# **2007** SURVEY RESULTS FOR THE TUCSON SHOVEL-NOSED SNAKE (*CHIONACTIS OCCIPITALIS KLAUBERI*), WITH EVIDENCE FOR ECOLOGICAL CHANGE IN SOUTH-CENTRAL ARIZONA

## **Final Report**

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### Summary

The goal of this project was to clarify the status of the Tucson Shovel-nosed Snake in the area where it has apparently declined most markedly, northeastern Pima County and southeastern Pinal County, Arizona (Fig. 1). Matching funds from Arizona Game and Fish Department (\$6K) and the Town of Marana (\$14K) were utilized to survey by drift fence-funnel trapping, road driving, and on-foot searches at night. We observed a total of 9 Western Shovel-nosed Snakes (*Chionactis occipitalis*) in the area occupied by the Tucson subspecies or its intergrade zone during the surveys, including 3 from the Santa Cruz Flats, 2 from near Mobile in Maricopa County, and 4 from western Pima County, but none in Avra Valley.

The three shovel-nosed snakes found in the main study area were all in Pinal County on the margins of the Santa Cruz Flats. Two were on Picacho Highway north of Picacho Peak, and one was on the lowermost bajada north of the West Silverbell Mountains. We also obtained a 2006 photo-vouchered record from south of Picacho Reservoir. Searches in Sonoran Desert National Monument on the Maricopa Mountains bajada and on State Route 85 between Gila Bend and Ajo (2 and 4 shovel-nosed snakes, respectively) indicated adequate snake activity for detection during our survey.

We found 51 snakes in the trapping effort, located in the heart of the formerly documented shovel-nosed snake distribution in Avra Valley. Included were two of the ecologically similar Variable (=Banded) Sand Snake *Chilomeniscus stramineus* (=*cinctus*), but no shovel-nosed snakes. Our other returns of 131 snakes includes 9 additional Banded Sand Snakes, most of which were in habitat and localities where shovel-nosed snakes would be expected or were previously recorded.

We also recorded 35 Regal Horned Lizards (*Phrynosoma solare*) in parts of the study region where the Desert Horned Lizard (*Phrynosoma platyrhinos*) was previously known and vouchered as a prominent horned lizard. These results are in parallel to the findings for the two snake species reported here: a Lower Colorado Valley (LCV), true desert species appears to be yielding ground gained by an Arizona Upland (AU), thornscrub-desert species. It is possible that a broader process of ecological change is affecting the transitional zone between the more xeric (LCV) and less arid (AU) provinces of the Sonoran Desert. We therefore initiated an examination of other species that might be similarly affected.

We documented the occurrence of the large kangaroo rats *Dipodomys* spectabilis (Semi-desert Grassland and AU) and *D. deserti* (LCV) within a "blank zone" in their mapped distributions, which corresponds to the center of our study region. Preliminary evidence places the Bannertail Kangaroo Rat (*D. spectabilis*) 15-30 miles further north (and possibly into the LCV) than previously mapped by Hoffmeister in The Mammals of Arizona. However, this species pair requires further taxonomic and distributional study before any firm conclusions can be drawn.

A second lizard species pair being examined in the study region has not, as yet been demonstrably affected. The Long-tailed Brush Lizard (*Urosaurus graciosus*;



Figure 1. Map of the 2007 survey region (modified using TOPO!, National Geographic software) indicating roads, valley regions, and other landmarks referred to in text and appendices. The blue asterisks represent the general area of drift fence trapping conducted during this study.

characteristic of the LCV) persists in southern Marana and probably elsewhere despite the presence of a likely – and possibly dominant – competitor, the Northern Tree Lizard (*U. ornatus*; abundant in the AU and into Upper Sonoran and Transition life zones).

Using the Christmas Bird Count and Arizona Breeding Bird Survey, I also examined the abundance trends for specialized, regionally endemic birds of the thrasher group. The species most characteristic of the LCV, LeConte's Thrasher, which is the only bird completely restricted to desertscrub in the American Southwest, appears to be declining significantly in the United States. It also appears to have retreated from the study region in a manner like that indicated for the Tucson Shovel-nosed Snake and Desert Horned Lizard.

The findings strongly confirm the previous indications that the Tucson Shovelnosed Snake has declined precipitously in Avra Valley, and that the Banded Sand Snake has increased in observable abundance in at least many of the same areas the shovelnosed snake has declined. We cannot confirm the complete extirpation of the shovelnosed snake in the Avra Valley based on these sample sizes, but it seems increasingly probable that it does not currently live in eastern Pima County.

Our findings suggest that this is not random biogeographic noise, but part of a broader pattern, whose extent cannot now be accurately delineated. Possible explanations for such a change include near-complete agricultural conversion of level, sandy valley floors, penetration of displacing, Arizona Upland species from bajadas or higher valley floors into remaining habitat patches, and road mortality and habitat fragmentation, which may affect less mobile species such as the two *Urosaurus* species and the Banded Sand Snake less severely than more mobile species – possibly including shovel-nosed snakes. However, the general persistence of essentially all other species in the herpetofauna in many of the remaining habitat fragmentation and could involve larger scale climatic or other ecological effects.

Genetic samples are available for the five road-killed shovel-nosed snakes we found, and additional samples can be obtained from sheds, or, if necessary scale clips or bleeding of the four live ones, which have been taken into captivity.

### Methods

Road cruising was done at 22-28 mph on paved roads and 10-12 mph on dirt roads. Onethree persons were in the vehicle looking for snakes. Road cruising was conducted starting at early dusk and generally continuing to 21:00-22:30 hr. On-foot searches were generally started during the sunset hour, and continued through 21:00-22:00 hr. Prior to on-foot searches, areas with loose sand were searched for tracks similar to those made by shovel-nosed snakes. Some on-foot searches were conducted during the morning. Snakes and other animals encountered were recorded on datasheet and as waypoints on GPS units and live animals were released immediately, except for the few collected shovelnosed and banded sand snakes.

Road cruising totals of 693 miles on paved roads and 144 miles on dirt roads were conducted during May and June of 2007, along with 90.65 person-hours of on-foot search, which included one search during early July (Appendix 6). Almost all of this

effort was exerted during peak times for shovel-nosed snake activity and all was under suitable thermal conditions.



Figure 2. Snake trap of the same design as those used in Avra Valley in 2007. The fence directs snakes into the screen funnel traps, from which snakes can only escape by falling into the buried, covered bucket, in which they are further trapped, while being protected from heat and flood.

Trapping consisted of 10 drift fence arrays with funnel traps (Fig. 2). Each trap consisted of a 50-ft length of fence (24" tall shade cloth with mesh openings less than 1/8" set 4-6" into the soil), leading to 1-ft tall X 2-ft wide hardware cloth mesh funnel. Plywood baffles were placed as wings next to the funnels to discourage animals from going around the trap. Snakes moving along the trap were almost all forced into the wire funnel trap (as indicated by tracks along the fences), and once in the funnel trap they exited via a wire cylinder into 20-gal, mostly buried plastic garbage cans, where they remained until removed. The garbage cans had flush, snap-on lids, and were covered by large pieces of plywood to prevent solar heating.

Traps were checked daily prior to sunset, and all animals were removed from each bucket at that time. Each animal was recorded on a datasheet. Trapped snakes were held in laboratory cages until the end of each approximately 2-wk long trapping period to avoid re-trapping or exposing animals to predation from trapped Coachwhip snakes. All other animals in the traps were released immediately during the trap checks. Snakes were measured, weighed, examined for injuries, and, if they were large enough, marked with PIT tags prior to release.

There were 17 d of trapping in May (166 trap-d, with 2 funnels per trap, i.e., 332 funnel-d) and 15 d of trapping in June (135 trap-d), as summarized in Appendix 4. One of

the traps was destroyed by livestock during May and was removed completely on 26 May, so a majority of the effort involved 9 traps, rather than the original 10.

### <u>Results</u>

*Burrowing Snakes*. A total of 182 snake captures were recorded during this study, 51 from trapping areas (including 2 found on roads during trap-checking) and 131 from other sampled areas (Tables 1 and 2). The traps captured 661 lizards and 87 rodents (Table 1). Thirty-one records of anurans were obtained during road-cruising and 81 lizard observations were also recorded during road cruising and on-foot searches (Table 2). All lizards and amphibians recorded on roads included in Table 2, along with they records of lizard species considered noteworthy such as horned lizards, tree/bush lizards, the Desert Iguana, Gila Monster, and, had any been seen, the Long-nosed Leopard Lizard (see Appendix 2).

	No. of		Total		Total		Total
	Indi-	Recap-	Cap-		Cap-		Cap-
Snakes	viduals	tures	tures	Lizards	tures	Rodents	tures
AREL	1		1	ASTI	515	CHPE	67
CHCI	2		2	CADR	18	NEAL	4
CRCE	2		2	COVA	49	ONTO	6
HYTO	11	1	12	DIDO	6	PEER	2
LEHU	1		1	GAWI	2	SPTE	4
MAFL	13	6	19	PHSO	11	DIME	3
PHBR	1	1	2	SCMA	15	MUMU	1
PICA	1		1	UROR	5	All Rodents	87
RHLE	9	2	11	UTST	40		
All Snakes	41	10	51	All Lizards	661		

Table 1. Vertebrates (all were snakes, lizards, and rodents) captured in drift fence traps in Avra Valley during May-June 2007. Recaptures pertain to individuals marked in May and found again in June. Abbreviations are listed in Appendix 3.

No Tucson Shovel-nosed Snakes were found in Avra Valley despite the large efforts exerted there. Three were found on the margins of the Santa Cruz Flats in 2007, two north of Picacho Peak and one across the Santa Cruz Flats just off the north bajada edge of the West Silverbell Mountains. Dr. Robert L. Bezy delivered a photo voucher of an additional Tucson Shovel-nosed Snake found in 2006 at the margin of the agricultural flats west of the Picacho Mountains and south of the site of Picacho Reservoir. These records are plotted in Fig. 3.

In contrast to these sparse records obtained with considerable effort, a single trip to the Maricopa Road in Sonoran Desert National Monument between Gila Bend and Mobile yielded two live Western Shovel-nosed Snakes, and four more were found during two runs between Ajo and Gila Bend on State Route 85.

Banded Sand Snakes were found at numerous localities during this and earlier 21<sup>st</sup> century surveys I have conducted (see Fig. 3, Appendices 1 and 2, and Rosen [2003, 2004]). Several records are from areas where habitat appears highly suitable for shovel-nosed snakes, and four records are available from sites where museum vouchers of

Tucson Shovel-nosed Snakes were collected between 1940 and 1980 (Fig. 3). Prior to 1980, no Banded Sand Snakes had been collected from the valley floors in the region formerly and currently occupied by the Tucson Shovel-nosed Snake.

species na	mes (see A	Appendix 3).	
Snakes:		Lizards:	Anurans:
AREL	4	CADR 3	BUAL 19
CHCI	7	COVA 43	BUCO 8
CHOC	9	DIDO 1	BUWO 2
CRAT	13	HESU 1	RACA 2
CRCE	32	PHSO 24	All Toads & Frogs 31
CRSC	12	URGR 4	
HYTO	3	UROR 5	
LAGE	4	All Lizards81	
LEHU	4		
MAFL	3		
MIEU	1		
PHBR	2		
PHDE	8		
PICA	7		
RHLE	14		
SAHE	4		
SOSE	1		
THMA	2		
TRBI	1		
All Snakes	s 131		

Table 2. Amphibians and reptiles recorded during 2007 shovel-nosed snake survey in southern Arizona (see Appendix 2), not including those found in traps (see Table 1). Abbreviations are the first two letters of the genus and species names (see Appendix 3).

Considerable efforts were also made in the sandy creosote valley bottom between Interstate Highway 10 and Pinal Air Park, in Pinal County between the Pima County line and Sasco-Red Rock Road. This is a substantial patch of habitat that appears suitable for shovel-nosed snakes, although neither the Tucson Shovel-nosed Snake nor the Banded Sand Snake has been recorded there yet.

*Horned Lizards and Tree/Brush Lizards*. During 2007, 35 records of the Regal Horned Lizard were obtained from throughout the study area in valley conditions potentially suitable for the Desert Horned Lizard. Although the latter species was formerly collected at around 10% of the horned lizard museum voucher record in this region (Rosen, unpublished review of museum records), none are known from the 21<sup>st</sup> century catalog from the study area, which is currently at or above 100 horned lizards; the most recent record is from 1991, on Avra Valley Road, collected as a road kill by Richard White (Rosen, unpublished).

The Northern Tree Lizard (*Urosaurus ornatus*) is less arid-adapted than the ecologically similar Long-tailed Brush Lizard (*U. graciosus*). I have nonetheless found



# Figure 3. Recent distributional records for the Tucson Shovel-nosed Snake (*Chionactis occipitalis klauberi*) and the Banded Sand Snake (*Chilomeniscus cinctus*) from Avra Valley and Santa Cruz Flats.

the latter surviving in small habitat patches adjoining irrigation agriculture from southeastern Avra Valley (Point of the Mountain) to the margins of the Santa Cruz Flats (11 Mile Corner Road at the West Silverbell Mountains bajada) during the 21<sup>st</sup> century. Data are limited, and a decreasing trend for the Brush Lizard cannot be ruled out, but this species pair does not present the same trend as the burrowing snakes and horned lizards.

*Giant Kangaroo Rats*. Several interesting records of mammals were also collected (Appendix 2). The species pair represented by the large kangaroo rats, the Desert Kangaroo Rat (*Dipodomys deserti*, an arid desert-adapted from) and the Bannertail Kangaroo Rat (*D. spectabilis*) is of special interest in presenting a situation potentially similar to those involving the Tucson Shovel-nosed Snake and the Desert Horned Lizard. There are few records of either species in the study region (Hoffmeister 1986; personal examination of the UAZ mammalogy collection).

Over the past four years, I have found these kangaroo rats and their mounds near Mile Wide Road (south of Avra Valley Road), in sandy desert east of Pinal Air Park, on the West Silverbell Mountains lower bajada, at the margin of the Santa Cruz Flats near Greene Canal, and in Aguirre Valley southwest of the Sawtooth Mountains. Only the latter animals, including a collected roadkill, were pallid and appeared to be *D. deserti*, I photographed one seen near Greene Canal – significantly north of the mapped range – that appeared to be *D. spectabilis*. However, the UAZ museum specimens suggest that poorly understood subspecies or species issues should be resolved before an understanding of these species will be possible in the study region.

*Thrashers*. Another set of regionally endemic species of interest is the thrashers, which also includes the mockingbird (a widespread species that has remained stable or increased over recent decades regionally and in Arizona). I analyzed data through 2003 from Arizona Breeding Bird Survey and Christmas Bird Count to explore trends in these species, all of which, except LeConte's Thrasher, were found in large numbers in the Tucson area by Lt. Bendire and Mr. Herbert Brown during the late 1800's.

The Curve-billed Thrasher, which occupies Arizona Upland Sonoran Desertscrub in and out of regional towns and cities, has maintained high abundance or declined slightly in Arizona. It is, of course, thriving and remarkably abundant throughout most of urban Tucson and outlying arid areas. Crissal Thrasher, which was not recorded abundantly in the deserts of the study region (Phillips et al. 1964), declined elsewhere in Tucson and the Tucson region (unpublished analysis), but persists in riparian and other settings with its characteristic habitat elsewhere nearby and throughout Arizona (Corman and Wise-Gervais 2005).

Meanwhile, the relatively specialized, but poorly understood Bendire's Thrasher has all but vanished from Tucson (Tucson Bird Count 2007; <u>www.tucsonbirds.org</u>). Although Phillips et al.'s (1964) map suggests a solid distribution in the study region, I know of but a single recent record for the Santa Cruz Flats near Friendly Corners (Janine McCabe, personal communication, 2005). Corman and Wise-Gervais (2005) map the recent distribution as sparse in both Avra Valley and Santa Cruz Flats, with major breeding areas found in the western parts of Maricopa and Pinal counties. Breeding Bird Survey results for Arizona (available 1966-2003; Fig. 4) display a highly significant trend with current abundance less than half that of four decades ago. The pattern is regionally complex, with data from Avra Valley displaying low but stable abundance from 1988-2003. Abundance has likely increased during recent decades in the Sulphur Springs Valley in southeastern Arizona (see Corman and Wise-Gervais 2005). The ecological requirements, adaptation, and regional change of this species are poorly understood, but there is abundant evidence demonstrating its decline at Tucson, and suggesting a major gap near Tucson may be developing in its distribution or abundance.

LeConte's Thrasher, which was recorded in the Santa Cruz Flats and lower (northern end of) Avra Valley (Phillips et al. 1964), has not, to my knowledge (and see Corman and Wise-Gervais (2005), been recorded in the study region for several decades. Christmas Bird Counts for this species in the United States display a statistically significant, roughly four-fold decline since the late 1950's (Fig. 5), steadily continuing into the 21<sup>st</sup> century. They still breed regularly in the low deserts south of the Gila Valley (Corman and Wide-Gervais 2005). The pattern of apparent decline in the LeConte's Thrasher closely mirrors those of the Tucson Shovel-nosed Snake and Desert Horned Lizard.



Figure 4. Abundance trends (number per survey route) suggested by breeding bird data for two thrasher species in Arizona.



Figure 5. Abundance trend (number observed / hr of survey per survey party) of North America's most desert-specialized bird, LeConte's Thrasher, suggested by results of the Christmas Bird Count.

### Discussion

This final report is interim in several respects. To begin with, although marked decline of the Tucson Shovel-nosed Snake in Avra Valley and its marginal persistence to the north in Santa Cruz Flats have now been demonstrated, its population status remains incompletely known. Whether it persists in between, or in remaining habitat fragments cannot be inferred based on existing sample sizes. Second, although population expansion of the Banded Sand Snake has been demonstrated, its causes and effects on the Tucson Shovel-nosed Snake are unknown. Third, although adequate samples exist to infer a decline of the Desert Horned Lizard that seems to parallel that of the Tucson Shovel-nosed Snake, the available data have yet to be formally summarized, and the causes of this population change remain obscure. Finally, information on other species (kangaroo rats, thrashers, and tree/brush lizards) suggests that a broader change may be occurring, although a more formal treatment of these taxa, and additional data are needed to establish a firmer empirical base. The problem is apparently large and complex, both geographically and ecologically.

Certain specific facts regarding habitat of the Tucson Shovel-nosed Snake have also come to light. First, all four 21<sup>st</sup>-century records of the Tucson Shovel-nosed Snake in the study region are on level, valley bottom terrain (as exemplified in Fig. 6), rather than bajadas, even lower bajadas. In Avra Valley, all the reliably plotted records of this snake came from this level, mid-valley environmental type.

Original conditions supporting this species are not immediately obvious, because millions of dollars of ground leveling operations to facilitate irrigation have obscured local heterogeneity that likely existed is soil composition and structure. The shovel-nosed snakes were very probably associated with sandy rises, small drifts, low stabilized minidunes, and similar formations created by wind and the shifting braids of Brawley Wash and in Avra Valley and the river's outwash delta in Santa Cruz Flats. Such features remain barely evident near Houser Road, in Brawley Wash south of Avra Valley Road, in Aguirre Valley west of Silverbell Estates, and near Greene Canal on the west margin of Santa Cruz Flats, respectively. This inference should be rigorously evaluated in other areas such as Florence and Valley of the Ajo where shovel-nosed snakes persist near the Arizona Upland.

In Avra Valley, there remain numerous intact fragments of valley floor flats this environment, including some areas with apparently suitable sand substratum. Although other snake species seem to have persisted in the mid-valley (Rosen 2003), including the locally rare and patchily distributed Western Groundsnake (Rosen 2004), none of these fragments have so far yielded shovel-nosed snakes in the years since 1979. To the north, almost the entirety of this environment in the Santa Cruz Flats has been converted to irrigation agriculture, with no substantial intact habitat fragments remaining. The four Tucson Shovel-nosed Snake records we now have for this century in the study region are all from within 1 mile of the irrigation agriculture that has, apparently, occupied most the subspecies former habitat. This obviously increases concerns that this taxon's regional persistence is extremely tenuous, at best.



Figure 6. Capture site for *Chionactis occipitalis klauberi* on 14 June 2007, west edge of the Santa Cruz Flats, Pinal County.

Meanwhile, the Banded Sand Snake has invaded or become much more prominent in the original local distributional areas of the Tucson Shovel-nosed Snake (Fig. 3). An inference of possible competitive or other species replacement raises a host of questions, particularly because these species are small, not exceedingly abundant, with modest metabolic rates and are therefore expected to be low-energy systems unlikely to exerts strong ecological effects of any kind. Yet the timing and magnitude suggest an interaction. Sympatry is infrequent in these closely related species, which are in a small tribe of snakes, the Sonorini, within which ecologically similar species rarely coexist. This pattern is also quite prominent in horned lizards, and therefore the species shifts involving the Desert and Regal horned lizards in the study region also point toward species interactions as a potential in regional faunal changes.

These problems cannot be answered simply. Hypotheses need to be posed to guide thinking and data collection that will guide conservation strategies in the region. Here I develop some such hypotheses in skeletal form.

**Hypothesis 1. Habitat loss and road mortality are leading to species losses.** This is nearly always the first-listed cause for species declines, but despite its self-evidence, reality is often less obvious. In the Avra Valley portion of the study region, the Tucson Shovel-nosed Snake is the only snake species that has disappeared, and even within its habitat there is currently no evidence of other snake species losses. The ecologically similar Banded Snake persists in its former habitat, and the previously rare and local Western Groundsnake is persisting in adjoining habitat. In the Santa Cruz Flats, habitat losses of the Tucson Shovel-nosed Snake apparently exceed those in Avra Valley, yet the species is persisting there. Much the same can be said for the Desert Horned Lizard. Clearly, habitat loss constitutes a massive impact on the Tucson Shovel-nosed Snake, but it cannot be the sole, simple explanation for the observed data. The same caveats apply to road mortality.

**Hypothesis 2. Habitat fragmentation is leading to species losses.** This off-cited concept also seems applicable to the species changes observed in this study. Peter Holm, Pete Mayne, and I have determined that the Banded Sand Snake is highly sedentary in our study region, and occurs in relatively densely population deme areas. It might therefore be able to persist in habitat fragments more successfully than the more mobile, and presumably less sedentary shovel-nosed snake. Similarly, Tree Lizards and Long-tailed Brush Lizards are sedentary animals that occur at relatively high density, and may thus be more tolerant of habitat fragmentation than more mobile, less abundant lizards such as horned lizards. This hypothesis falters in much the same way as Hypothesis 1: many other snake (and lizard) species that occur at low density and are quite mobile have persisted. Habitat fragmentation is certain to prove a significant conservation problem as the study region urbanizes, yet it does not appear to provide a suitable explanation for the observed data, even in combination with simple habitat destruction.

Hypothesis 3. Increased humidity associated with the proximity of irrigation agriculture has favored less arid-adapted, Arizona Upland species such as the Banded Sanded Sand Snake and Regal Horned Lizard over closely related, ecologically similar species that are more arid-adapted. This hypothesis is somewhat plausible and not strongly contradicted by available data. Possibly working in tandem with such an effect, there was an extremely wet period during 1977-1984, which occurred during the general time frame in which arid-adapted reptile species declined or disappeared and less arid-adapted ones increased or at least remained abundant. Nonetheless, the subtlety expected of increased humidity effects is such that the hypothesis seems suspect on mechanistic grounds, at least as a primary effect. However, if species interactions are involved in driving faunal changes (see Hypothesis 4), effects of subtle ecophysiological factors may be magnified by interactions between closely similar species.

Hypothesis 4. Interspecific competition or apparent competition (or pre-emption of predator-free niche space) between ecologically and morphologically similar species pairs is accentuating the decline of species whose habitat is most impacted by anthropogenic change. The observed declines of species in the study area are consistent with this hypothesis in that the declining species are paired with ecologically and morphologically similar species that are relatively stable or increasing. In general, declines have not been observed in unpaired species such as the Sidewinder Rattlesnake, Desert Iguana, and Chuckwalla, which are characteristic of the LCV but do not have AU congeners with which intense species interactions are likely. However, the persistence of the Long-tailed Brush Lizard despite the presence of its congener the Northern Tree Lizard is at least weakly inconsistent with this hypothesis. Hypothesis 4 might be tested

by careful distributional and comparative ecological study of these species and other species pairs, such as the large kangaroo rats discussed above and the woodmice, *Peromyscus merriami* (Merriam's Mesquite Mouse) and *P. eremicus* (Cactus Mouse).

**Working Hypothesis.** A reasonable synthetic hypothesis is that habitat destruction and fragmentation (conversion of level, valley floor habitat from Lower Colorado Valley Sonoran Desertscrub to agriculture, along with urban and suburban development and road mortality) has undermined the metapopulation dynamics of species that specialize in that natural habitat in the study region. The persistence of adjoining, relatively intact Arizona Upland Sonoran Desertscrub on bajadas surrounding the central valley floors may allow species that are well adapted to that environment to sustain healthy metapopulation dynamics that supply immigrants to mid-valley habitat fragments. Habitat fragmentation may contribute to faunal changes because declining metapopulations fail to supply migrants to sustain or re-establish populations in fragmented habitat. Home range ecology, population size, anthropogenic micro-climatic effects and macro-climatic change may interact with these processes to alter the balance of species interactions and thus contribute to the observed changes. There are other possibilities.

Building an empirical basis for evaluating changes in this ecosystem is essential. Comparative data are appropriate starting points to refine the set of hypotheses that have been established here. In such large and complex systems, controlled, replicated experiments are not directly feasible. Only sophisticated, mechanistic hypotheses could feasibly be tested, and only such hypotheses are likely to prove useful for such conservation and management of the ecosystem as may be practicable in the future.

# Recommendations

The status of the shovel-nosed snakes in the study region remains incompletely documented, even though the trends are abundantly clear. Although results of the 2007 survey support the possibility that the species is extirpated from Avra Valley, a larger sample size is necessary to support such a conclusion, which may be relevant from legal and genetic standpoints.

The Tucson Shovel-nosed Snake may also persist on State Lands between the Pima County line and Red Rock, near Pinal Air Park. These lands are under long-term lease to the University of Arizona, which might facilitate conservation there.

Off-road vehicle recreation is so intensive in this area that major ecological damage is occurring. The activity seems completely un-regulated, and the damage has rapidly become more widespread and intensive during just the past few years. Sensible regulation might eliminate the bulk of the damage without preventing people from enjoying this activity.

The desert flats south and west of Picacho Peak also encompass a large fragment of possibly suitable habitat for the Tucson Shovel-nosed Snake. Although difficult of access, this area should also be surveyed.

The status and trend of the Tucson Shovel-nosed Snake in the lands immediately adjoining the agricultural zone of the Santa Cruz Flats remains unknown. Although there are good hypothetical reasons to expect that this population may rapidly decline, further survey is still needed and trends monitoring would be useful, especially if carried out in a framework useful for understanding potential driving forces in the system's ecology.

A study contrasting habitat utilization of the shovel-nosed snakes in the Florence region to that in the study region may provide important insight regarding why the taxon has apparently remained viable under current conditions near Florence. The area of the Florence population is slated for intensive urbanization. Without an understanding of factors enhancing the persistence of shovel-nosed snake populations, it is highly unlikely that the species will survive the coming decades there.

Areas in Avra Valley that previously supported shovel-nosed snakes have been previously identified as potential ecological reserves, and the new records near the Santa Cruz Flats also provide guidance for land conservation. However, research appears to be essential. We currently have no basis for assuming that setting aside remaining small habitat areas will allow us to successfully manage and conserve declining species in the study region. The same applies to the Florence region.

Thus, the following priorities for continuing work on the decline of the Tucson Shovel-nosed Snake can be offered:

- 1. Continue focused trapping and sampling in Avra Valley
- 2. Thoroughly survey the sandy environments near Pinal Air Park.
- 3. Extensively investigate sandy margins of the Santa Cruz Flats
- 4. Compare habitat utilization between Santa Cruz Flats and the Florence region.
- 5. Accumulate comparative data for other species showing major population changes in the study region, especially horned lizards, *Urosaurus* lizards, thrashers, kangaroo rats, and woodmice.
- 6. Remaining large habitat areas near Picacho Reservoir, the Picacho Mountains, Picacho Peak, and the West Silverbell Mountains should be protected from blading and conversion from desertscrub to modern urban developments whenever possible. These are the last examples of a formerly widespread regional environment. They can provide refuges for a host of specialized desert floor species, as well as recreation and education for the growing regional human population.

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SDECIES	data (2007)	DIT Tag ID#	Pager 2		SVL (mm)	TAIL (mm)	tail	MASS	LOC1	LOC2	CAPT
MAEL	12 Mars	4020022404	Keeap !	SCA	(11111)	(11111)	conu	(g) 270.0		(end)	type
MAFL	13-May	4239022404	n	m c	10/5	157	e	279.0	B2	IN N	trap
MAFL	13-May	4239403F2D	n	I	1090	369		351.0	B2	N	trap
MAFL	13-May	42390000/A	n	Î	8/5	318		1/2.0	B2	8	trap
НҮТО	14-May	died in transit	n	m	315	72		14.8	B4	S	trap
НҮТО	14-May	423847607A	n	f	212	43			B4	Ν	trap
НҮТО	14-May	423931106B	n	f	373	66		22.4	SB2	Е	trap
НҮТО	15-May	416204153E	n	m	384	79		19.5	B4	Ν	trap
MAFL	16-May	4238366A06	n	m	895	319		166.0	В3	S	trap
HYTO	17-May	42393F733A	n	m	361	78		18.9	SB2	Е	trap
PICA	17-May	4239156C28	n	f	648	81		99.0	SB2	W	trap
RHLE	17-May	4239010763	n	m	699	114		119.0	N1	Е	trap
MAFL	18-May	501D571770	n	m	879	305		143.0	B1	Ν	trap
LEHU	18-May	none-rel	n	q	273	9		2.4	A1	W	trap
CRCE	19-May	none-rel	n	m	LOA	ca.	475		SB3	Е	trap
RHLE	19-May	423933400B	n	m	571	100		59.8	SB3	W	trap
MAFL	19-May	4239134228	n	f	795	156	e	132.0	B1	S	trap
MAFL	19-May	4239180B10	n	m	974	302		187.0	B1	S	trap
CHCI	19-May	held live	n	f	265	26			B1	Ν	trap
MAFL	20-May	3-5L	n	f	953	333		258.0	Past. B	s-cent	road
MAFL	21-May	4239436B43	n	f	514	178		34.0	SB2	W	trap
HYTO	22-May	41616F4041	n	m	349	69		11.9	B4	Ν	trap
HYTO	22-May	42393A5202	n	f	365	45	e	17.2	B4	Ν	trap
AREL	24-May	4239315A60	n	f	644	84		84.0	SB4	Ν	trap
MAFL	25-May	4239173A66	n	m	613	224		51.3	SB2	Е	trap
RHLE	25-May	42391B7953	n	f	575	87		72.3	SB2	Е	trap
MAFL	26-May	4239434011	n	m	1030	324		242.0	B2	Ν	trap
MAFL	28-May	4239436B43	r	f					SB1	S	trap
HYTO	9-Jun	5-1D613B3F	n	f	331	70		15.0	A1	Е	trap
MAFL	10-Jun	501D57770A	n	m	924	330		183.0	B2	Ν	trap
MAFL	10-Jun	4239434011	r	m				244.0	B2	S	trap
MAFL	11-Jun	4239173A66	r	m	630	224		66.0	SB2	W	trap
PHBR	11-Jun	501D47652C	n	m	280	44		19.0	SB4	S	trap
MAFL	12-Jun	4239022404	r	m	1081	155	b	290.0	В3	S	trap
RHLE	12-Jun	501D490344	n	m	624	113		80.0	SB1	S	trap
RHLE	13-Jun	501E632A16	n	m	662	99		88.0	B1	Ν	trap
RHLE	16-Jun	501E59344B	n	f	539	90		63.0	B1	S	trap
HYTO	16-Jun	501D502D00	n	m	316	63		15.0	B2	Ν	trap
CHCI	16-Jun	held live	n	m	187	28			В3	S	trap
PHBR	18-Jun	501D47652C	r	m	301	45		19.0	SB3	W	trap
RHLE	19-Jun	42391B7953	r	f	574	84		60.0	SB2	W	trap
RHLE	19-Jun	501D4B3049	n	m	644	101		79.0	SB4	Ν	trap
MAFL	20-Jun	423900007A	r	f	869	311		171.0	B3	S	trap
MAFL	20-Jun	4239403F2D	r	f	1079	349		272.0	B2	Ν	trap
НҮТО	20-Jun	501D4A2865	n	f	341	63		15.0	B1	s	trap

Appendix 1. Snakes captured on Avra Valley trapping areas during shovel-nosed snake survey in 2007. Species abbreviations are listed in Appendix 3. Trap locations are in Appendix 4.

RHLE	20-Jun	501D5C7100	n	f	594	83	69.0	SB1	Ν	trap
НҮТО	20-Jun	42393F733A	r	m	353	74	15.0	SB2	Е	trap
НҮТО	21-Jun	501D4A1349	n	m	344	66	18.0	SB3	Е	trap
MAFL	22-Jun	501D577D78	n	f	870	194	140.0	В3	S	trap
RHLE	22-Jun	501D4E4C09	n	m	703	109	88.0	B2	Ν	trap
RHLE	22-Jun	423933400B	r	m	552	91	58.0	B3	Е	trap

Appendix 2. Reptiles, amphibians, and selected other animals recorded during shovel-nosed snake survey in southern Arizona, 2007, excluding those found in trapping operations. All amphibians and reptiles recorded on roads are included, but not all lizards seen during daytime work, and not all geckos found by observers other than PCR were recorded. Abbreviations are in Appendix 3. All UTMs are in zone 12S, with datum reference WGS1984.

			Date				
Species	UTM E	UTM N	(2007)	Time	Obs	Locality-Notes	Other Notes
SNAKES							
AREL	484041	3585091	29-Apr	12.31	PCR	AREL (ad) DOR on Avra Valley Rd E of Sandario	
AREL	101011	5565671	18-May	21.12	DOS	Minuteman Dr 0 5 mi E 110 access Rd	DOR
AREL	457860	3626711	28-May	20:39	PCR	AREL ad M LOR on Houser Rd	2011
AREL	470185	3599561	18-Jun	20:34	PCR	AREL ad M active N Avra Sand area	active crawlingin Larrea, exc condition, no inis
CHCI	484462	3581666	29-Apr	9:23	PCR	CHCI (dead) at White Stallion Guest Ranch	dead and dried, in housing area
CHCI			16-May	6:53	PAH	Rt 85, ORPI mile 66.5	DOR, Upland bajada; female, SVL=223mm, tail=32mm; mass=10.2g
CHCI	332681	3578055	24-May	20:12	PCR	CHCI sub DOR N of Why (Coll)	hit recently
CHCI	454610	3626772	28-May	20:00	PCR	CHCI sm ad M LOR on Houser Rd 1.7 mi E Hwy87 (coll)	just at dark; on blacktop edge; collected live
CHCI	473975	3598169	10-Jun	21:39	PCR	CHCI (ad M) DOR Missle Base Rd at I-10 Frontage (Coll)	15m NE RR tracks; collected
CHCI	460149	3627789	11-Jun	21:25	DAK	Brady Pump Rd 0.7 mi N Houser Rd	none
CHCI	459277	3626709	15-Jun	21:45	PCR	CHCI ad M LOR Houser Rd	coll; anom ant blotch; parallel wash, mesq, Atriplex, open sandy, SAGU
CHOC	348471	3648371	11-Jun	20:43	PCR	CHOC ad M LOR W Maricopa Rd 4.1 mi (rd) E Rt85	lg ad ("klauberi" color), coll, nr wash
CHOC	366800	3651869	11-Jun	21:56	PCR	ad F LOR W Maricopa Rd 9.9 (air) mi WSW Mobile	LOR, NG, ("annulata" phase), Larrea, but levee-wash 30 m N of rd
CHOC	453197	3615877	12-Jun	21:02	PCR	ad M LOR Picacho Hwy 0.23 mi N Harmon Rd	klauberi colors, Coll; in Larrea (both sides)
CHOC	323432	3601071	14-Jun	21:05	CH	Rt 85 S of Gila Bend	DOR, photo, coll
CHOC	325925	3617011	14-Jun	21:37	CH	Rt 85 S of Gila Bend	DOR, photo, coll
CHOC	326297	3618546	14-Jun	21:41	CH	Rt 85 S of Gila Bend	DOR, photo, coll
CHOC	334596	3636777	14-Jun	22:30	CH	Rt 85 S of Gila Bend	DOR, photo, coll
CHOC	447158	3604640	14-Jun	20:00	PCR	Santa Cruz Flats W edge at 11 Mile Corner Rd alignment	Fnd Dale Turner-sandy area, on sandy rd. sm ad M
CHOC	453203	3615956	15-Jun	20:50	DAK	Picacho Hwy 0.3 mi N Harmon Rd	none
CRAT	485265	3582598	8-May	19:48	PCR	CRAT (juv) DOR Twin Peaks Rd nr White Stallion GR	2006 yg
CRAT	429655	3603019	14-May	20:15	DAK	Sawtooth Mts S end	none
CRAT			16-May	20:19	DOS	Pecan Rd 1.2 mi N Park Link Dr	juv
CRAT			16-May	22:14	DOS	Pecan Rd 2.9 mi N Park Link Dr	juv
CRAT	455141	3615624	17-May	19:21	DT	Picacho Hwy area (on-foot)	450 mm LOA
CRAT	453172	3614263	25-May	20:21	PCR	CRAT LOR ad Picacho Hwy	sm ad w straight-sided rattle (looked male)
CRAT	460149	3628478	28-May	19:44	PCR	CRAT juv (4 seg complete) LOR Brady Pump Rd	early twilight; 4 segs = complete
CRAT	469277	3623978	9-Jun	19:50	DT	Pecan Rd (20 m E of) 10.9 mi N of Park Link Dr	juv

CRAT	468376	3606216	9-Jun	21:30	DT	Park Link Dr nr 110 Access Rd	ad lg M
CRAT	467681	3606962	10-Jun	21:22	PCR	CRAT (juv) LOR I-10 Frontage NW Park Link Dr	5 seg = complet
CRAT	360963	3652576	11-Jun	20:20	PCR	CRAT ad F LOR W Maricopa Rd 6.6 mi (air) NE Bosque	NG, c 6 seg, stra
CRAT	469182	3611510	15-Jun	20:20	LFU	Pecan Rd N Park Link Dr	LOR
CRAT	455252	3626771	15-Jun	20:05	PCR	CRAT juv active nr Houser Rd	4  seg = complet
CRCE	429307	3603021	14-May	19:00	DAK	Sawtooth Mts S end	none
CRCE	429354	3603008	14-May	19:40	DAK	Sawtooth Mts S end	none
CRCE	431117	3600019	14-May	19:01	PCR	CRCE ad LOR Trans Line RD W Silverbell Estates	6 seg = comlpet
CRCE	428877	3603668	14-May	19:49	PCR	CRCE ad fnd S end Vulture Butte Dune	1.5 yr male, skir
CRCE	430117	3602450	14-May	23:18	PCR	CRCE ad LOR Trans Line RD NW Silverbell Estates	4 seg + 2 missin
CRCE	429284	3603036	15-May	08:10	DAK	Sawtooth Mts S end	none
CRCE	429396	3603036	15-May	08:10	DAK	Sawtooth Mts S end	none
CRCE			16-May	21:52	DOS	Pecan Rd 3.5 mi N Park Link Dr	ad
CRCE	449943	3600974	16-May	18:52	PCR	CRCE ad along Morris Tank Rd E of Pipeline Rd	8 seg = compl; l
CRCE	443589	3600908	16-May	21:10	PCR	CRCE ad LOR Morris Tank Rd W of Pipeline Rd	6  seg = complet
CRCE	455262	3612146	17-May	20:41	PCR	CRCE juv LOR 2-track rd W Picacho Peak bajada	4  seg = complet
CRCE			18-May	21:00	DOS	Minuteman Dr 0.7 mi E I10 acces Rd	ad
CRCE	429361	3603008	19-May	20:30	DAK	Sawtooth Mts S end	none
CRCE	474376	3587678	19-May	20:51	PCR	CRCE ad LOR Trans Line Rd N end SB sand ridge	12 seg straight-s
CRCE	334216	3575843	24-May	20:07	PCR	CRCE ad DOR N of Why	
CRCE	333945	3635487	24-May	21:49	PCR	CRCE juv DOR N of Ajo (Ceoll)	
CRCE	337898	3644928	24-May	22:01	PCR	CRCE juv DOR S of Gila Bend	
CRCE	453196	3616037	25-May	20:08	PCR	CRCE LOR ad Picacho Hwy	older ad
CRCE	454623	3626771	9-Jun	19:38	PCR	CRCE emerging fr burrow 0.1 mi N WP (N of Houser)	
CRCE	455281	3626774	9-Jun	20:23	PCR	COVA ad LOR Houser Rd E Rt89	4 seg=compl, si
CRCE	460152	3629750	9-Jun	21:01	PCR	CRCE ad LOR Houser Rd E Rt92	8 seg=complete
CRCE	459619	3626699	9-Jun	21:15	PCR	ad LOR Houser Rd E Rt92	4 seg=compl
CRCE	469192	3613483	9-Jun		DT	Pecan Rd mi 3.1 N of Park Link Dr	LOR. photos
CRCE	367023	3652054	11-Jun	22:05	PCR	juv F LOR W Maricopa Rd 9.7 (air) mi WSW Mobile	LOR, 5 seg=cor
CRCE	326728	3619664	14-Jun	20:20	СН	Rt 85 S of Gila Bend	LOR
CRCE	326728	3619664	14-Jun	20:40	СН	Rt 85 S of Gila Bend	LOR, photo
CRCE	454357	3613111	15-Jun	20:30	DAK	Picacho Hwy (0.7 mi E of at S end Aux Airfield)	none
CRCE	453581	3614281	15-Jun	20:45	DAK	Picacho Hwy (0.25 mi E of at Aux Airfield)	none
CRCE	456999	3626715	15-Jun	20:56	PCR	juv F LOR Houser Rd	5  seg = complet
CRCE	453702	3614173	18-Jun	21:10	DAK	Picacho Hwy (0.3 mi E of at Aux Airfield)	none
CRCE	453702	3614173	18-Jun	21:25	DAK	Picacho Hwy (0.3 mi E of at Aux Airfield)	none
CRCE	330481	3579634	27-Jun	20:51	PCR	juv LOR Rt85 N of Why	rattle broken, bu
CRCE	335938	3572333	27-Jun	21:18	PCR	sub M LOR Rt85 N of Why	5 seg=complete

ad lg M 5 seg = complete; tracking (ate) Chaeto pen on rd NG, c 6 seg, straight LOR 4 seg = complete; hunting coil at burrow entrance at sm Atriplex polycarpa none none 6 seg = comlpete; Not Gravid 1.5 yr male, skinny 4 seg + 2 missing; 1.5 yr male, skinny none none ad 8 seg = compl; lg ad, hunting coil nr sunset, Larrea base 6 seg = complete; sm ad 4 seg = complete; open snady area ad none 12 seg straight-sided; old male, not large; in sandy Larrea

4 seg=compl, similar to one below 8 seg=complete, tapered 4 seg=compl LOR. photos LOR, 5 seg=complete LOR LOR, photo none none 5 seg = complete; thus, juv, NG none none rattle broken, but like the next 5 seg=complete

CRSC			15-May	19:35 DOS	Pecan Rd 1.6 mi N Park Link Dr	none
CRSC	466005	3598191	15-May	21:18 PCR	ad 1 mi E Pinal Air Park sewage site	med-lg ad in burrow entrance under mesq (found by trake only)
CRSC			16-May	20:34 DOS	Pecan Rd 2.2 mi N Park Link Dr	juv
CRSC			17-May	21:10 DT	Picacho Hwy 7.4 mi S of I10	LOR
CRSC			23-May	20:01 DOS	Picacho Hwy 7.4 mi W I10	juv
CRSC	453214	3616794	25-May	20:29 PCR	LOR juv Picacho Hwy	juvenile 3-4 seg
CRSC	382539	3658511	11-Jun	22:42 PCR	juv M DOR W Maricopa Rd 0.8 mi ENE Mobile	DOR, coll, 4 seg=complete
CRSC	467478	3673546	12-Jun	20:15 CH	Rt 79, Florence area	DOR
CRSC	429647	3603247	12-Jun	21:15 DAK	Sawtooth Mts S end	none
CRSC	453220	3616747	12-Jun	20:02 PCR	sm ad M LOR Picacho Hwy 0.8 mi N of Harmon Rd	Photo (Foldi); 4-5 seg sl taper 3-5 mising
CRSC	453198	3615976	12-Jun	20:06 PCR	sm ad M LOR Picacho Hwy 0.3 mi N of Harmon Rd	Photo (Foldi); 4-5 seg sl taper 3-5 mising
CRSC	453210	3615973	15-Jun	21:05 DAK	Picacho Hwy 0.3 mi N Harmon Rd	none
HYTO	474396	3598321	12-Jun	21:59 PCR	HYTO sm ad M DOR Missile Base Dr 0.4 mi E I-10	Dying when found, Coll
HYTO	467846	3599791	13-Jun	21:29 PCR	HYTO ad F active N Avra Sand Knoll	NG, 1 cestode evident; active under mesq
HYTO	473080	3584056	18-Jun	21:27 LFU	Avra Valley Rd	LOR
LAGE	484476	3581775	29-Apr	9:26 PCR	LAGE (lg ad F) at White Stallion Guest Ranch	active on veranda among people, poss gravid
LAGE			17-May	21:33 DT	Picacho Hwy 1.0 mi S of I10	LOR, photos
LAGE	466874	3608122	10-Jun	21:15 PCR	LAGE (ad M) DOR I-10 Frontage NW Park Link Dr	regular Californiae; stomach empty
LAGE	382649	3658545	11-Jun	22:44 PCR	LAGE ad M DOR W Maricopa Rd 0.9 mi ENE Mobile	DOR
LEHU	454979	3626768	17-May	21:32 PCR	LEHU LOR (run over, coll) on Houser Rd S Picacho Res	to UAZ Herp Coll
LEHU	459167	3626701	17-May	21:44 PCR	LEHU LOR on Houser Rd S Picacho Res	
LEHU			14-Jun	6:25 PAH	Rt 85, mile 47.6, Valley of the Ajo	DOR, SVL=276mm, tail=25mm.
LEHU	453702	3614173	18-Jun	21:25 DAK	Picacho Hwy (0.3 mi E of at Aux Airfield)	none
MAFL	443664	3600109	17-May	9:31 PCR	ad LOR Trans Line Rd nr Morris Tank, W SB MT bajada	LOR at PV wash; deep red w bl had and neck
MAFL	481585	3581634	20-May	17:38 PCR	ad hand cap Pasture B	black phase, ad female 6 ova (see data sheet
MAFL	415916	3664698	11-Jun	18:04 PCR	ad M (DOR) Casa Blanca Dr just W Casa Blanca (W I-10)	pink form, no black; at broken concrete irr in fallow fields
MIEU			13-Jun	6:29 PAH	Rt 85, 0.35 miles north OPCNM north boundary	DOR, Male, SVL=448mm, tail=37mm, mass=21.7g
PHBR	327780	3622285	14-Jun	21:55 CH	Rt 85 S of Gila Bend	DOR, photo
PHBR	467498	3582452	18-Jun	21:41 LFU	Avra Valley Rd	LOR ad F (SVL 344, tail 26, wt 32g)
PHDE	469189	3612727	9-Jun	DT	Pecan Rd mi 2.7 N of Park Link Dr	LOR. photos
PHDE	344190	3647546	11-Jun	20:55 PCR	PHDE juv DOR W Maricopa Rd 1.4 mi (rd) E Rt85	perkinsi, DOR coll
PHDE	429277	3603025	12-Jun	20:50 DAK	Sawtooth Mts S end	none
PHDE	467892	3599782	13-Jun	20:36 DAK	N Avra Sands (Pinal AP) - on PCR database	none
PHDE	467851	3599716	13-Jun	20:36 PCR	PHYDE ad F active N Avra Sand Knoll	active nr mesq (Kahrs fnd M same time activ nr Larrea)
PHDE	467851	3599716	13-Jun	20:36 PCR	PHYDE ad M active N Avra Sand Knoll	active nr Larrea (PCR fnd F same time activ nr mesq)
PHDE	447154	3604639	14-Jun	20:22 DT	Santa Cruz Flats W edge at 11 Mi Corner Rd-UTM approx	active in sandy area
PHDE	325314	3613370	14-Jun	21:25 CH	Rt 85 S of Gila Bend	DOR, photo
PICA			16-Mar	11:45 PAH	Ajo, 1620 W Hoover Street	active, In front yard; F, SVL=1359mm, tail=157mm, mass=669g

PICA	390825	3660250	11-Jun	22:57	PCR	ad M DOR W Maricopa Rd 6.1 mi ENE Mobile	DOR
PICA	467267	3671951	12-Jun	20:30	CH	Rt 79, Florence area	DOR
PICA			13-Jun	6:24	PAH	Rt 85, 1.0 miles north OPCNM north boundary	DOR, Male, SVL=574mm, tail=95mm.
PICA	468623	3599313	17-Jun	20:18	PCR	juvnr rd N Pinal Air Park Rd	crawling in open nr mesq
PICA	470202	3598086	12-Jul	21:29	PCR	juv F LOR sand rd near Pinal Air Park	rich brown and ochre dorsal colors
PICA	471413	3594851	12-Jul	21:56	PCR	ad F DOR Trico Rd farm fields bet Co line and SC River	strong diamond rhombs
RHLE	429792	3603012	19-May	20:45	DAK	Sawtooth Mts S end	none
RHLE	453203	3616384	25-May	20:06	PCR	LOR juv Picacho Hwy	
RHLE	479575	3591823	28-May	21:55	PCR	ad F DOR I10 Frontage Rd at Marana	rose clarus, fat, poss gravid but too damaged
RHLE	460153	3627264	11-Jun	21:50	DAK	Brady Pump Rd 0.4 mi N Houser Rd	none
RHLE	343442	3647393	11-Jun	21:10	PCR	juv M D-LOR W Maricopa Rd 1.0 mi (rd) E Rt85	sl hit, held alive; lecontei phase
RHLE	344849	3647665	11-Jun	21:14	PCR	juv M DOR W Maricopa Rd 1.8 mi (rd) E Rt85	DOR, , antonii phase
RHLE	368224	3652918	11-Jun	22:15	PCR	ad DOR W Maricopa Rd 8.6 (air) mi WSW Mobile	DOR, lecontei phase
RHLE	401816	3639277	11-Jun	23:36	PCR	juv M DOR S Maricopa Rd 1 mi N Petes Corner (StF Rd)	DOR, just S of farms
RHLE			12-Jun		PAH	Ajo	DOR,
RHLE	455252	3626771	15-Jun	20:10	PCR	ad F actie nr Houser Rd	lecontie phase, NG, somewhat skinny
RHLE	458729	3626710	15-Jun	20:44	PCR	sub M LOR Houser Rd	lecontei phase
RHLE	453230	3617746	16-Jun	21:05	DAK	Picacho Hwy 0.3 mi N Nutt Rd	none
RHLE	468423	3599313	17-Jun	20:23	PCR	ad nr rd N Pinal Air Park Rd	lecontie phase, NG, crawling in open
RHLE	467784	3599810	17-Jun	20:41	PCR	ad active NE Pinal Air Park	lecontei phase, active nr rodent holes
SAHE			10-Mar		PAH	Sauceda Mts.,	active, Upland lower slope; female, SVL=778mm, tail=238mm.
SAHE			4-Jun	6:57	PAH	Rt 85, mile 55.9, near Gunsight Hills	LOR, Hugging road; male, SVL=576mm, tail=182mm, mass=42.3g.
SAHE	341909	3647102	11-Jun	21:04	PCR	SAHE juv F DOR W Maricopa Rd 0.2 mi E Rt85	DOR
SAHE	406795	3541075	27-Jun	19:27	PCR	SAHE ad M DOR Ajo Way nr Itoi Ki Hils (W of Sells)	
SOSE	453167	3614221	25-May	20:48	PCR	SOSE DOR lg ad Picacho Hwy (coll)	dark red mid-dorsal stripe; hit <10 min previous
THMA			25-May	20:28	DOS	Pinal Air Park Rd o.5 mi W I10	Gr, coll
THMA	457368	3664519	12-Jun	22:45	CH	Arizona Farms Rd at Felix Rd	DOR
TRBI			14-Jun	6:36	PAH	Rt 85, 0.1 miles north OPCNM north boundary	DOR, SVL=432mm, tail=91mm; blotches=H+25+12.

# LIZARDS:

CADR	459697	3626702	15-Jun	20:37	PCR	CADR ad DOR Houser Rd	
CADR	460153	3629596	15-Jun	21:29	PCR	CADR ad F LOR Brady Pump Rd	sleeping on rd; NG
CADR	460263	3630072	15-Jun	21:30	PCR	CADR ad DOR Brady Pump Rd	DOR
COVA			15-May	20:25	DOS	Pecan Rd 6.3 mi N Park Link Dr	none
COVA			23-May	20:36	DOS	Picacho Hwy 5.6 mi W I11	none
COVA			24-May	20:26	DOS	Pinal Air Park Rd 0.0 mi W I10	none
COVA	333521	3577088	24-May	20:09	PCR	COVA ad LOR N of Why	
COVA	330876	3579355	24-May	20:15	PCR	COVA ad LOR N of Why	

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COVA	460338	3630156	28-May	20:20	PCR	COVA ad LOR on Brady Pump Rd	
COVA	458936	3626707	28-May	20:35	PCR	COVA ad LOR on Houser Rd	
COVA	458515	3626709	28-May	20:36	PCR	COVA ad LOR on Houser Rd	
COVA	455247	3626773	28-May	20:45	PCR	COVA ad LOR on Houser Rd	
COVA	455177	3626773	28-May	20:45	PCR	COVA ad LOR on Houser Rd	
COVA	456347	3626770	28-May	20:52	PCR	COVA ad LOR on Houser Rd	
COVA	455453	3626775	28-May	21:07	PCR	COVA ad LOR on Houser Rd	
COVA	454600	3626774	28-May	21:09	PCR	COVA ad LOR on Houser Rd	
COVA	458944	3626704	9-Jun	20:11	PCR	COVA ad LOR Houser Rd E Rt87	
COVA	456039	3626772	9-Jun	20:18	PCR	COVA ad LOR Houser Rd E Rt88	NG
COVA	455245	3626772	9-Jun	20:30	PCR	COVA ad LOR Houser Rd E Rt90	
COVA	458350	3626705	9-Jun	20:40	PCR	COVA ad LOR Houser Rd E Rt91	
COVA	460141	3626786	9-Jun	21:09	PCR	COVA ad LOR Houser Rd E Rt93	NG, fat
COVA	456539	3626767	9-Jun	21:22	PCR	COVA ad LOR Houser Rd E Rt95	barred
COVA	455635	3626772	9-Jun	21:25	PCR	COVA ad LOR Houser Rd E Rt96	NG, sp & barred
COVA	453173	3614300	10-Jun	20:38	PCR	COVA (ad F) LOR Picacho Hwy	NG
COVA	345668	3647832	11-Jun	20:51	PCR	COVA LOR W Maricopa Rd 2.4 mi (rd) E Rt85	
COVA	344038	3647518	11-Jun	20:57	PCR	COVA LOR W Maricopa Rd 1.3 mi (rd) E Rt85	fat, pre-gravid
COVA	342705	3647253	11-Jun	21:06	PCR	COVA LOR W Maricopa Rd 0.5 mi (rd) E Rt85	
COVA	360427	3652640	11-Jun	21:45	PCR	COVA ad F LOR W Maricopa Rd 6.4 mi (air) NE Bosque	NG
COVA	467861	3599691	13-Jun	20:44	PCR	COVA ad F active N Avra Sand Knoll	fat, pre-gravid
COVA	467782	3599630	13-Jun	20:52	PCR	COVA ad F active N Avra Sand Knoll	unk reprod
COVA	467888	3599756	13-Jun	21:25	PCR	COVA ad F active N Avra Sand Knoll	gravid
COVA	467888	3599756	13-Jun	21:40	PCR	COVA sub F active N Avra Sand Knoll	loc approx
COVA	447154	3604639	14-Jun	20:49	DT	Santa Cruz Flats W edge-11 Mi Corner Rd-UTM approx	active in sandy area
COVA	446303	3600789	14-Jun	20:27	PCR	COVA juv active nr Morris Tank Rd	Nr lower bajada wash at dusk
COVA	446469	3600673	14-Jun	21:02	PCR	COVA sub F active nr Morris Tank Rd	Nr lower bajada wash at dusk
COVA	455252	3626771	15-Jun	20:26	PCR	COVA ad M LOR Houser Rd	spotted
COVA	467735	3599702	17-Jun	20:56	PCR	COVA ad M active NE Pinal Air Park	spotted
COVA	467667	3599631	17-Jun	21:07	PCR	COVA ad active NE Pinal Air Park	barred
COVA	467651	3599612	17-Jun	21:10	PCR	COVA ad M active NE Pinal Air Park	
COVA	470154	3599553	18-Jun	20:30	PCR	COVA sub active N Avra Sand area	in catclaw
COVA	472450	3584059	19-Jun	21:00	LFU	Avra Valley Rd	LOR
COVA	475491	3587426	21-Jun	20:36	LFU	Silverbell Rd	LOR
COVA	331155	3579147	27-Jun	20:55	PCR	COVA sm ad M LOR Rt85 N of Why	barred
COVA	467637	3599696	12-Jul	20:16	PCR	COVA ad active N Avra Sand (N Pinal Air Park)	
COVA	467676	3599733	12-Jul	20:22	PCR	COVA ad active N Avra Sand (N Pinal Air Park)	
COVA	467864	3599715	12-Jul	20:35	PCR	COVA ad F active N Avra Sand (N Pinal Air Park)	gravid (2 eggs visible)

DIDO	446607	3604841	17-May	11:16	PCR	DIDO (2 ad) active sand mesq fringe S of 11 Mi Corner Rd	
HESU	467820	3599789	13-Jun	21:41	PCR	HESU juv actie N Avra Sand Knoll	juv, active investigating burrow
PHSO	484615	3581732	29-Apr	10:53	PCR	(juv) at White Stallion Guest Ranch	active on tennis court (PHOTO)
PHSO	480289	3583402	8-May	16:11	PCR	(juv) nr levee in Pasture A NW of Twin Peaks	
PHSO	481929	3582908	10-May	8:28	PCR	(juv) DOR Twin Peaks Rd nr CAP Canal Hill	
PHSO			18-May	20:30	DOS	Minuteman Dr 0.6 mi E I10 acces Rd	DOR
PHSO	480663	3581978	20-May	17:51	PCR	ad F LOR dirt rd Pasture B	
PHSO	478000	3582415	26-May	20:37	PCR	juv DOR Sanders Rd 1/4 mi S of Twin Peaks Rd	
PHSO	473904	3587863	27-May	20:00	PCR	juv on desert floor at trap SB3 (Trico end of sand ridge)	active at early dusk
PHSO	473904	3587955	27-May	20:10	PCR	juv on desert floor at trap SB3 (Trico end of sand ridge)	active at mid dusk; missing lower hind legs (healed)
PHSO	473701	3587964	8-Jun	18:30	PCR	juv on desert floor nr trap SB3 (Trico end of sand ridge)	
PHSO	479523	3581037	8-Jun	19:51	PCR	juv LOR Emigh Rd at Sandario	
PHSO	458581	3626708	9-Jun	19:55	PCR	juv LOR Houser Rd ca 2.5 mi E Rt 87	
PHSO	474360	3588225	14-Jun	19:40	LFU	Avra Valley, Sliverbell Rd	none
PHSO	474355	3588215	14-Jun	19:57	LFU	Avra Valley, Sliverbell Rd	none
PHSO	447154	3604639	14-Jun	22:00	DT	Santa Cruz Flats W edge at 11 Mi Corner Rd-UTM approx	active in sandy area
PHSO	446274	3600918	14-Jun	20:21	PCR	ad F active nr Morris Tank Rd	Nr lower bajada wash at dusk
PHSO	446371	3600937	14-Jun	21:23	PCR	juv active nr Morris Tank Rd	Nr lower bajada wash at dusk
PHSO	473701	3587964	16-Jun	18:00	PCR	ad at S end trap SB3, Silverbell Sand Ridge N end	active before sunset in Larrea
PHSO	481695	3582500	16-Jun	18:56	PCR	ad F LOR 2-track in Pasture B	
PHSO	472390	3596574	17-Jun	20:03	PCR	ad F Pinal Air Park Rd	NG
PHSO	470980	3583410	18-Jun	19:48	LFU	Avra Valley Rd	DOR ad
PHSO	457510	3626715	18-Jun	20:00	DAK	Houser Rd 1.5 mi W Brady Pump Rd	none
PHSO	465745	3591310	20-Jun	19:57	LFU	Silverbell Rd	LOR
PHSO	465347	3591066	21-Jun	19:59	LFU	Silverbell Rd	LOR
PHSO	470202	3598088	12-Jul	21:30	PCR	ad M LOR sand rd near Pinal Air Park	
URGR	446334	3604860	17-May	11:01	PCR	ad broken tail S end 11 Mi Corner Rd	on Catclaw Acacia
URGR	447207	3604638	15-Jun	10:17	PCR	ad M on mesq nr end 11 Mi Crner Rd	w 2nd Urosaurus (prob the F) on good mesq
URGR	447311	3604641	15-Jun	10:48	PCR	ad F on mesq nr end 11 Mi Crner Rd	on good mesq w packrat nest
URGR	447209	3604681	15-Jun	10:59	PCR	ad F on catclaw nr end 11 Mi Crner Rd	on catclaw complex w packrat nest
UROR	484347	3582132	29-Apr	10:10	PCR	(ad) seen NW of White Stallion Guest Ranch	active on woodpile in lower bajada desert
UROR	447302	3600970	17-May	9:02	PCR	Morris Tank Rd on W SB Mt N bajada	on <i>Olneya</i>
UROR	443674	3600103	17-May	9:32	PCR	ad Trans Line Rd nr Morris Tank, W SB MT bajada	on Blue PV
UROR	459233	3607320	17-May	17:19	PCR	ad S Piocacho Pk (main wash at bottom of bajada)	main wash, bosque, on woody debris pile
UROR	446281	3600973	14-Jun	19:35	PCR	ad nr Morris Tank Rd	On Olneya lower bajada wash

# ANURANS:

BUAL			17-May	20:03	DT	Picacho Hwy ca 4.5 mi S of I10	LOR
BUAL			17-May	20:05	DT	Picacho Hwy ca 4.5 mi S of I10	LOR
BUAL	453229	3617493	25-May	20:56	PCR	BUAL LOR ad Picacho Hwy	
BUAL	404462	3638370	11-Jun	23:44	PCR	BUAL ad DOR Stanfield Rd 2 mi W Stanfield	DOR, within 3 ft of each other, nr house
BUAL	453230	3617444	12-Jun	20:21	PCR	BUAL sub LOR Picacho Hwy N of Harmon Rd	
BUAL	453229	3617558	12-Jun	20:22	PCR	BUAL sub LOR Picacho Hwy N of Harmon Rd	
BUAL	453234	3617895	12-Jun	20:24	PCR	BUAL sub LOR Picacho Hwy N of Harmon Rd	
BUAL	453241	3618357	12-Jun	20:25	PCR	BUAL sub LOR Picacho Hwy N of Harmon Rd	
BUAL	453242	3618419	12-Jun	20:26	PCR	BUAL sub LOR Picacho Hwy N of Harmon Rd	
BUAL	453234	3617916	12-Jun	20:31	PCR	BUAL juv, BUCO ad LOR Picacho Hwy N Harmon Rd	
BUAL	453221	3617117	12-Jun	21:09	PCR	BUAL ad LOR Picacho Hwy N of Harmon Rd	
BUAL	453230	3617125	12-Jun	21:11	PCR	BUAL ad DOR Picacho Hwy N of Harmon Rd	Hit by car as we passed
BUAL	453253	3618747	12-Jun	21:13	PCR	BUAL ad LOR Picacho Hwy N of Harmon Rd	
BUAL			12-Jun	na	LFU	Avra Valley (no further data)	n=6
BUAL	470063	3598898	13-Jun	22:21	PCR	BUAL juv LOR desert E Pinal Air Park	LOR nr puddle
BUAL	469188	3609563	15-Jun	20:28	LFU	Pecan Rd N Park Link Dr	ad
BUAL	469183	3609073	15-Jun	20:30	LFU	Pecan Rd N Park Link Dr	ad
BUAL	458039	3626709	15-Jun	21:12	PCR	BUAL juv LOR Houser Rd	
BUAL	458348	3626706	15-Jun	21:16	PCR	BUAL juv LOR Houser Rd	LOR
BUCO			16-May	20:16	DOS	Pecan Rd 1.0 mi N Park Link Dr	none
BUCO			17-May	20:25	DT	Picacho Hwy 5.8 mi S of I10	LOR
BUCO			23-May	20:52	DOS	Picacho Hwy 1.5 mi W I12	none
BUCO			9-Jun		DT	Pecan Rd mi 1.9 N of Park Link Dr	4 calling
BUCO	453226	3617264	12-Jun	20:20	PCR	BUCO ad LOR Picacho Hwy N of Harmon Rd	
BUCO	453234	3617916	12-Jun	20:31	PCR	BUAL juv, BUCO ad LOR Picacho Hwy N Harmon Rd	
BUCO	459300	3626706	15-Jun	20:40	PCR	BUCO juv LOR Houser Rd	
BUCO	460381	3630208	15-Jun	21:36	PCR	BUCO chorus nr Brady Pump Rd	sm chorus heard in tank E of rd
BUWO			17-May	20:23	DT	Picacho Hwy 6.0 mi S of I10	LOR
BUWO	450734	3674624	12-Jun	22:20	CH	Schnepf Rd, Florence region	LOR, photos
RACA	461083	3600550	16-May	15:00	PCR	RACA (25+ juv) Park Link jct nr I10, in pool under tracks	adults seen, squawks heard
RACA			17-May	20:03	DT	Picacho Hwy ca 4.5 mi S of I10	Heard calling E of rd
MAMMA	LS:						
bobcat			15-Mav	21:51	DOS	Pecan Rd 0.8 mi N Park Link Dr	none
bobcat	479800	3583242	19-Mav	19:30	PCR	Bobcat perched on irr canal N of Pasture A NW Tw Pks	
coyote	480746	3581852	10-May	11:36	PCR	Coyote den in Pasture B NW Twin Peaks	active

coyote			15-Jun	16:44	PAH	Rt 85 in front of OPCNM Visitor Center	DOR,
kit fox			9-Jun		DT	Pecan Rd mi 8.9 N of Park Link Dr	
Dip_des	427327	3602573	14-May	17:22	PCR	Dipo des mounds seen WSW Vulture Butte Dune	
Dip_des	431459	3598928	14-May	23:46	PCR	Dipo des DOR (Coll) Trans Line Rd W Silverbell Estates	to UA Mammal Collection
Dip_des	446412	3600969	14-Jun	21:15	PCR	DipDes nr Morris Tank Rd	Nr lower bajada wash at dusk
Dip_des	441633	3606895	14-Jun	23:24	PCR	DipDes nr Laguna and Greene Canal	sand rd along Greene Canal N of Laguna
Dip_specQ	441786	3606864	14-Jun	23:50	PCR	Dip cf spectabilis nr Laguna and Greene Canal	sand rd along Greene Canal N of Laguna
Dip_specQ	467805	3599624	17-Jun	20:32	PCR	Dips cf spectab mound NE Pinal Air Park	mound w lg burrows
Dip_specQ	470006	3599220	18-Jun	20:15	PCR	Dip cf. spectabilis mound N Avra Sand area	Several mounds unquestionably spectab or deserti
<b>Other</b>							
GAAF	461083	3600550	16-May	15:00	PCR	GAAF abund Los Robles Wash bed pool at Sasco Rd	
							Also saw 14 Dip mer, 1 Per amp, 2 unk heteromyids, Eleodes on ants, 1
ants	467869	3599555	13-Jun	20:14	PCR	Ants (Pogo - bl; Acromyrmex; Novomessor [Q])	Hadrurus, 2 Lycosa

Species	Scientific Name	English Name
AREL	Arizona elegans	Glossy Snake
ASTI	Aspidoscelis tigris	Tiger Whiptail
BUAL	Bufo alvarius	Sonoran Desert Toad
BUCO	Bufo cognatus	Great Plains Toad
BUWO	Bufo woodhousii	Woodhouse Toad
CADR	Callisaurus draconoides	Zebra-tailed Lizard
CHCI	Chilomeniscus cinctus	Banded Sand Snake
CHPE	Chaetodipus penicillatus	Desert Pocket Mouse
CHOC	Chionactis occipitalis	Western Shovel-nosed Snake
COVA	Coleonyx variegatus	Western Banded Gecko
CRAT	Crotalus atrox	Western Diamondback
CRCE	Crotalus cerastes	Sidewinder
CRSC	Crotalus scutulatus	Mohave Rattlesnake
DIME	Dipodomys merriami	Merriam's Kangaroo Rat
Dip_specQ	Dipodomys spectabilis (?)	Banner-tailed Kangaroo Rat
Dip_des	Dipodomys deserti	Desert Kangaroo Rat
DIDO	Dipsosaurus dorsalis	Desert Iguana
GAAF	Gambusia affinis	Mosquitofish
GAWI	Gambelia wislizenii	Long-nosed Leopard Lizard
HESU	Heloderma suspectum	Gila Monster
HYTO	Hypsiglena torquata	Night Snake
LAGE	Lampropeltis getula	Common King Snake
LEHU	Leptotyphlops humilis	Western Blindsnake (Threadsnake)
MAFL	Masticophis flagellum	Coachwhip
MIEU	Micruroides euryxanthus	Sonoran Coralsnake
MUMU	Mus musculus	House Mouse
NEAL	Neotoma albigula	White-throated Packrat
ONTO	Onychomys torridus	Southern Grasshopper Mouse
PEER	Peromyscus eremicus	Cactus Mouse
PHBR	Phyllorhynchus browni	Saddled Leaf-nosed Snake
PHDE	Phyllorhynchus decurtatus	Spotted Leaf-nosed Snake
PHSO	Phrynosoma solare	Regal Horned Lizard
PICA	Pituophis catenifer	Gopher Snake
RACA	Rana catesbeiana	Bullfrog
RHLE	Rhinocheilus lecontei	Long-nosed Snake
SAHE	Salvadora hexalepis	Western Patch-nosed Snake
SCMA	Sceloporus magister	Desert Spiny Lizard
SOSE	Sonora semiannulata	Western Groundsnake
SPTE	Spermophilus tereticaudus	Round-tailed Ground Squirrel
THMA	Thamnophis marcianus	Checkered Gartersnake
TRBI	Trimorphodon biscutatus	Sonoran Lyre Snake
URGR	Urosaurus graciosus	Long-tailed Brush Lizard
UROR	Urosaurus ornatus	Northern Tree Lizard
UTST	Uta stansburiana	Side-blotched Lizard

Appendix 3. Abbreviations used in the report (usually the first tow letters of genus and species names).

Appendix 4. Drift fence trap locations set for shovel-nosed snakes in Avra Valley, 12-28 May and 8-22 June 2007. Traps are described in text. Trap N1 was destroyed by livestock and removed on 26 May. Pasture names are for this project only. UTMs are all in zone 12S with reference to the datum WGS1984.

Trap_No	b Location	UTM E	UTM N	Ecological Setting
N1	Pasture N, N of AV Rd, E of CAP	481659	3585772	Paloverde-triangle bursage flat
A1	Pasture A, S of AV Rd, W of CAP	480223	3583397	Open bosque near farm levee
B1	Pasture B, S Twin Peaks Rd W & N of CAP	480495	3581926	Across small mesquite-lined wash in creosote flat
B2	Pasture B, S Twin Peaks Rd W & N of CAP	480346	3582108	Across small mesquite-lined wash in creosote flat
B3	Pasture B, S Twin Peaks Rd W & N of CAP	480337	3582237	Across small mesquite-lined wash in creosote flat
B4	Pasture B, S Twin Peaks Rd W & N of CAP	480397	3582134	Creosote flat
SB1	Silverbell rise pasture 1 near AV Rd	477676	3585155	Mesquite-creosote flat near road
SB2	Silverbell rise pasture 1 near AV Rd	477655	3585244	Creosote flat near open mesquite savannah
SB3	Silverbell rise pasture 2 WNW of Nelson	473920	3587844	Across very small wash on sandy creosote slope
SB4	Silverbell rise pasture 2 WNW of Nelson	473760	3587997	Across washlet on sandy creosote slope

Appendix 5. Personnel participating in the fieldwork and

contributing data during 2007	, with initials used elsewhere in the
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report.			
Kevin A. Baker	KAB	Robin Llewellyn	RL
Kimberly D. Baker	KDB	Patty Mahaney	PM
Dennis J. Caldwell	DJC	Danielle O'dell	DO
Jennifer Christelman	JC	David Prival	DP
Catherine Crawford	CC	Dennis O. Suhre	DOS
Steve Foldi	SF	Julia C. Rosen	JCR
Julia Fonseca	JF	Philip C. Rosen	PCR
Carianne Funicelli	CF	Sander D. Rosen	SDR
Trevor Hare	TH	Jen Spawn	JS
Colby Henley	СН	Dale Turner	DT
Peter A. Holm	PAH	Lirain F. Urreiztieta	LFU
David A. Kahrs	DAK	Bruce Weiss	BW
Guillermo Lev	GL	Erin Zylstra	ΕZ

Appendix 6. Survey effort for 2007 shovel-nosed snake study, southern Arized	ona. Abbreviations of personnel are in Appendix 5.

		Lead				No.	
		(Data)		Time	Time	Per-	Person-Hr
Date (2007)	) Survey Location (with annotations on survey activity record)	Person	Other personnel	Start	Stop	sons	or Rd Dist
14-May	Sawtooth (Vulture Roost) Dune and surrounding area	PCR	DAK, DJC, LFU, GL	19:45	22:45	5	15.00
16-May	W Silverbell Mts lower bajada (on-foot)	PCR	DAK, JS	19:30	22:30	3	9.00
17-May	W Silverbell Mts lower bajada (on-foot and drive)	PCR	DAK, JS	6:00	11:30	3	16.50
17-May	Picacho Hwy area (N of) on-foot	DT	PCR, DAK. RL, SF	18:50	19:40	6	5.00
9-Jun	Houser Rd Atriplex-Larrea (on-foot at CHOC site - Bezy)	PCR	KDB, GL	19:15	19:45	2	1.00
12-Jun	Sawtooth (Vulture Roost) Dune and Silverbell Estates areas	DAK	DAK, unk	19:30	21:00	2	3.00
13-Jun	Pinal Air Park region, sand desert (on-foot)	PCR	DAK, KDB	19:50	21:45	3	5.75
14-Jun	Santa Cruz Flats edge at W Silverbell bajada, 11 Mile Corner Rd alignment	DT	DJC, BW, EZ	19:10	21:35	4	9.67
14-Jun	W Silverbell lower bajada (on foot)	PCR	DAK, DP, DO	19:35	21:35	4	8.00
15-Jun	Santa Cruz Flats (W edge) and W Silverbell lower bajada (on foot)	PCR	DAK	7:30	11:51	2	8.70
17-Jun	Pinal Air Park region, sand desert (on-foot)	PCR	DAK	19:30	21:15	2	3.50
18-Jun	Pinal Air Park region, sand desert (on-foot)	PCR	KDB	20:09	21:15	3	3.30
12-Jul	Pinal Air Park region, sand desert (on-foot)	PCR	JC	19:56	21:03	2	2.23
			<b>TOTAL On-Foot Pers</b>	son-Hour	·s		90.65
14-Mav	Sawtooth Dune-Silverbell Estates (one 8 mi roundtrip)	PCR	LFU GL	18·30	19.30	3	10
15-May	Pinal Air Park dirt roads 16 mi driving)	PCR	DAK	18.15	22.45	2	16
15-May	Pecan Rd to 9.2 mi N Park Link Dr.	DOS		19:07	22:17	1	18
16-Mav	Pecan Rd to 8.5 mi N Park Link Dr.	DOS		20:00	22:57	1	17
17-May	Picacho Hwy area (2 passes dirt roads ca 6 mi round trip)	PCR	DAK, SF	19:12	21:00	3	12
9-Jun	Pecan Rd to 9 mi N Park Link Dr, back to 110 Access Rd	DT	JF	18:34	21:35	2	23
15-Jun	Pecan Rd (one 10 mi round trip), Minuteman Rd (two 2 mi round trips)	LFU		19:32	21:30	1	14
16-Jun	Picacho Hwy and adjoining dirt rds (ca. 2 runs)	DAK	unk	19:30	21:00	2	10
18-Jun	Picacho Hwy and adjoining dirt rds (ca. 1 run)	DAK	unk	21:00	21:30	2	10
12-Jul	Pinal Air Park desert-Trico Rd (ca 14 mi)	PCR	JC	21:05	22:00	2	14
			<b>TOTAL Road-Cruise</b>	Mi (Dirt	Rds)		144
16-Mav	W Silverbell Mts lower bajada (6 mi dirt rd cruise)	PCR	DAK IS	18·45	19.30	3	6
17-May	Picacho Hwy (three passes 6 mi round trin)	PCR	DAK SF	19.12	21.00	3	18
17-May	Emigh Sanders Twin Peaks (3 mi loon run once)	DOS	D/111, 01	19.12	19.40	1	3
17-May	Picacho Hwy 110-Baumgartner Rd (1 9 nasses)	DUS	BI	19.20	21.38	2	32
1 / - 1v1ay	reaction my mo-baungarner Ru (1.7 passes)			19.55	21.30	4	54

17-May	Pinal Air Park-Trico-Silverbell (end at Sanders (11.1 mi)	DOS		20:07	21:05	1	11
17-May	Houser Rd (one 7 mi round trip)	PCR	DAK, SF	21:30	22:00	3	7
18-May	Minutman (Missile Base) Dr to 2 mi E I10 Access Rd - one 4.1 mi round trip)	DOS		20:17	21:16	1	4
20-May	Pinal Air Park region, sand ridge S of Sasco Rd (total ca. 11 mi driving)	PCR	GL	19:45	21:00	2	11
23-May	Picacho Hwy fr I10 to Baumgartner Rd (one 17.2 mi round trip)	DOS		19:04	20:58	1	17
24-May	Rt 85 ORPI, C palarostris run (Cherioni - Kuakatch)	PCR		19:15	19:35	1	9
24-May	Pinal Air Park Rd W fr I10 (three 4.0 mi roundtrips)	DOS		19:28	20:48	1	12
24-May	Rt 85 Why-Ajo C occipitalis run	PCR		19:40	20:00	1	5
24-May	Rt 85 Ajo area C occipitalis habitat run	PCR		20:20	21:00	1	8
24-May	Rt 85 Goldwater Range C occipitalis run	PCR		21:00	22:45	1	26
25-May	Picacho Hwy fr Nutt Rd to O.35 mi N of Pretzer Rd	PCR	DOS	19:30	21:00	2	14
26-May	Emigh, Sanders, Twin Peaks, Sandario (1 4 mi loop, + 3 mi E on Twin Peaks)	PCR	JCR, SDR	20:15	20:45	3	7
28-May	Houser (three round trips) Brady Pump (2 round trips)	PCR	DJC, PM	19:30	21:05	3	30
8-Jun	Emigh, Sandario, Sanders, Twin Peaks (4 mi loop run once)	PCR		19:30	19:55	1	4
9-Jun	Houser Rd (2 roundtrips of 7 mi), Brady Pump Rd (1 Rd trip of 5 mi)	PCR	KDB, GL	19:45	21:40	3	19
10-Jun	Picacho Hwy, I10 Frontage Road, Missile Base Road) (ca 30 mi)	PCR	LFU, CC	19:45	21:30	3	30
11-Jun	Maricopa Rd fr Gila Bend to E of Mobile (1 pass)	PCR	SF	19:25	23:00	2	40
11-Jun	Emigh, Twin Peaks, Sanders, Sandario rd loop (two 4.0 mi loops)	LFU		19:30	20:30	1	8
11-Jun	Houser-Brady Pump rds (2-3 runs)	DAK	unk	19:30	21:00	2	30
12-Jun	Avra Valley, Trico, Anway, Sandario- rds (ca. 15 mi)	LFU	DJC	19:30	22:00	2	15
12-Jun	Florence area (2 mi S of, on 79, 60, S to Arizona Farms)	СН		19:35	22:45	1	28
12-Jun	Picacho Hwy I10-state prison grounds (three passes, ca. 10 mi)	PCR	SF	19:45	21:20	2	10
14-Jun	Silverbell Rd fr Sanders-Trico (three trips at 9.6 mi) + N to Pinal Air Park-110	OLFU		19:30	21:00	1	36
14-Jun	Rt 85 south from Gila Bend to MP 31, turn back northbound to Gila Bend	СН		19:45	23:00	1	62
15-Jun	Picacho Hwy and adjoining dirt rds (ca. 2 runs)	DAK	unk	19:30	21:00	2	20
18-Jun	Avra Valley Rd (Sanders-Pump Sta (two round trips) + 3 mi on Pump Sta Rd	LFU		19:30	21:35	1	39
18-Jun	Houser-Brady Pump rds (ca 2 runs)	DAK	unk	19:30	20:45	2	22
19-Jun	Avra Valley Rd (once?, Sanders-Pump Sta round trip)	LFU		19:30	21:10	1	18
19-Jun	ORPI-Ajo area, effort not recorded	PAH		April	June	1	na
20-Jun	Silverbell Rd (three round trips Sanders-Pump Sta)	LFU		19:30	21:05	1	30
21-Jun	Silverbell Rd (three round trips Sanders-Pump Sta)	LFU		19:30	21:10	1	30
21-Jun	Picacho Hwy to Friendly corners + 3 roundtrips nr prison	CF	TH	20:10	22:50	2	20
27-Jun	Rt 85 fr Why to N of Ajo (ca 12 mi)	PCR		20:30	21:30	1	12
			<b>TOTAL Road-Cruis</b>	e Mi (Pav	ed Rds)		693