike Emery of Walnut Canyon National Monument developed an interpretive program based on the research and capture of an Arizona black rattlesnake in the park. Mr. Emery took images provided in part by researchers and created a PowerPoint slide show, which was made into sequential posters and displayed at the parks' visitor center (Appendix C).

Discussion

Survey Results and Relative Abundance

We found fewer Arizona black rattlesnakes (four in 2004) than we anticipated given our survey efforts. We also did not find any recaptures of animals previously detected, and we cannot make reliable population estimates.

At Saguaro, we went to areas where more than a few individuals had been previously detected (e.g. Appendix B). It is likely that had we spent more time in these areas over the course of the summer, we would have detected more Arizona black rattlesnakes. Logistics and limited funding prevented us from doing these more intensive surveys. Based on our experience with the species at other parks in this survey and in the Flagstaff area (unpublished data), and from previous data at Saguaro, we suspect the species could be patchily distributed but locally common near suitable hibernation sites.

At Tonto, we feel fairly confident that with all of our targeted survey efforts and incidental observation opportunities while radio tracking other venomous reptiles that we would have detected more Arizona black rattlesnakes had they been present. Typically, telemetered rattlesnakes lead researchers to others of the same species (Nowak and van Riper 1999). In our research, this was also true of one of our telemetered males; we found one or two new females by following him. However, in two years, we have detected only four or five adults of the species at the park: three in 2003 and one or two in 2004. While we cannot estimate population sizes, we suspect that the species is rare at Tonto.

At Walnut Canyon, we conducted initial surveys without knowing where Arizona black rattlesnakes had previously been detected, so our low detection rates for that park are not as surprising. As at Saguaro, the logistics of surveying outcrop areas in Walnut Canyon

was a major factor inhibiting more intensive surveys of the park. We have seen (and been provided with photographs of) several individual Hopi rattlesnakes (*C. viridis nuntius*) from the park (Persons and Nowak 2005). It is possible that the two subspecies undergo competitive exclusion at the park, where one forces the other from potentially suitable habitats in the part due to having increased adaptive advantage (Reinert 1993). Hopi rattlesnakes are detected more frequently than Arizona black rattlesnakes on the rim of Walnut Canyon according to park staff, but we suspect that Arizona black rattlesnakes would be the more common species within the canyon and its higher-elevation tributaries. The species has apparently been detected more than once at the mouth of Walnut Canyon near the Lower Lake Mary dam (Jeff Lovich, pers. comm.).

Natural History of Arizona black Rattlesnakes

Most of the information learned about the natural history of Arizona black rattlesnakes comes from telemetered animals at Tonto, so it is not known how much of this is applicable to the species in other parts of its range. Based on our unpublished data from the species in the Flagstaff area, we offer some generalizations for the species.

Active Season. We detected Arizona black rattlesnakes from May to August in our surveys and telemetered Arizona black rattlesnakes at Tonto were active from late March to late October. At Saguaro, our single detection was in late May. At Tonto, detections occurred in May and August. At Walnut Canyon, the sole detection was in late August. In 2003 at Tonto, new snakes were detected in July and September. These detection patterns fit with previous observations that more Arizona black rattlesnakes are detected during the summer monsoon season in southern Arizona (D. Swann and R. Repp, pers. comm.). It is likely that Arizona black rattlesnakes in northern Arizona are also most active during this period because it is the warmest time of the year.

Body Size. For three males found in national parks in southern Arizona, body size (SVL) ranged from 74 to 84 cm SVL, and weights ranged from 300 to 468 g. The heaviest snake was from Saguaro. The lengths are slightly longer than those of 29 males found near Flagstaff, Arizona (unpublished data) where adult male body size ranged from 45.4 to 74 cm SVL (average = $61.0 \text{ cm} \pm 7.9$ standard deviation [SD]). Weights for the Flagstaff population were also lighter, ranging from 69 to 374 g, with an average of $212.3 \text{ g} \pm 91.5 \text{ SD}$. The largest male detected at Saguaro was 10 cm longer and 94 g heavier than the largest Flagstaff male.

For three Arizona black rattlesnake females detected in the national parks, body size ranged from 53.5-67 cm, with the Walnut Canyon female being intermediate in size. Weights for the three national park females ranged from 122 to 355 g. These numbers are similar or slightly larger than those for females at the Flagstaff den sites, where 12 adult females ranged between 45-61 cm SVL (average = $53.4 \pm 5.5 \text{ cm}$). Weights for the Flagstaff females ranged between 72 and 200 g (average = $281.5 \pm 53.3 \text{ g}$). However, the Flagstaff data may be subject to biases associated with small sample size, as the Walnut Canyon female, also found near Flagstaff, had an SVL of 64 cm and a weight of 302 g.

Overall, it appears that southern Arizona black rattlesnakes are larger than those at a northern population near Flagstaff. These data are supported by Ashton (2001), who

found that the body size of adult *C. oreganus* (including *C. v. cerberus*, the Arizona black rattlesnake) was significantly negatively associated with seasonality; i.e., the more pronounced the seasons, the smaller the body size.

Mating Period and Reproduction. We found Arizona black rattlesnakes in courtship in late August and early September, indicating the species has a late summer and fall mating period coinciding with the summer rains. These results are consistent with Goldberg (2002). Goldberg also found evidence of a potential spring mating period through histology of the kidneys and testis of male Arizona black museum specimens; however, to our knowledge this has not yet been confirmed in wild snakes.

The minimum size (SVL) documented for reproductively active Arizona black females is 59 cm (Goldberg 2002); however, we observed a female with an SVL of 53.5 cm in active courtship, thus potentially revising the known size range of reproductive females (if we assume that males only court reproductively mature females). Our telemetered female was 67 cm SVL, and had four or five enlarged follicles when detected in mid-May. She subsequently gave birth in August to four or five embryos. This litter size is consistent with published records; previous litter sizes for Arizona black rattlesnake females range from 2-11, with means of 5.8 (Goldberg 2002), and 7.4 (Lowe et al. 1986).

Diet. During our study, telemetered Arizona black rattlesnakes were documented to consume a white-throated woodrat and an ash-throated flycatcher. Schuett et al. (2002) reported a neonate Arizona black rattlesnake near Flagstaff that had consumed an adult Southern Plateau lizard (*Sceloporus tristichus*, formerly called eastern fence lizard, *S. undulatus*). These data indicate that Arizona black rattlesnakes eat a variety of prey.

Hibernation Season and Sites. We documented hibernation in telemetered Arizona black rattlesnakes only at Tonto. The hibernation period lasted from late October to late March in 2003-2004, and from late October to at least early March in 2004-2005. This hibernation period is about two months shorter than that observed for Arizona black rattlesnakes near Flagstaff (unpublished data), where the snakes appear to enter hibernation in early October and begin to emerge in mid-April. As well, the Flagstaff population tends to stay near the den sites for up to a month after emergence, where they may be encountered on warm days basking near or under rocks. We found no evidence of the Tonto populations basking at their den sites in the spring or fall. This difference is likely due to a higher prevalence of unexpected spring snow storms in the Flagstaff area, forcing the snakes to stay near suitable cover longer into the spring.

The Arizona black rattlesnake hibernation sites at Tonto were unique in that they were all in small rubble talus slides on the sides of steeply-sloped washes. We rarely saw the telemetered rattlesnakes at their den sites so we were unable to determine how they accessed the interstitial spaces under these slides. These hibernation sites were notably different from those used by telemetered western diamond-backed rattlesnakes (*C. atrox*) and black-tailed rattlesnakes (*C. molossus*) at Tonto. Those species tended to use large rock outcrops or burrows in flat washes as hibernation sites (unpublished data). The sites selected by Tonto Arizona black rattlesnakes were similar to those used by the Flagstaff area populations in that all areas had a strong rocky talus component. However, Flagstaff populations appear to select talus slides against large basalt outcrops, probably to

maximize over winter temperatures and decrease chances of the snakes accidentally freezing in the dens over winter.

All species at Tonto tended to use hibernation sites with a south- or west- facing component to the aspect and little or no vegetation nearby. Thus, the sites receive high amounts of direct solar radiation during the winter hibernation period. This trend has been well-established for southwestern rattlesnake species, as the combination of aspect and lack of cover maximizes site temperatures over winter (Klauber 1972).

Although all of the hibernation sites selected by Arizona black rattlesnakes in 2003-2005 were in talus slides, a den area found by Don Swann at Tonto in the mid-1990's was different. This den site area was in a small rock outcrop between Deadman and Cave Washes, on a steep east-facing hillside containing many small outcrops. Given that we did not document Arizona black rattlesnakes at this site in 2004, we cannot be sure that it is still being used by the species. It would be useful to check the area in future years to determine if snakes are still found there.

Management Implications and Future Research

Given the paucity of Arizona black rattlesnakes we found during 2004, it is not possible to make broad management recommendations for the species in Arizona National Parks. The rattlesnake appears to be rare at Tonto. While it is possible that the species is simply difficult to detect rather than rare, active Arizona black rattlesnakes in other parts of their range tend to rattle when first encountered by humans (Nowak, personal observation). Thus, we feel it likely that the species is indeed rare at Tonto, and perhaps in Walnut Canyon as well. It appears more common in Saguaro based on previous observations (Appendix B). The relative scarcity of this snake in Arizona National Parks is not surprising given that Arizona black rattlesnakes are known to live primarily at elevations higher than those common in the three parks surveyed (Lowe et al. 1986).

We encourage future repeated surveys for the species in all three parks, especially if potential future warming and drying of the climate occurs. If such climate change were to happen in Arizona, this species could be affected due to its current distribution in cooler and wetter habitats. Given the low frequency of detections during our surveys, we would advocate more intensive surveys be conducted by experienced biologists or trained seasonal rangers or interpreters living in or near each park, rather than by researchers living far off-site. This strategy could maximize potential survey time and detections.

We especially encourage surveys for Arizona black rattlesnakes at Walnut Canyon, due to the interesting evolutionary questions posed by the apparent geographic overlap of two subspecies (or a species with a subspecies) of western rattlesnakes. In particular, telemetry studies could determine if the species overlap temporally or spatially, and if they partition winter or summer habitats.

Based on our knowledge of the species at Tonto and in other parts of its range, we suggest that future searches for Arizona black rattlesnakes start with rocky talus areas during the spring and fall months, keeping in mind that the species can be hard to detect during actual hibernation. In the summer, searching riparian areas and areas near rock

outcrops or talus would appear to produce the most fruitful results, especially during the monsoon period.

Given the rarity of the species and its known propensity to inhabit talus slides in the winter and riparian or mesic areas (at least at Saguaro and Tonto) in the summer, we recommend that management actions in those areas include consideration of measures to protect the rattlesnakes. For example, these habitats could be managed to ensure summer cover (under vegetation or rocks) and winter cover (under talus slides) for the snakes. At Tonto, active collaboration with USFS rangers and biologists would help ensure protection of those rattlesnakes living in the park during the summer months but hibernating in sites outside park boundaries. At all parks, fire management plans should take into consideration potential effects on rattlesnakes; for example, restricting managed burns in snake habitat during the egress period of late March to mid-April, and during the birthing season in late summer.

To help decrease the potential for negative human-snake encounters, advisory signs could be posted in areas known to be frequented by Arizona black rattlesnakes (e.g. the Happy Valley area at Saguaro, the riparian area in Cave Wash at Tonto, and the picnic area/ pit house ruins are at Walnut Canyon). To our knowledge, however, there has not been a bite by this species in any of the national parks surveyed. Given fairly specific habitat usage, especially for hibernation, long-distance (> 1 km) translocation of this would be detrimental to the individual moved (see also Nowak and van Riper 1999). We suggest that Arizona black rattlesnakes perceived as a human safety threats (or vice-versa) be moved not more than 100 m from their capture point, and not outside the original habitat type.

As a final cautionary note, this species is highly sought after by collectors due to its restricted range and beautiful color pattern (Bruce Taubert, Arizona Game and Fish Department, pers. comm.). It is highly likely that if hibernation sites (in particular) in National Parks become known to collectors, illegal poaching of snakes from the sites will occur. National Parks should educate all law enforcement personnel on the reptile trade in Arizona, perhaps working with the Arizona Game and Fish Department or other National Park programs to provide training in recognizing the trademark signs of this activity and its pursuers.

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Acknowledgments

The project was funded by a grant from the Western National Parks Association, and equipment and materials were provided by Tonto National Monument. The Resource Management staff of each park assisted with research and provided logistical support, and without their initial support this work would not have been possible. These folks are: Shirley Hoh at Tonto National Monument, Don Swann and Matt Daniels at Saguaro National Park, and Paul Whitefield and Steve Mitchelson at Walnut Canyon National Monument. Mike Emery graciously contributed materials from an interpretive program he developed on the research. We thank Shirley Hoh, Jeff Lovich, Phil Rosen, Mark Sogge, and Paul Whitefield for their very helpful comments and suggestion on the draft.

Amyann Madara and Jon Bortle assisted with fieldwork for this project. Dale Denardo performed the radio-transmitter implants at Arizona State University. The following volunteers assisted with surveys or rattlesnake processing during this project: Emily Taylor and Jon Davis (Arizona State University), Marty Feldner, Roger Repp, Jeannie Stevens Schofer, and Bill Bridgeland and Robin Rauch (Northern Arizona University). NPS volunteers included: Patrick Yagla, Shirley Hoh, and many other staff members of Tonto National Monument; Don Swann, Reagen Greenfield, and Patrick Royer of Saguaro National Park; and Mary Blasing, Jordan Lesser, Steve Nycz, Dianne Pennington, and Mike Emery of the Flagstaff Area National Monuments.

Appendix A. Date, location, weather, and GPS coordinates for locating routes surveyed for Arizona black rattlesnakes (*C. viridis cerberus*) in 2004. Table 4 contains data for Saguaro National Park, Table 5 for Tonto National Monument, and Table 6 contains data for Walnut Canyon National Monument.

Table 4. Date, location, weather, and GPS coordinates for locating routes surveyed for Arizona black rattlesnakes (*C. viridis cerberus*) in 2004 at Saguaro National Park. "Point"= the location of each GPS point on the maps in Figure 1a. An asterisk * indicates that a snake was captured during the survey. "CG"= campground. Times are given in military time. "Sun condition" (e.g., sunny or not sunny), air temperature (in degrees Celsius), % relative humidity ("% rH"), and the average wind speed ("av. wind", in meters/second) were taken at the start and end of each survey. GPS Data is in NAD 27 Datum.

Saguaro NP Location	Date	Time	Weather				UTM Easting	UTM Northing	Point
			Sun Condn.	Air Temp (°C)	% rH	Wind av. (m/s)			
3.2 MILES UP MILLER CREEK TRAIL	5/4	1545-1745	SUNNY-SUN BEHIND RIDGE	28.8-26.4	10-15	0.6-0.4	548819	3557391	1
							548819	3557391	1
							548819	3557391	1
MILLER CREEK TRAIL- HAPPY VALLEY CG- RETURN	5/6	0830-1600	SUNNY-SUN BEHIND RIDGE	30.3-28.4	13-15	0.3-0	547146	3558349	
							545084	3556922	3
							548819	3557391	1
MILLER CREEK TRAIL- HAPPY VALLEY CG- RETURN	5/7	0750-1450	SUNNY-SUNNY	22.9-30.1	21-11	0-0.5	548819	3557391	1
							545084	3556922	3
							548819	3557391	1
MILLER CREEK TRAIL AND NEARBY, ALSO TO SE OF TRAIL ON PARK EDGE	5/21	1512-1723	SUNNY-SUN BEHIND RIDGE	29.3-26.5	10-11	1.3-0.6	547198	3558143	4
							547106	3558305	5
							547418	3557797	6
MILLER CREEK TRAIL AREA- NOT ON TRAIL	5/22	0850-1021	SUNNY-SUNNY	18.9-24	19-11	0.6-2	547316	3558483	7
							547177	3558420	8
							547323	3558398	9
MILLER CREEK TRAIL TO HAPPY VALLEY CG	5/27	0715-1615	SUNNY-SUNNY	19.1-20.4	13-11	0-0.4	548819	3557391	1
							545084	3556922	3
							545164	3557067	
* BETWEEN HAPPY VALLEY CG AND HAPPY VALLEY LOOKOUT CABIN ON HEARTBREAK RIDGE TRAIL	5/28	0700-1500	SUN RISING-SUN BEHIND RIDGE	17.2-17.4	26-28	0.6-11	545037	3558937	11
							544194	3562967	12
							544053	3562890	13
SPUD ROCK CG- MANNING CG-RETURN	5/29	0900-1600	SUNNY-SUN BEHIND RIDGE	17.1-18.6	29-33	0-0	543128	3563412	14
							541995	3563233	

Table 4. continued Date, location, weather, and GPS coordinates for locating routes surveyed for Arizona black rattlesnakes (*C. viridis cerberus*) in 2004 at Saguaro National Park. "Point"= the location of each GPS point on the maps in Figure 1a (some numbers are omitted for clarity of presentation). An asterisk * indicates that a snake was captured during the survey. "CG"= campground. Times are given in military time. "Sun condition" (e.g. sunny or not sunny), air temperatures (in degrees Celsius), % relative humidity (" % rH"), and the average wind speed ("av. wind", in meters/second) were taken at the start and end of each survey. GPS Data is in NAD 27 Datum

Saguaro NP Location	Date	Time	Weather				UTM Easting	UTM Northing	Point
			Sun Condn.	Air Temp (°C)	% rH	Wind av. (m/s)			
SPUD ROCK CG VIA DEER VALLEY TRAIL	5/30	0830-1300	SUNNY-SUNNY	16.8-22.4	26-10	0.4-0	544183	3562901	
							548891	3559965	17
							548551	3557276	18
MANNING CG TRAIL- GRASS SHACK CG	7/19	1300-1840	SUNNY-SUNNY	31.8-29.6	27-31	1.6-0	536731	3557140	19
							536799	3559945	20
							538580	3560842	21
GRASS SHACK CG- MANNING CG, ABOVE MANNING CG APPROX. 3 KM	7/20	0800-1626	SUNNY-SUNNY	23-22.1	36-33	0-0	538737	3560772	22
							542033	3563282	32
							542912	3563216	24
MANNING CG- SPUD ROCK- HAPPY VALLEY CG- MANNING CG	7/21	0730-2000	SUNNY-SUNSET	22.3-22.6	47-33	0.7-0	541897	3563238	25
							544150	3562907	
							544180	3562305	27
MANNING CG- COWHEAD SADDLE TRAIL- MICA MTN	7/22	0730-1630	SUNNY-SUNNY	17.3-19.6	64-33	1.3-1.6	545175	3557152	28
							541833	3563097	29
							541918	3563915	30
MANNING CG-GRASS SHACK CG- TRAILHEAD	7/23	0930-1330	SUNNY-SUNNY	18.9-26.8	30-10	0-0	543231	3564691	31
							542031	3563320	32
							538029	3560733	33
							536884	3556999	34

Table 5. Date, location, weather, and GPS coordinates for locating routes surveyed for Arizona black rattlesnakes (*C. viridis cerberus*) in 2004 at Tonto National Monument. "Point"= the location of each GPS point on the maps in Figure 1b. An asterisk * indicates that a snake was captured during the survey. "USFS"= US Forest Service, "VC"= visitor center. Times are given in military time. "Sun condition" (e.g., sunny or not sunny), air temperature (in degrees Celsius), % relative humidity ("% rH"), and the average wind speed ("av. wind", in meters/second) were taken at the start and end of each survey. "NA" means no measurement was taken. GPS Data is in NAD 27 Datum.

Tonto NM Location	Date	Time	Weather				UTM Easting	UTM Northing	Point
			Sun Condn.	Air Temp (°C)	% rH	Wind av. (m/s)			
CHOLLA WASH SLOPES-USFS LAND EAST OF HONEY BUTTE	3/26	940-1440	SUNNY-NA	18-22	19-18	0.7-0	489458 489319 489949	3722478 3722436 3722082	1 2 3
VC- HONEY BUTTE-DEADMAN WASH	3/27	1200-1700	SUNNY-SUN BEHIND RIDGE	29.8-23.1	18-18	0.8-0	489658 489990 489118	3722504 3722081 3723117	5 6 7
CHOLLA WASH-TALUS AREA UPSLOPE-RIPARIAN AREA	4/16	1350-1850	INDIRECT SUN	30.1-28.1	18-18	0-0	489446 489316 489589	3722466 3722440 3722228	7 2 8
RIPARIAN AREA UP SWITCHBACKS TO UPPER CLIFF DWELLING	4/30	1240-1640	PARTLY CLOUDY-CLOUDY	30.1-28.2		0-0.2	489560 489513 489503	3722230 3722130 3722277	
* DEADMAN WASH AREA	5/14	1852	SUN BELOW RIDGE	27.7-NA	12-NA	0.3-NA	488815 489575	3722270 3722262	CERB 13
CAVE WASH NEAR VC-RIPARIAN AREA NEAR SPRING	5/18	1300-1940	SUNNY-SUNSET	32.4-26.7	12-19	0-0.6	489503 489511	3722280 3722266	11
RIPARIAN AREA AND ABOVE	6/29	1400-1930	SUNNY-DUSK	30.9-NA	6-NA	0.2-NA	489560 489103	3722252 3722640	
RIPARIAN AREA- SWITCHBACKS TO UPPER CLIFF DWELLING	7/7	1200-1800	SUNNY-SUNNY	37.7-NA	NA	0.4-NA	489548 489624	3722178 3722010	18
RIPARIAN AREA- DEADMAN WASH- CAVE WASH	7/8	1200-1830	SUNNY-SUNNY	39.4-NA	6-NA	0.5-NA	489548 489116 489444	3722170 3723140 3722107	17 19 20
PUMPHOUSE-DEADMAN WASH-CHOLLA WASH	7/14	1130-1630	NA	31.4-NA	16	0-NA	489672 488796 489618	3722656 3722290 3722696	21 22 23

Table 5. continued Date, location, weather, and GPS coordinates for locating routes surveyed for Arizona black rattlesnakes (*C. viridis cerberus*) in 2004 at Tonto National Monument. "Point"= the location of each GPS point on the maps in Figure 1b. An asterisk * indicates that a snake was captured during the survey. "USFS"= US Forest Service, "VC"= visitor center. Times are given in military time. "Sun condition" (e.g. sunny or not sunny), air temperatures (in degrees Celsius), % relative humidity (" % rH"), and the average wind speed ("av. wind", in meters/second) were taken at the start and end of each survey. "NA" means no measurement was taken. GPS Data is in NAD 27 Datum

Tonto NM Location	Date	Time	Weather				UTM Easting	UTM Northing	Point
			Sun Condn.	Air Temp (°C)	% rH	Wind av. (m/s)			
RIPARIAN AREA-HONEY BUTTE-USFS LAND-CAVE WASH	7/15	930-1430	NA	NA-32.2	NA-21	NA-0	489618	3722696	23
							490043	3721875	24
							489540	3722604	25
RIPARIAN AREA-VC-UPPER CLIFF DWELLING TRAIL	8/3	1945-2200	DUSK-DARK	33.7-33.6	27-29	0.6-0.3	489435	3721847	26
							489528	3722114	27
							489668	3722532	28
* AT BASE OF BLUFF OVERLOOKING DEADMAN WASH	8/22	946	IN SHADE	24.8-NA	31-NA	0-NA	489039	3722445	29
BASE OF BLUFF OVER DEADMAN WASH AND EAST- SADDLE EAST AND ABOVE RIPARIAN AREA	9/3	830-1430	NA	NA-28.7	NA-43	NA-0.6	489548	3722178	17
							489120	3723147	19
							488988	3722301	30
HILLSIDE OPPOSITE LOWER CLIFF DWELLING-UPPER CLIFF DWELLING-RIPARIAN AREA	10/16	1230-1900	SUNNY-NA	32.7-NA	18-NA	0.8-NA	489381	3722481	31
							488789	3722218	32
							489548	3722180	17

Table 6. Date, location, weather, and GPS coordinates for locating routes surveyed for Arizona black rattlesnakes (*C. viridis cerberus*) in 2004 at Walnut Canyon National Monument. "Point"= the location of each GPS point on the maps in Figure 1c. An asterisk * indicates that a snake was captured during the survey. ". Times are given in military time. "Sun condition" (e.g. sunny or not sunny), air temperatures (in degrees Celsius), % relative humidity (" % rH"), and the average wind speed ("av. wind", in meters/second) were taken at the start and end of each survey. "NA" means no measurement was taken. GPS Data is in NAD 27 Datum

Walnut Canyon NM Location	Date	Time	Weather				UTM Easting	UTM Northing	Point
			Sun Cond.	Air Temp (°C)	% rH	Wind av. (m/s)			
WALNUT CANYON WEST OF PICNIC AREA AND RIM TRAIL	5/23	1010-1410	CLOUDY-OCCASIONAL SUN	19.6-21.8	12-12	0.8-1.2	453739	3892083	1
							454200	3891587	2
							454284	3891460	3
VC- RIM TRAIL AND INTO CANYON VIA RANGER CABIN	5/24	1110-1410	SUNNY-PARTLY CLOUDY	20.2-22.6	14-13	1.1-0.6	453655	3892165	4
							452387	3891505	5
							452773	3891700	6
VC AND EAST ALONG RIM TRAIL-INTO CANYON AND RETURN	6/18	1110-1440	PARTLY CLDY-SUNNY	20.2-23.6	13-15	0-0	453704	3892162	
							453455	3891714	8
							454383	3891839	9
VC- WEST ALONG CANYON RIM	7/2	1115-1415	SUNNY-SUNNY	25.4-26.8	5-5	0.6-0.9	453682	3892113	
							454175	3891631	
							454149	3891642	12
VC-PICNIC AREA-RIM TRAIL	7/16	1010-1353	CLOUDY-RAINING	NA-NA	74-100	0.9-0.7	453766	3892061	
							453856	3892075	14
							454088	3891702	15
PAVED ROAD FROM VC TO I-40	7/17	1900-2200	DUSK-DARK	21.4	66-60	0.8-0	454088	3891702	15
							452997	3896014	17
							453777	3892205	
VC-PICNIC AREA-CANYON TRAIL-ROAD	8/3	1853-2148	DUSK-DARK	27.2-21.1	30-36	0.8-0	453711	3892190	
							453760	3892148	20
							453676	3891930	21
VC-PICNIC AREA	8/20	1036-1410	SUNNY-CLOUDY, STORMY	22.5-20.2	38-45	0.6-0.9	452749	3896986	22
							452314	3892592	23
							453806	3892055	
							453378	3892337	25

Table 6. continued Date, location, weather, and GPS coordinates for locating routes surveyed for Arizona black rattlesnakes (*C. viridis cerberus*) in 2004 at Walnut Canyon National Monument. "Point" = the location of each GPS point on the maps in Figure 1c. An asterisk * indicates that a snake was captured during the survey. "CG" = campground. Times are given in military time. "Sun condition" (e.g. sunny or not sunny), air temperatures (in degrees Celsius), % relative humidity (" % rH"), and the average wind speed ("av. wind", in meters/second) were taken at the start and end of each survey. "NA" means no measurement was taken. GPS Data is in NAD 27 Datum

Walnut Canyon NM Location	Date	Time	Weather				UTM Easting	UTM Northing	Point
			Sun Cond'n.	Air Temp (°C)	% rH	Wind av. (m/s)			
VC- NORTH ALONG CANYON 2 KM	8/21	1030-1440	SUNNY-SUNNY	22.3-23.6	47-43	0.4-0.6	453773	3892123	
							453774	3892026	27
* BY ENTRANCE STATION KIOSK	8/27	1048	NA-SUNNY	27.1	12	0.9	453741	3892202	28
							453701	3892118	
VC-PICNIC AREA, WEST PARK BOUNDARY AND WEST FROM RANGER CABIN	9/9	920-1336	PARTLY CLOUDY-NA	26.6-26.4	19-19	0.3-0.7	452298	3891547	30
							452299	3891710	31
							452320	3892446	32

Appendix B. Capture information for Arizona black rattlesnakes detected during herpetological inventories at Saguaro National Park in 2001. Data was collected by Dave Prival and Dan Bell, and provided by Brian Powell of the National Park Service Sonoran Desert Network.

Table 7. Capture data for 19 adult Arizona black rattlesnakes detected in Saguaro National Park in 2001 by the Sonoran Desert Inventory and Monitoring Network. The general location of each capture is given, along with date, sex (M=male, F=female), snout-vent length (SVL) in mm, weight in g, tail in mm, and total number of rattle segments. UTM coordinates are in WGS 84 Datum.

Saguaro Location	Date	Sex	SVL	Wt	Tail	Total # Rattles	UTM Easting	UTM Northing
South boundary of FP 120, Plot 1	5/14	M	685	305	56.4	8	535688	3563494
Wasp Spring Canyon	6/27	M	900	531	61.5	12	535881	3558807
Douglas Springs Campground	8/8	M	795	465	67.1	9	537031	3565792
E of Douglas Springs Trail	5/16	M	903	455	59.1	13	537686	3563342
Cowhead Saddle Trail ~200 m E of saddle.	8/7	M	699	245	53.7	10	537804	3563060
Drainage ~2 km NE of Cowhead Saddle.	8/8	M	798	375	59.5	9	538121	3564569
Canyon near FP 125, south of Plot 6	5/15						538293	3564528
Canyon SW of Plot 1, FP 125	5/15	M	717	335	57	7	538504	3564358
Canyon S of FP 125, Plot 2.	5/15	M	883	495	61.3	8	538606	3564259
~900 m E of Grass Shack Spring in Chiminea Canyon.	5/11	F	676.3	150	33.7	9	539285	3561517
FP 155, Plot 1 on W border	5/23	M	710	335	58.8	6	544567	3559145
~400 m SW of junction of Rincon Creek Trail and Rincon Peak Trail	9/5	F	618	230	37	10	544921	3556991
Happy Valley Campground	5/22	F	605	215	35.1	9	544976	3557205
Happy Valley Campground	9/5						544992	3557911
500 m N of Happy Valley Campground	9/7	M	710	330	52.8	10	545016	3557380
Happy Valley Saddle Campground	9/5	M	723	245	49.2	10	545018	3557124
Miller Creek Trail ~1 mile from NPS boundary.	9/5	M	745	390	66.1	6	546602	3558167
Miller Creek Trail ~1 mile from NPS boundary.	9/5	M	631	160	48.4	7	546605	3558153
Turkey Creek drainage ~500 m W of NPS boundary	9/3	M	635	215	46.5	7	546900	3561595

Appendix C. PowerPoint Presentation developed by Interpretive Ranger Mike Emery about Arizona black Rattlesnake capture at Walnut Canyon National Monument in August 2004.



Justin is writing down information pertaining to the park where the snake was captured.



The rattlesnake is in the bucket with the see-through lid on, Justin is going to try to coax the snake into crawling up into a long plastic tube.

...but first he has to get his equipment ready.



Come on, come on... crawl in the tube....
pretty please!!!



Once in the tube the rattlesnake is easy to handle. Justin can see how long it is, count the rattles it has, even find out the sex of the snake. This one is a female about three feet long.

This rattlesnake has eight and a half rattles.





Hold still, this
won't hurt a
bit...

..while Justin
inserts the tag
in the snake so
he can track
her location.

(Don't worry she doesn't feel any pain at all)



Time to take some blood to
identify her species.



(Don't worry she doesn't feel any pain at all)



Let's see
how much
she weighs.
Humm, 349
grams.
(3/4 pound)

Perfect time to educate our visitors on rattlesnakes.





Time to let her go back home. We'll see ya another
time, bye, bye.

Appendix D. Confidential Information on Arizona Black Rattlesnake Hibernation Site Characteristics at Tonto National Monument, Arizona.

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Tonto Hibernation Site Locations and GPS Coordinates

No Arizona black rattlesnake hibernation sites were found at Tonto for animals that did not have implanted radio transmitters, even though a den was found by Don Swann in the mid-1990's. This den is located between Cave and Deadman Wash and its GPS coordinates (NAD 27 datum) are: 489120E and 3723147N. We did not take environmental and habitat measurements at this site because we could not confirm it being used by Arizona black rattlesnakes, despite repeated surveys there in March, April, May, and October.

General locations for each site are as follows: male 03 in Cholla Wash southeast of the Lower Cliff Dwellings and female 40 in Deadman Wash below the saddle west of the Lower Cliff Dwellings. Male 22 used different sites in subsequent years, both outside park boundaries. From December 2003 to April 2004 he was approximately 200 m southeast of the park boundary, east of the saddle below Honey Butte. From November 2004 to March 2005 he was approximately 80m to the west of this location in a different wash (approximately 150 m east of the park boundary).

Habitat and environmental parameters were collected around each site using 2-m radius plots in December 2004. Table 3a lists the environmental characteristics of each den site. Table 3b ... (in main body of text).

Table 3a. Environmental characteristics of four hibernation sites selected by three adult Arizona black rattlesnakes (listed by channel number) at Tonto National Monument, Arizona, characterized in December 2004. Year of use is given, as are slope and aspect along the slope (both in degrees), elevation (in m), and UTM coordinates (NAD 27 datum). The dominant abiotic ground cover (determined by densitometer) is also given: "gravel" is rocks in size class 0.6-7.6 mm; "rubble" is rocks in size class >7.6-61cm (Rosgen 1996).

Snake Channel	Years of Use	Slope	Aspect	Elevation	% abiotic ground cover	Dominant abiotic ground cover	UTM Easting	UTM Northing
03	03-04, 04-05	8	214	879	80	gravel	489285	3722453
22	03-04	35	195	924	20	rubble	489929	3722054
22	04-05	8	215	879	70	rubble	490079	3722041
40	04-05	11	85	1008	40	rubble	488810	3722276

The hibernation sites selected by telemetered Arizona black rattlesnakes at Tonto were striking in that all were found in rocky talus (rubble) slope areas on the edges of or in washes (Figure 8a-d). The area covered by these talus slides averaged 20 m or less in length by 5 m in width. Aspects of three sites were toward the southwest, but one den (Channel 40, in Deadman Wash) faced northeast. Two of the four dens had more rock and soil (abiotic) cover than vegetation.



Figure 8a. Hibernation (“den”) site for adult male Arizona black rattlesnake #113612716A (Channel 03) at Tonto National Monument. Site is located in Cholla Wash. GPS coordinates and other environmental parameters are given in Table 3a-b.



Figure 8b. Hibernation (“den”) site for adult male Arizona black rattlesnake # 113447644A (Channel 22) at Tonto National Monument in 2003-2004. Site is located on USFS land east of the park. GPS coordinates and other environmental parameters are given in Table 3a-b.



Figure 8c. Hibernation (“den”) site for adult male Arizona black rattlesnake # 113447644A (Channel 22) at Tonto National Monument in 2004-2005. Site is located on USFS land east of the park. GPS coordinates and other environmental parameters are given in Table 3a-b.



Figure 8d. Hibernation (“den”) site for adult female Arizona black rattlesnake #113665543A (Channel 40) at Tonto National Monument in 2004-2005. Site is located in Deadman Wash. GPS coordinates and other environmental parameters are given in Table 3a-b.
