Biological Inventory of the Río Aros, Sonora, Mexico—A River Unknown

By Chris O'Brien, Aaron D. Flesch, Eric Wallace, Michael Bogan, Samia E. Carrillo-Percástegui, Sky Jacobs, and Charles van Riper III

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Abstract

The largest tributary of the Rio Yaqui, the Rio Aros lies at a geographical intersection of subtropical and temperate regions in central Sonora, Mexico, and drains much of northeastern Sonora and western Chihuahua. Due to its rugged character and remote location, the flora and fauna of the Rio Aros region has not been well documented; however, it is habitat for jaguar and other species of concern, and is of increasing interest to conservationists and ecologists. To document the flora and fauna of this region and provide baseline information for future studies, we rafted the Rio Aros and upper Rio Yaqui tributaries, surveying for aquatic invertebrates, amphibians, reptiles, birds, and mammals in the summer of 2005. Our findings fill previous gaps in biogeographical data for several species; they document notable range extensions.

Introduction

The Río Yaqui basin is the largest watershed in northwestern Mexico, covering 79,162 km^2, or 30% of the land area of the state of Sonora (Revenga *et al.* 1998). This watershed delivers 70% of the surface flow for northwestern Mexico (Gallo-Reynoso *et al.* 2002) and is considered a conservation area of concern by the Mexican Government (Arriaga *et al.* 2000a, 2000b). The Río Yaqui drainage contains large tracts of roadless areas that have been little explored by naturalists; it serves as an important economic area for forestry, agriculture, ranching, and mining in northwestern Mexico (Bojorquez *et al.* 1985).

The Río Yaqui's largest tributary, the Río Aros, is a major river that drains much of northeastern Sonora and western Chihuahua, and is at the biogeographic confluence of both subtropical (Sinaloan) and temperate (Madrean, Sonoran, and Chihuahuan) flora and fauna. This region is extremely rugged, accessible only by foot, horseback, or boat, and harbors one of the largest unfragmented wild areas of foothills thornscrub in the state of Sonora (Lorenzana-Piña *et al.* 2004). It supports the largest known population of jaguars (*Panthera onca*) in northern Mexico (Brown and Lopez-González 2001), which in 2003 prompted the purchase of the 10,000-acre Los Pavos-Northern Jaguar Preserve to serve as a core area for their protection. This reserve, established by Naturalia and operated in cooperation with the Northern Jaguar Project and Defenders of Wildlife, has fostered increasing biological and conservation interest in the area.

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Recent surveys within the Yaqui basin have noted several species of birds that are at or near the northernmost edge of their range, including military macaw (*Ara militaris*), yellow-green vireo (*Vireo flavoviridis*), fan-tailed warbler (*Euthlypis lachrymose*), and yellow grosbeak (*Pheucticus chrysopeplus*) in isolated patches of tropical deciduous and tropical semideciduous forest and thornscrub (Russell and Monson 1998, Flesch 2008). On the Aros in our study area, tropical river otter (*Lontra longicaudis annectens*) (B. Brown, pers. comm.) and spotted box turtle (*Terrapene nelsoni*) (S. Carrillo-Percástegui, unpub. data; A. Flesch and S. Jacobs, unpub. data) have also been recently observed.

The Yaqui basin is also at the southern range boundary for temperate species such as bald eagle (*Haliaeetus leucocephalus*) (Brown and Warren 1985) and beaver (*Castor canadensis frondator*) (Gallo-Reynoso *et al.* 2002), and is at the southwestern limits of the ranges of lowland leopard frog (*Rana yavapaiensis*) (Platz and Frost 1984) and Chiricahua leopard frog (*R. chiricahuensis*) (Platz and Mecham 1979). Because of this biogeographic setting and a lack of basic biological information for the region, we predicted that biological surveys in the area would yield observations of species outside of their currently known geographic ranges. To test this prediction we conducted a baseline biological inventory along the Aros and upper Yaqui River corridor, as well as in select tributaries, in the summer of 2005.

Methods and Materials

We traversed the Río Aros and upper Yaqui from Nátora (700 m) to El Río (350 m) in inflatable boats during the 2005 monsoon period to ensure adequate flows for river travel (figs. 1, 2). We adopted an expeditionary approach using inflatable kayaks and oar-power rafts, and carried all supplies and equipment for the duration of the trip. Rafting logistics were coordinated by Caiman Expeditions (the late Lane Larson of Tucson, Arizona, who provided knowledge of the local area and rafting equipment). Local support in Sahuaripa provided transport to the launching point of Nátora, located 100 km to the east over unimproved roads. From Nátora, the Aros flows north through alternating steep rolling hills and narrow barrancas, passing around the Sierra los Pavos and joining the Río Bavispe to form the Río Yaqui. Below the confluence, the Yaqui flows south towards Presa El Novillo (fig. 2). We ended our trip at El Río.

For the duration of the study, floating surveys were conducted on an opportunistic basis, with occasional stops in areas of interest. We rafted during the day, traveling between 3 and7 km/hr and averaged 26 river km/day, stopping to camp at areas that afforded access to major tributary canyons that we surveyed the following morning (table 1). We selected tributaries for surveys based on their size and aspect because our primary objective was to document vegetation communities and associated fauna that were rare in the regional landscape or at the edges of their geographic ranges. Tributaries were surveyed for two to three hours, starting at dawn, and sometimes additionally for one to two and a half hours in the early evening. We hiked tributary canyons, surveying the plants, aquatic invertebrates, herpetofauna, birds, and large mammals using the following methods. Additionally, we visited a high-elevation site en route to Nátora (fig. 2).

Vegetation and Flora

We qualitatively described the flora of the study area, identifying many species of trees and shrubs while focusing on uncommon and rare species of distributional or conservation interest. We noted the distribution and approximate abundance of species of interest and identified plants with the use of botanical keys and specimen vouchers located at the University of Arizona Herbarium or

by using our knowledge of woody plants of the region. Many of our observations along the river corridor were from boats; binoculars allowed identification of many tree species growing on canyon walls or steep slopes. We occasionally landed a boat to collect plants of interest along the river, and when on the ground we focused our efforts in tributaries and near campsites. Because space was limited for the preservation and transportation of plant specimens, we only collected species of interest and often used digital photographs to aid in later identification.

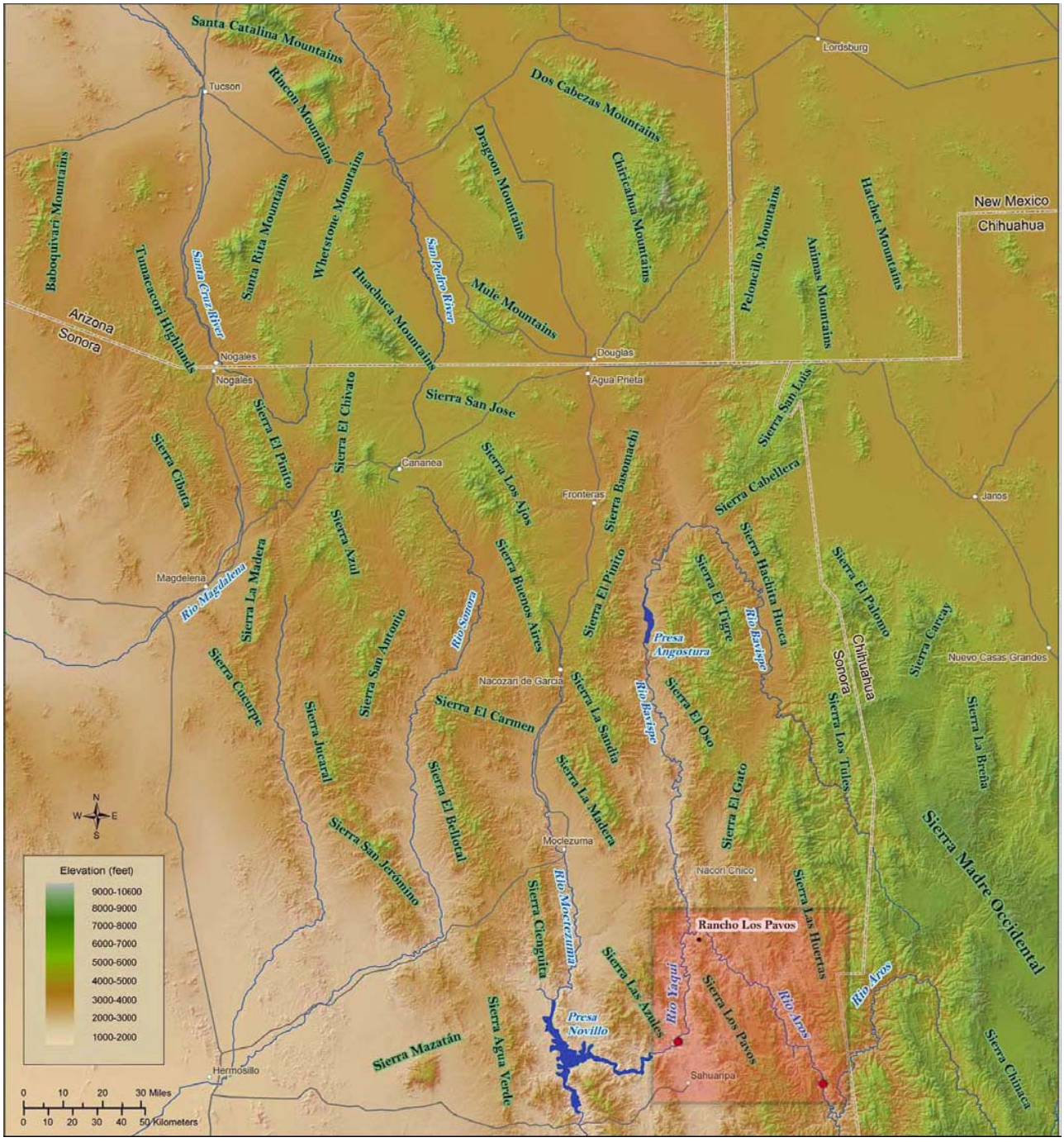

Figure 1. Area map showing southwestern U.S. and northwestern Mexico, with inset showing study area.

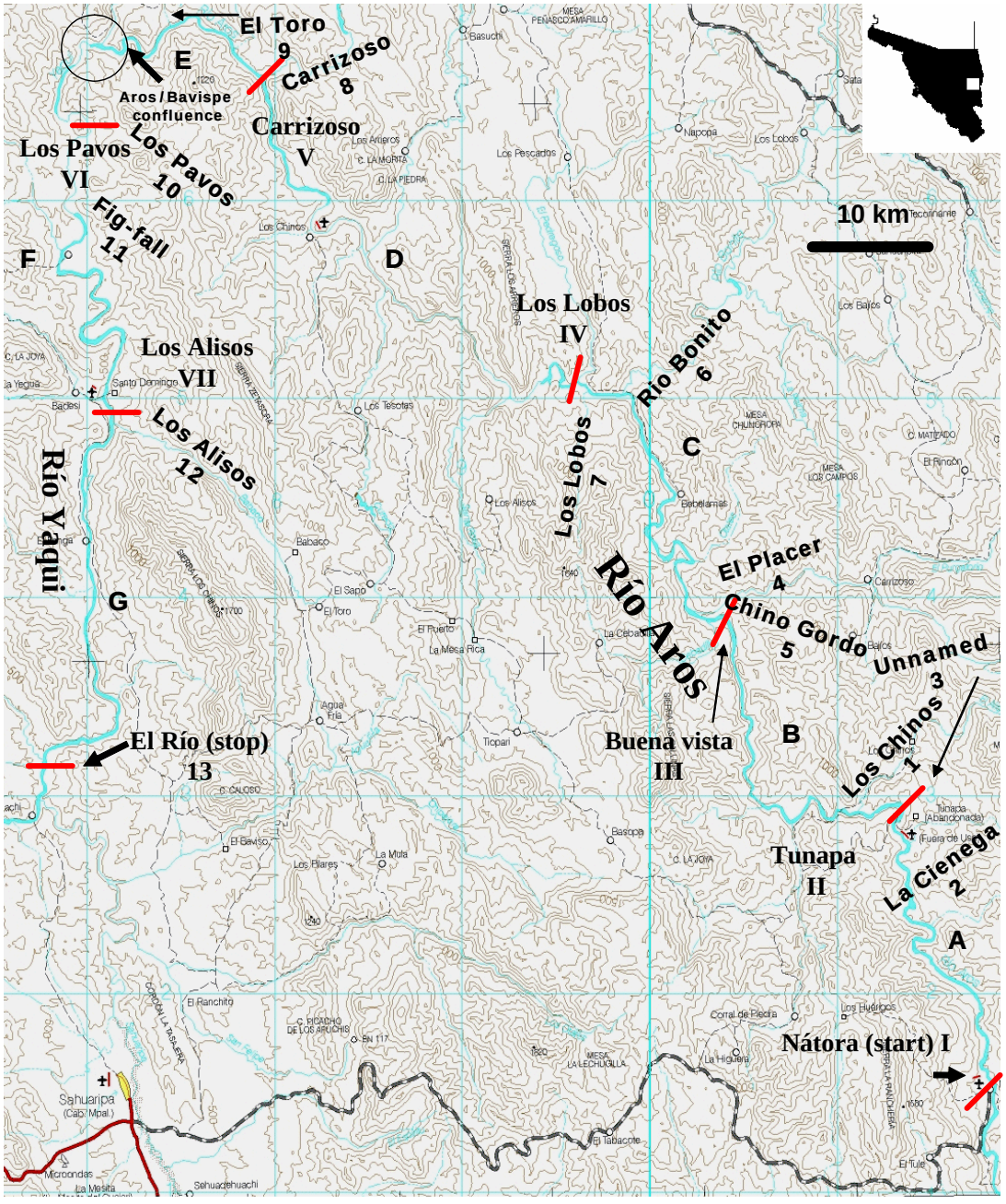

Figure 2. Map of the Río Aros canyon and upper Río Yaqui valley. River sections between red slashes (capsites) are labeled with capital letters, which take the name of the nearest surveyed tributary (see table 1). Surveyed tributaries are labeled by name and designated with numbers (see table 1).

Aquatic Invertebrates

We employed a variety of survey techniques to collect aquatic insects in the mainstem river and tributaries. We vigorously swept pools in flowing (fig. 3a) and non-flowing side canyons with a 1-mm mesh d-frame net (d-net) until we visually detected no new species. We sampled riffles in flowing side canyons by disturbing a $0.1m^2$ patch of substrate to a depth of 5 cm, and caught insects downstream with a 1-mm and/or a 325-µm mesh d-net. High flows and sediment loads made it impossible to take benthic kick samples in the mainstem (fig. 3b); so, instead, surface netting and drift samples were employed to collect specimens. We collected surface-dwelling and free-swimming insects from the upper 0.5 m of the water column in the main river via vigorous sweep netting with a 1-mm mesh d-net. Drift samples were collected between dusk and dawn as drift rates are elevated during this time (Williams and Hynes, 1976). We placed a 325-µm mesh d-net on the bottom substrate, ensuring that the upper portion of the net was submerged and held in this position for 10 minutes for each sampling event. High turbidity and large amounts of detritus prevented longer drift sampling times. All pool, benthic, and drift samples were preserved in 95% ethanol and transported to Oregon State University for identification.

Figure 3. Carrizoso Canyon, tributary (a). Mainstem Río Aros at Los Pavos camp (b).

Many aquatic insects have extended aerial stages as adults during the summer months, often a strategy to avoid flash floods (Lytle 2003). Therefore, we visually surveyed both the mainstem and tributary canyons during daylight hours, and employed blacklights after dark on the mainstem. We employed blacklights both by placing the light against a white sheet hung in riparian areas adjacent to the river and by placing a clear container filled with ethanol over a light at the river's edge; in all cases lights were deployed for 90 minutes. We preserved all insects in 70% ethanol and transported them to Oregon State University for identification (SEMERNAT Permiso #SGPA/DGVS/04147).

At most sites where aquatic insects were collected, we recorded water temperature, pH, and conductivity using a handheld multi-meter. We recorded sampling locations with a Garmin Etrex

Vista GPS unit. Flows in tributary canyons were visually estimated, and flows in the mainstem were visually estimated in relation to the known flow amount at the gauging station near Rancho Los Pavos (see table 2).

We used non-metric multidimensional scaling (NMS), to compare the community structure of different sites sampled within the Río Aros basin. NMS, an ordination technique, reduces redundancy in the data matrix, based on a rank-based metric to reduce community data from many dimensions to a two- or three-dimensional ordination and does not make distributional assumptions of the data matrix (McCune and Grace 2002). Environmental parameters were then overlain on the community composition-based ordination to elucidate relationships between measured parameters and community changes along the gradient. Sorensen distances were used to calculate community dissimilarity between samples and regions. Since collection techniques varied between samples, and therefore absolute numbers of individuals varied greatly between samples, abundance data were presence-absence transformed before any ordination analyses. We used Multi-response Permutation Procedure (MRPP) with Sorensen distances to quantify and test within-group agreement and distinctness (see Mielke and Berry 2001) between mainstem river and tributary canyon samples. This procedure yields two statistics, an A-statistic ($-1 \leq A \leq 1$), describing the effect-size of the grouping, and a p-value, which evaluates the likelihood that observed differences are due to chance. We performed all community analysis using the program PC-ORD (McCune and Mefford 1999).

Herpetofauna

We surveyed 14 localities for herpetofauna (table 4), focusing on major tributary canyons of the Ríos Aros and Yaqui, and made incidental observations adjacent to the rivers and at campsites. We concentrated our efforts on riparian and aquatic environments, as we expected a greater diversity of species to be found in these habitats. We also recorded observations of easily observed herpetofauna in the uplands en route to and from survey canyons.

We surveyed for aquatic and semi-aquatic herpetofauna using visual encounter surveys (VES), usually during daylight and often during early morning hours (Crump and Scott 1994). We approached aquatic environments silently to visually search and listen for active or escaping herpetofauna. We searched along the water's edge and used d-nets and flashlights to probe vegetation and undercut banks for hidden herpetofauna. Once a perimeter search was complete, we waded through pools to access undercut banks and boulder piles unapproachable from the perimeter. Following VES, we dipnetted runs, riffles, and pools for amphibian larvae and aquatic turtles or snakes. VES and dipnetting efforts were more intensive around perennial pools. Digital photographs were taken of most pools and aquatic environments. We also searched under cover objects (for example, logs, small boulders, debris piles) to detect species likely to be inactive during our surveys. Additionally, we listened for breeding vocalizations of frogs and toads.

Encountered herpetofauna were recorded based on visual observation if identification was certain, or captured to confirm positive identification. For target species captured, we recorded sex and pertinent morphological measurements (for instance, snout-vent length [SVL], color pattern descriptions). We documented locations of our observations of target species with hand-held GPS units and photographed captured individuals using digital cameras. Based on previous observations from the area (S. Carrillo, unpub. data), target species included ranid frogs (*Rana pipiens* complex, *R. tarahumarae*), indigo snakes (*Drymarchon corais*), and spotted box turtles (*Terrepene nelsoni*). Photographs provide a permanent record of our observations and will allow herpetologists familiar

with the species of the region to confirm questionable identifications (for example, leopard frogs). We accessioned photographs into the University of Arizona Herpetological Collections.

Birds

We used two approaches to examine the distribution and abundance of birds, one along the main river and another along its tributaries. While on or near the river we noted the presence of all bird species detected either aurally or visually and recorded the number of individuals, pairs, or dependent young for species that were less common. Due to the challenges of simultaneously navigating the river, surveying, and data recording, we only estimated the abundance of species of interest. Our knowledge of bird vocalizations facilitated identification of nearly all audible species. We surveyed eight major tributaries or side canyons for 1 to 5 km and recorded the numbers of individuals, pairs, flocks, and singing males of each species. We often mimicked a pygmy-owl call to increase detections (Marshall 1957). Along each river segment and tributary we noted evidence of breeding and recorded nest contents when possible. We noted the start and end points of each survey and estimated the length of river segments and tributary transects using 1:50,000-m scale topographic maps. We also described the structure and composition of vegetation at sites where we observed bird species of interest. To compare bird communities among or between river segments and tributary transects, we calculated species richness and frequency of occurrence (number detected/transects) of each species. To quantify and describe breeding and residency status, we used the criteria of the *Arizona Breeding Bird Atlas* (Corman and Wise-Gervais 2005), published information (Russell and Monson 1998), and our own knowledge and observations. All tributary surveys were completed within approximately five hours after sunrise or initiated within two hours of sunset. Surveys along the river corridor were conducted throughout the day.

Mammals

We employed four main techniques to document the mammal fauna of the Río Aros region: camera traps, mechanical live-traps, track and scat searches, and opportunistic sightings. We used a 35-mm camera trap (Deercam Inc.) to increase detection rates of secretive or nocturnal species. These cameras, which are triggered by a passive infrared sensor that detects heat and movement (Lynam 2002), were set opportunistically along trails where tracks and minimal cattle activity were detected. Our camera was left mounted to a tree trunk overnight and retrieved the following morning.

To sample terrestrial species of small mammals, we used 20 Sherman traps that were set overnight on a 400-m transect oriented along trails at the mouths of tributary canyons or along the Aros mainstem. Traps were baited with oatmeal and coarsely ground peanut butter. Animals captured were identified, photographed, and released. All traps were set in foothills thornscrub or broadleaf riparian forest.

We searched for tracks and scat opportunistically on beaches along the river corridor during midday stops and at evening camps. Additionally, tributary canyons (table 1) were systematically searched for evidence of large mammals. We especially focused on areas of soft wet sand and wet or dry mud, where tracks were more likely to be preserved. Easily identified tracks were recorded and a photo was taken when possible. Large felid tracks were traced on a piece of Plexiglas with a nonpermanent marker and then traced again on a plastic bag with a permanent marker to copy the exact track for future confirmation of identification. Measurements of tracks were taken following the protocol established by Childs (1998). We also identified scrapes that large cats make on trunks to sharpen their claws and mark their territories. Scats were identified based on appropriate

measurements, diet contents, shape, and association with distinctive tracks (Elbroch 2003). Large felid scats (jaguar and mountain lion) were collected and stored in a paper bag, documented with GPS location and observations, and deposited at the University of Arizona for DNA analysis as part of an ongoing master's thesis on large cats in the region (S. Carrillo-Percástegui, unpub. data). All smaller scats were left on site and documented with photographs and location.

Finally, while floating the river and during stops and tributary surveys, we opportunistically recorded all visual sightings of large mammals. When possible, photo vouchers were taken to confirm identification, and location and vegetation types were recorded.

Results and Discussion

Between 27 July and 4 August 2005 we traversed 184.8 km of the Ríos Aros and Yaqui, surveying river reaches, areas around campsites, and 26.5 km of tributaries. We camped at seven sites along the river and surveyed eleven tributaries of the Río Aros. Figure 1 provides a map of the region; the study area is shown in figure 2; and all survey sites are shown in table 1.

At the water levels we encountered of 56 to 114 m^3/s (1977-4025 $feet^3$/sec), the Aros is largely a class III river of moderate difficulty, requiring constant scouting and maneuvering. The river was easily negotiated at monsoon discharges, except for one class IV rapid above Carrizoso Canyon where the river cuts through a more resistant layer of limestone. The river level fluctuated daily as the result of large monsoon storms in local areas and far upstream. For example, on 30 July, between 06:30 and 10:00, flow in the mainstem increased such that the water level increased 1.2 m in vertical distance

Land use along the river consisted primarily of grazing, and we found evidence of cows in nearly all riverside camps and in many of the surveyed tributaries. Additionally, there were stock trails leading away from the river at important access points and at many of the larger tributary mouths. Several small human dwellings were observed that are likely used seasonally or intermittently. Results of our surveys by taxonomic group are outlined below.

Vegetation and Flora

The Aros and Yaqui Rivers flow through the lower western foothills of the Sierra Madre Occidental. Vegetation in this region is comprised of tropical-subtropical scrublands (Brown 1994)—specifically, foothills thornscrub that occurs east of the Sonoran Desert and at higher elevations within it (Felger *et al.* 2001).

Upland vegetation was dominated by foothills thornscrub; *Lysiloma microphyllum* and *L. watsonii*, *Bursera fagaroides, B. laxiflora*, *Ceiba acuminata, Jatropha cordata, Fouquieria macdougalii, Acacia cochliacantha, Ipomoea arborescens,* and *Stenocereus thurberi* were widespread and common. We observed palms (*Brahea brandegeei* and *Sabal uresana*) in scattered locations, often in small stands on slopes, and they were common in only a few canyons such as Los Alisos and El Carrizoso. Flowering *Hintonia latifolia* and *Parthenium tomentosum* were less common and were found scattered on slopes in thornscrub. Hecho cactus (*Pachycereus pecten-aboriginum*) was uncommon along most of the Aros corridor but locally common along the Yaqui, often on low slopes and flats near the river. Oaks were restricted to upper elevations, often on north-facing slopes along the upper Aros corridor. Small stands of *Quercus chihuahuensis* occurred on hillsides and in drainages along some tributaries often >1 km from the river. We observed *Q. tuberculata* mixed with thornscrub species in uplands and as a riparian species in the first 40 river km below Nátora above 680 m in elevation; *Q. tuberculata* was also a dominant riparian tree above

600 m in the north-facing Canyon Los Lobos (fig. 1). We observed many large areas of upland thornscrub, often >5 ha in size, on slopes near the bottom of the river canyon or on north-facing slopes where recent frosts had top-killed most vegetation (fig. 4). Most of these areas were in the first 60 river-km below Nátora, and none were observed along the Yaqui. In many cases, new branches and foliage of uniform height had resprouted from the base of the top-killed woody trees, most commonly *Acacia cochliacantha*; the new branches and foliage were approximately 1/6 to 1/3 the height of standing dead material. The relative short height of dead vegetation, which rarely exceeded approximately 5 m, suggested a recurring history of frost damage in these areas.

Figure 4. View from above Tunapa camp, looking WSW. Note top-killed vegetation (appearing brown) on slopes above the river in center-left of photo.

We observed associations of several species of riparian trees along the river. Narrow bands of broadleaf riparian woodland dominated by *Salix gooddingii* and *S. bonplandiana* were common on shallow sandy terraces. Other riparian woodlands, dominated by *Prosopis velutina*, *Havardia mexicana*, *Sapindus saponaria*, and *Vitex mollis,* occurred on sandy to rocky terraces that also often harbored *Celtis reticulata*, *Ceiba acuminata*, and *Lysiloma watsonii* above the high-water line; where steep slopes extended down to the river's edge these woodlands occupied narrow linear

bands one tree wide. We found no riparian vegetation in the rockiest and steepest areas. *Cephalanthus salicifolius* was fairly common along the river's edge, generally well below the high-water line, and had large flood-damaged trunks anchored to rock outcrops or depressions. *Guazuma ulimifolia* was common along the Yaqui and in some tributaries, but only at lower elevations at and below Los Alisos Canyon (fig. 1). *Sideroxylon persimile* was locally common in riparian vegetation in the upper portion of the Aros river corridor and was not found above 650 m. We first observed this broadleaf semideciduous tree approximately 12 river km below Tunapa and at only one location on the Yaqui just above the Sahuaripa bridge. The largest and tallest stands of *S. persimile* were in Canyon Los Lobos, where it reached heights of >15 m and dominated the canopy along with *Plantanus racemosa,* which was rare along the upper river corridor. *P. racemosa* was common only in Canyon Los Lobos; it was rare in Canyon El Placer and was seen from the river at the mouths of several smaller side canyons.

In addition to *S. persimile*, we observed only two other species of tropical broadleaf semideciduous trees: *Ficus pertusa* was found in moist situations, and *F. petiolaris* was common on rock walls and piles along the river corridor and in sheltered canyons. The uppermost occurrences of *F. pertusa* along the Aros consisted of several trees approximately 7-8 m tall in a deep, sheltered glen where the river dropped through a narrow canyon approximately 3 km below the mouth of Canyon Los Lobos at approximately 500 m elevation. We also observed *F. pertusa* at three locations along the Río Yaqui within 10 river-km of the confluence with the Río Aros; additionally, a small flood-scoured plant was found along a deep rocky canyon draining the Sierra Los Pavos, northeast of the confluence with the Aros. Aside from the mixed broadleaf-deciduous (such as *Platanus*) and broadleaf semideciduous (such as *S. persimile*) riparian vegetation in Canyon Los Lobos, we did not observe other riparian vegetation dominated by tropical semideciduous species.

We observed other species of interest, including several *Tabebuia impetiginosa* trees that were roughly 5 - 6 m tall in El Placer Canyon. *Bernardia cinerea*, a euphorbiaceous shrub or short tree with tomentose leaves was in flower and uncommon, occurring mainly in riparian areas below 500 m. Other plants we identified that are of interest include the woody shrubs *Sebastiania bilocularis*, *Karwinskia humboltliana*, *Zanthoxylum fagara*, *Croton sonore*, *Esenbeckia hartmanii*, *Tecoma stans*, *Guaiacum coulteri, Euphorbia colletioides*, and *Randia sonorensis*; vines such as *Funastrum clausum*; grasses such as *Lasiacis ruscifolia*; and the trees *Cordia sonore*, *Eysenhardtia orthocarpa*, *Alvaradoa amorphoides*, and *Jatropha cordata*. We did not observe other species more typical of tropical deciduous forest and more southern thornscrub, such as *Brongniartia alamosana*, *Bursera penicillata*, *Lonchocarpus hermannii*, or *Wimmeria mexicana*.

Conclusions

Much of the vegetation we observed was typical in both structure and composition to that found in the northern portion of the thornscrub. Many species more typical of tropical deciduous forest and southern thornscrub were absent (Brown 1994, Gentry 1982, Martin *et al.* 1998, Robichaux and Yetman 2000). Although the structure and composition of thornscrub along the Río Aros seemed similar to that further south compared to the surrounding landscape, thornscrub in the Aros Valley is somewhat isolated and connected to more extensive areas of thornscrub only by a narrow low-elevation corridor created by the river canyon. In fact, thornscrub in this area, which continues on up the river corridor as an ever-narrowing band of subtropical lowlands into neighboring Chihuahua, is at the north-easternmost extent of its distribution (Brown and Lowe 1980) and is nearly surrounded by Madrean oak, pine, and mixed conifer forest and grassland.

Although we observed several species associated with tropical deciduous forest or more southern thornscrub to the south—including *B. cinerea*, *S. persimile*, and *F. pertusa*—lower minimum temperature and lower precipitation likely limits the distribution of many species that are found to the south and west. Inversions of cold air during winter resulting from steep regional gradients in elevation may prevent other more tropical species from occupying lowlands. The Aros canyon is close to the highlands of the Sierra Madre Occidental of nearby Chihuahua that reach a maximum of 2,820 m elevation within 60 km of our study site and to mountains east of Bacadehuachi that reach 2,560 m elevation within 50 km. Just 10 km northeast of the Río Aros at Tunapa, the Mesa Cienega de San Jorge reaches an elevation of 1,920 m. As a result, freezing air from these highlands may occasionally penetrate some lowland canyons, thereby limiting the distribution of frost-sensitive tropical species. In the case of plant distribution, it is often the extreme, not mean, environmental conditions that are limiting, and even an occasional severe frost every few decades may have major impacts on plant distribution (Taylor 1934, MacArthur 1972). Our observations of large patches of frost-killed thornscrub suggest freezing events occur regularly, especially in the upper portion of the Aros corridor.

Frost is possibly more important than precipitation in limiting plant distribution and community structure along the Aros than it is to the south and west of our study area. For example, along the lower Río Bavispe to the west, where maximum elevations above the river canyon are lower and adjacent areas of highland much smaller, at least one canyon supports a large riparian gallery forest of the tropical semideciduous species *F. pertusa* and *F. petiolaris* at similar latitude and elevation as those we visited along the Aros (A. Flesch, unpub. data). Still further to the west in the neighboring Moctezuma Valley, where adjacent highlands are much lower and smaller, more diverse tropical riparian associations of *Ficus trigonata*, *F. pertusa*, *Sideroxylon persimile*, *Drypetes gentryi*, and *Xylosma flexuosum* occur in a wet canyon at approximately 700 m, again at similar latitudes to those we visited (A. Flesch, unpub. data). In comparison to these areas, riparian vegetation was never dominated by broadleaf semideciduous elements anywhere along the Aros, except to some degree in Canyon Los Lobos. Riparian areas with broadleaf semideciduous structure and physiognomy are characteristic of Sinaloan riparian evergreen forest (Minckley and Brown 1982a). These areas, especially when found north of 29° north latitude, are of great conservation interest, because they often harbor isolated and mesic refugia that support populations of many plant and animal species typically found far to the south.

As with other taxa, we observed plant species of distributional interest with nearest known localities that were far to the south. Species of note include *S. persimile* and *F. pertusa* that were approximately 100 km north of their known ranges (Felger *et al.* 2001); the latter species occurs still further to the north in canyons draining into the Río Bavispe near 29° 30” north latitude (A. Flesch, unpub. data). The nearest published locality for *Tabebuia impetiginosa* is also approximately 100 km south (Turner *et al.* 1995, Felger *et al.* 2001); this species has also been recorded further to the north in canyons draining into the Río Bavispe (A. Flesch, unpub. data). Observations of *Cephalanthus salicifolius* are among the most north-easternmost (Felger *et al.* 2001). This tree has a limited distribution in Sonora and is considered a variety of the more widespread *C. occidentalis* (T. van Devender pers. comm.). We are unsure of the significance of *Euphorbia colletioides*, *Funastrum clausum*, and *Bernardia cinerea* in the region.

Time available to study the flora was limited due to expedition time constraints and the complexity of river and overland navigation. Despite these challenges we gained a firm overview of the floristic composition and distribution of vegetation communities in a remote region that has not been previously described.

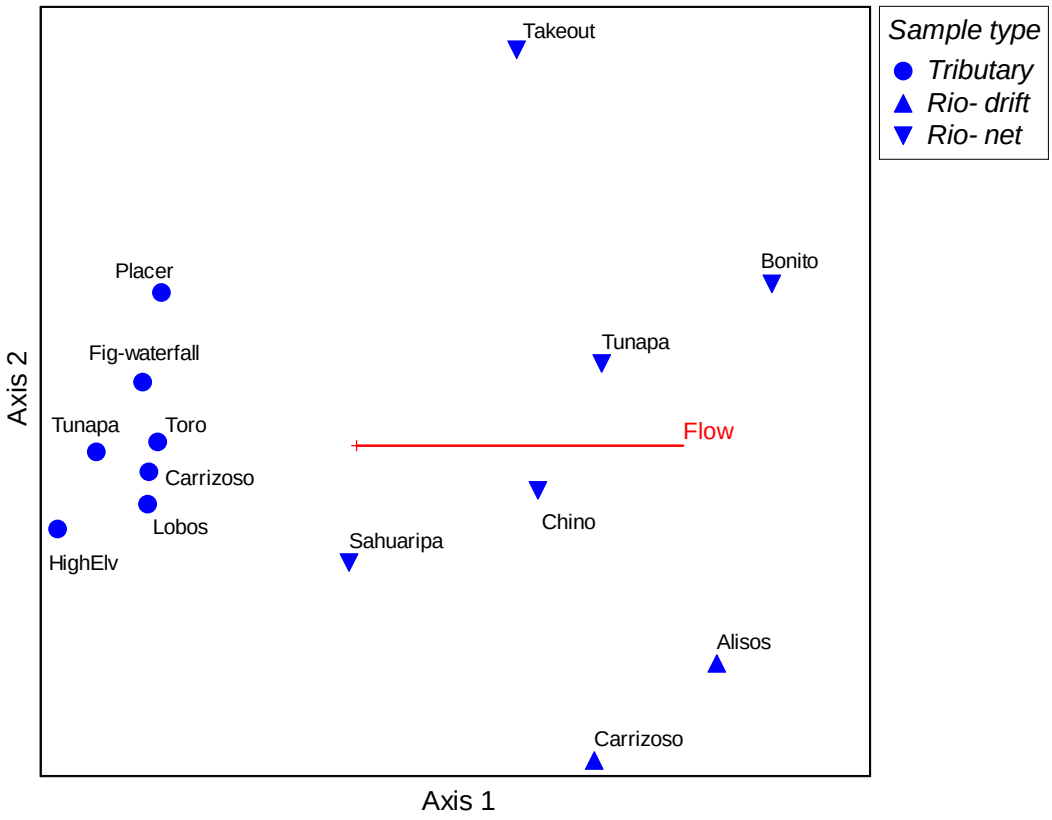

Figure 5. NMS ordination graph of tributary and mainstem samples, with significantly associated physical characteristics overlain.

Aquatic Invertebrates

We detected at least 102 aquatic insect taxa from the Ríos Aros and Yaqui and tributaries during our surveys (table 3), representing 8 orders and 42 families. The vast majority of taxa we collected were aquatic beetles (Coleoptera) and true bugs (Hemiptera). Species richness at individual collection sites varied from 2 species (Río Aros at Río Bonito) to 47 species (Carrizoso Canyon). We observed an average of 17 species per site. Side canyon tributaries supported 93% of all species we detected (95 species). In contrast, the mainstem river supported only 19 species. Seven of the mainstem species, found in slower edgewaters and eddies or in drift, were exclusive to the mainstem and not observed in tributaries.

Community composition varied significantly by habitat type. NMS ordination of the community samples converged on a stable and significant solution (stress = 15.5; final instability = 0.001; p = 0.0099) illustrating that tributary and mainstem environments supported different communities with no overlap in ordination space (fig. 5, A=0.15; p=0.0001 for MRPP analyses). Community composition in tributaries varied little among sites, especially when compared to variation between mainstem and tributary samples. When physical environmental characteristics (temperature, pH, and conductivity) were overlain on the NMS ordination, only flow characteristics described community composition (Axis 1; r=0.95). Clearly, the disparity between tributary flows (0-3 cfs) and mainstem flows (1000-3500cfs) was very large, so the very strong association

between flow and community composition is not surprising. The range of temperature (20-29ºC), pH (7.25-8), and conductivity (60-590 µS) may not have been large enough to detect a significant effect on community composition. Alternatively, a lack of data from some sites (table 2) may have made it difficult to detect the effects of these parameters on community composition.

We collected six aquatic insect species in drift samples, but in extremely low numbers. Flow dynamics in the mainstem likely contributed to the very low numbers of individuals in the drift. Unfortunately, all mainstem drift samples were collected after a large increase in flow, so the drift densities were likely diluted by increased flow. In the Río Aros, only several individuals of three taxa were collected (riffle beetles, Elmidae; midges, Chironomidae; net-spinning caddisflies, Hydropsychidae). The drift collection site on the Río Yaqui yielded four taxa (blackflies, Simuliidae; mayflies, Leptophlebiidae; moths, Pyralidae; net-spinning caddisflies, Hydropsychidae) and higher overall densities than sites on the Aros. The Río Yaqui was much less turbid than the Aros and appeared to have not been as affected by the increased flows given its wider channel, perhaps explaining the higher drift rates in the Yaqui. Only one tributary, El Placer, had sufficient flow to collect drift and kick samples; despite five replicate samples, not one individual insect was collected. This tributary is likely normally dry, and recent rainfall had increased flow at the site, resulting in the lack of sufficient time for the recolonization of newly-wetted habitats.

Light-trapping on three different nights yielded numerous terrestrial and three aquatic insect species. The giant water bug (*Abedus vicinus sonorensis*) was collected at lights on two nights. This collection is significant because nearly all *Abedus* species are flightless, and examples of *A. v. sonorensis* flying to light are rare in the literature. Adults of the dobsonfly *Corydalus* were abundant at light traps (fig. 6a). *Corydalus* larvae (fig. 6b) were also present in large numbers in the riparian areas immediately adjacent to mainstem; the larvae of this genus are normally completely aquatic, but high humidity and fluctuating river levels may have led to larval individuals foraging out of the water as well. On the lower Río Aros and on the Río Yaqui, large numbers of the leptophlebiid mayfly *Traverella* were collected at lights. Incredible numbers of *Traverella* individuals emerged from the mainstem Ríos Aros and Yaqui at both dawn and dusk; subimago males were abundant adjacent to the rivers, while mature adults were present in large swarms of thousands of flying individuals and also congregated on mesquite trees at the rivers' edges.

Figure 6. Dobsonfly (Corydalidae: *Corydalus*) adult (a) and larva (b) from the Río Aros.

The aquatic insect fauna of the Río Aros and its tributaries is very similar to that of streams in the Madrean Sky Islands (MSI) to the north and west of the Aros basin. Nearly 87% of the species collected in the Aros basin are also present in MSI streams (for description of MSI stream fauna see Bogan 2005). Of the 13% of species that did not overlap, many are species with more subtropical distributions (such as *Rhantus calidus*, *Buenoa thomasi*, *Abedus breviceps*). In Sonora, these species have typically been found in lower latitude streams, such as the Río Cuchujaqui in southern Sonora (M. Bogan, unpub. data). Thus, the Río Aros represents a northern and upper elevation outpost in the distributions of many subtropical aquatic insect taxa.

This study produced range extensions for several aquatic insect species. The dytiscid beetle *Macrovatellus mexicana* has been observed in isolated ranges southwest of the Aros basin (Bogan 2005: Sierra Aguaje near Guaymas, Sonora) and from the east of the Sierra Madre Occidental (Jasper and Challet, 2004), but not in between. Collections at Carrizoso and Lobos Canyons act to fill a large gap in the distribution of this beetle. The backswimmer bug *Martarega mexicana* was historically known only from central Mexico southward. In the 1960s it was first collected in the Salt-Gila River Basin of Arizona (Truxal and Menke 1966), leaving a distributional gap of nearly 1,500 km. In 2004 this species was found in the Cajon Bonito, an extreme northern tributary of the Río Yaqui (Bogan 2005), and that collection, together with its presence in the Río Aros and Río Yaqui, indicates that the distribution of this species is not as disjunct as previously thought. Instead, more surveys are needed to fully understand the distribution of *M. mexicana* between these two distributional extremes. Two other species of backswimmers collected in the Río Aros, *Buenoa albida* and *B. thomasi*, represent northern extensions of their previously known ranges. The previous northernmost collections of these species were from the Río Mayo in southern Sonora (Truxal 1953).

Conclusions

The Río Aros and its tributaries support diverse aquatic insect communities. Community structure varied dramatically between the mainstem river and tributary canyons. Tributary canyons supported most of the diversity during our summer sampling period. This pattern is likely due to the relative flow stability of tributary canyons during the monsoon season and the relative ease of sampling these habitats thoroughly. However, the tributary aquatic insect diversity recorded in this study is likely a modest estimate. At many tributary sites we sampled for as little as 30 minutes due to time constraints and were still detecting new species when we departed. With increased sampling time we would surely have detected many more species. Aquatic insect diversities from the mainstem habitats are certainly dramatic underestimates, because, while monsoon discharge in the Río Aros is conducive to boating, these flows make aquatic insect sampling difficult. There is likely a relatively diverse benthic fauna in the mainstem that was undetected during our survey due to the high, fluctuating flows and very high turbidity. Future studies in the Río Aros basin should focus on more time-intensive benthic surveys of tributary habitats, and winter, spring, or fall surveys would allow better assessment of river-dwelling species. The position of the Río Aros as a transitional basin between the Madrean Sky Islands and the subtropical portion of the Sierra Madre Occidental is clear from the aquatic insect communities present in the basin. This transitional location, combined with the additional aquatic insect diversity yet to be described in the basin, make the Río Aros basin an important area for future surveys, exploration, and conservation.

Herpetofauna

Amphibians

We observed eight species of amphibians, including one salamander (*Ambystoma rosaceum*) that was seen on the access road between Sahuaripa and Nátora, and seven species of frogs and toads representing five families (table 5). We recorded three species of true toads (Bufonidae), two species of true frogs (Ranidae) and one species each of narrow-mouthed toads (Microhylidae) and treefrogs (Hylidae).

Tarahumara salamander (*Ambystoma rosaceum*) larvae were found in a plunge pool at the high elevation site in Madrean evergreen woodland vegetation (fig. 1, table 4), approximately 10 km SW of the Río Aros. Mazatlán toads (*Bufo mazatlanensis*) were found in the upper reaches of the study area at Nátora, Tunapa, and Buena Vista; they were active and abundant around campsites, likely due to the warm, humid conditions. Sonoran desert and red spotted toads (*B. alvarius, B. punctatus*) were each found at three sites in low numbers. We encountered small *Bufo* tadpoles at several sites but positive identification at this life stage is very difficult, so these were not included in table 4.

Leopard frogs (*Rana* cf. *yavapaiensis*) were by far the most common amphibian encountered (n=6 sites, table 4). We heard what seemed to be a leopard frog vocalizing in Chino Gordo at the only deep plunge pool in the canyon, yet further intensive VES and dipnetting failed to confirm presence. We observed leopard frogs most often in low numbers ($n \leq 3$) in and around perennial pools. Most individuals encountered were juveniles. Leopard frogs were found to be relatively abundant at Los Lobos, where we observed individuals of all life stages except eggs (tadpoles, juveniles, and adults). We captured four large, robust adults at the only large perennial pool surveyed in the canyon. Females (n=3) measured 72-74 mm SVL and the male measured 61.5 mm SVL. We captured one juvenile Tarahumara frog (*R. tarahumarae*) in La Ciénega in a small cobble and boulder stream. Most ranids captured had light infestations of trombiculid mites (*Hannemania* spp.) on the posterior thigh and ventral surfaces.

We recorded the diminutive and highly secretive Sinaloan narrow-mouthed toad (*Gastrophryne olivacea mazatlanensis*) at La Ciénega and Carrizoso. The former observation was a gravid female (34 mm SVL) in a moist, cobbled wash with no standing water and the latter was a single tadpole from a long, muddy pool lined with dense common reed (*Phragmites communis*). We encountered tadpoles and adults of canyon treefrogs (*Hyla arenicolor*) in four rocky canyon sites and heard one individual calling at Carrizoso (table 4).

Noteworthy amphibian observations include those of leopard frogs (*Rana* cf. *yavapaiensis*), and Tarahumara frog (*R. tarahumarae*). We tentatively assigned leopard frogs encountered to *R. yavapaiensis*, a conservative approach because leopard frogs are notoriously morphologically conserved, making field identification of closely related species difficult. The Northwest Mexico leopard frog (*R. magnaocularis*) is sister species to *R. yavapaiensis* (Hillis and Wilcox 2005) and little definitive morphological data exists with which to distinguish these two species in the field (Frost and Bagnara 1976, Platz and Frost 1984). The extent to which lowland leopard frogs range south into Mexico is unknown (Platz and Frost 1984), and the northern extent of the Northwest Mexico leopard frog (*R. magnaocularis*) is also little known (Frost and Bagnara 1976). Both species are found in similar aquatic environments from near sea level to 1500 m.

The northernmost published record for Northwest Mexico leopard frog is ~40 km south of our study area, although this species assignment is based on one individual and a morphological characteristic (incompleteness of supralabial stripe) that is common to both species (Lemos-Espinal

et al. 2004b). Based on our experience with *R. yavapaiensis* and published accounts of Northwest Mexico leopard frogs, we could find no obvious deviations from typical *R. yavapaiensis* from Arizona and, therefore, tentatively assigned our observations to the latter species. Considerable work needs to be done to better delineate these two species' range and their potential zone of sympatry, and also to develop diagnostic field characters for field identification.

Leopard frogs, including *R. yavapaiensis,* have suffered precipitous declines throughout the southwestern United States (Clarkson and Rorabaugh 1989). The extent to which these declines may be occurring in northwestern Mexico are unknown primarily due to a lack of baseline distributional data on leopard frogs and the general inaccessibility of this region. Most recently, a newly described pathogenic chytrid fungus implicated in declines of amphibians worldwide, including pristine wilderness areas, has been identified in leopard frogs in Arizona (Bradley *et al.* 2002). Leopard frogs were relatively common in our area and are known to be so on the Los Pavos Northern Jaguar Preserve (P. Warshall pers. comm.) suggesting that populations in the area are widespread. Certainly, more extensive (such as inventory) and intensive (such as chytrid sampling) work needs be done in order to provide a baseline of species presence and their distribution, abundance, and population status in order to develop conservation and management strategies for leopard frogs in the region.

Tarahumara frogs are relatively well documented from the sierras of northeastern Sonora and were considered to be experiencing population declines in parts of this region during the 1980s and 1990s (Hale *et al.* 1998). We observed only one juvenile frog in La Ciénega Canyon, suggesting that it was a dispersing individual from a population higher in the drainage. The area surveyed in La Cienega contained very few rocky plunge-pools, which are considered habitat for Tarahumara frogs (Stebbins 2003). Based on our observation, we believe other populations may exist in the basin, which could be important when considering the conservation status of this species.

Reptiles

We observed 12 species of reptiles representing 7 families, including 3 species of turtles, 7 species of lizards, and 3 species of snakes. Turtles represented 2 families (Emydidae, Kinosternidae); lizards, four families (Helodermatidae, Phrynosomatidae, Scincidae, Teidae); and snakes, one family (Colubridae) (table 5).

We found one slider shell (*Trachemys scripta* subspp.), a largely riverine taxa, on the beach at Buena Vista and made several observations of basking individuals as we floated the river. There is only one slider native to the Yaqui River basin (*Tracheymys scripta yaquia*) (Ernst and Barbour 1989) but there have been reports of an introduced subspecies (*Tracheymys scripta* subspp.) in the basin (C. Schwalbe pers. comm.). Despite the remote nature of our study area, we would be remiss to assign our observation to a particular subspecies based solely on a weather-beaten shell and visual observations made from a distance. The most commonly encountered turtle was the Sonoran mud turtle (*Kinosternon sonoriense*); we observed both adults and young-of-the-year hatchlings. We recorded mud turtles from five localities, four of which were rocky canyons, their typical aquatic habitat (table 4).

We observed spotted box turtles, a terrestrial species of interest, at Buena Vista camp and in Los Lobos canyon. Based on plastron shape and length of tail (Ernst and Barbour 1989), the Buena Vista individual found in a dry arroyo with foothills thornscrub appeared to be a female. The Los Lobos individual was also found in a dry arroyo in foothills thornscrub just above a perennial

reach. This individual had a crimson stained beak, suggesting it had been eating organ-pipe cactus fruit in the area.

Tree lizards (*Urosaurus ornatus*) and Clark's spiny lizards (*Sceloporus clarkii*) were common arboreal species found throughout the study area and were often observed on trees and rocks around camp and in tributary canyons. Whiptails (*Aspidoscelis* spp.) were the most abundant surface-dwelling species encountered, although none were captured and no positive identifications to species were made. We observed one Great Plains skink (*Eumeces obsoletus*) at the gauging station below Buena Vista. No photos were taken before this skink escaped into a deep rock crack above the river. A Gila monster (*Heloderma suspectum*) was found dead on the road between El Río and Sahauripa at the conclusion of our trip.

In general, we encountered few snakes during our surveys. One neonate black-headed garter snake (*Thamnophis cyrtopsis*) was found at La Cienega, but, surprisingly, was not found at any of the other aquatic sites surveyed. We observed the semi-fossorial Yaqui black-headed snake (*Tantilla yaquia*) in the uplands above Los Pavos camp. This was a fortuitous observation as this species is rarely active on the surface during daylight hours.

Indigo snakes (*Drymarchon corais*), another target species, were the most abundant snake encountered. We observed five individuals at two sites (including one corpse) and obtained photographic vouchers of two individuals. All observations of this snake were made in or near dense riparian strand vegetation (Minckley and Brown 1982b).

Conclusions

Amphibians and reptiles of the lower Río Aros and its tributaries have been little studied, and few records exist for the region. In contrast, extensive herpetological surveys in Sonora have occurred south of our study area in the vicinity of Alamos (Bogert and Oliver 1945, Heringhi 1969, Schwalbe and Lowe 2003) and Yécora, Sonora (Van Devender and Ferguson 2003, Lemos-Espinal *et al.* 2004b, Smith *et al.* 2005a, Smith *et al.* 2005b). Surveys to the west of our study area include those by Langebartel and Smith (1954), Smith *et al.* (2005a), and Smith *et al.* (2005b). Based on University of Arizona Herpetological Collections, considerable effort has been conducted to the north as well. Additionally, the western region of Chihuahua, bordering our study area to the east, has received much attention in the last 50 years (Van Devender and Lowe 1977, Tanner 1985, Tanner 1987, Tanner 1989, Lemos-Espinal *et al.* 2004a, Smith *et al.* 2005a, Smith *et al.* 2005b). These surveys were generally focused on the Madrean evergreen woodlands that occur at higher elevations than our study area.

Our observations of spotted box turtles at two sites along the river, and previous observations from the Los Pavos Northern Jaguar Preserve (S. Carrillo Percástegui, unpub. data) and in the El Riito drainage approximately 10 km east of Nacori Chico (A. Flesch and S. Jacobs, unpub. data), extends their known range in Mexico by approximately 90 km east-northeast of the nearest known locality (Myers 1945, G. Ferguson pers. comm.). Little is known of the life history of spotted box turtles (Dodd 2001); the closely related ornate box turtle (*Terrepene ornata luteola*) in Arizona is primarily active during the monsoon season and detectability can be relatively high during this period in appropriate habitat. Based on our observations, it is likely that spotted box turtles follow a similar monsoon-active pattern. Our study area centered on the Los Pavos Northern Jaguar Preserve could provide an ideal conservation area in which to more closely study the life history of spotted box turtles near the northern extent of their range.

Indigo snake observations on the expedition extend the known range of this species in Sonora by approximately 70 km east-northeast of the nearest known record (below Presa Novillo,

C. Schwalbe pers. comm.). Indigo snakes were certainly abundant in our study area and likely occur further north of the study area.

Our herpetological inventory was successful in that we were able to extend the known range of two species and to fill distributional gaps for other species. However, this work does not constitute a complete inventory of the region. There is much work that remains to be done in the Río Aros region, and future work in the study area will undoubtedly yield many more distributional records and natural history observations of the diverse herpetofauna of east-central Sonora.

Birds

Effort and Species Richness

We surveyed a total of 184.8 km of river corridor along 7 reaches that averaged 26.4 km in length, and surveyed a total of 22.5 km along 8 tributaries that averaged 2.8 km in length (table 1). We detected 80 species of birds, 71 along the river and 61 along tributaries (table 6). On average, we detected 23% more species along the river corridor (38.3 ± 3.2 species/segment/day) than along tributaries (29.6 ± 3.0 species/transect). We observed 19 species along the river corridor that were not observed along tributaries, and only 6 were associated with open water. Cliff Swallow, Happy Wren, Yellow Warbler, and Brown-headed Cowbird (scientific names in table 6) were detected only along the river corridor and song sparrows were conspicuously absent. We detected 9 species along tributaries that were not detected along the river corridor, including Montezuma Quail, Elegant Trogon, Sulphur-bellied Flycatcher, and Rose-throated Becard. We also detected 14 species that were not observed along the river or its tributaries on the road between Sahuaripa and Nátora on 27 July 2005; 10 were associated with oak or oak-pine woodland and 4 with grassland or shrubland communities not found along the river corridor (table 7).

Breeding and Residency Status

We confirmed breeding of 16 species, which included observations of occupied nests of 8 species, dependent young of 7 species, and nest building of one species (table 8). We obtained evidence of probable breeding of 20 species and possible breeding of 34 species. We considered Great Egret, Mallard, and Green Kingfisher as non-breeders because they were not observed in breeding habitat. We are unsure of the breeding status of Common Merganser, Phainopepla, and Black-headed Grosbeak, and did not consider them possible nesters. Warbling Vireo, Western Tanager, and Painted Bunting were migrants that likely winter elsewhere, whereas Spotted Sandpipers were migrants that may winter in the study area. We considered Lucy's Warblers as migrants, although we expect they commonly breed in riparian areas until early summer.

Frequency of Occurrence

Frequency of occurrence across each river segment and tributary varied among species (table 8). Most species occurred at relatively few locations with 51% detected at ≤33% of river segments or transects and 30% detected at ≤13%. The most common species we observed included Canyon Wren and Northern Cardinal, which were detected along all river segments and tributaries, and Sinaloa Wren, Yellow-breasted Chat, and Five-striped Sparrow, which were detected along 93% (14 of 15) of river segments. Species that were least frequently detected (one observation each) included Gray Hawk, Peregrine Falcon, Western Wood-Pewee, Common Yellowthroat, and Painted Bunting.

Frequency of occurrence for many species varied between river segments and tributaries. Black-vented Oriole and Curve-billed Thrasher were ≥2.5 times more abundant along tributaries than along the river corridor, whereas frequency of Common Black-Hawk, Tropical Kingbird, and Northern Mockingbird were ≥4 times higher along the river corridor. Yellow-billed Cuckoo, Dusky-capped Flycatcher, Rufous-capped Warbler, and Streak-backed and Hooded Orioles were equally abundant along the river and in tributaries (table 8).

Notable Observations

We observed 12 singing Yellow-green Vireos; 8 were located on slopes between 630 and 670 m along an approximately 1 km stretch of river corridor 10-river km below Nátora and 4, including a pair, were in riparian vegetation in Canyon Los Lobos. Yellow-green Vireos along the river were in thornscrub that had well-defined shrub, sub-canopy, and canopy layers dominated by mauto (*Lysiloma microphyllum*), and large emergent kapok (*Ceiba acuminata*) up to 10 m tall. In Canyon Los Lobos, habitat was dominated by dense associations of Mexican ebony (*Havardia mexicana*), mauto, bebelama (*Siderloxylon occidentale*), netleaf hackberry (*Celtis reticulata*), Mexican jumping bean (*Sebastiania bilocularis*), and soapberry (*Sapindus saponaria*).

We flushed five Military Macaws from a large limestone cliff above the river approximately seven river-km below Los Chinos and observed two flying down Los Pavos Canyon. Common Black-Hawks were common along the uppermost 160 km of the river corridor, where we detected an average of 1 occupied site per 4 km of river. We also observed Common Black-Hawks along two tributaries, both of which had flowing water. In total we detected Common Black-Hawks at 42 localities, 10 where they were paired and 8 where they were with dependent young. We observed Black-vented Orioles at 4 localities in riparian vegetation that always included palms (*Sabal uresana* or *Brahea brandegeei*). We heard a single singing Happy Wren along the Aros at the mouth of Arroyo Bonito and on the Yaqui near Batui in very dense riparian thickets near the river. Rufous-capped Warblers were locally common in rocky canyons with a combination of thornscrub and riparian vegetation and were also detected in thornscrub on slopes along the river corridor. We flushed an adult Bald Eagle from a hillside at the mouth of Arroyo Bonito and observed a vocalizing pair of Peregrine Falcons above the river near the mouth of Los Pavos Canyon. We observed a female Painted Bunting on 28 July approximately 5 river-km below Nátora. We flushed a pair of Montezuma Quail attending at least three young ≤1 to 3 days old at 760 m approximately 2 km north-northeast of Tunapa. We detected these Montezuma Quail near an arroyo in an open association of thornscrub and mesquite (*Prosopis velutina*) that included scattered low shrubs, bunchgrasses, and forbs; only four Chihuahua oaks (*Quercus chihuahuensis*) were present nearby, otherwise the closest oaks were located >800 m away on north-facing hillsides.

Conclusions

High detectability of birds relative to other taxa enabled us to obtain many observations along the river corridor and in selected tributaries. Although our effort was limited to only eight days, conditions along the river were often calm with high visibility, which enabled us to identify most of the species we encountered and to investigate further those of interest. Previous surveys of birds along the portions of the Ríos Aros and Yaqui that we visited are limited to surveys by Bryan Brown who, along with his associates, made several trips by canoe, often during winter and spring, between 1981 and 1991 primarily to survey bald eagles (Brown and Warren 1985, Brown 1988, Russell and Monson 1998). Other surveys of birds on the Ríos Yaqui and Bavispe region were completed in the 1990s and 2000s (Flesch 2008; A. Flesch, unpub. data; R. Mesta, pers. comm.).

Given limited accessibility, rarity of summer surveys, and our focus on species of conservation and distributional interest, our efforts produced important information in an area where little data were previously available. For example, we observed 47 species that have not been documented previously along and immediately adjacent to the Río Aros (van Rossem 1945, Russell and Monson 1998); we considered two of these species abundant, 18 common, 12 uncommon, and 15 rare.

Many species we detected are typical summer residents in foothills thornscrub or broadleaf-riparian vegetation; yet others are usually associated with more tropical environments to the south (Howell and Webb 1995, Russell and Monson 1998) and were therefore often found only locally. Yellow-green Vireos, although rare, were detected in two locations, one where thornscrub structure was tall, vertically stratified, and approached structure similar to that of tropical forest, and another location where riparian vegetation was dense and floristically diverse in the middle and lower stories. Although we expect that Yellow-green Vireos occur locally further to the north in canyons east of Bacadéhuachi and near Tecoriname, where Russell and Monson (1998) reported a single locality, individuals along Río Aros are near the northernmost extent of their range. Happy Wrens were also rare yet seem to be regular summer residents in areas were riparian thickets are exceptionally dense, as indicated by observations of singing birds near Batui each year since 2003 (A. Flesch, unpub. data). Despite these observations, Happy Wrens were not detected elsewhere on the Yaqui or Aros, or on the Bavispe below Granados in August 2004 (Flesch 2008, A. Flesch, unpub. data). We observed Military Macaws within 50 km of the northernmost observations of the species (Russell and Monson 1998) and suspect they regularly occur where large limestone cliffs such as those commonly found in and around the Sierra Los Pavos occur, near stands of tropical vegetation. All observations of macaws in this region (Flesch 2008, N. Snyder pers. comm. to R. Williams, and R. Williams pers. comm.) suggest they are present during the breeding season and likely nest on cliffs in the region.

Other species we observed were associated with the river itself and some are more common to the north. The Bald Eagle we observed was in an area where they have nested in the past (Brown 1988); Bald Eagles along the Río Yaqui are at the southernmost extent of their breeding range in mainland Mexico (Howell and Webb 1995). Common Black-Hawks regularly hunt from perches above water or while perched or walking along shore (Johnsgard 1990). As such, we regularly flushed them while floating the river, and the speed that we floated reduced the likelihood of double counting. Although some Common Black-Hawks we observed might not have nested, many were in pairs, had dependent young, or were detected near large nest structures suggesting that they had recently nested. Despite reports of only seven presumed breeding territories of Black-Hawks along the sections of river we floated (Russell and Monson 1998), our findings suggest a larger breeding population, especially given the fact that many of these birds were possibly attending hard-to-detect young. Given the large size of the lower Río Aros relative to other permanent waterways in Sonora and our observations of 42 occupied sites, this area likely supports both the highest densities and largest overall population of common Black-Hawks in Sonora. By comparison, only five presumed breeding localities have been identified along the Río Bavispe between Granados and the confluence of the Río Aros (A. Flesch, unpub. data).

Although we obtained some new information, our efforts were late in the breeding season for many species and produced almost as many questions as answers. For example, we failed to detect Song Sparrows despite presence of what seemed to be habitat along the river corridor, suggesting none were present. By comparison, two singing Song Sparrows were detected along the Río Bavispe between Granados and the confluence of the Río Aros in mid-August 2004 (A. Flesch, unpub. data). Although the breeding status of Yellow Warblers is unknown in this area (Russell and

Monson 1998), we observed several singing males in tall stands of willow (*S. gooddingii* and *S. bonplandiana*), especially along the first 30 river-km below Nátora, suggesting the possibility of nesting. We also observed many non-singing males that were likely migrants. Montezuma Quail are usually associated with oak woodland but can occur in other vegetation communities at higher elevations or in semidesert grasslands (Corman and Wise-Gervais 2005); in Sonora they primarily occur between 1,200 and 2,000 m (Russell and Monson 1998). Therefore, our observation of recently hatched young at only 760 m in thornscrub was unusual. Additional effort will be required to elucidate these questions.

Mammals

To be most effective, camera traps are generally set for long periods of time (4-8 weeks). Because of limited trapping periods (~8 hrs) for the duration of the study, we only obtained twelve photographs which consisted of: humans (n=6), a domestic dog (*Canis familiaris*) (n=2), a coyote (*Canis latrans*) (n=1), a mouse (*Peromyscus*) (n=1), and two blank photos.

We sampled small mammals with Sherman traps at three camps (see table 1, fig. 2), but unfortunately, perhaps due to overnight rain, our trap success was very poor. At Buena Vista camp we caught four individuals: three pocket mice (*Chaetodipus penicillatus*) and one kangaroo rat (*Dipodomys* spp.). The kangaroo rat escaped before processing, thus making identification to species impossible. At Los Lobos, we made no captures and at Los Pavos camp, we caught two desert pocket mice (fig. 7a).

Figure 7. *Chaetodipus penicillatus*, desert pocket mouse, captured at Los Lobos Camp. Right, Coatimundi (*Nasua narica*).

We observed a coatimundi (*Nasua narica*) along the river on 30 July between Buena Vista and Los Lobos. It was observed on a rocky point along the river and upon noticing our river party moved away from the river corridor. We were able to get a positive visual identification and a photographic voucher (fig. 7b). Additionally, we observed a coatimundi at Los Lobos canyon, although we could not obtain a photo. Additional sightings of mammals included rock squirrel (*Spermophilus variegatus*) and a cottontail (*Sylvilagus* spp.) (table 9). We recorded large felid (mountain lion or jaguar) scat and cougar tracks at three sites: Buena Vista, Carrizoso, and Los Pavos (figs. 8a, 8b). A large felid scrape was also recorded at Buena Vista on a tree morning glory (*Ipomoea arborecens*) (table 1), and a mountain lion (*Felis concolor*) skull was found and photographed at this camp. The presence of Neotropical river otter tracks at the confluence of the

Figure 8. Mountain lion scat (a) and tracks (b) from Buena Vista.

Río Bonito and Río Aros were significant findings since there are very few published records from the state of Sonora (Gallo-Reynoso 1996). This sighting coincides with previous observations from the area (O. Rosas and B. Long, pers. comm.).

Conclusions

Because of the brevity of the research trip, we detected a low number of species and individual mammals in the study region as compared to other taxonomic groups. This by no means implies that the region does not harbor a great diversity of mammal species; certainly more effort is needed in this regard.

Current studies of the mammal fauna in northeast Sonora include those on beaver (*Castor canadensis frondator*) in the upper Río Bavispe (Gallo-Reynosa *et al*. 2002), carnivores in general (Lorenzana-Piña *et al.* 2004), Jaguars (López-González and Lorenzana-Piña 2001, López-González and Brown 2002), and black bears (*Ursus americanus*) and cougars (Carlos López-González, University of Queretaro). López-González and associates have also studied medium and large mammals in east central Sonora using camera traps (Lorenzana-Piña *et al.* 2004). Other studies include those by Octavio Rosas and Raul Valdez (New Mexico State University) on large felids in the Aros region. Currently, important conservation projects and research on jaguars is being conducted on the Los Pavos Northern Jaguar Preserve.

In-depth studies of species of biogeographic and conservation interest, such as the neotropical river otter and ocelot, are lacking in the study area. Additionally, the population dynamics of collared peccary (*Pecari tajucu*) and white-tailed deer (*Odocoileus virginianus*), both important prey species for large felids, remain unknown in the region. Clearly, more work is needed for a more comprehensive view of the geographic distribution and conservation issues of mammals along the Río Aros and its tributaries.

Summary

Preliminary surveys of the flora and fauna of the Río Aros region support our prediction that an inventory in the region would identify notable observations and range extensions for multiple taxa. In the limited 8-day survey period, we identified many such species and report the range extension of 3 species of plant, 4 aquatic invertebrates, and 2 reptiles, with numerous other observations of biogeographic note.

The Río Aros region lies at the border of temperate and subtropical biogeographic provinces; however the majority of notable species we encountered were species with ranges extending to the south, likely due to the fact that the dominant vegetation type in this area is subtropical in origin (Brown 1994). In the upper reaches of our study area along the river, we noted large areas of frost-killed vegetation, suggesting that infrequent frost events likely limit some plant species and associated animals in the region. Whereas frost could be a limiting factor for vegetation, groups such as aquatic invertebrates would be unaffected by brief periods of freezing weather, suggesting that global warming could differentially affect the distributional ranges of different plant and animal groups in the region. Further work should identify the role of rare weather events on the distribution of plants in Aros and Yaqui valleys.

Our findings clearly underscore the need for future work in the region. For logistical reasons we chose to conduct our study during the monsoon season when water flows were elevated. However, research during other seasons would allow a better assessment for certain groups. During the monsoon period many reptiles and amphibians may be more detectable, however, other groups such as aquatic invertebrates and some birds may be harder to detect.

This study contributes to biological knowledge of the Río Aros and upper Río Yaqui region. Not only did we compile preliminary species lists that can be used for future efforts in the region, we also identified range extensions for nine species and gained further biogeographic information for many other notable species, underscoring the importance of this region as an outpost for northern limits of subtropical flora and fauna in North America. This region harbors a labyrinth of canyons, mesas, and mountains that await further, more detailed, exploration by naturalists.

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Table 1. Summary of river sections (Ríos Aros and Yaqui), tributaries, and campsites surveyed.

River Section	Map code	Date	Distance (km)
Natora to Tunapa	A	7/27-28	21.0
Tunapa to Buena Vista	B	7/29	33.0
Buena Vista to Lobos	C	7/30	29.6
Los Lobos to Carrizoso	D	7/31	29.7
Carrizoso to Los Pavos	E	8/1	11.4
Los Pavos to Los Alisos	F	8/2	34.8
Los Alisos to El Rio	G	8/3	25.3

River camp	code	Date
Natora	I	7/27-28
Tunapa	II	7/29-30
Buena vista	III	7/30-31
Los lobos	IV	7/31-8/1
El Carrizoso	V	8/1-2
Los Pavos	VI	8/2-3
Los Alisos	VII	8/3-4

Surveys conducted by tributary								
Tributary	Map code	Date	Distance	Plant	Bird	Invert.	Herps	Mammals
Los Chinos	1	7/28-29	3.3	X	X		X	X
La Cienega	2	7/29	2.5	X	X		X	
Unnamed at Tunapa	3	7/28-29	1.5			X	X	X
El Placer	4	7/30	3.0	X	X	X		
Chino Gordo	5	7/30	1.8	X	X		X	X
Río Bonito	6	7/30	0.5			X	X	X
Los Lobos	7	7/31	2.6	X	X	X	X	X
Carrizoso	8	8/1	2.5	X	X	X	X	X
El Toro	9	8/2	1.0			X	X	
Los Pavos	10	8/2	1.4	X	X		X	X
Fig-fall	11		1.0				X	
Los Alisos	12	8/3	5.4	X	X	X	X	

Table 2. Sampling locations and abiotic conditions for aquatic and invertebrate sampling

Sites	Date	N UTM	E UTM	Water (ºC)	pH	Cond (S)	Estimated flow (cfs)
Tributary Canyons							
Carrizoso	1-Aug-05	3266472	679414	28	8	480	0.1
El Placer	30-Jul-05	3239426	702416	23	8	310	3
El Toro	1-Aug-05	*	*	28	*	*	0.01
Chino Gordo	30-Jul-05	3238838	704898	*	*	*	0.01
Los Lobos	31-Jul-05	3249866	692628	25	7.75	590	0.01
Unnamed trib. @ Tunapa camp	29-Jul-05	3217863	718064	*	*	*	0.1
Fig-Waterfall	1-Aug-05	3259176	669758	29	*	*	0
High Elevation Creek b/w Nátora & Sahuaripa	27-Jul-05	3212880	695440	20	*	*	0
Mainstem - Drift Samples							
El Carrizoso camp	31-Jul-05	3266394	679294	25	7.75	60	3200
Los Alisos camp	3-Aug-05	3249780	671174	24.5	7.25	*	4000
Mainstem - Net Samples							
Río Aros at Buena Vista camp	30-Jul-05	3238838	704898	26	7.75	60	3200
Río Aros at Río Bonito	30-Jul-05	3250409	698062	26	*	*	3200
Río Aros at Tunapa camp	28-Jul-05	3217683	718064	27	*	*	2500
Río Sahuaripa at road crossing to Nátora	27-Jul-05	3210117	674-656	*	*	*	1000
Río Yaqui at takeout	3-Aug-05	3231824	667642	25	*	*	3500

* no data taken

Table 3. Species occurrences of aquatic invertebrates by sampling location.

Taxa	Tributary Canyons								Mainstem-Drift		Mainstem-Net				
	Carrizoso	Chino	FigFall	HighElv	Lobos	Placer	Toro	Tunapa	Alisos	Carrizoso	Bonito	Chinos	Sahuaripa	Takeout	Tunapa
COLEOPTERA															
sp.					X										
Dryops arizonensis					X										
Postelichus	X														
Dytiscidae							X								
Desmopachria dispersa															
Desmopachria mexicana	X		X		X		X	X							
Desmopachria pormanni				X	X										
Laccophilus fasciatus	X		X			X	X	X							
Laccophilus horni					X										
Laccophilus mexicanus	X				X										
Laccophilus pictus	X		X	X	X		X	X					X		
Liodessus obscurellus				X										X	
Macrovatellus mexicana	X				X										
Neoclypeodytes	X			X	X			X					X		
Rhantus atricolor				X											
Rhantus calidus					X										
Rhantus gutticollis gutticollis				X											
Stictotarsus aequinoctialis				X	X										
Stictotarsus roffi	X				X								X		
Stictotarsus striatellus					X										
Thermonectus marmoratus			X	X	X		X	X							
Elmidae										X		X	X		
Gyrinidae															
Dineutus sublineatus	X			X				X							
Gyretes torosus	X														
Gyrinus plicifer				X											
Haliplidae															
Peltodytes dispersus	X				X			X							
Helophoridae															
Helophorus	X														

Table 3. Species occurrences of aquatic invertebrates by sampling location.—Continued

Taxa	Tributary Canyons								Mainstem-Drift		Mainstem-Net				
	Carrizoso	Chino	Fig-Fall	High Elv	Lobos	Placer	Toro	Tunapa	Alisos	Carrizoso	Bonito	Chinos	Sahuaripa	Takeout	Tunapa
Heteroceridae															
Hydraenidae															
Hydraena				X	X										
Ochthebius discretus					X										
Hydrochidae															
Hydrochus	X				X										
Hydrophilidae															
Anacaena limbata					X										
Berosus blechrus				X	X		X								
Berosus miles			X												
Berosus moerens			X	X	X			X							
Berosus notapeltatus				X	X										
Berosus nr. *salvini*	X														
Berosus nr. *stylifer*								X							
Berosus rugulosus	X		X		X	X	X	X							
Berosus salvini				X											
Berosus sp.	X						X								
Chaetarthrea sp. 1					X										
Chaetarthrea sp. 2					X										
Enochrus	X		X		X		X								
Helocharus normatus	X		X		X		X								
Hydrophylus triangularis	X							X							
Paracymus							X								
Tropisternus ellipticus	X		X	X			X	X							
Tropisternus lateralis	X						X	X							
Scirtidae															
Cyphon					X										
Staphlynidae				X	X										
DIPTERA															
Ceratapogonidae					X										
Chironomidae	X				X					X			X		
Culicidae	X				X										
Simuliidae									X						

Table 3. Species occurrences of aquatic invertebrates by sampling location.—Continued

Taxa	Tributary Canyons								Mainstem-Drift		Mainstem-Net				
	Carrizoso	Chino	FigFall	HighElv	Lobos	Placer	Toro	Tunapa	Alisos	Carrizoso	Bonito	Chinos	Sahuaripa	Takeout	Tunapa
Stratiomyidae															
Oxycera					X										
Stratiomis			X					X							
Tabanidae															
Tabanus								X							
EPHEMEROPTERA															
Baetidae															
Callibaetis	X			X	X	X		X							
Caenidae								X							
Caenis															
Leptophlebiidae															
Traverella									X			X			X
LEPIDOPTERA									X						
Pyralidae															
MEGALOPTERA															
Corydalidae															
Corydalus											X	X			X
ODONATA															
Aeshnidae															
Aeshna					X										
Calopterygidae															
Hetaerina americana	X														
Coenagrionidae															
sp.					X							X			
Argia	X						X	X							
Libellulidae	X				X										
TRICHOPTERA															
Calamoceratidae															
Phylloicus aeneus					X										
Hydropsychidae															
Smicridea									X	X					
Odontoceridae															
Marilia flexuosa							X	X							

Table 4. Amphibian and reptile detections by site name or tributary canyon.

Species	High Elev	Nátora	Tunapa	La Cienega	Buena Vista	Chino Gordo	Arroyo Bonito	Los Lobos	Carrizoso	El Toro	Los Pavos	Fig Fall	Los Alisos	El Río
Salamanders														
Ambystoma rosaceum	X													
Frogs and toads														
Gastrophryne olivacea				X					X					
Hyla arenicolor						X			X			X	X	
Bufo alvarius									X	X				
Bufo mazatlanensis		X	X											
Bufo punctatus			X			X						X		
Rana tarahumarae				X										
Rana c.f. yavapaiensis	X						X	X	X				X	X
Turtles														
Trachemys spp.					X							X		
Terrepene nelsoni					X			X						
Kinosternon sonoriense	X		X	X		X		X						
Lizards														
Heloderma suspectum														X
Callisaurus draconoides											X			X
Sceloporus clarkia	X				X	X			X?	X				
Urosaurus ornatus						X					X	X	X	
Eumeces obsoletus								X						
Aspidoscelis spp.									X					
Snakes														
Drymarchon corais			X			X			X					
Tantilla yaqui											X			
Thamnophis cyrtopsis				X										

Table 5. Species list for reptiles and amphibians. Latin nomenclature and common names given.

Scientific Classification and Latin name	Common name
Caudata	Salamanders
Ambystomatidae	Mole Salamanders
Ambystoma rosaceum	Tarahumara Salamander
Anura	Frog and Toads
Microhylidae	Narrow-mouthed Toads
Gastrophryne olivacea mazatlanensis	Sinaloan narrow-mouthed toad
Hylidae	Treefrogs
Hyla arenicolor	Canyon treefrog
Bufonidae	True Toads
Bufo alvarius	Sonoran Desert toad
Bufo mazatlanensis	Mazatlán toad
Bufo punctatus	Red-spotted toad
Ranidae	True frogs
Rana tarahumarae	Tarahumara frog
Rana c.f. yavapaiensis	Lowland leopard frog
Testudines	Turtles
Emydidae	Box and Water turtles
Trachemys spp.	Slider turtle (spp. unknown)
Terrepene nelsoni	Spotted box turtle
Kinosternidae	Mud turtles
Kinosternon sonoriense	Sonoran mud turtle
Squamata	Lizards
Helodermatidae	Beaded lizards
Heloderma suspectum	Gila monster
Phrynosomatidae	
Callisaurus draconoides	Zebra tailed lizard
Sceloporus clarkii	Clark's spiny lizard
Urosaurus ornatus	Tree lizard
Scincidae	Skinks
Eumeces obsoletus	Great Plains skink
Teiidae	Whiptails
Aspidoscelis spp.	Whiptail (spp. unknown)
Squamata	Snakes
Colubridae	
Drymarchon corais	Indigo snake
Tantilla yaquia	Yaqui black-headed snake
Thamnophis cyrtopsis	Black-headed garter snake

Table 6. Relative abundance and breeding status of birds (n = 80) detected along the Ríos Yaqui and Aros and adjacent tributaries.

Common name	Scientific name	Abundance	Breeding evidence	Comments
Great Blue Heron	*Ardea herodias*		Abundant	Present in suitable habitat. As many as 70 to 100/ day
Great Egret	*Egretta alba*	Uncommon	Not in breeding habitat	
Mallard (Mexican variety)	*Anus platyrhynchos*	Rare	Not in breeding habitat	
Common Merganser	*Mergus merganser*	Uncommon	Paired, breeding status unknown	Mainly females in groups of 8 or fewer
Black Vulture	*Coragyps atratus*	Common		
Turkey Vulture	*Cathartes aura*	Common		
Bald Eagle	*Haliaeetus leucocephalus*	Rare	At past nesting location	Single adult flushed at mouth of Arroyo Bonito after nesting season
Common Black-Hawk	*Buteogallus anthracinus*	Common	Dependent young	Forty-two sites, 9 w/ dependent young, 10 w/ pairs
Gray Hawk	*Buteo nitidus*	Rare	Calling territorially	One detection at takeout
Red-tailed Hawk	*Buteo jamaicensis*	Uncommon	Dependent young	
Peregrine Falcon	*Falco peregrine*	Rare	Paired and calling	Observed only at mouth of Los Pavos Canyon
Montezuma Quail	*Cyrtonyx montezumae*	Rare	Dependent young	Pair w/ yg <3 days old in thornscrub w/ few oaks
Elegant Quail	*Callipepla douglasii*	Common	Singing, paired	
Spotted Sandpiper	*Actitis macularia*	Common		As many as 14 day
White-winged Dove	*Zenaida asiatica*	Common	Paired	
Mourning Dove	*Zenaida macroura*	Uncommon	Nest w/ 2 eggs	
Inca Dove	*Columbina inca*	Rare	Singing, paired	
Common Ground-Dove	*Columbina passerina*	Common	Nest w/ eggs and young	
White-tipped Dove	*Leptotila verreauxi*	Uncommon	Singing	Found throughout in dense thornscrub
Military Macaw	*Ara militaris*	Rare	Paired	Group of 2 and 5 near large limestone cliffs

Table 6. (cont.) Relative abundance and breeding status of birds (n = 80) detected along the Ríos Yaqui and Aros and adjacent tributaries, cont.

Common name	Scientific name	Abundance	Breeding evidence	Comments
Yellow-billed Cuckoo	*Coccyzus americanus*	Common	Nest w/ 4 eggs	In riparian groves and thornscrub
Greater Roadrunner	*Geococcyx californianus*	Uncommon		
Great Horned Owl	*Bubo virginianus*	Uncommon		Using rock alcoves along River
Broad-billed Hummingbird	*Cynanthus latirostris*	Common		
Violet-crowned Hummingbird	*Amazilia violiceps*	Common		
Elegant Trogon	*Trogons elegans*	Uncommon	Calling territorially	In tall thornscrub and riparian trees in side canyons
Green Kingfisher	*Chloroceryle americana*	Rare		Not along river and only in wet side canyons
Gila Woodpecker	*Melanerpes uropygialis*	Common	Dependent young, pairs	
Ladder-backed Woodpecker	*Picoides scalaris*	Common	Paired	
Northern Beardless-Tyrannulet	*Camptostoma imberbe*	Rare	Singing	
Western Wood-Pewee	*Contopus sordidulus*	Rare	Singing	Observed only in Sycamores in El Placer Canyon Canyon
Black Phoebe	*Sayornis nigricans*	Common	Singing, paired	
Vermilion Flycatcher	*Pyrocephalus rubinus*	Rare	Dependent young	
Dusky-capped Flycatcher	*Myiarchus tuberculifer*	Common	Singing, paired	In thornscrub on slopes and riparian bottoms
Ash-throated Flycatcher	*Myiarchus cinerascens*	Uncommon		At lower elevations in more open arid thornscrub
Nutting's Flycatcher	*Myiarchus nuttingi*	Rare		Detected only once in tall thornscrub
Brown-crested Flycatcher	*Myiarchus tyrannulus*	Uncommon		Restricted to groves of large chinos and willows

Table 6. (cont.) Relative abundance and breeding status of birds (n = 80) detected along the Ríos Yaqui and Aros and adjacent tributaries, cont.

Common name	Scientific name	Abundance	Breeding evidence	Comments
Sulphur-bellied Flycatcher	*Myiodynastes luteiventris*	Rare	Dependent young	2 family groups in Sycamores in Los Lobos Canyon
Tropical Kingbird	*Tyrannus melancholicus*	Common	Singing, paired	In riparian groves along Río
Cassin's Kingbird	*Tyrannus vociferans*	Uncommon		
Thick-billed Kingbird	*Tyrannus crassirostris*	Uncommon		Single birds in 3 side canyons
Western Kingbird	*Tyrannus verticalis*	Uncommon		
Rose-throated Becard	*Pachyramphus aglaiae*	Rare	Nest building, copulating	Found mainly in Sycamores in side canyons
Bell's Vireo	*Vireo bellii*	Common	Singing	
Warbling Vireo	*Vireo gilvus*	Rare		Few migrants in riparian trees
Yellow-green Vireo	*Vireo flavoviridis*	Rare	Singing, paired	8 singing along 2 km of river above Tunapa, 4 in Canyon Los Lobos
Common Raven	*Corvus corax*	Common	Used nest	
Cliff Swallow	*Hirundo pyrrhonota*	Uncommon	Occupied and used nests	Found at only 3 to 5 sites
Verdin	*Auriparus flaviceps*	Common	Used nests, paired	
Cactus Wren	*Campylorhynchus brunneicapillus*	Common	Used nests, paired	
Rock Wren	*Salpinctes obsoletus*	Uncommon	Singing	
Canyon Wren	*Catherpes mexicanus*	Common	Singing, paired	
Sinaloa Wren	*Thryothorus sinaloa*	Common	Singing, used nests	Throughout especially in riparian woodland adjacent

Table 6. (cont.) Relative abundance and breeding status of birds (n = 80) detected along the Ríos Yaqui and Aros and adjacent tributaries, cont.

Common name	Scientific name	Abundance	Breeding evidence	Comments
Happy Wren	*Thryothorus felix*	Rare	Singing	Observed at mouth of A. Bonito and Batui where detected since 2003
Black-capped Gnatcatcher	*Polioptila nigriceps*	Common	Singing, paired	
Northern Mockingbird	*Mimus polyglottos*	Uncommon		Mainly in lower section of Río
Curved-billed Thrasher	*Toxostoma curvirostre*	Rare	Calling	
Phainopepla	*Phainopepla nitens*	Uncommon		
Lucy's Warbler	*Vermivora luciae*	Uncommon		Migrants in riparian vegetation
Yellow Warbler	*Dendroica petechia*	Common	Singing, others not singing	Restricted mainly to willow groves along Río
Common Yellowthroat	*Geothlypis trichas*	Rare	Singing	Detected only near Nátora
Rufous-capped Warbler	*Basileuterus rufifrons*	Uncommon	Singing	More common in side canyons
Yellow-breasted Chat	*Icteria virens*	Abundant	Nest w/ 4 eggs	
Summer Tanager	*Piranga rubra*	Common	Singing, pairs	Often in willows along Río and adjacent thornscrub
Western Tanager	*Piranga ludoviciana*	Rare		
Canyon Towhee	*Pipilo fuscus*	Common	Singing, paired	
Rufous-winged Sparrow	*Aimophila carpalis*	Uncommon	Singing	
Five-striped Sparrow	*Amphispiza quinquestriata*	Abundant	Dep. young, nest w/ 4 eggs	Singing throughout thornscrub
Black-headed Grosbeak	*Pheucticus melanocephalus*	Common	Singing	No sign of nesting
Northern Cardinal	*Cardinalis cardinalis*	Uncommon	Singing, paired	
Blue Grosbeak	*Guiraca caerulea*	Common	Singing, paired	
Varied Bunting	*Passerina versicolor*	Common	Singing, paired	

Table 6. (cont.) Relative abundance and breeding status of birds (n = 80) detected along the Ríos Yaqui and Aros and adjacent tributaries, cont.

Common name	Scientific name	Abundance	Breeding evidence	Comments
Painted Bunting	*Passerina ciris*	Rare		1 female approx. 10 km below Nátora
Bronzed Cowbird	*Molothrus aeneus*	Uncommon		
Brown-headed Cowbird	*Molothrus ater*	Uncommon		
Black-vented Oriole	*Icterus wagleri*	Rare	Paired	9 birds near Buena Vista and in 3 large side canyons, often in plams
Hooded Oriole	*Icterus cucullatus*	Uncommon	Nests w/ young	As with previous species often near palms
Streak-backed Oriole	*Icterus pustulatus*	Uncommon	Occupied and used nests	Mainly in chinos along large side canyons and Río
House Finch	*Carpodacus mexicanus*	Common	Singing, paired	
Lesser Goldfinch	*Carduelis psaltria*	Uncommon		

Table 7. Birds species (n = 14) detected while traveling the road from Sahuaripa to Nátora (100 km) through Sinaloan thornscrub and Madrean evergreen woodland that were not detected along the Río Aros or Yaqui, Sonora, Mexico, 27 July 2005.

Common name	Scientific name
Acorn Woodpecker	*Melanerpes formicivorus*
Arizona Woodpecker	*Picoides arizonae*
Northern Flicker	*Colaptus auratus*
White-striped Woodcreeper	*Lepidocolaptes leucogaster*
Greater Pewee	*Contopus pertinax*
Loggerhead Shrike	*Lanius ludovicianus*
Mexican Jay	*Aphelocoma ultramarina*
Bridled Titmouse	*Parus wollweberi*
Bushtit	*Psaltriparus minimus*
White-breasted Nuthatch	*Sitta carolinensis*
Eastern Bluebird	*Sialia silias*
Hepatic Tanager	*Piranga flava*
Cassin's Sparrow	*Aimophila cassinii*
Rufous-crowned Sparrow	*Aimophila ruficeps*

Table 8: Distribution and abundance of birds (*n* = 80) detected along the Rios Yaqui and Aros and adjacent tributaries from Natora to Batacomachi Sonora, Mexico 27 July to 3 August 2005. Numbers indicate singles, singing males, or pairs, x indicates common species for which abundance was not estimated. Kilometers indicate distance floated along river or distance walked along tributaries. C = colony, p = pair, y = young, NE = nest with eggs, UN = used nest, ON = occupied nest. For example a 9,2p1y indicates we observed the species at 9 locations and at 2 there was a pair and at 1 there was dependant young.

Common name	Rio Aros and Yaqui Mainstem							Tributaries							
	Natora to Tunapa	Tunapa to Buena Vista	Buena Vista to Los Lobos	Los Lobos to Carriz-oso	Carriz-oso to Los Pavos	Los Pavos to Los Alisos	Los Alisos to El Rio	Los Chino	La Cien-ega	El Placer	Chino Gordo	Los Lobos	Carriz-oso	Los Pavos	Los Alisos
Map reference	A	B	C	D	E	F	G	1	2	3	4	5	6	7	8
Kilometers	21	33	29.6	29.7	11.4	34.8	25.3	3.3	2.5	3.0	1.8	2.6	2.5	1.4	5.4
Date	7-27-8	7-29	7-30	7-31	8-1	8-2	8-3	7-28-9	7-29	7-30	7-30	7-31	8-1	8-2	8-3
Great Blue Heron	15	50+	70+	50+	x	x	x								
Great Egret							2								
Mallard (Mexican variety)						1									
Common Merganser		3	15	5		2									
Black Vulture	X	x	x	x		x	x								
Turkey Vulture	X	x	x	x		x	x					x	x		1
Bald Eagle			1												
Common Black-Hawk	7	6,3py	7,2py	7,2p1y	3,1p	9,2p1y	1			1,1y	1				
Gray Hawk							1								
Red-tailed Hawk		1	1	1	1	3		1	1	1			3		2, 1y
Peregrine Falcon						1p									
Montezuma Quail								6, 3y							
Elegant Quail	3	x	x	x	x	x	x	x	x			1		3	x
Spotted Sandpiper	8	3	4	4	5	14	x								
White-winged Dove	X	x	x	x	x	x	x	x	x	x		20	x	x	x
Mourning Dove	X	x						x		x	x				
Inca Dove	X														

	Natora to Tunapa	Tunapa to Buena Vista	Buena Vista to Los Lobos	Los Lobos to Carriz-oso	Carriz-oso to Los Pavos	Los Pavos to Los Alisos	Los Alisos to El Rio	Los Chino	La Cien-ega	El Placer	Chino Gordo	Los Lobos	Carriz-oso	Los Pavos	Los Alisos
Common Ground-Dove	X	x	x	x	x	x	x	x		x	x	x	x	x	x
White-tipped Dove		2	5	x	x	3	1	5		3	2	5	6	1	3
Military Macaw				5										1p	
Yellow-billed Cuckoo	4	x	x	x		8	1		3	2		1	3,1ON		2
Greater Roadrunner	1					2		1							2
Great Horned Owl		2		1					1						
Broad-billed Hummingbird	2	1	x	x	x	x	x	1	x	1			3	2	x
Violet-crowned Hummingbird	4					1							4	1	2
Elegant Trogon								1				2			5
Green Kingfisher		2													2
Gila Woodpecker	x	x	x	x	x	x	x	1			2,2y	x	1	x	x
Ladder-backed Woodpecker			x	x	x	x	x	1				x	1	x	x
Northern Beardless-Tyrannulet	2	x	1					x	1			2	x	1	
Western Wood-Pewee										1					
Black Phoebe	x	x	x	x	x	x		x	x	x			x		x
Vermilion Flycatcher	x	x	x	x		x	x	x		x				x	x
Dusky-capped Flycatcher		2	2	x		x	x	6	x	4		5	8	1	x
Ash-throated Flycatcher						x	x	1			1			1	x
Nutting's Flycatcher															1
Brown-crested Flycatcher	2		1			1		1		1		2	1	1	
Sulphur-bellied Flycatcher												15,10y			
Tropical Kingbird	20	x	x	x	x	x	5	2			1				
Cassin's Kingbird	2														
Thick-billed Kingbird										1			1		
Western Kingbird							5								
Rose-throated Becard										1UN		3,1ON			

	Natora to Tunapa	Tunapa to Buena Vista	Buena Vista to Los Lobos	Los Lobos to Carriz-oso	Carriz-oso to Los Pavos	Los Pavos to Los Alisos	Los Alisos to El Rio	Los Chino	La Cien-ega	El Placer	Chino Gordo	Los Lobos	Carriz-oso	Los Pavos	Los Alisos
Bell's Vireo	12	x	2	x	x	x	x	x		2			x	x	x
Warbling Vireo					1								1		1
Yellow-green Vireo	8											4			
Common Raven		x	x									x			x
Cliff Swallow		2C	1				1C								
Verdin	x								x	2				x	x
Cactus Wren				x		x	x		x		x		x	x	x
Rock Wren	x				x								x		
Canyon Wren	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Sinaloa Wren	40+	20+	x	x	x	x	x	x	x	10	3	x	x		2
Happy Wren			1				1								
Black-capped Gnatcatcher	2	3			2	x		x		x		x	x	x	6
Northern Mockingbird	1	1		2		x									2
Curved-billed Thrasher						1	1	2		1		1	1	x	1
Phainopepla													1		
Lucy's Warbler	3							2							
Yellow Warbler	7	x	2	x			x								
Common Yellowthroat	1														
Rufous-capped Warbler		1		2	3					5		5	10		1
Yellow-breasted Chat	x	x	x	x	x	x	x	x	x	x	x		x	x	x
Summer Tanager	5	10	2	x		x	x	x		4		2			x
Western Tanager	1	1													
Canyon Towhee	2	x						x		x		x		x	1
Rufous-winged Sparrow	x						x	x						x	
Five-striped Sparrow	3	x	x	x	x	x	x	x	1NE	x		x	x	x	x
Black-headed Grosbeak	1	x				x	x	2				1	1		1

	Natora to Tunapa	Tunapa to Buena Vista	Buena Vista to Los Lobos	Los Lobos to Carriz-oso	Carriz-oso to Los Pavos	Los Pavos to Los Alisos	Los Alisos to El Rio		Los Chino	La Cien-ega	El Placer	Chino Gordo	Los Lobos	Carriz-oso	Los Pavos	Los Alisos
Northern Cardinal	x	x	x	x	x	x	x		x	x	x	x	1	x	x	x
Blue Grosbeak	x	x	x		x	x	x		x	x	x		x	x	x	x
Varied Bunting	x	x	x		x	x	x		x	x	x		x	x	x	1
Painted Bunting	1															
Bronzed Cowbird	2	x	x								x					
Brown-headed Cowbird		x	x	x												
Black-vented Oriole		1											3	3		1
Hooded Oriole	7	x	1	x		x	x		3	x	2		1	3	1	1ON
Streak-backed Oriole	2UN	3UN	3UN						1ON		2UN		2UN			
House Finch	x		x								x		x	x	1	x
Lesser Goldfinch									2							
Species richness - transect	47	45	40	34	25	40	37		37	19	33	12	32	34	29	41
- river and tributary				71									61			
- region								80								

Table 9. Mammal detections by site. Codes indicate detection type: SC=scat, SP=scrape, TR=track, P=picture, C=capture, SI=sighting.

Species	Common name English/Spanish	Site Name						
		Natora	**Unnamed at Tunapa camp**	**Buena Vista**	**Arroyo Bonito**	**Los Lobos**	**Carrizoso**	**Cajon los Pavos**
Odocoileus virginianus	White tail deer/Venado cola blanca		TR	TR		TR	TR	
Pecari tajacu	Javelina/Coshi jabali		TR		SC	TR	TR	
Canis latrans	Coyote/Coyote	TR	SC		TR/SC	PI	TR	
Urocyon cinereoargenteus	Grey fox/Zorra gris			TR/SC		TR		TR
Puma concolor	Puma/Leon			SC/SP			TR	TR/SC
Lynx rufus	Bobcat/Gato pochi			SC			TR	
Conepatus mesoleucus	Hog-nosed skunk/Zorrillo cadeno						TR	
Spilogale putuorious	Spotted skunk/Zorillo manchado		TR					
Bassariscus astutus	Ringtail/Cacomixtle		TR			TR	TR	
Procyon lotor	Racoon/Batepi	TR	TR		TR	TR	TR	TR
Nasua narica	Coatimundi/Chulo		TR		SI	SI	TR	TR
Lutra longicaudis	Neotropical river otter/Perro de agua				TR			
Lepus alleni	Antelope jack rabbit/Liebre	SI						
Sylvilagus sp.	Cottontail/Conejo		SI					TR
Spermophilus variegatus	Rock squirrel/Ardilla					SI		
Chaetodipus penicillatus	Desert pocket mouse/Raton			CA				CA
Dypodomys sp.	Kangaroo rat/Rata canguro			CA				
Peromyscus sp.	Mouse/Raton de campos		TR?					TR