RESOLUTION 2008 – BASELINE BIOLOGICAL SURVEYS
SUMMARY OF MAMMAL OBSERVATIONS AND
MOTION-SENSITIVE CAMERA RESULTS

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EXECUTIVE SUMMARY

WestLand Resources Inc. (WestLand) biologists set up three motion-sensitive cameras beside springs within a study area along Devils Canyon (the Study Area; Figure 1). Cameras 1 and 2 were set up on April 25, 2008 at two springs in the alder grove (Figure 2). Camera 3 was set up on May 9, 2008 at a spring below the Crater Tanks (Figure 2). Cameras 1 and 2 were revisited on June 10, August 28, 2008, and January 24, 2009 to check on their functionality, replace batteries, and download pictures. Camera 3 was revisited on February 15, 2009 for these purposes. Two more cameras (4 and 5) were set up on February 15, 2008 near Camera 3. As of February 15, 2009, five cameras are in the Study Area (Figure 2). Cameras 1, 2, and 3 had periods during this study when the cameras were not functioning (due to memory card malfunction, low batteries, or damage from being pulled to the ground by coati [*Nasua narica*]). However, the three cameras were demonstrably functioning for a total of 433 camera-days. During this period, Cameras 1 and 2 captured 82 identifiable images of animals representing eight mammals and two birds. Mammal species photographed included mountain lion, bobcat, black bear, coati, ringtail, collared peccary, white-tailed deer, and cottontail. The two bird species were Bewick's wren and spotted towhee. Camera 3 captured 36 identifiable images of animals representing five mammals: cattle, white-tailed deer, coati, gray fox, and skunk. The most common images obtained by the three cameras combined were coatis (59), cottontails (17), deer (15), and cattle (11).

Three individual bears were photographed. Young bear, coatis, and white-tailed deer were also photographed, indicating that these species are reproducing in the vicinity of the Study Area.

1. INTRODUCTION

Resolution Copper Mining, LLC (Resolution) proposes to develop an underground copper mine within Resolution's holdings east of Superior, Arizona. Resolution has retained WestLand to conduct a variety of baseline biological studies within Resolution's holdings.

During their baseline biological studies, WestLand biologists have made observations on fish, amphibians, reptiles, birds, and mammals in the area. In 2008, birds were censused at permanent census stations and surveys for fish were conducted along Devils Canyon, Mineral Creek, and two stock ponds within Resolution's holdings. The results of the fish survey and bird census are summarized in separate reports. During field surveys, amphibians and reptiles, when encountered, have been identified and located using a hand-held GPS, but concerted efforts to locate the more cryptic reptile and amphibian species and to develop local range maps or population estimates have not been conducted.

Perhaps the most understudied of the vertebrate groups as part of the biological baseline studies have been the mammals. Bats are the only mammal group that has been a focus of WestLand's baseline biological studies in within Resolution's holdings. WestLand biologists, in coordination with Arizona Game and Fish Department, set up mist nets at the entrance of one adit on July 13, 2004 and across one stock tank on July 14, 2004, both sites with a high probability of bat use. No bats were caught at the adit, but eight bats representing three species (*Antrozous pallidus*, *Eptesicus fuscus*, and *Myotis ciliolabrum*) were caught at the stock tank, identified, and immediately released (WestLand 2004). Other than these focused bat surveys, the only mammal observations that have been made during baseline studies prior to 2008 have been opportunistic.

WestLand's opportunistic visual observations of mammal evidence in the area are, at best, fragmentary. Examples of our opportunistic observations include the following:

- Mountain lion (*Puma concolor* [*Felis concolor*]). On January 30, 2008, fresh mountain lion tracks were seen on the dirt road about 100 meters southeast of Hackberry stock tank (Figure 2; **Photo 1**; 496339E, 3681576N, NAD 27). It rained the day before, so the tracks were less than 24 hours old. The lion had crossed the road and was heading out of the drainage and up the south-facing slope. The tracks in the photos were about 10 cm (4 inches) in diameter – the typical size of mountain lion tracks.

Photo 1. *Mountain lion tracks photographed January 30, 2008 on dirt road near Hackberry Creek stock tank.*

- Black bear (*Ursus americanus*). Bear claw marks had been observed on the alder trees at Bear Spring (Figure 2) prior to the motion-sensitive camera set up. We found a dead black bear at Pipe Spring (Figure 2) in 2004. The bear had been dead for several weeks and was found among the boulders within the flood channel next to the spring. On May 8, 2008, we photographed and collected bear dung about 20 meters down-slope from where we set up camera 3 at Pipe Spring. The bear dung was outside of an excavated depression in earth under dense vegetation. The depression was circular, about 1.5 meters in diameter, and was likely dug by a bear as a resting spot. The bear dung was composed entirely of the berries of graythorn (*Ziziphus obtusifolia*), an abundant understory shrub at Pipe Spring and, at the time of our visit, still with a large amount of ripe fruits on the plants.
- Coati (*Nasua narica*). While hiking to and from the alder transects during the summer of 2008, WestLand biologists saw, on several occasions, groups of coatis in Devils Canyon. On April 23 at 18:05, we observed about 6 coatis running out of the channel area near Sycamore Spring (Figure 2). On April 24 at 12:45, we observed two coatis traveling along the east cliffs above Alder Transect #12 in Devils Canyon (**Photo 2**).
- Gray fox (*Urocyon cinereoargenteus*). We observed a gray fox running along the ledges above the canyon bottom in Queen Creek in the summer of 2008. In 2004, we observed a dead gray fox on the side of the paved road only about 100 meters below the gate at Mineshaft #9.
- Collared peccary (*Pecari tajacu*). Several years ago, we observed where a group of peccaries had visited a pool of water in lower Rancho Rio wash. The peccaries had created two wallows in the wet sand beside the pool; peccary hairs were present in the wallows. Tracks of adult and young peccaries were seen in the sand. We have seen peccary tracks in the sand at several pools within Rancho Rio and Devils Canyon and have seen peccary dung in an area of Devils Canyon south of Oak Canyon. On February 15, 2009, along the trail between the power line to the west and the Crater Tanks, we found at least fifty prickly pear plants with roots exposed by peccaries digging and feeding. The soil was wet and relatively soft to dig at this time.

Photo 2. *Two coatis above Alder Transect #12 in Devils Canyon on April 24, 2008*

- Deer (Odocoileus sp.). We have observed tracks, dung piles, and trails of deer along the dirt roads and in the chaparral west of Devils Canyon in 2008 and 2009. When camping above Devils Canyon near Hackberry Canyon in 2008, we heard deer walking and snorting nearby during the night. In February 2009, we frequently found fresh deer dung and deer tracks on the slopes to the west and southwest of the Crater Tanks. In contrast, in 2004 and 2005 while surveying the drainages and slopes to the west of Anxiety Fault in Rancho Rio watershed, we walked along wildlife trails and found no recent signs of deer. All of the deer dung was sun-bleached and probably more than a year old. The absence of deer may have been part of the lingering effects of the severe drought in the area in the early 2000s.

Realizing the fragmentary nature of non-bat mammal observations that have been collected since 2004, WestLand considered different approaches to characterize other mammal populations in the area including the use of spotting scopes for large mammals, baited Sherman-type live-traps for rodents, and baited Havahart®-type live-traps for medium-sized mammals. WestLand biologists did not use these approaches because they are time-intensive, and the area that encompasses the Resolution holdings is vast, with large portions that are remote and comprised of cliffs, unstable steep-sloped Tertiary deposits, dense chaparral, thorn-scrub, or some combination of these features.

Based on their opportunistic observations of mammals in Devils Canyon, WestLand determined that a focused effort to qualify animal use in Devils Canyon would be appropriate for the baseline studies. In order to augment these observations of mammals in a study area along Devils Canyon (the Study Area), infra-red triggered motion-sensitive cameras were purchased. These cameras provide a more economical alternative to logging in long hours of observation of wildlife. Benefits of using motion-sensitive cameras are reliability in the identification of most images of animals obtained and knowledge of the location and time that each image is taken. Commercial camera systems became widely available in the early 1990s and infrared-triggered cameras have been used by wildlife biologists for more than 40 years.

Cutler and Swann (1999) and Swann et al. (2004) recently reviewed the application of infrared-triggered cameras in vertebrate ecology. Camera systems are now used by researchers to develop population estimates (ex. Martorello et al. 2001 for black bears, Mace et al. 1994 for grizzly bears (*Ursus horribilis*), Jacobson et al. 1997 for white-tailed deer), to assess potential wildlife corridors such as highway underpasses (Foster and Humphrey 1995), to confirm the presence of rare species such as marten (*Martes americana*) (Bull et al. 1992), opossum (*Didelphis virginiana*) in southern Arizona (Babb, Brown, and Childs 2004), and jaguars (*Panthera onca*) in southern Arizona (Childs 1998, Childs and Childs 2007), and to conduct mammal inventories. A few examples of how motion-sensitive cameras have been employed by wildlife biologists are provided in the following paragraph.

In a large experimental design by Fenske-Crawford and Niemi (1997) to measure predation of artificial ground nests in three ages of forests in north-central Minnesota, two motion-sensitive cameras were employed to identify the nest predators. The two cameras, after 1,728 hours of operation, recorded 28 predation events caused by eight species of mammals. Camera systems have also been used to evaluate relative predation risks of mule deer (*Odocoileus hemionus*) to mountain lions in different vegetation types (Hernández et al. 2005). Main and Richardson (2002) used eight cameras in a 4 x 2 grid design in each of 52 fire management

units (mean size = 206 ha) to document relative abundance of wildlife in stands of slash pine (*Pinus elliottii*) in southern Florida that were at different stages in a four-year burn rotation. Gompper et al. (2006) compared four techniques (camera traps, track-plates, scat surveys, snow tracking) to survey carnivores at two study sites in New York. Gompper et al. found that no single technique was ideal for surveying all species of carnivores in their study area; however, they found that baited camera stations detected the most species but tended not to detect coyotes (*Canis latrans*) and underestimated small carnivores (ex. weasels). Gompper et al. found that baited cameras were efficient at surveying black bears. Bridges et al. (2004) used an infrared-triggered camera at each of ten black bear dens in the mountains of western Virginia. The camera results provided more accurate den-emergence dates, cub age at den emergence, and several seldom-documented behaviors associated with den exit. This brief review of the use of infrared-triggered cameras in wildlife studies suggests that even relatively few cameras employed in a study can greatly increase the amount and precision of information obtained regarding mammal activity in small areas (at bird nests, bear dens, springs, etc.).

Photo 3. *Cuddleback® motion-sensitive camera wired to fallen log at Bear Springs; cover removed while servicing camera on August 28, 2008.*

There are four useful kinds of information that the infrared-triggered cameras set up at several springs in the Study Area may provide:

- the frequency at which different species are moving through a small monitored area at each spring
- information about the number of bears and coatis in Devils Canyon
- documentation of movement of distinctively marked bears and coatis between the upper cameras (1 and 2) and the lower camera (3) that are separated by about 3.2 km (2 miles)
- documentation of rare species that are currently not anticipated to occur in Devils Canyon

Photo 4. *View of Bear Spring on August 28, 2008. Camera on log between alder and boulder in background. Bear claw marks are present on the alder tree about 7ft above ground.*

2. METHODS

In 2008, motion-sensitive cameras were placed at three springs in the Study Area (Figure 2, 2 **Photos 3 and 4**). Cameras 1 and 2 were set up April 25, 2008; Camera 3 was set up May 9, 2008. Two more motion-sensitive cameras (Cameras 4 and 5) were set up on February 15, 2009. UTM coordinates (NAD 27) for the locations of each of the cameras are provided in Table 1. Cameras 1 and 2 are at springs within the major alder grove. Camera 3 is at a large spring downstream (south) of the

alder grove and below the Crater Tanks. Camera 4 was set up about 8 meters southeast of Camera 3. Camera 5 was set up along the east bank of Devils Canyon stream 200 meters upstream from Cameras 3 and 4. All cameras were placed within State Trust Lands. Cameras 1 and 2 are in Section 9 and Cameras 3, 4, and 5 are in Section 21 of Township 2S, Range 13E.

Table 1. Locations of each camera (UTM coordinates, NAD 27).

Camera Location	Northerly	Easterly	Meters accuracy	Approx. elevation (m; ft)
Camera 1 (Bear Spring)	3681877	497463	8 m	1,095 m; 3,592 ft
Camera 2 (Sycamore Spring)	3681655	497484	6 m	1,100 m; 3,608 ft
Camera 3 (Pipe Spring)	3678734	498464	5 m	877 m; 2,876 ft
Camera 4 (Pipe Spring)	3678730	498469	5 m	877 m; 2,876 ft
Camera 5 (stream-side)	3678854	498302	10 m	866 m; 2,840 ft

The cameras used were Cuddeback® NoFlash Infrared Digital Camera Systems, which were capable of both daylight color digital photography (3.0 megapixel) and nighttime digital infrared photography (1.3 megapixel). According to the manufacturer, this Cuddeback model had a trigger speed of ¾ second. The cameras were programmed to take one photograph after being triggered and had a one-minute delay between triggered events. (One minute was the minimum time between triggers for this model.) Cameras 1 through 4 were placed near springs because the three springs had an abundance of wildlife tracks and diggings. Additional animal signs that indicated the springs were focal points of large mammal activity were bear claw marks on nearby tree trunks and roots, wildlife trails, and at the lower spring, a black bear "bed" with bear scat around the bed. Initially, the cameras were wired to a fallen log (Camera 1) and to live tree trunks (Cameras 2 and 3), and all three cameras were less than 1 meter from the ground. Cameras 1 and 2 were located at Bear Spring and Sycamore Spring (Figure 2), near the upper end of the alder stand. Both of these cameras were first installed on April 25, 2008. The cameras' memory cards were changed and batteries were checked on June 10 and August 28, 2008. Cameras 1 and 2 were revisited five months later, on January 24, 2009; their batteries were replaced, and their memory cards were changed. Camera 3 was installed on May 9, 2008 at Pipe Spring

Photo 5. *Camera 4 set up on a young hackberry tree, February 15, 2009 (Pipe Spring)*

(Figure 2), below the Crater Tanks, and was checked on February 15, 2009. Camera 4 was set up about 2 meters above ground on the trunk of a young hackberry tree (**Photo 5**). Camera 5 was set up about 2 meters above ground on the trunk of a mature mesquite tree (**Photo 6**). Camera 5 was directed towards an open area between a bedrock cliff about 2-3 meters in height to the east and the stream to the west; wildlife are expected to use this constricted corridor. Cameras 3 and 4 are directed towards two segments of the same wildlife trail that leads to flowing spring water about 15 meters to the northwest.

Photo 6. *Camera 5 set up on a mesquite tree on the edge of lower Devils Canyon stream; February 15, 2009*

In this report, the Wilson and Reeder (2005) compendium on current nomenclature for mammals and the AOU (2008) compendium for current bird nomenclature were used. Both sources are available online. Because some of the mammals that occurred in this study have older nomenclatures still in use by researchers and recognized by Hoffmeister (1986) in his *Mammals of Arizona*, the older nomenclatural synonyms are included in brackets

3. OBSERVATIONS ON EQUIPMENT FUNCTION

After five months, the four D-type batteries in the cameras were down to 10 percent charge in Camera 1 and had failed in Camera 2. Camera 2 was not triggered on January 24 even though the biologist moved around within the field of view for at least a minute; the last image on Camera 2 was December 13, 2008. On January 24, 2009, Camera 1 was attached about 2 meters above ground to alder tree 121 on Alder Transect #5, and Camera 2 was moved about 1.5 meters above ground to a net-leaf hackberry about 12 meters south of the camera's first position. Camera 3 was checked on February 15, 2009; it was found on the ground (**Photo 7**), face up, with the Fresnel lens bitten (**Photo 8**), and mud and water within the casement and on the casement windows for the infrared flash lens and Fresnel lens. After seven months, Camera 3's batteries were dead. After replacing its batteries and memory card, Camera 3 was tested and found still to be working. Camera 3 was

Photo 7. *Camera 3 pulled from the Pipe Spring cache on September 27, 2008, as it appeared February 15, 2009 (Pipe Spring)*

remounted on the trunk of a live hackberry tree about 2 meters above ground and secured with several lengths of heavy insulated copper wire.

4. RESULTS

There were 292 camera-days during which Cameras 1 and 2 were functioning between April 25, 2008 and January 24, 2009 (Table 1). There were 141 camera-days during which Camera 3 was functioning between May 9, 2008 and February 15, 2009. The number of camera-days for a given interval was determined from the date the camera was set up to the date of the last photograph. Camera-days therefore include only those days for which we have evidence the camera(s) were functioning.

Table 2. Camera-days for Camera 1 and 2.

Camera 1	Camera 2	Camera 3	Sum
46 days (4-25 to 6-10)	7 days (4-25 to 5-02)	141 days (5-09 to 9-27)	53 + 141
79 days (6-10 to 8-28)	53 days (6-10 to 8-02)		132
0 days (start 8-28)	107 days (8-28 to 12-13)		107
125 days	167 days	141 days	433 camera-days

A total of 193 images have been recovered from Cameras 1 and 2 over the time period from first installation on April 25 to the second data recovery on August 28, 2008. Camera 1 produced most of these images, with a total of 168 images (87%). The first image on Camera 1 was recorded on April 26, the morning after installation, and the final image was recorded on August 28, shortly before the data were recovered. Camera 2 was apparently knocked down shortly after installation and recorded no images between May 2 and June 10, when the memory cards in both cameras were changed and the cameras reset. From June 10 to August 10, Camera 2 recorded only 23 images, and four of those were of biologists at the time of setup on June 10. The first image after that time was on June 12, and the final recorded image was on August 2.

Photo 8. *Camera 3 with its coati-bitten Fresnel lens as it appeared February 15, 2009 (Pipe Spring*

Nineteen images were recorded from Camera 2 between August 28, 2008 and January 24, 2009. No images were recorded during this same period of time from Camera 1 because of a malfunction in

the memory card. Of the nineteen images from Camera 2, one was a WestLand biologist (on August 28), fourteen showed at least part of an animal and four showed nothing. The first image after August 28 was October 28, the final recorded image was December 13, 2009.

Seventy-four images were recorded from Camera 3 between May 9, 2008 and February 15, 2009. The last 14 images were of the sky and canopy on September 27, 2009 - all taken 70 minutes after a coati pulled the camera to the ground. It is not clear why more photos of the canopy were not taken by the face-up camera. Perhaps after four months and 16 photos in quick succession on September 27, the batteries lost their charge. Of the 60 non-sky images from Camera 3, 38 included at least one animal and 22 showed nothing. The first image after May 9 was the following day at 4:02 pm with no animal in the image; the last image was on September 27.

Of the 272 recorded images, there were 119 images of identifiable animals (44%) and another nine animal images that could not be identified (3%). Images of 11 mammal species and two bird species were recorded. There were also 14 images (5.2%) of WestLand biologists setting up cameras or passing through the canyon while working on other aspects of the baseline surveys. Many of the 142 images (52% of all recorded images) do not show any animals and appear to have been triggered by wind moving the vegetation or by animals that moved out of the field of view during the ¾-second trigger delay. Many of the images of animals show only a blurred image because the animal was moving rapidly or show part of the animal because of the slow trigger delay of the camera. The animal species photographed and the number of images of each are provided in Table 3.

Table 3. Species photographed by Cameras 1 (April 25, 2008 – August 28, 2008), Camera 2 (April 25 – January 24, 2009), and Camera 3 (May 9 - September 27, 2008).

Mammal Species	Camera 1	Camera 2	Camera 3	Total Images
Mountain lion (*Puma concolor* [*Felis concolor*])	0	1	0	1
Bobcat (*Lynx rufus*)	2	1	0	3
Black bear (*Ursus americanus*)	2	1	0	3
Gray fox (*Urocyon cinereoargenteus*)	0	0	2	2
Coati (*Nasua narica* [*Nasua nasua*])	37	3	19	59
Ringtail (*Bassariscus astutus*)	0	1	0	1
Collared peccary (*Pecari tajacu* [*Tayassu tajacu*])	0	4	0	4
Skunk, probably Hooded Skunk (*Mephitus macroura*)	0	0	1	1
White-tailed deer (*Odocoileus virginianus*),	5	7	3	15
Cattle (*Bos taurus*)	0	0	11	11
Cottontail (*Sylvilagus* cf. *floridanus*)	17	0	0	17
Bird Species				
Bewick's wren (*Thryomanes bewickii*)	1	0	0	1
Spotted towhee (*Pipilo maculatus*)	1	0	0	1
Sum	65	18	36	119

Photographs discussed in this section can be found in Appendix A.

One mountain lion was photographed by Camera 2 on November 11, 2008 at 3:32 am (**Photo 9**). It appears to be a mature animal.

Bobcats were recorded twice at Camera 1, both on infrared after dark (**Photos 10 and 11**) and once at Camera 2 during early morning. Although Camera 1's bobcat images were recorded on June 22 and August 8, 2008, it is possible that they represent the same individual. The patterns of spots on the hind legs are very similar, but a conclusive comparison is not possible because of the different angles of each camera and lighting. Only the tail and hind leg of a bobcat was photographed by Camera 2 on November 6, 2008 (**Photo 12**).

Three different black bears were recorded. An adult, reddish-brown in color, was recorded at Camera 1 on April 26, 2008, the morning after initial installation (**Photo 13**). A bear with black fur was recorded at Camera 2 in early July (**Photo 14**), and a juvenile bear was recorded at Camera 1 in early August of 2008 (**Photo 15**). It is interesting that all of the bear photos were recorded during daylight, during hours when biologists could be working in the canyon.

We contacted Pat Feldt[1] who has about 15 years of experience guiding bear hunters in Arizona and showed him the photographs of the bears in Devils Canyon. In his e-mail reply (January 22, 2009), Mr. Feldt considered the bear in **Photo 13** to be "a 10+ year old bear about 300 lbs", **Photo 14** to be "just mature, can't tell much other than that," and **Photo 15** to be "2.5 yrs old and 100-125 lbs."

Gray fox was photographed twice (**Photos 16 and 17**). Although the photographs were taken 67 hours apart, the fox is in nearly the same spot with a different stance, as if the two photographs were only a few frames apart in a motion film. This nearly identical position of the fox during two different nights may be due to the fox stopping in mid-track to smell a scent-post on the ground.

Coatis were the most frequently photographed animal, with 59 recorded images. Most images of coatis (37) were recorded by Camera 1, and 14 images were recorded at Camera 3, but only three images were recorded at Camera 2. The images recorded at Camera 3 were similar to those recorded at Camera 2. As with the cottontail (see below), there are several sequences of two to six images of the same animal over a relatively short period of time. On May 2, a coati was recorded seven times over a period of 50 minutes, but the animal never presented a good view of its head (**Photo 18)**. A similar sequence of two photos in the span of two minutes on May 4 provided no good head views (**Photo 19**). An image recorded less than an hour later may or may not be the same individual (**Photo 20**). Three images within two minutes on June 21 (**Photo 21**) are undoubtedly the same individual, but another image 20 minutes later may or may not be the same individual. A good, full-body profile was finally captured on July 17, 2008 (**Photo 22**). This animal shows a large patch of hairless skin behind and below its left ear; the hairless patch appears to be either a recent injury or a scar. The hairless patch of this animal is just visible in an earlier photo taken on June 6, more than a month earlier. Two coatis, presumably a mother and young, are visible in several photos. On May 19, an adult is clearly visible at the spring (**Photo 23**), with a second, much smaller, animal nearly hidden in the grass. On August

17, a young coati is barely visible behind an adult (**Photo 24**). Two coatis are also visible on August 19, although only the heavily striped tail of the young coati is visible (**Photo 25**). The two photographs of coatis taken by Camera 2 at Sycamore Spring show the tail of a coati very near the camera on May 2, and only a portion of the tail of a coati on December 11 (**Photo 26**). Camera 3 photographed at least four coatis (and possibly more), a light yellow coati and a chestnut-and-white coati (**Photo 27**), a dark brown-and-white coati (**Photo 28**), and what appears to be a young coati with the chestnut-and-white coati (**Photo 29**). In one photograph, a coati is seated and is either resting or grooming (**Photo 30**). Photographs on September 26 and 27 show the front legs and later the hind legs as a coati reaches up to the camera to manipulate it; on September 27, the camera fell to the ground within ten minutes after the last coati photograph was taken.

A ringtail (*Bassariscus astutus*) was photographed once, by Camera 2 on October 31, 2008 at 3:06 am (**Photo 31**). Ringtails apparently need and use water and are most abundant in rocky canyons (Hoffmeister 1986). It is possible that this animal had descended from the cliffs only 100 feet to the east and using the spring which is about 30 feet to the northwest.

An indistinct image of a skunk walking away from the camera was photographed by Camera 3 at night on August 11, 2008 (**Photo 32**). The tail and the posterior half of the back of the animal are white. The hog-nosed skunk (*Conepatus mesoleucus*) and the white-marked forms of the striped skunk (*Mephitus mephitus*) and hooded skunk (*Mephitus macroura*) have white tails and backs similar to the skunk in the photograph. To be definitive to species of skunk, it would be useful to have the front portion of the animal in view. The markings that can be seen appear to conform most closely to the white-marked form of the hooded skunk. The hooded skunk is known to occur in mid-elevation rocky canyons in this area of Arizona (Hoffmeister 1986). Hoffmeister examined one specimen of a hooded skunk that was reported to have been collected from Williams Ranch 3.2 km (2 miles) west of Superior (and perhaps 10 to 16 km [6 to 10 miles]) from where the cameras are in Devils Canyon). Until more sightings or photographs are available, it is not possible to say which skunk species occur within Devils Canyon and which are most common in the canyon. All four species are known to occur in Arizona, hog-nosed, striped, hooded, and spotted (*Spilogale gracilis*), are known from the general area between Superior and Globe and could potentially occur within the canyon.

Collared peccaries were photographed by Camera 2 four times, once on October 28 at 9:01 am, twice on November 7 (11:04 and 11:09 pm), and once on December 13, 2008 at 7:39 pm (**Photo 33**). On October 28 (**Photo 34**), only the nose of the peccary is visible, and another unidentified mammal (possibly coati) appears to be hanging on the tree where the camera was mounted, changing the angle of the photograph. In each of the other images, the peccaries appear to be running along the wildlife trail.

White-tailed deer were recorded at least several times at each camera. The first two images, probably the same adult individual, were recorded in infrared on Camera 1, after dark on April 29, 2008, within a time span of about four minutes (**Photo 35**). Daylight images of adult white-tailed deer were recorded on Camera 1 on June 13, July 30, and August 6, 2008 (**Photos 36, 37,** and **38**). A white-tailed deer fawn (with natal spots) was recorded on Camera 2 on July 22, 2008 (**Photo 39**). In addition, white-tailed deer adults were recorded

[1] Owner, Arizona Guided Hunts (www.arizonahunting.net)

six times on Camera 2 between August 28, 2008 and January 24, 2009, once each on October 31 (**Photo 40**), November 5 (**Photo 41**), and November 17, and three times on November 18. Five of the Camera 2 deer images were daylight images, one was an image taken at dusk on November 18, 2008, 5:35 pm (**Photo 42**). White-tailed deer were photographed three times at Camera 3, two images of a buck with antlers in velvet on July 25 and one image of a doe on August 4, 2008. The buck was walking downstream along the wildlife trail at 5:48 pm (**Photo 43**) and returning at 5:53 pm (**Photo 44**), five minutes later.

Cattle were photographed eleven times by Camera 3, but not once by Cameras 1 or 2. Of the eleven photographs of cattle, nine were taken within a thirty minute period in the afternoon of May 16 and two were taken two minutes apart on July 3, 2008. At least five different animals were photographed, all of which appear to be either steer (**Photo 45 and 46**) or male feeder-calf (**Photo 47**). Two brand marks are evident on the animals, JI and an inverted V. No sign of cattle was observed at the springs next to Cameras 1 and 2 during this camera study.

Cottontails were recorded 17 times; all occurrences were on Camera 1. There are two cottontail species in central Arizona, the eastern cottontail (*Sylvilagus floridanus*) found in mountain forests and the desert cottontail (*S. audubonii*) found in a variety of vegetation types at lower elevations. Among the characters used to distinguish the two species, the ear-to-hind foot ratio can be used to identify at least some of the photographed cottontails at Camera 1. For eastern cottontails the length of the ear is shorter than the hind foot; and for the desert cottontail, the length of the ear is greater than the hind foot (Reid 2006). Based on the relative lengths of ears and hind feet in the photographs, these animals are probably all eastern cottontails. These animals were apparently foraging in the camera's view, because multiple photos were recorded on three out of five instances. On June 16, 2008one individual was recorded twice in a ten minute period late in the evening (**Photo 48**). On June 19, 2008one individual was recorded four times within a nine minute period in the early evening (**Photo 49**). On June 21, 2008one individual was recorded on nine consecutive photos over a period of 48 minutes (**Photo 50**). Based on the distinctive patterns of venation in the ears, the animals recorded on June 19 and June 21 are the same individual. On June 25, 2008, another eastern cottontail was recorded. The presence of a growth or parasite on the right hip identifies this cottontail as a different individual (**Photo 51**). The infrared photographs of cottontails on June 16 and August 15, 2008 (**Photo 52**) do not provide sufficient details to recognize the individual.

Two images of birds were recorded during this project, both at Camera 1. However, it is possible that some of the photos showing only vegetation were triggered by a bird flying past the sensor and disappearing before the image could be recorded. A spotted towhee was recorded on June 15, 2008 in a patch of bare ground in front of the grasses (**Photo 53**). A Bewick's wren was recorded on July 8, 2008 perched on the log to which the camera was attached (**Photo 54**).

Several photographs had images that could not be identified. For example, on May 19, 2008 an unidentified mammal approached Camera 1 after dark. This mammal apparently contacted and repositioned the camera, because subsequent images are aimed differently. A similar change in aiming occurred at Camera 2 on June 19, 2008. Camera 2 recorded an image, perhaps of a bobcat's face, on October 28, 2008, when the

animal was moving the camera (**Photo 55**); in subsequent images, Camera 2 had returned to its original orientation.

5. DISCUSSION

Three motion-sensitive cameras placed in the study area have successfully captured a total of 119 identifiable images representing 11 species of mammals and two species of birds. The cameras took photographs of animals at the rate of 119 images in 433 camera-days, or one animal image per 3.64 camera-days. Most published motion-sensitive camera studies do not report the number of images and number of camera-days. Childs and Childs (2007) provide enough data to suggest a mean rate of image capture. They used 12 motion-sensitive cameras from January 2001 to June 2004 and 45 cameras from June 2004 to January 2006 when Emil McCain joined the study as part of his graduate studies at Humbolt College. During this five-year period, they acquired 15,000 images of animals in 39,968 camera-days, or one image per 2.7 camera-days. Childs set up the cameras where wildlife was likely to frequent and where humans were not likely to discover the cameras. They placed their cameras near pools of water in the canyons and where wildlife were likely to be funneled through narrow canyons. It is not clear to what extent they used scent-baits in front of their cameras. They visited their cameras, changed batteries and film, and downloaded memory cards for each camera once every six weeks. What is evident in the Childs' photographs is that Childs and his collaborators chose sites that were either wildlife corridors or water sources. Childs cameras were positioned with a greater range of view than our cameras. Also, Fenske-Crawford and Niemi (1997) provide the length of time of their study (72 days) and the number of predation events (28) on artificial nests with eggs in Minnesota to determine the number of days per event, 2.57. They had only two cameras and moved the cameras from nest to nest and the nests were baited with eggs, so their observed rate of "image capture" is not directly comparable to ours.

Our cameras were set near springs which were beside a perennial stream along more than one mile of Devils Canyon (Figure 2). Camera 1 was aimed at a patch of grass and sedge that appeared from the photographs to be a food source for the cottontails and a place coatis hunted, presumably for invertebrates. Cameras 2 and 3 were directed towards wildlife trails near water. Had we attached the cameras higher in the tree or in a site with a greater range of view and placed a scent-bait in front of the camera, the number of camera-days per image might have been reduced. Aside from the studies by Childs and by Fenske-Crawford and Niemi and a few others, the literature on motion-sensitive cameras does not describe the results in terms of camera-days per image. Our rate of camera-days per image is not comparable to those from studies in which the cameras were aimed towards scent-baits or artificial bird nests baited with edible eggs.

The images obtained by Cameras 1, 2, and 3 confirm that this area is used by multiple individuals of several species. The images also confirm repeat visits by some of the same individuals. The images of young bear, coati, and deer indicate that these species are reproducing in the vicinity of the study area.

Each of the three bear photographs was of a different bear. Mature bears are the largest animals (aside from cattle) in the study area and along with mountain lions may constitute the fewest animals of a given species in the vicinity of the study area. It is interesting to consider how many bears may have home ranges that include

the study area and how many additional bears may occasionally be present within Devils Canyon. In Arizona, bear populations have increased in the 1900s from very low numbers when they were regarded primarily as pests to a state-wide population of perhaps 2,000 to 3,500 (Hoffmeister 1986). From 1977 to 1979, Thomas Waddell and David Brown (1984) of the Arizona Game and Fish Department studied black bears in the Pinaleño Mountains which is about 96 km (60 miles) southeast of Devils Canyon. They actively trapped and marked bears as well as collected data on both nuisance (campsite) bears and wild bears that were harvested or found dead. Based on the data they collected, they estimated the annual population in the Pinaleño Mountains to be between 102 and 150 bears, with a bear density of 1 bear/3.0-4.2 km^2. It is the mid-elevation vegetation with junipers, oaks, prickly pear, and other species that provides much of the food base for black bears in the Pinaleño Mountains. Similar vegetation occurs near Devils Canyon. Continued long-term use of the motion-sensitive cameras may enable an estimate of the bear population in and around Devils Canyon. Comparison of long-term sets of bear photographs from the study area may suggest which bears are frequent visitors to or residents of the canyon and which bears are only occasional visitors.

The photographs of the coatis at Bear Spring are interesting with respect to coati life-history and locomotion. Hoffmeister (1986) states that "mating is thought to take place in April and young are born in June" (p. 490). As described in the results, we obtained three photographs of small, young coatis, May 19, August 17, and August 19, 2008. Although the May 19 photograph (**Photo 23**) does not show much of the young coati, it is clearly much less than one year of age. It was certainly born before June, and likely closer to the beginning of May. An interesting feature of coati postures seen in these photographs is the stiff-horizontal-tail posture in several coati photographs (ex. **Photo 22**). Almost always when coatis are seen walking or foraging in Arizona or elsewhere in tropical forests in Central America, their tail is held vertically. When foraging in one spot and relaxed, the tail often hangs down touching the ground (McCLearn 1992). The stiff-horizontal-tail posture may be exhibited by solitary coatis, where the vertical tail may play no role in social communication and instead may present a liability, attracting the attention of predators. The camera has documented this interesting posture; however, we would like more information on the context in which the coati used the stiff-horizontal-tail posture (whether foraging in deep grass, whether other coatis may have been in the local area, etc.). These two examples, recording time of first appearance of coati young and the unusual horizontal tail posture, suggest that the cameras in the study area have the potential of providing new information on coatis and other mammals in Arizona. Bridges et al. (2004) used motion-sensitive cameras set up at black bear den entrances to record the date of first emergence of the cubs. The dates recorded with the cameras in Bridges' study were earlier than previously known for their region (western Virginia).

One unexpected observation of this study is the low number of images that were captured after dark. Only 28 out of 286 images (9.8%), with or without animals in the images, were recorded as infrared images after dark. Because many mammals are nocturnal, a higher proportion of nighttime images were expected. While the bobcat, deer, peccaries, and cottontails were recorded in daylight and at night, the bear and coati were only photographed during daylight, and the ringtail, mountain lion, gray fox, and skunk were only photographed at night. These patterns may likely shift as larger numbers of images of these animals become available. Another unexpected result of this study was the absence of images of mammals that are known to be or are likely to occur in Devils Canyon. For example, there are no images of raccoon (*Procyon lotor*), even though we have observed dead raccoons along the roadside at Top of the World (Pinal Ranch), about 8 km (5 miles)

northeast of Cameras 1 and 2. No rock squirrels (*Spermophilus variegatus*), cliff chipmunks (*Eutamias dorsalis*), or coyotes (*Canis latrans*) were photographed.

Another surprise result is that no human traffic, other than WestLand biologists, was recorded. Camera 2 and 3 are positioned towards wildlife trails near springs. The amount of brush in the areas near Cameras 2 and 3 would be difficult for people to push through. People are unlikely to go through these areas unless searching for something associated with the springs. However, Camera 1 is positioned near a large, open trail about 10 feet above the channel bed of Devils Canyon. This animal trail is used by people as well when there is flood water in Devils Canyon (during late winter and perhaps after heavy summer storms). Devils Canyon is a popular hiking area, but from April 25 to August 28, 2008, hikers apparently did not traverse this trail. WestLand biologists usually walk through this area by following the stream channel and not following the game trail where the camera is located. WestLand biologists met a group of five people in mid-summer of 2008 hiking along the Devils Canyon stream between Hackberry and Oak Canyons on their way to and from the Crater Tanks. They had entered and left the canyon bottom from a location near Hackberry Canyon, downstream from Camera 1.

The motion-sensitive cameras in Devils Canyon have provided evidence of the presence of particular mammal species in a given area at a particular time.

6. RECOMMENDATIONS

If this study were to be continued, we would suggest that:

- each camera be visited at least once every two months. The cameras have performed well but glitches have happened. Camera 1 had a memory card that did not work from August of 2008 until January of 2009. Camera 2 was pulled down by a coati and took no photographs during most of May and part of June of 2008. Camera 3 was pulled down by a coati and took no photographs between late September of 2008 and mid-February of 2009. [Even if the camera had not been pulled to the ground, the batteries were likely to be near 0% charge.] More frequent visits reduce the chance that a large period of time will go by without a camera functioning. Childs and Childs (2008) visited their motion-sensitive cameras on the United States-Mexican border once every six weeks,
- a spot within the camera's range of view be baited with commercially available lures[2] for predators, and
- descented rubber gloves and rubber boots be worn by the field biologists when handling the cameras. This precaution might reduce both the time to first trigger (detection) by an animal and the likelihood that the cameras would be reoriented or pulled down by visiting animals.

If individual animals can be recognized from different locations, it would provide valuable information on use and movement patterns within Devils Canyon. With more images, it is very likely that additional species and individuals would be recorded. During our visits in 2009, we remounted the cameras higher (about 2 to

[2] Examples of lures available on-line from Murray's Lures & Trapping Supplies (Walker, WV) include Pred-a-getter, Creek Walker, and Coon Pone; skunk-scented lure is available as Gusto®, Minnesota Trapline Products, Pennock Minnesota.

2.5 m) on the trunks of trees and aimed the cameras about 20 to 30 degrees below the horizontal. This downward orientation of the camera is likely to capture images of entire animals more so than when the cameras were low to the ground, is more likely to be triggered while most of the animal's body is still within the field of view, and, provided the field of view does not include moving branches, sedges, and grass, may be less susceptible to being triggered by plants moving in the wind. In setting up the cameras in February 2009, we used latex disposable gloves (but not descented rubber boots) while handling the cameras. A disadvantage of placing cameras in the Study Area where animals are likely to be photographed is the possibility that the cameras are discovered (and removed) by hikers in Devils Canyon.

7. REFERENCES CITED

American Ornithologists' Union (AOU). 2008. Check-list of North American Birds. Available at internet site: http://www.aou.org/checklist/north/. Accessed February 19. 2009.

Babb, R. D., D. E. Brown, and J. L. Childs. 2004. On the status of the opossum (*Didelphis virginiana*) in Arizona. Journal of the Arizona-Nevada Academy of Science 36(2): 120-126.

Bridges, A. S., J. A. Fox, C. Olfenbuttel, and M. R. Vaughan. 2004. American black bear denning behavior: observations and applications using remote photography. Wildlife Society Bulletin 32(1): 188-193.

Bull, E. L., R. S. Holthausen, and L. R. Bright. 1992. Comparison of 3 techniques to monitor marten. Wildlife Society Bulletin 20: 406-410.

Childs, J. L. 1998. Tracking the felids of the borderlands. Printing Corner Press, El Paso. 77 pp.

Childs, J. L., and A. M. Childs. 2007. Ambushed on the jaguar trail: hidden cameras on the Mexican border. Rio Nuevo Publishers, Tucson. 151 pp.

Cutler, T. L., and D. E. Swann. 1999. Using remote photography in wildlife ecology: a review. Wildlife Society Bulletin 27: 571-581.

Fenske-Crawford, T. J., and G. J. Niemi. 1997. Predation of artificial ground nests at two types of edges in a forest-dominated landscape. The Condor 99: 14-24.

Foster, M. L., and S. R. Humphrey. 1995. Use of highway underpasses by Florida panthers and other wildlife. Wildlife Society Bulletin 23: 95-100.

Gompper, M. E., R. W. Kays, J. C. Ray, S. D. Lapoint, D. A. Bogan, and J. R. Cryan. 2006. A comparison of noninvasive techniques to survey carnivore communities in northeastern North America. Wildlife Society Bulletin 34(4): 1142-1151.

Hernández, L., J. W. Laundré, and M. Gurung. 2005. The use of camera traps to measure predation risk in a puma-mule deer system. Wildlife Society Bulletin 33(1): 353-358.

Hoffmeister, D. F. 1986. Mammals of Arizona. University of Arizona Press and Arizona Game and Fish Department, Tucson. 602 pp.

Jacobson, H. A., J. C. Kroll, R. W. Browning, B. H. Koerth, and M. H. Conway. 1997. Infrared-triggered cameras for censusing white-tailed deer. Wildlife Society Bulletin 25(2): 547-556.

Mace, R. D., S. C. Minta, T. L. Manley, and K. E. Aune. 1994. Estimating grizzly bear population size using camera sightings. Wildlife Society Bulletin 22: 74-83.

Main, M. B, and L. W. Richardson. 2002. Response of wildlife to prescribed fire in southwest Florida pine flatwoods. Wildlife Society Bulletin 30(1): 213-221.

Martorello, D. A., T. H. Eason, and M. r. Pelton. 2001. A sighting technique using cameras to estimate population size of black bears. Wildlife Society Bulletin 29(2): 560-567.

McClearn, D. 1992. Locomotion, posture, and feeding behavior of kinkajous, coatis, and raccoons. Journal of Mammalogy 73(2): 245-261.

Reid, F. A. 2006. A Field Guide to Mammals of North America, Fourth Edition. Peterson Field Guide Series, Houghton Mifflin Company, New York. 579 pp.

Swann, D. E., C. C. Hass, D. C. Dalton, and S. A. Wolf. 2004. Infrared-triggered cameras for detecting wildlife: an evaluation and review. Wildlife Society Bulletin 32(2): 357-365.

Waddell, T. E., and D. E. Brown. 1984. Exploitation of two subpopulations of black bears in an isolated mountain range. Journal of Wildlife Management 48(3): 933-938.

WestLand Resources, Inc. December 2004. 2004 Bat Survey, Federal Parcel, Pinal County, Arizona. Prepared for Resolution Copper Company. Job 807.09. 11 pp.

Wilson, D. E. and D. M. Reeder (editors). 2005. Mammal Species of the World. A Taxonomic and Geographic Reference (3rd ed), Johns Hopkins University Press, 2,142 pp. Available at internet site: http://www.bucknell.edu/msw3/. Accessed February 19, 2009.

FIGURES

CONTEXT MAP

LEGEND

- Study Area
- Resolution Parcel Boundary
- State Trust Land

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Scale 1" = 1 MILE

Pinal County, Arizona
Mesa and Globe1:100,000 USGS Maps

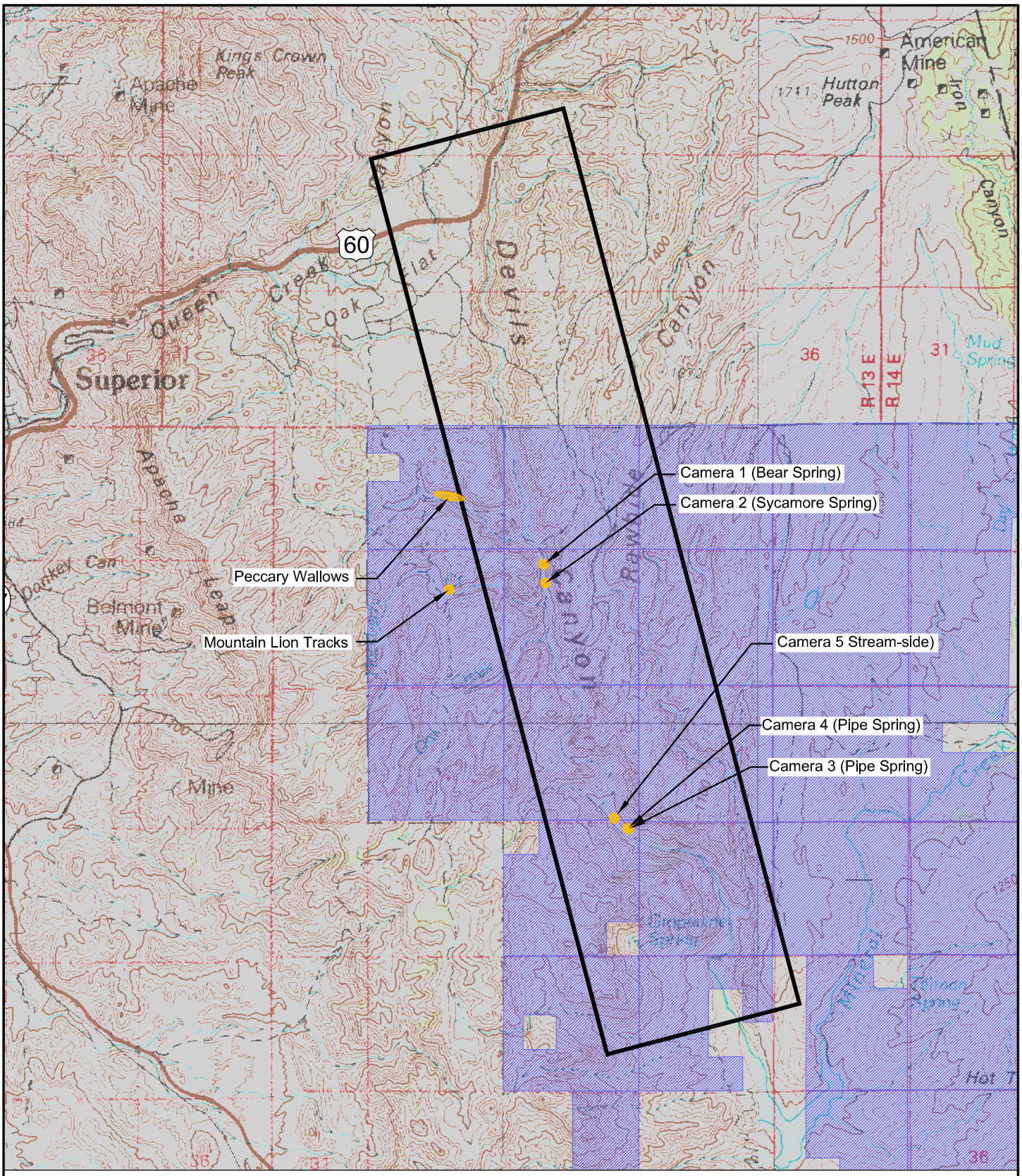
DEVILS CANYON
MOTION SENSITIVE CAMERA REPORT

Vicinity Map and Study Area

Figure 1

WestLand Resources Inc.
Engineering and Environmental Consultants
2343 E. Broadway Blvd. Suite 202
Tucson, Az 85719 (520) 206-9585

M:\projects\807.16\Devils Canyon Survey Transects\Motion Sensitive Camera\FIG1 VICINITY MAP & STUDY AREA.dwg



Pinal County, Arizona
Mesa and Globe1:100,000 USGS Maps

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Scale 1" = 1 MILE

LEGEND

Study Area

State Trust Land

RESOLUTION 2008
BASELINE BIOLOGICAL STUDIES
MOTION-SENSITIVE CAMERA SURVEY

Locations of the five motion sensitive cameras and evidence of mountain lion, black bear, and collared peccary

Figure 2

WestLand Resources Inc.
Engineering and Environmental Consultants
2343 E. Broadway Blvd. Suite 202
Tucson, Az 85719 (520) 206-9585

M:\projects\807.16\Devils Canyon Survey Transects\Motion Sensitive Camera\FIG1 VICINITY MAP & STUDY AREA.dwg

PHOTOSHEETS

Photo 9. (*D011*)

Photo 10. (*B0026*)

Photo 11. (*B0056*)

Photo 12. (*D007*)

Photo 13. (*A0003*)

Photo 14. (*C0014*)

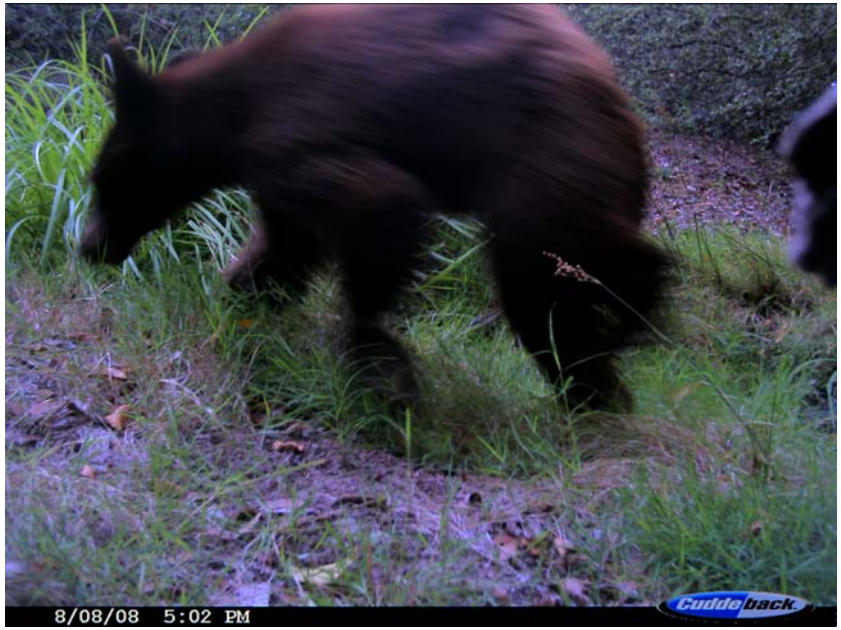

Photo 15 (*B055*)

Photo 16. (*E0036*)

Photo 17. (*E0048)*

Photo 18. (*A0033)*

Photo 19. (*A0037*)

Photo 20. (*A0038*)

Photo 21. (*B0013*)

Photo 22. (*B0043)*

Photo 23. (*A0076*)

Photo 24. (B0060)

Photo 25. (*B0061*)

Photo 26. (*D0017*)

Photo 27. (*E0049*)

Photo 28. (*E0050*)

Photo 29. (*E0045*)

Photo 30. (*E0054*)

Photo 31. (*D0004*)

Photo 32. (*E0024*)

Photo 33. (*D0018*)

Photo 34. (*D0002)*

Photo 35. (*A0014*)

Photo 36. (*B0004*)

Photo 37. (*B0047)*

Photo 38. (*B0053)*

Photo 39. (*C0017*)

Photo 40. (*D005)*

Photo 41. *D006*)

Photo 42. (*D0015*)

Photo 43. (*E0017*)

Photo 44. (*E0018*)

Photo 45. (*E004)*

Photo 46. (*E006*)

Photo 47. (*E0012)*

Photo 48. (*B0007*)

Photo 49. *B0009*)

Photo 50. (*B0023*)

Photo 51. (B0030)

Photo 52. (*B0058*)

Photo 53. (*B0006)*

Photo 54. (*B0039*)

Photo 55. (*D0002*)