Desert Plants

Volume 32, Number 2
April 2017

Published by The University of Arizona for
the Boyce Thompson Arboretum

Biotic Resources of the Lower Santa Cruz River Flats, Pinal County, Arizona

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Emory's crucifiction thorn (*Castela emoryi*)
with Picacho Peak in backround.
Photo: Elizabeth Makings, 13 September 2013

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A journal devoted to broadening knowledge of plants indigenous or adapted to arid and sub-arid regions and to encouraging the appreciation of these plants.

Volume 32, Number 2
Published by The University of Arizona for the Boyce Thompson Arboretum
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Superior, AZ 85173

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From the editor

Look westward as you drive between Tucson and Phoenix on Interstate 10, and the general area of the Lower Santa Cruz River Flats will be a familiar sight. With an elevation change of only eleven feet per mile, it is most notably flat. In fact, the contour line intervals of this area on a topographic map can be as wide as the map itself. Frequent highway signs warn of strong cross-winds and potential sand storms—*haboobs*—that can approach from almost any direction, fueled by advancing summer thunderstorms and a plentiful supply of bare soil.

The Santa Cruz River is free flowing, with its headwaters in Tucson where it drains the Rillito River and La Cañada wash, then flows northwest, roughly paralleling I-10. The main focus of this issue is the lower Santa Cruz River and the adjacent outwash flood plain from the river's intersection with the Green Canal (about ten miles west of Picacho Peak), extending north to the Ak Chin and Gila River Indian communities. Take the Interstate 8 branch from I-10 towards San Diego, and you will drive through the study area at nearly its north/south midpoint.

In this issue, both the human and natural history of this area is examined, with separate chapters on vegetation, herps, birds, and mammals. Three appendices document the non-plant species that are found in The Flats, along with comments about their abundance and affinities.

Seven authors teamed up to present this thorough introduction to the Lower Santa Cruz River Flats, a region that figures squarely in conceptual plans for future transportation corridors and sub-urban development. Perhaps, this issue will help counter the misconception of this area as simply a windswept swath of barren desert to pass through on a long drive between Arizona's two largest cities—and help everyone understand that The Flats, like the rest of the Sonoran Desert, is full of life.

As a final editor's note, I am retiring from the University of Arizona, making this issue of *Desert Plants* my last as editor. *Desert Plants*, however, will live on, edited and produced twice per year at Boyce Thompson Arboretum. As was the original intent of the very first issue back in August of 1979, *Desert Plants* will continue to be a semi-technical journal of interest to layman and professional alike. Cheers.

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Desert Plants Journal is included with Boojum Club, Picket Post Society, and Director's Circle level memberships at Boyce Thompson Arboretum. One-year subscriptions are also available: individual $25 ($35 outside US), institution $55 ($65 outside US). Back issues $5 each, plus $3 shipping and handling. Additional copies of Vol. 29(2) are $20, plus $5 shipping and handling. Mailing address: Boyce Thompson Arboretum 37615 E US Highway 60, Superior, AZ 85173 cals.arizona.edu/DesertPlants DesertPlants@cals.arizona.edu 520.689.2723

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Abstract: We present a human and natural history of the lower Santa Cruz River and adjacent flood plain from the river's confluence with Los Robles Wash downstream to the Ak Chin and Gila River Indian communities. This work highlights the importance of the Flats, a large outwash flood plain with little topographic relief within the lower reaches of the Santa Cruz River. The geology, history, and vertebrate inhabitants of the "Flats" are summarized as a perspective on the area's flora and fauna. Particular attention is paid to the Flats relict and emerging riparian communities, the unique habitats present, and the biogeographic affinities of its inhabitants. Wildlife values include a variety of big and small game mammals, resident and migratory birds, and a diversity of reptiles and amphibians. The importance of the area to wintering raptors and small game hunting is emphasized as are the region's conservation challenges.

Introduction

While camped in a drizzle in the vicinity of Picacho Pass: "*I will pronounce it the most extensive desert I have seen: clay, sand, gravel, Artemisia, mesquites, and a few other bushes... But every two or three miles were seen a little grass (a sort I had never seen) of a silky light, straw color, with a head like a plume; also a very little grama. Between the two mountains (along McLellan Wash?) there was much grass, and trees, too– a new species of mesquite, or perhaps locust, large and pretty, the wood light and porous (= Parkinsonia floridum?*

General George Cooke, December 20, 1846

Although dozens of articles and at least two books have been written about the Santa Cruz River and its course through the Tucson area, little attention has been paid to the River's lower 161 km (100 mi). This reach and its immediate surroundings, described by Logan (2002) as a "bioregion," represents a significant percentage of the Santa Cruz River's 388 km (241 mi) length and 22,224 km2 (8,581 mi2) watershed (Webb et al. 2014). The ignominy might be attributed to the undammed flow being underground except during flood events, but is also explained by the massive alterations brought on by intense agricultural development, livestock grazing, and flood control measures. These activities, particularly land leveling and ground water pumping, have been disruptive to the River's

character resulting in stream flow interception, bank alteration, and surface water diversion. Despite few riparian communities having been subject to more modifications than the lower Santa Cruz, the River and adjacent floodplain remains popular with birders, hunters, and other natural history enthusiasts, and deserves the recognition that the revitalized and celebrated upstream reaches of the Tucson Basin have recently received (Sonoran Institute and Pima County 2014, Webb et al. 2014). The purpose of this paper is to bring these values to the attention of the conservation-minded public lest this stretch of river continue to be ignored and its values lost to posterity.

Geographic Setting

River situation

Our Lower Santa Cruz River begins at its junction with Los Robles Wash ca. 3 km (2 mi) north of Cerro Prieta near Sasco Road at 552 m (1810 ft) elevation. We also include the delta between these two drainages upstream to where Blanco and Brawley washes join to form Los Robles Wash near the Pima-Pinal county line west of Marana Air Park (**Figure 1**). Our main focus, however, is the Santa Cruz Flats, a large outwash flood plain with little relief that begins immediately downstream from where the Santa Cruz River channel captured Greene Canal during a 1914-1915 flood event. From here, the main course of the river now extends westward along Greene Canal (sometime referred to as Greene Wash) for 21 km (13 mi) to the site of Greene Reservoir east of the Sawtooth Mountains: 32.600057, -111.637614, 481 m (1578 ft). The waters of the Santa Cruz continue ephemerally northwest across the northeast corner of the Tohono O'odham Nation where a channelized Greene Wash joins an also channelized Santa Rosa Wash north of Stanfield at 400 m (1310 ft).

The canals collecting the waters of the Santa Cruz and Santa Rosa Wash continue northward to the agricultural fields on the Gila River and Ak-Chin Indian Communities before reforming north of the Southern Pacific railroad tracks as Santa Cruz Wash. Santa Cruz Wash then flows north to join Vekol Wash south of the village of Santa Cruz at 314 m (1036 ft) before meandering northward to join the Gila River near Komatke at 309 m (1014 ft) (**Map 1**). The total elevation drop from where the river enters the Santa Cruz Flats to its juncture with the Gila is 243 m (796 ft) over 118 km (73 air miles) or a drop of a little over 2m/km (~11ft/mile), in an area covering ~932 km2 (360 mi2).

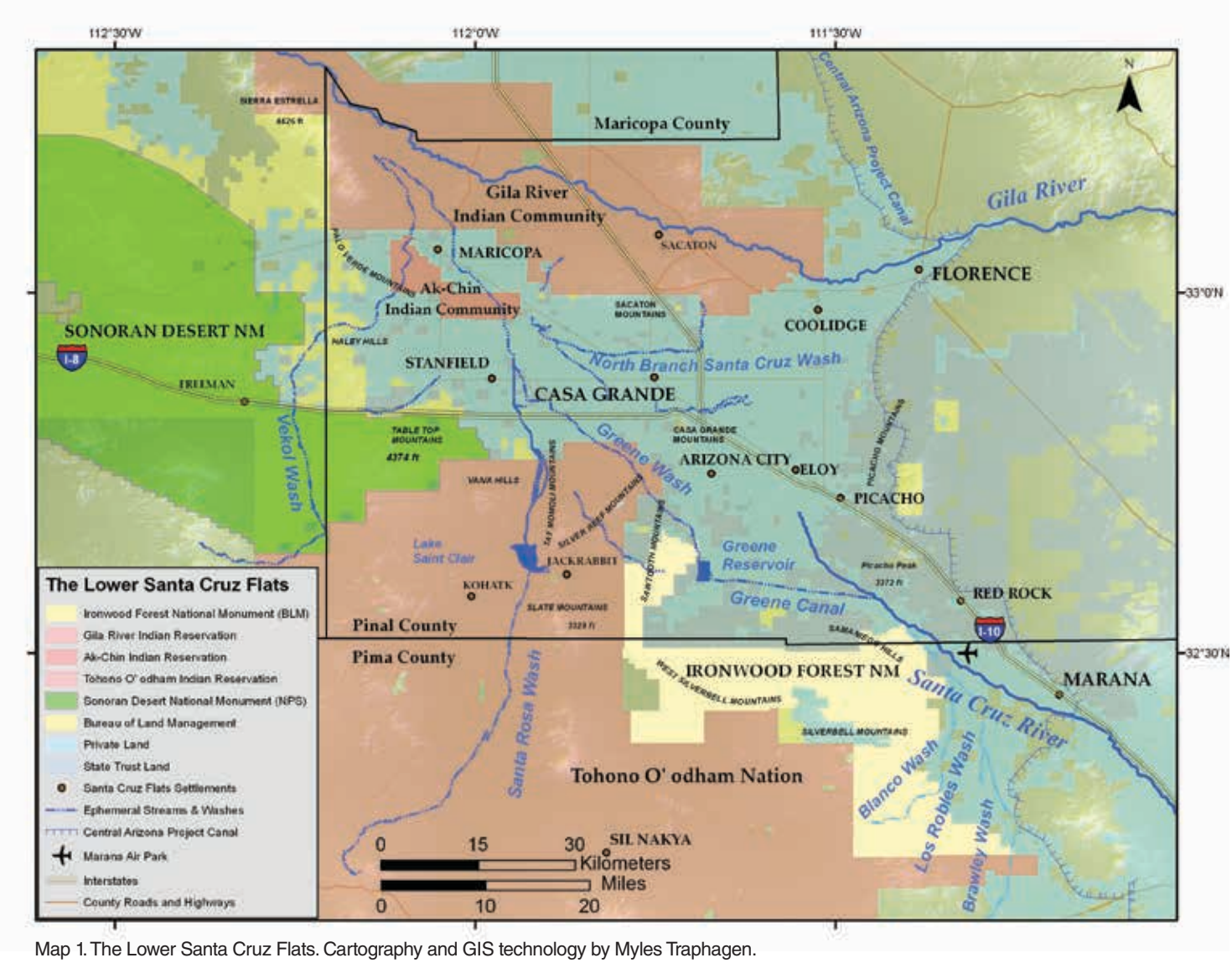
But the course of the River was not always so. Prior to the construction of Greene Canal in 1910, an intended conduit for Santa Cruz flood waters to Greene Reservoir, the periodic flows of the Santa Cruz spread out on to the Santa Cruz Flats to be drained by distributaries. Two main drainages constituted the "North Forks" that flowed northwest by west. The lower "Old North Fork" of the Santa Cruz (now a narrow concrete canal) crosses the Southern Pacific Railroad northwest of Bon (now Sunshine Boulevard) near Toltec: 32.777597°, -111.549670; 470 m (1543 ft)[1]. North of the railroad tracks the Old North Fork is lost in a myriad of distributaries now transferred into farmland before reappearing as the "North Branch" of the Santa Cruz north of Casa Grande (Stafford 1908). Both of these branches are now much interrupted by farmlands and subdivisions before joining near the town of Maricopa at 32.933792, -111.889523; 396 m (1298 ft) then continuing on to join Greene Canal on the Ak Chin Indian Community as Santa Cruz Wash. The historic stagecoach station at Maricopa Wells was between two branches of the Santa Cruz Wash west of Pima Butte in a mesquite bosque known as Komatke or New York Thicket (Becker 1933).

The most significant tributary of the Santa Cruz River within the Flats is the Santa Rosa Wash, a northward flowing drainage now dammed at the southwest base of the Tat Momoli Mountains (**Figure 2**). The Lake St Clair reservoir and dam, designed by the U. S. Army Corp of Engineers, ambitiously overestimated the amount and duration of potential water storage—so much so that the Corps' claims of its ecological benefits were challenged by the O'odham Nation who won a legal settlement involving acquisition of 50 acres of mitigation lands in Glendale, Arizona for the unfulfilled expectations. The channelized Santa Rosa Wash below the reservoir currently meets an also channelized Greene Wash north of Stanfield where both drainages disappear through intensely cultivated farmlands south of the town of Maricopa and west of Casa Grande. The Santa Cruz Wash then collects the Vekol Wash on the Gila River Indian Community and emerges as a dry riverbed where it enters the Gila River at 33.220764°, -112.137555°; 323 m (1059ft).

Geology

This Basin and Range topography comprising the Santa Cruz Flats is the result of both tectonic and volcanic events over the last 13 million ybp (Logan 2002). The alluvial fill of the Lower Santa Cruz Basin and the Flats is imperfectly surrounded by mountain ranges < 1220 m (4000 ft) that clockwise include the San Maniego Hills, West Silverbell Mountains, Slate Mountains, Sawtooth Mountains, Tat Momoli Mountains, Vaiva Vo Hills, Vekol Mountains, Table Top Mountains, North Table Top Mountains, Haley Hills, Paloverde Hills and the Estrella Mountains in the west, and the Salt River Mountains, Sacaton Mountains, Picacho Mountains, and Picacho Peak to the north and east. These mountains range in age from ca. 50 million to 0.5 million ybp with the most recent

[1]The North Fork of the Santa Cruz now temporarily disappears as a farmland canal north of Harmon Road, 6 miles W of Picacho Peak and 5 miles south of Eloy, 32.730717°, -111.490919°. During exceptional flood events, Old North Fork flows might even enter McClellan Wash before discharging into the "Little Gila" at Blackwater west of the Casa Grande Ruins (Reed 1919). It now reappears just west of the Casa Grande sewage facility where effluent flows proceed to Santa Cruz Wash northwest of Francisco Grande.



Map 1. The Lower Santa Cruz Flats. Cartography and GIS technology by Myles Traphagen.

volcanic activity resulting in the formation of the San Maniego Hills < 1 million ybp. Most of these mountains are of volcanic or granitic origin, the exception being the Vekol Mountains, which are limestone. In general, the surrounding mountain ranges are a minor and local sediment source, most of the valley alluvia having been deposited from sources upstream (Logan 2002).

Soils

The Flats are a sedimentation trap consisting of 30 – 40 m (100 to 130 ft) deep deposits laid down by the Santa Cruz and Santa Rosa washes and dissected by arroyos of Holocene origin. The smaller Picacho Basin is composed of sedimentary material transported by the Santa Cruz River past Marana and has no long term history of channel entrenchment other than the head-cuts associated with the capture of Greene Canal. Sedimentation rates may be high during flood events and most of the "river bed" is aggregating even as arroyo formation continues in other reaches (**Figure 3**). While still subject to fluctuating bed levels, lateral shifts in Greene Canal and the other distributaries are presently rare (Parker 1995). In general, the Santa Cruz as represented by Greene Canal is now narrower and shorter than previously, with soil accumulation greater than removal. The most recent changes are concentrated where Los Robles Wash enters the River as a much incised arroyo with unstable banks.

The Santa Cruz Flats tilt gently to the north-north-west where the area is subject to riverine deposits ranging from early Pleistocene to modern. Most of these flood deposits consist of gravel, clay, sand, and silt of late Holocene origin. Until recently, surface flows of the Lower Santa Cruz River were confined to flood events, and its waters originated almost entirely from underground water flow (Logan 2002). Most of the Flats' soils are flood deposited alluvium < a few thousand years old, show minimal soil development, little desert pavement, and are basically un-dissected. The exceptions are a few old deposits, some hundreds of thousands of years old, isolated from the more substantial fluvial deposits. These soils are composed of strongly developed clays with calcium

Figure 1. A characteristic image of the upper Lower Santa Cruz River. This photo taken near Sanders Road looking southeast towards Tucson at 604 m (1980 ft). Note the abundance of the dominant tree, *Tamarix aphylla*. EM, 23 June 2015.

carbonate rich horizons and are entrenched 1 to10 m below the surface with strongly developed varnish.

The following soil types have been identified by Jackson (1990) and Klawan et al. 1998: a Holocene alluvium (0-10 ka) composed of sand, silt, clay or sandy loam and gravel close to the mountains or laid down by recent channel deposits. These soils are prone to inundation in moderate to large flow events and may be clothed in grasses and herbs with mesquite typically present.

Middle to early Holocene alluvial soils (2 to 10 ka) are mostly isolated from modern flow regimes and are composed of sand or gravel with the lowest lying areas subject to sheet flow. Channel patterns are distributary, the soils composed of gravelly and loamy sands with little clay or carbonate development and separated from the main channel system. Many of the finer grained surface areas experience shallow flows during large floods and may have formerly been savannas but are now, or recently have been, under cultivation. Those areas not under cultivation are typically populated by saltbushes (*Atriplex* spp.).

Level silt and clay surfaces, referred to as playacitas (little beaches), often experience sheet flooding due to their impermeable nature (**Figure 4**). Playacitas, with their hard pan clay bottoms, are thought to have developed during the Late Pleistocene, and continue to expand today – probably at an accelerated rate. Where not periodically flooded, they are typically inhabited by crucifixion thorn (*Castela emoryi*), creosote (*Larrea tridentata*), and/or mesquite (*Prosopis juliflora*), but large areas of playacitas are devoid of vegetation due to grazing pressure (**Figure 5**).

The coarser Middle and Early Pleistocene alluvia (>10 ka) found outside the immediate flood plain is usually populated by desert vegetation, and the reddish alluvial soils found in much of the region are due to iron oxide—a common characteristic of tropical soils. Some such laterite areas as the plains surrounding the Tator Hills have annual grass understories reminiscent of Shreve's "Plains of Sonora" (Turner and Brown 1994, Brown and Makings 2014). (**Figure 6a**).

Prior to intensified agricultural development after World War II there were abundant sand dunes west of Santa Rosa Wash from the Papago Indian Reservation northward to the Gila Bend–Casa Grande Highway and the Gila Indian Reservation (Becker 1933). These dunes are now much reduced in extent but some excellent

Figure 2. Lake St. Clair, the large dam constructed in the early 1980s that captures the Santa Rosa Wash southwest of the Tat Momoli Mountains. The reservoir failed as a recreation site as the water levels never exceed a foot or two in depth, but waterfowl continue to enjoy the ephemeral shallows and mud flats. EM, 5 November 2015.

examples remain on the Tohono O'odham Nation (**Figure 7**).

Although the flood of most impact was probably the winter of 1914-15, most floods are the result of tropical depressions of southern origin with events occurring in September and October 1926, 1929, 1930, 1961, 1971, 1977, 1983, 1993, and most recently, on September 9, 2014 (**Figure 8**).

The largest flood of record, however, was the result of Tropical Storm Octave which came in off the coast of Baja California from September 27 through October 3, 1983-- the 6th major flood in 21 years (Roeske et al. 1989). Stream flow gauges at Cortaro (there are none in the study area) showed a peak discharge of 1840 m^3/sec (65,000 ft^3/sec) on October 2 with an additional discharge from Brawley Wash into Los Robles Wash of 354 m^3/sec (12,500 ft^3/sec), the highest on record. The result was a river 6.4 km (4 mi) wide between Red Rock and Sasco with a 126 km (78 mi) swath of the Flats covered with water and many channel changes. Former distributaries such as the North Fork and Santa Cruz Wash were inundated with some waters even entering McLellan Wash north of Interstate 10. Although the river was 6.5 km (4 mi) wide at Chuichu, the widest flood waters occurred between Stanfield and Maricopa where waters from Santa Rosa Wash resulted in a flooded area of 694 km2 (268 mi^2).

Climate and Weather

"As the sun sank below the horizon, the dark cloudbank which we had observed far to the south ascended, and we could see the rain already falling on the distant mountain. Night now set in; the thick clouds, rose higher and higher, and before nine o'clock had completely obscured every star… But nature's light-house opened its portals, and vivid lighting flashed around us… Peals of the most terrific thunder burst upon us, leaving scarcely an interval of repose. Next came violent gusts of wind, accompanied by clouds of sand and dust, reminding one of the African simoom. The wind was from the south, and brought the sand directly in our faces. To avoid it was impossible… Lastly came torrents of rain, and this terrific storm was at its height."

James Bartlett: summer 1854

Figure 3. Arroyos and head cuts near Greene Canal. Los Robles Wash in backround. EM, 21 February 2014.

Table SC-1. Mean precipitation at stations near the Lower Santa Cruz River.

Station	Elevation m	Σ Annual Precip. (cm)	Σ Annual Precip. (in)	Σ Jul-Sep. Precip. (cm)	Σ Jul-Sep. Precip. (in)	Percent	Σ Minim. Temp. C
Redrock		24.84	9.78	11.6	4.58	47	11.6
Eloy 4NE		24.21	9.53	9.04	3.56	37	12.1
Casa Grande		21.31	8.39	8.81	3.47	41	11.8
Maricopa		20.12	7.92	6.96	2.74	35	12.3

The climate data were taken from Climatography of the U. S. No. 20, supplement No. 1. 1988. National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, N. C.

The entire lower Santa Cruz River and adjacent Flats are characterized by an arid Sonoran Desert climate with hot days and high evaporation rates. Rainfall is unequally divided between an October to March period of Pacific frontal storms and a shorter, more intense July-August monsoon with September and October often seeing the remnants of Pacific hurricanes (Turner and Brown 1994). Nighttime temperatures on the Flats can be cool due to temperature inversions; mean minimum temperatures ranging from 11.6° C (52.8° F) at Red Rock, through 12.1° C (53.8°F) 6.4 km (4 mi) NE Eloy to 12.3° C (54.1°F) 16 km (10 mi) north of Maricopa (**Table SC-1**) with a mean of 236 frost-free days a year at Casa Grande (Koss et al. 1990).

Going downstream, the mean annual precipitation at Red Rock is 9.78 inches—close to the minimum amount of precipitation needed to support an annual grassland. This total precipitation gradually declines as one proceeds northwesterly along the river

Figure 4. Sheet flooding on clay surfaces of a playacita after a winter rain. DEB, 3 March 2013.

to 20.12 cm (7.92 in) per annum at Maricopa (Table SC-1). Of more significance may be the decline in the amount and percentage of summer rainfall, July through September amounts falling from 11.6 cm (4.58 in) (47%) at Red Rock to 6.96 cm (2.74 in) (35%) at Maricopa. Areas subject to periodic overflows or high groundwater levels may be characterized as wetlands.

The most pronounced weather phenomena of the Lower Santa Cruz Flats are dust-devils and the dust storms popularly known as *haboobs* (Arabic for blown). Dust-devils are small whirlwinds from 3 to 30 m (10 to 100 ft) in diameter that can reach heights of up to 305 m (1000 ft). These whirlwinds are usually formed in fair weather as the ground heats up during the afternoon hours. Hot air near the ground surface rises through pockets of lower pressure, cooler air. As hot air flows horizontally inward to replace the hot air lost at the bottom of the vortex a spinning effect is created that results in the whirlwind picking up and transporting soil, sand, and small amounts of debris.

Of more concern are the dust storms known as haboobs (**Figure 9**). Unlike dust-devils, haboobs are caused by strong winds rushing downward and outward ahead of advancing thunderstorms. These storms are most common in desert areas barren of vegetation and having an abundance of loose surface materials. The size and extent of a haboob can be impressive with winds greater than 80 km/hr (50 mi/hr) and fronts up to 161 km (100 mi) wide with columns of dust up to 1525 m (5,000 ft) tall. The amount of soil and sand thus transported may reduce visibility to practically zero.

The Flats are an advancing desert area especially prone to haboobs, which most often form during the mid-summer monsoon when the ground is dry. Because of its geographic location and the presence of *playacitas* and other areas of bare ground, the Flats are a center of haboob development, the storms tending to drift north by northwest into Maricopa and then the Salt River Valley.

Unlike some other arid areas, annual precipitation and antecedent rainfall does not appear to be a determining factor for frequency or intensity of haboobs on the Santa Cruz Flats (Brazel et al. 1986). Rather, the variability, size and rate of haboobs is related to the presence of bare ground and anthropomorphic changes in soils. Unfortunately for motorists and especially truckers, the busy I-10 corridor between Phoenix and Tucson passes directly through this risk area and is frequently struck by these dangerous conditions.

Figure 5. A playacita under heavy grazing pressure, Picacho Mountains in background. EM, 21 February 2012.

Human History

The Santa Cruz Flats were occupied by Archaic hunter-gatherers from 3900 to 1500 ybp with incipient agriculture being practiced along the Lower Santa Cruz during wet years from ca. 2000 to 1500 ybp (Greene and Mathews 1976, Haury 1976, Szeuter 1991). Several ceramic sites indicate the presence of Hohokam peoples practicing flash flood or "Ak Chin" farming to at least 1450 AD, and the Pima Indians practiced irrigated agriculture along the lower Gila River into historic times. Although there have been a number of Hohokam excavations along the Lower Santa Cruz (see e.g., Johnson 1980, Szeuter 1984a, 1984b, Gillespie 1989), and the discovery of former dwellings and a canal, Hohokam presence appears to have been mostly seasonal rather than in the form of permanent settlements such as were present along the lower Gila River in the vicinity of the Pima villages.

Major petroglyph sites close to the river can be found in the San Maniego Hills, in the Tater Hills, and undoubtedly elsewhere. Animals depicted are mostly bighorn sheep and deer although the bones found in nearby middens are mostly from small game species with cottontails and jackrabbits predominating—the ratio of black-tailed jackrabbits to antelope jackrabbits being close to 1:1 (Johnson 1980, Gillespie 1989, and Weaver 1988). Other archeological sites include a still used shrine in Aguirre Valley and a "Man-in-the Maze" rock figure of recent origin.

The principal use of the Santa Cruz Flats after 1500 AD appears to have been by Indian and later Spanish and Mexican explorers and travelers wanting to traverse the lower Santa Cruz Basin en route to the Gila River and the Pima Indian settlements. The same can also be said for the first American visitors, many of them taking what was a known route from Tucson to California and back. All of the travelers, a number of them driving stock to California, address the lack of surface water along the lower Santa Cruz, which appears to have been populated by mostly desert vegetation and annual grasses (Davis 1982, Brown 2009). In July 1849 Cox

(1925) reported:

> "*In the dry season there is not a drop of water and but little or no grass. But luckily for us, there had been seasonal rains, and we found holes of water all along the road. And there was considerable young grass springing up, which helped amazingly; but it was only in spots that we found this.*"

That grass was more or less an annually available commodity as indicated by Bartlett (1854: 252-260) who reported meeting a herd of 14,000 sheep near Picacho en route to San Francisco. Despite the heavy demands of 49ers and their livestock, Bartlett (293) reported "*plentiful grass along the road.*"

In April 1863 the situation was different. Conner (1964) stated:

> "*The country from Tucson to this village was nothing but one continuous desert. The only grass on the route of any consequence was coarse like wheat-straw [Hilaria rigida] and stood in bunches six or eight inches in diameter about the desert, with sand drifted against it … When we got about halfway to the Pimas on this trip, we encamped amongst some thinly scattered mesquite trees in the sand to rest at noonday.*"

Watered as it is, principally by underground flows, the Santa Cruz Flats were only available for settlement where ground water was extracted. The first wells along the lower Santa Cruz were dug by the Overland Mail Co. between 1858 and 1864 (Logan 2002). One site, known as Blue Water near Picacho Peak was the site of Arizona's only Civil War battle. The well was 21 m (69 ft) deep, furnished 4,000 gallons a day, and "near good grama and galleta grass" (Shin 1862 in Barnes 1988). These wells were primarily to benefit travelers, however, and the lack of permanent surface water hindered homesteading and agricultural development through to the turn of the 20th Century. Sufficient grassland habitats persisted for Mearns (1907) to collect a doe antelope from a herd seen between Red Rock and Rillito in 1885 and Breninger (1899) to obtain a white-tailed hawk nest near Red Rock in 1891 – a species restricted to tropic-subtropic grasslands and now extirpated from

Figure 6a. Representative photo of the Plains of Sonora—all aspect of an annual grassland near the Tator Hills. Local intense rains made for an exceptional year for many annuals, especially *Bouteloua aristidoides* (needle grama) shown here. EM, 3 October 2016.

Figure 7. Cocklebur Dunes on the Tohono O'odham Nation, clumps of big galleta (*Hilaria rigida*) the dominant vegetation here. DEB, 24 October 2013.

Arizona (Adams 1903, Brown and Glinski 2009).

Farming began farther south along the lower Santa Cruz near Rillito Creek where water was closer to the surface and at least intermittently present during the wet years of 1868-1870. More than 80 farmers had settled at "Nine Mile Water Hole" by 1869 with ca. 500 acres cultivated near Rillito Stage Stop (Gustafson 1966). Farming downstream at this time was still dependent on flood water overflows, "Ak Chin" farming, and years of above average rainfall along the river and its tributaries—the exception being a large spring of Santa Cruz water at Maricopa Wells, which continued to provide travelers with grains and other crops.

It wasn't until after 1884 that windmills and reservoirs allowed ranching and farming along the Lower Santa Cruz to become permanent operations. Windmills, however, can only pump water from 9 to 12 m (30 to 40 ft), so that there was little or no development in much of the lower basin of the Santa Cruz until the advent of steam pumps after 1900. What development that did occur was more mining than cultivation, the annual forage succumbing to grazing pressures. Homesteading families, having sunk a successful windmill to groundwater would irrigate a few acres, graze out the available grasses and move on to another site to repeat the process – which continued and accelerated through the 1920s and 1930s (Aguirre 1983). Fire, never a common phenomenon, ceased entirely with the lack of fine fuel.

According to Aguirre (1983) whose family homesteaded in the Sasco area, grasses that reached the stirrups of a saddled horse were present. One could hoe "grama" grass [possibly Rothrock grama (*Bouteloua rothrockii*) or, jackrabbit grass (*Bouteloua barbata*) to feed mules at night. More wells were dug in 1890s not for farming but for ranching. Cattle ran freely along the lower Santa Cruz and its tributaries including the Picacho Reservoir, Altar and Avra Valley areas. Both dry farming and well irrigation began around 1903 and greatly expanded after 1912. Hay fields, formerly grown in wet years, ceased (**Figure 10**), and grassy areas such as a site called "El Llano," five miles west of Rattlesnake Pass in Avra Valley, disappeared. By 1919 grazing and droughts had changed the complexion of the Santa Cruz flats as earlier homesteads were abandoned and new ranches were built. Game, including antelope, declined greatly by 1921 (Aguirre 1983).

The greatest changes to the Santa Cruz Flats were yet to come, however, the result of irrigated agriculture on a large scale. In 1908 work began on the "Santa Cruz Reservoir Project," a large

Figure 8. Flooding from a tropical storm. DEB, 9 September 2014.

scale irrigation scheme first proposed in the 1880s and financed by Colonel William Cornell Greene, the mining and cattle magnate of Cananea fame (Sonnichsen 1965). This $10 million project consisted of a 21 km (13 mi) canal to transport flood waters from the Santa Cruz River to Greene Reservoir, the latter designed to hold 300,000 acre feet of water. To augment the inconsistent flow of the river, wells were drilled 10 km (6 mi) southwest of Red Rock where water was found at 38 m (125 ft) (Carpenter 1993, Logan 2002). Despite crops being planted as early as 1909, the venture failed when flood waters during the winter of 1914-15 rechanneled the Santa Cruz into Greene Reservoir, taking out the water delivery system. The low gradients, and lack of a proper dam site, coupled with upstream head-cuts and arroyo formation, showed the impracticability of surface water impoundments for large scale irrigation projects. Future irrigation efforts would depend solely on ground water

Massive agricultural development based on groundwater received a major impetus during the World War I cotton boom when Edward Post drilled 10 new wells in the River's floodplain between Rillito and Marana. Pumps operated by 1500 kilowatt steam turbine generators proved highly successful. Downstream developments soon followed as well farms opening up new fields at Carder, Marana and Red Rock (Logan 2002). Water pumped into impoundments increased the acreage available to farm and new irrigation districts proliferated between 1930 and 1950 in the Avra-Marana, Eloy, Casa Grande-Florence, Sacaton, and Stanfield-Maricopa areas. By the mid-1930s, well water was being used to irrigate >98,000 acres from the Santa Cruz's confluence with Rillito Creek to the Gila River.

In the meantime, the damage wrought by homesteading families continued. Wells that did not lift enough water for large scale irrigation supplied stock waters, and the government was now aiding ranchers by constructing stock tanks on state and private lands. Although these tanks proved a boon to migrating waterfowl and made ideal water sources for wildlife, they also allowed cattle and horses to access the Flat's last vestiges of forage (**Figure 6a**). On a more subtle basis, these water retention features interrupted both drainage and surface flows, thereby effecting plant distribution and contributing to the expansion of playacitas and frequency of haboobs.

The use of diesel engine pumps after the 1920s was such that ground water levels on the Santa Cruz Flats levels dropped > 91

Figure 9 (above). A dust storm (haboob) on the Santa Cruz Flats. DEB, 25 July 2013.

Figure 10 (left). A grassland near Casa Grande, Arizona, circa 1915. The species of grass are unknown and may be cultivated but modern grasslands in ungrazed portions of the Flats are remarkably similar. Photo courtesy of Casa Grande Valley Historical Society.

m (300 ft). As more lands were leveled after World War II, ground water depletion accelerated. The result was a subsidence of alluvial deposits and the appearance of earth cracks. First noted in the 1920s, these fissures proliferated in the 1960s due to the compaction of the aquifer - in places, as much as 4 m (13 ft). One fissure, known as the Picacho Fissure or "El Grande," was > 16 km (10 mi) long and 300 m (984 ft) deep (Carpenter 1993). By the 1970s, subsidence events and earth fissures had appeared south of Eloy, west of Arizona City, and west of Stanfield (Laney et al. 1978). Although these earthen fissures tended to down-throw westward and close over time, like irrigation canals, stock tanks, and other human related features, "earth cracks" contributed to the destabilization of surface flows (Laney et al. 1978, Carpenter 1993).

In 1950 there were some 867 farms along the Santa Cruz in Pinal County and 358,383 acres of cultivated land. One thousand five hundred and fifty wells pumped water at an average depth of 53 m (174 ft). Ground water depths had declined 11 m (37 ft) from 1942 to 1952; the land surface near Eloy dropped 14.5 m (15 ft)

Figure 11. An Organ pipe cactus (*Stenocereus thurberi*) growing on a south slope in the West Silverbell Mountains. This species is found mainly in portions of southern Arizona and northern Mexico and is rare in central Arizona. This is among the rare scattered individuals that reach their northern limits in the area. EM, 4 October 2016.

from 1952 to 1985 (Carpenter 1993). The solution, if there was one, was said to be the importation of water from elsewhere to recharge the aquifer.

By 1982 the number of farms had declined to 454 while the number of acres under cultivation had increased to 1,110,000. As a result, a number of farms in areas having deep cones of water depression were retired, and the amount of ground water pumping lessened (Carpenter 1993). Then, in 1990-1992, the Central Arizona Project brought the first water to the Lower Santa Cruz Basin, transporting Colorado River water 541 km (336 mi) from Lake Havasu. The Central Arizona Irrigation District in Eloy contracted for 132,000 acre feet of CAP water per year and had 87,000 acres under cultivation in 1993. The main effect of the CAP on regional ecology, however, was for the canals to block incipient drainages and eliminate natural surface flows.

Another major development beginning in 1966 was the addition of diurnally fluctuating flows into the Santa Cruz River from Tucson's Roger Road and Ina Road water reclamation facilities. Beginning immediately downstream from Canada del Oro, theses discharges, augmented by runoff from the Central Arizona Irrigation District, contributed >50,000 acre feet of secondary effluent a year. The result is a potential perennial effluent flow of from .6 – 2 m^3 (20 to 70 ft^3) for 6.5 to 40 km (4 to 25 mi) below Cortaro despite the ground water level being 76 m (250 ft) below the surface (Carpenter 1993). At present the "Living River" series documents annual changes in flow along a 37 km (23 mi) stretch of the Lower Santa Cruz River from the Sweetwater Treatment Plant to Trico Road (Sonoran Institute 2015). Unfortunately, the municipal flows now rarely enter Pinal County due to commitments upstream. The only surface flows in the Lower Santa Cruz are now from rains and irrigation drains, which may result in water being present as far downstream as the site of Greene Reservoir. These intermittent discharges permit the establishment of such riparian plants as Athel tamarisk (*Tamarix aphylla*) and tree tobacco (*Nicotiana glauca*), with drain-waters contributing to the retention of riparian vegetation as far down as Komatke. Although these flows become seasonal past Marana, there may now be more surface water in the Lower Santa Cruz River than at any time in history.

From the 1960s through the 1970s the City of Tucson purchased 20,000 acres in Avra Valley, and retired these lands as water banks. This "conservation" acreage has since grown substantially, and the Santa Cruz Flats watershed in Pinal County could benefit from a similar program. As it is, the crop situation on the Santa Cruz Flats is more extensive, "cleaner," and perhaps more varied than upstream in Avra Valley. The impact of irrigated agriculture is mostly a plus, as far as wildlife is concerned. Major crops, depending on season and market prices, are in rough order of occurrence: cotton, alfalfa, wheat, maize, barley, sorghum, and safflower. A pecan grove is present just west of the town of Picacho and a smaller one is a few miles west of Red Rock.

Of significant but lesser environmental impact was "Operation Corona." Between1968 and 1972 a joint effort by the U. S. Corp of Engineers and Army Map Service resulting in 267 white Maltese crosses constructed in an area 27 km (17 mi) long and 27 km (17 mi) wide on section corners of State Lands south and west of Casa Grande. Each cross was made up of 4 tapered concrete slabs 9 m (30 ft) long with the outer edges being 2 m (6 ft) across. Located exactly one mile (1.6 km) apart, the purpose of these markers was to calibrate and orient cameras in satellites so that they could take precise photos from an elevation of 100 feet (30 m). The Corona program was abandoned in 1972 with the advent of GPS technology, leaving the crosses in situ as cold war relicts.

The Santa Cruz Flats and adjacent areas continue to be a major communication thoroughfare. Highway traffic has increased on Interstate 10 and the Southern Pacific Railroad grade has been improved with plans for greater railroad activity in the future. Other developments include a proliferation of power transmission lines throughout the Lower Santa Cruz watershed. Like the stock tanks,

Figure 12. A saltbush community along Sunland Gin Road - mostly *Atriplex polycarpa* with scattered creosote (*Larrea tridentata*) and cane cholla (*Cylindropuntia spinosior*). EM, 8 October 2012.

these features come with both positive and negative effects, the poles and other structures providing roosting sites for the increasing numbers of raptors using the area. The same can be said for the borrow pits resulting from the construction of Interstate 10 – although interfering with natural drainage patterns, these features are important stopovers for migratory waterfowl and other birds.

The activity threatening the most change to the area's natural landscape is the suburban development that has sprung up since 1960. Communities such as Arizona City, Francisco Grande, Red Rock, and especially Maricopa, have the potential to impact the natural environment of the Lower Santa Cruz as much or more than agriculture. Although the area taken up by these communities is nowhere near that occupied by farmland, the demands of their citizens for recreational waters, flood control, domestic use, and urban cultivation will continue to grow.

Vegetation

Elizabeth Makings and David E. Brown

The entire watershed of the Santa Cruz flats lies within a Sonoran Desert climatic regime and most of the natural vegetation consists of some form of Sonoran Desertscrub (Turner and Brown 1994, Wiens 2015).

Arizona Uplands

Arizona upland communities characterize the mountains and *bajadas* with such typical arboreal components as saguaro (*Carnegiea gigantea*), foothill paloverde (*Parkinsonia microphylla*), blue paloverde (*P. florida*), whitethorn acacia (*Acacia constricta*) and ironwood (*Olneya tesota*) – the latter tree being so prominent in the drainages that much of the area to the south and west is the eponymous inspiration for the designation of Ironwood National Monument in 2000 (Wiens et al. 2015). Saguaros are especially notable and the abundance of young plants on bajadas emanating from the West Silverbell Mountains and Picacho Peak attest to a bright future for this species. Chollas are common, especially *Cylindropuntia*

acanthocarpa, *C. arbuscula*, *C. bigelovii*, and *C. fulgida*. Other frequently encountered cacti are the barrel (*Ferocactus wislizeni*), the hedgehog (*Echinocereus engelmannii*), the pincushion (*Mammillaria grahamii*) and prickly-pears (*Opuntia phaeacantha* and *O. chlorotica*). Understory shrubs are represented by triangle-leaf bursage (*Ambrosia deltoidea*), creosote (*Larrea tridentata*), and less commonly, brittlebush (*Encelia farinosa*). Jojoba (*Simmondsia chinensis*) is locally present in the Silverbell, Sawtooth, and Newman mountains. The study area hosts some of the northernmost organ pipe cacti which occur in the Slate and Santa Rosa mountains. Two individuals have been vouchered with physical specimens at regional herbaria -an isolated plant in the West Silverbell Mountains (**Figure 11**) and another at Desert Peak, a small mountain range southeast of the Picacho Mountains (SEINet 2016).

The presence of herbaceous vegetation in the Arizona Uplands is entirely dependent on seasonal rains and winter precipitation brings forth ephemerals such as foothill deervetch (*Acmispon maritimus*), red brome (*Bromus rubens*), Western tansymustard (*Descurainia pinnata*), California poppy (*Eschscholzia californica*), pepperweeds (*Lepidium* spp.), lupines, (*Lupinus* spp.), combseed (*Pectocarya recurvata*), distant phacelia (*Phacelia distans*), and Bigelow's bluegrass (*Poa bigelovii*). Summer monsoon rains usher in another suite of herbaceous species, most commonly trailing four o'clock (*Allionia incarnata*), fivewing spiderling (*Boerhavia intermedia*), fall tansyaster (*Dieteria asteroides*), sandmats (*Euphorbia* spp.), and slender goldenweed (*Xanthisma gracile*).

Figure 13. *Mammillaria thornberi*, a rare fishhook cactus, reaches its northern limit among the creosote and mesquite shrublands of the Santa Cruz Flats. EM, 13 September 2013.

Lower Colorado River Subdivison

The Santa Cruz Flats are punctuated by small mountain ranges on the periphery with Upland Sonoran Desert vegetation on their slopes, but most of the area is flat, open, and treeless, and can be portrayed by its shrub component. These Lower Colorado River Valley communities are mostly represented by stands of either creosote or saltbush (*Atriplex polycarpa*, *A. canescens*) depending on flood history and soil deposition (**Figure 12**). Creosote shrublands are expansive, and can be dominated by this single species, with white bursage (*Ambrosia dumosa*) being an infrequent associate and a local co-dominant. Other associates include ironwood, crucifixion thorn (*Castela emoryi*) and the barrel cactus, *Ferocactus wislizeni*.

When soils become more alluvial and fine textured the community transitions into mesquite-saltbush scrub. The finer and more alkali saltbush communites typically contain wolfberry (*Lycium andersonii*, *L. fremontii*), velvet mesquite (*Prosopis juliflora*), and an occasional graythorn (*Ziziphus obtusifolia*). Other areas of shrubby mesquite interspersed with areas of bare ground are also best described as desertscrub, and as is the case with some creosote shrublands, are in flux with some populations dying, or less often advancing, due to ongoing changes in the local flooding regime. Cacti include cane cholla, *Cylindropuntia spinosior* and chain fruit cholla, *C. fulgida* (and hybrids of the two), with small but important areas populated by the club cactus (*Grusonia kunzei)*. A rare and endemic fishhook cactus (*Mammillaria thornberi)*, also makes its home among the mesquite and creosote of the Flats and reaches its northern distribution here (**Figure 13**).

The Santa Cruz Flats are notable for their diversity of the so-called salt bushes with species distribution based on a continuum of moisture, soil texture, and salt tolerance. Areas just east of the Sierra Estrella on the Gila River Indian Community are excellent examples of thriving salt bush stands with Mojave seablite (*Suaeda nigra*), several species of Atriplex (*A. canescens*, *A. lentiformis*, and *A. polycarpa*) as well as the more uncommon iodine bush (*Allenrolfea occidentalis)*, a monotypic genus, as is greasewood (*Sarcobatus vermiculatus*). These species are not rare, in fact they are quite widespread in the west, but remarkable for their localized distribution and tolerance to highly alkaline habitats (**Figure 14**).

A few remnants of formerly more extensive sand dunes re-

Figure 14. An area along the Santa Cruz Wash east of the Sierra Estrella Mountains just below the confluence with the Gila River where salt tolerant species such as *Allenrolfea occidentalis*, *Sarcobatus vermiculatus*, *Suaeda nigra*, and several species of *Atriplex* are thriving. EM, 4 November 2015.

main and also host their own suite of specially adapted species. Populations of big galleta, *Hilaria rigida*, consistently appear on stable dunes and characterize the dominant vegetation with joint fir (*Ephedra aspera*), goldenbush (*Isocoma acradenia*, *I. tenuisecta*), and creosote as common associates. Transitions between dunes and finer-textured soils can be abrupt but easily detected by the presence/absence of big galleta (see **Figure 7**).

Castela emoryi (Emory's crucifixion thorn) is a local but not uncommon shrub/tree along the Flats where it occupies low, seasonally moist areas of fine textured soils in plains, washes, playas, and alluvial bottoms. The species occurs from northwest Mexico, where it is very uncommon, to central and western Arizona and into California's Mojave desert. In California it has rare plant status and even a natural area named after it in Imperial County.

Most populations of *Castela* are small and scattered and rarely exceed 100 individuals, and on the Flats, *Castela* is often seen in sparsely vegetated areas with little in the way of herbaceous understory (**Figure 15**). Distribution is well known since it is such a conspicuous plant on the landscape, but population dynamics, demographics, pollination biology, reproduction, seed dispersal, and other life history traits, remain relatively undocumented. For example, *Castela emoryi* was thought to be an obligate dioecious species, but hermaphrodite individuals have recently been found (Bell & Herskovitz 2013). The fruits are held on branches for multiple seasons and female trees can be seen with up to five years of undispersed seed clusters which suggests they are being presented to a vertebrate herbivore, perhaps an extinct member of the Pleistocene fauna such as a camel, horse, or sloth? This supposition is also supported by the adaptation of a thick seed coat which would be necessary for passing through the gut of a mammal, and even the architecture which consists of hard stems and intricately woven spiny branch tips seems to suggest a response to a large herbivore of the past.

Recruitment and germination rates are also unknown. Seedlings are certainly rare (the authors have never seen one) and juvenile plants have been observed infrequently. Age classes appear to be

Figure 15 (left). *Castela emoryi*, crucifixion thorn. Picacho Mountains in background. EM, 13 September 2013.

Figure 16 (top). Some large individuals of a mature population of *Castela emoryi* in the Santa Rosa Wash. EM, 4 May 2016.

skewed toward mature cohorts, one particularly interesting association, with 4.6 m (15 ft) tall examples occurs with velvet mesquite approximately 5.6 km (3.5 mi) south of Interstate 8 in the Santa Rosa Wash floodplain (**Figure 16**). Unfortunately, both surface and subsurface flow to this "*Castela* forest" is blocked by a Central Arizona Project canal and the trees appear to be suffering from long term water deprivation and the overall demographics, especially lack of younger individuals, may be a concern for the future of *Castela* on the Santa Cruz Flats.

Sonoran Savanna Grasslands

Certain areas of the Santa Cruz Flats were, and remain successional grasslands. These relict, and/or disclimax communities decrease in extent as one progresses downstream from Sasco Road toward the Gila River Indian Reservation, which is mostly saltbush. As with some successional communities of retired farmland, the species composition includes annual grasses and forbs, usually at-

Figure 17. Reconstituted Sonoran Savanna Grassland on retired farmland, similar to the historic Figure 10, page 14. Santa Cruz Flats off Greene Resevoir, Greene's Wash in backround. DEB, 14 July 2016.

tended by velvet mesquite, in what has been described as a Sonoran Savanna Grassland (Brown and Makings 2014) (**Figure 17**, see also **Figure 6a**). On the Flats, the typical winter and spring ephemerals are stork's bill (*Erodium cicutarium*), woolly plantain (*Plantago patagonica*), blood weed (*Plagiobothrys arizonicus*), Arabian grass (*Schismus arabicus*), Coulter's globemallow (*Sphaeralcea coulteri),* and London rocket *(Sisymbrium irio*); giving way in the summer months to C4 species such as the Six weeks three awn (*Aristida adscensionis*), the gramas (*Bouteloua aristidoides*, *B. barbata*), Arizona poppy (*Kallstroemia grandiflora*), sprangletop (*Leptochloa panicea*), Mexican panicgrass (*Panicum hirticaule*), and fivewing spiderling (*Boerhavia intermedia*). Woolly tidestromia (*Tidestromia lanuginosa*), and cinchweed (*Pectis papposa*) are also common monsoon annuals that have the capacity to erupt in wetter years. The greenery of Bermuda grass (*Cynodon dactylon*), and Palmer's pigweed (*Amaranthus palmeri*) tends to follow low points that gather moisture. With the exception of Bermuda grass and spider grass (*Aristida ternipes*), herbaceous perennials are sparse and often entirely lacking due to past grazing pressures and/or interruption of surface flows.

Grass species vary with location as do the forbs. Of particular interest due to their rarity are vernal pools on abandoned farmland northeast of the Sawtooth Mountains (**Figure 18**).

Croplands

Perhaps as much as 50% of the natural vegetation of the Santa Cruz Flats has been replaced by irrigated agriculture, the water being supplied by either canals from outside aquifers (e.g., CAP) or deep water wells in situ. Cotton is the dominant crop with a few hundred acres in sod-farms and an even smaller acreage planted in pecans. Alternating crops with cotton have recently included alfalfa, winter wheat, barley, maize, and safflower, roughly in that order. It is these irrigated crops and their itinerant weeds that now provide most of the biotic diversity.

Riparian and Other Wetlands

Surface water on the Santa Cruz Flats is supplied by rainfall, agricultural runoff, and effluent discharge, and while no portions of the river are truly perennial, there are reaches where riparian communities have developed due to reliable surface water such as downstream of the Sweetwater water treatment facility in Tucson to the farmlands drained by Greene Canal. There are several types of wetlands scattered throughout the Flats with varying degrees of permanence and extent.

Figure 18. Low areas accumulate greenery where the moisture gathers in vernal pools such as this one southeast of the Sawtooth Mountains. DEB, 9 March 2012.

Aquatic Habitats: An historic alkali marsh 5 km (3 mi) west of Pima Butte (Walcott 1907) between the site of Maricopa Wells and the Santa Cruz River has long since dried up and perennial aquatic habitats are now mostly limited to concrete-lined canals lacking in riparian vegetation. Aquatics have probably always been scarce in the post-settlement era and are nearly non-existent today where frequent scour with irrigation water prevents the establishment of a submerged flora. Collections of the pondweed (*Stuckenia pectinata*), made in 1927 by Ivar Tidestrom near Sacaton seem to be the only records of a true aquatic (SEINet 2016). Other than the small marsh along the North Fork, there are virtually no marshlands, natural or otherwise. Those few that are encountered are ephemeral in nature and dependent on irrigation overflows. Cattails (*Typha domingensis*) are therefore limited to a few farm ponds and wastewater drains along with willow-weed (*Polygonum lapathifolium*), hydric grasses and other marsh plants.

Riparian Mixed Evergreen-Deciduous Forest: Riparian zones are limited to the naturalized channels of Greene Wash and the Santa Cruz River below the Sweetwater water treatment facility in Tucson. Surface water from this release of secondary effluent reaches the Flats at Rillito and continues intermittently approximately 37 km (23 river miles) at which point the Santa Cruz becomes Greene Wash. An interesting combination of both evergreen and deciduous trees comprise the dominant riparian vegetation along the Santa Cruz River and Greene Wash (**Figure 19**). As trees go, Fremont cottonwoods (*Populus fremontii*) are relatively rare, but Goodding willow (*Salix gooddingii*) is common, particularly along the upper reaches of the Flats closer to the effluent supply. Mesquite, salt cedar (*Tamarix ramosissima*), Mexican palo verde (*Parkinsonia aculeata*), and tree tobacco (*Nicotiana glauca*) are also common, but Athel tamarisk (*Tamarix aphylla*) is the dominant tree from Rillito to the base of the Silver Reef Mountains, at which point, the "River" ceases to have the character of a riparian corridor. Athel tamarisk was introduced from the Old World into the US in the 1920s as a drought-tolerant shade tree and wind break for homesteads and agriculture. Reproducing clonally and by seed both in and outside the flood channel, its presence along this reach of the Santa Cruz is notable for its abundance and dominance. No other Western river throughout its introduced range appears to harbor so many naturalized trees and indeed, the situation along the Flats seems to be unique. Even the Wikipedia page for *Tamarix aphylla* says, "This species has not naturalized in areas of the United

Figure 19 (top). A reach of the Santa Cruz River called Greene Wash. Trees include left: saltcedar (*Tamarix ramosissima*), middle: Mexican palo verde (*Parkinsonia aculeata*), right: Athel tamarisk (*Tamarix aphylla*). Tree tobacco (*Nicotiana glauca*), and mesquite are also present. DEB, 24 October 2012. Figure 20 (above). A cattail (*Typha*) marsh along the North Fork of the Santa Cruz River northeast of Casa Grande. DEB, 29 December 2015.

Figure 21. A wetland sustained by agricultural runoff at the intersection of Shay and Norma roads. The tall reed is *Arundo donax*. Johnsongrass (*Sorghum halepense*) and desert broom (*Baccharis sarothroides*) in the foreground. The trees are Goodding willows (*Salix gooddingii*). EM, 13 September 2013.

States where it is grown, unlike other species in the *Tamarix* genus, that are serious invasive species" (Wikipedia 2016). Regardless of current ecological dogma suggesting Athel tamarisk lacks the "invasive" capacity of its saltcedar cousin, the trees on the Santa Cruz Flats are thriving, reproducing, and abundant. Athel tamarisk, of course coexists with many other plant species, provides excellent habitat for birds and other vertebrates, forage nectar for insects, and erosion control of stream banks, and is a critical component of the local riparian ecosystem.

Three important shrub species that share space with Athel tamarisk are seep willow (*Baccharis salicifolia*), desert broom (*Baccharis sarothroides*), and burrobrush (*Ambrosia monogyra*). Along banks and gravel bars of perennial or ephemeral reaches are wetland forbs such as barnyardgrass (*Echinochloa crus-galli),* common cocklebur *(Xanthium strumarium*), Bermuda grass, knotweed (*Polygonum lapathifolium*), common sunflower (*Helianthus annuus*), toothed dock (*Rumex dentatus*) and Johnsongrass (*Sorghum halepense*).

Other than the effluent discharge from the North Fork (**Figure 20**), there are virtually no marshlands since the dewatering of Picacho Reservoir with the completion of the Central Arizona Project, which in its heyday hosted such rarities as nesting black-bellied whistling ducks (*Dendrocygna autumnalis*) and Yuma clapper rails (*Rallus longirostris ridgwayi*), not to mention such visiting oddities as roseate spoonbills (*Platalea ajaja*) (Brown 2013). Those few wetlands that are encountered are ephemeral in nature, relatively small and dependent on irrigation overflows. A classic example is at the intersection of Shay and Norma Roads where a community of Goodding willow, giant reed (*Arundo donax*), cattails (*Typha domingensis*), California bulrush (*Schoenoplectus californicus*), and other wetland species is evolving (**Figure 21**). As is the case with areas of standing water in the desert, interesting species are often observed, for example, a large specimen of an escaped ornamental, Chinaberry (*Melia azedarach*), adds to the diversity of the flora of the Santa Cruz Flats.

Mesquite Bosques

Of special interest are the many seral stages of mesquite communities. Although some old stands are dying due to ground water depletion and surface water interception, others are in the process of becoming mesquite bosques or woodlands. Impressive

Figure 22. Dying mesquites northwest of Red Rock. As is the case with creosote, the cause of death of these plants is complex, and may be due to changes in water availability brought on by drought, flow alterations, or even flooding. Fire may also impact the long term health of the vegetation. DEB, 23 July 2012.

examples include the delta formed by the junction of Los Robles Wash with the Santa Cruz, and where Greene Wash enters the Tohono O'odham Indian Reservation. Should these woodlands receive even a modicum of protection from wood cutting and water withdrawal the trees should continue to mature and rival the Santa Cruz's best remaining forest—the area on the Gila Indian Reservation where Santa Cruz and Vekol washes join near the village of Santa Cruz. This bosque, a remnant of the once extensive so-called New York Thicket, is being maintained by the river's subsurface flow in contrast to the bosque upstream from Sasco Road and along Greene Canal which are irregularly watered by stream flow. As it is, however, these young bosques are subject to unregulated grazing, clearing, and wood cutting.

More threatened are the smaller woodlands occupying incipient drainages on the Flats. Many of the older individuals in these small bosques are dying due to groundwater pumping and surface flow interception. These mesquites, like those in the developing bosques along the main drainage, presently lack grandeur, support little mistletoe, and do not always have the full component of mesquite bosque associates. Moreover, many of the smaller bosques are transitional in nature as trees are dewatered, drowned, or revitalized by stream flow interruptions (**Figure 22**). In contrast, young, thriving mesquite bosques can be found next to playacitas where surface water is caught by herbaceous vegetation. Such situations are probably mostly temporary, however, as ground water levels are too deep for mature trees to tap.

Stock tanks

Charcos and borrow pits are another surface water source that serve as refugia and habitat for migrating waterfowl and a variety of amphibian, bird and mammals such as coyotes (*Canis latrans*) and raccoons (*Procyon lotor*). Tanks however, also intercept the flow of surface water, and like the extensive canal system, reduce the effective amount of available moisture on the Flats. Also, because of the concentrated livestock use around these charcos, herbaceous vegetation is much reduced leaving mesquite as the only forage available.

Playacitas

The playacitas are the most xeric of the wetlands and these seasonally flooded hardpan depressions are now the Flat's most characteristic habitat type as many a motorist traveling southbound

from Phoenix on Interstate 10 on their way to Tucson may have noticed. Unlike the sand and other substrates that allow growth of grasses and other vegetation, the clay pan surfaces of playacitas discourage plant growth by preventing water percolation and inhibiting root establishment. While subject to flooding, playacitas dry out rapidly, water typically evaporates within 48 hours, the soils shrinking and cracking with the finer soil particles prone to wind erosion. The mesquites and other plants that do not drown tend to starve for water and nutrients (see **Figure 22**). Unprotected by natural vegetation and subjected to continued cattle grazing, the sands and finer particles on playacitas blow away, increasing their size and facilitating the incidence of haboobs.

The Flats of the Lower Santa Cruz River and adjacent floodplains is an interesting study of the resilience of riparian communities and their ability to persist in spite of profound human impacts. The plant communities of the Santa Cruz Flats, as with any river system will continue to change over time as species come and go and climate fluctuates. If predictions of a hotter and dryer Southwest are realized, however, it will be a perilous existence for wetland and even xeroriparian species that are dependent on surface and subsurface water for their existence. To maintain the character of the Flats, its riparian corridors, shrublands, noteworthy and rare taxa, will require active and adaptive management to restore the River's access to its broad floodplain, including for example, removal of various impoundments, and new introductions of effluent discharge from urban sources like Casa Grande and Maricopa. Conservation easements in areas of special concern such as some of the larger populations of *Castela emoryi* are examples of human impacts that will benefit this remarkable place.

Figure 23. Aletris Neils (left) and student with captured fox—both grey and kit foxes occur on the Flats. DEB, 20 September 2013.

Mammals

Aletris Neils

Mammal records were obtained from the University of Arizona mammalogy class using Sherman and Have-A-Heart traps located at 7 selected sites (**Figure 23**). Supplementing these records were the species accounts in Hoffmeister (1984), bat data collected by the Arizona Game and Fish Department, and incidental observations by the author. An attempt was made during each trap night to sample as many habitats as practical including riparian forest, mesquite bosque, two subdivisions of the Sonoran desert, Sonoran Savanna Grassland and a *Castela* community within a playacita.

Some 64 mammalian species were documented as occurring in the study area (**Appendix A**). Commonly encountered species include raccoons, badgers, gray foxes, coyotes, and striped skunks. The most abundant mammals are burrowing rodents, which explains the high numbers of raptors and mesopredators present. Absent from this list is the extirpated pronghorn antelope (Brown and Ockenfels 2007) and probably some of the less numerous members of the orders Insectivora and Chiroptera (bats), which do not lend themselves to capture. No endemics were reported, but the bura deer (*Odocoileus hemionus eremicus*) and antelope jackrabbit (*Lepus alleni*) are characteristic and find the northern limits of their range just north of the study area (**Figure 24**).

Species of special interest include the antelope jackrabbit and kit fox, which find the Flats ideal habitat. Also of interest are small game animals--the desert cottontail, black-tailed jackrabbit and antelope jackrabbit, which supply sport for firearms hunters, muzzleloader aficionados, archers, and falconers. These small animals are joined by a host of big game species in the mountains surround-

Figure 6b. Bare ground is transformed into grassland following the monsoon rains of 2016. Fields of *Bouteloua aristidoides* were especially common in this area ju

ust north of the Tator Hills. EM, 6 September 2016.

Figure 24. Adult female Antelope jackrabbit (*Lepus alleni*) in summer breeding pelage near Coolidge Air Park. DEB, 23 July 2012.

ing the Flats in Game Management Unit 37C that include javelina, desert bighorn sheep and desert mule deer—the latter providing hunters with one of the best opportunity to obtain a bura deer north of Mexico.

Birds

Doug Jenness and Rich Glinski

In addition to the authors' 10 years surveying raptors (Jenness 2016a) and conducting studies of Crested Caracaras (**Figure 25**) and Black Vultures (Jenness 2015, Glinski 2016b), the observations summarized in this report are the result of breeding bird surveys conducted from mid-May to early June, 2013 and 2014 and a winter bird survey conducted in February 2014. Each survey consisted of 3 roadside counts from 32 -48 km (20 to 30 mi) in length that included a northern route beginning at Pearl and Hauser roads and ending at Montgomery Road north of Highway 85; a central route traveling south from Pearl and Hauser roads on Sunland Gin Road and ending on Aries Road; and a southern route starting 2.4 km (1.5 mi) south of where the river crosses Sasco Road and ending northeast of Sunland Gin and Pearce roads. Procedures on these roadside surveys followed the Breeding Bird Index guidelines (see e.g., Sauer and Link 2011) and were conducted by Doug Jenness, Claudia Kirscher, Sue Williams, Susie Vaught, Larry Norris, Brian Walsh, Keith Kamper and Patty Tersey. Additional information was gleaned and confirmed by consulting Glinski (1998) and Corman and Wise-Gervais (2005).

The known number of bird species reported from the Flats currently stands at 267 (**Appendix B**). These records include not only a full complement of resident Sonoran Desert species but also a plethora of migrants including a number of accidental and/or casual visitors. Various factors contribute to this variety including the area's tropic-subtropic location, a complex mix of natural vegetation and irrigated farmland, and an abundance of roosts in the form of power poles, utility lines, dead cottonwoods and eucalyptus trees. All in all, these factors make for some remarkable birding opportunities despite the altered state of the lower Santa Cruz River and the degraded condition of the Flats.

Breeding birds with a few exceptions such as the Crested Caracara, Black Vulture and Tropical Kingbird usually found in habitats farther south, are generally what one would expect in a Sonoran Desert locale. Especially common species include the Curve-billed Thrasher, Cactus Wren, Northern Mockingbird, Black-tailed Gnatcatcher, Greater Roadrunner, Gila and Ladder-backed woodpeckers, Gilded Flicker, Verdin, and Western Kingbird with Common Ravens being notably numerous in pecan groves. Less common as breeding birds are grassland species such as the Western Meadowlark, Rufous-winged Sparrow and Burrowing Owl due to the degradation of Sonoran grasslands as a result of grazing and agriculture. An exception is the Loggerhead Shrike in that this miniraptor is relatively common on the Flats—an unusual situation as this bird is now reduced over much of its range.

As elsewhere, the Flat's relatively few riparian areas are particularly rich in birdlife. Species such as the Yellow Warbler, Yellow-breasted Chat, Bell's Vireo, Song Sparrow and Vermillion Flycatcher frequent the wooded watercourse of the Greene Canal while the area's mesquite thickets support good populations of Lucy's Warbler. Willow Flycatchers are occasionally reported in migration, but no breeding has been documented though this requires further investigation. In addition to migrating waterfowl, several species of waterbirds find resting sites in the region's stock tanks and farm ponds (**Figure 26**), while Cliff Swallows, Barn Swallows, Black Phoebes, Say's Phoebes and Lesser Nighthawks take advantage of the insects cruising the area's canals.

The birdlife of the Flats is pursued by a large and growing cadre of both bird hunters and birders. Hunters appreciate the Flats fall and winter concentrations of Mourning Doves and the premigratory flights of White-winged Doves as most of the Flats are still rural enough to be open to shooting. Adding to the area's reputa-

Figure 25. Crested Caracaras at an agricultural carcass dump. RLG, 21 November 2015.

tion as a bird hunting destination are the now large populations of Eurasian Collared-Doves, which are subject to a year-long open season. That Gambel's Quail are found each year in varying numbers enhances the attractiveness of the area for wing-shooting, and the use of stock tanks and barrow pits by water-fowlers is a popular pastime. Add to these values, the opportunities provided by irrigation water and wastewater fields for shooting Wilson's Snipe, and the Flat's value as a premier small game locale is second to no other area in the state.

An equal or more number of "birders" visit the Flats, mainly in the winter, to view select species, notably the Crested Caracara, Mountain Plover, Mountain Bluebird, and Sagebrush Sparrow. Even more attractive is the assembly of wintering raptors, a phenomenon that has generated an annual count of these birds since January 2006. In the first 10 years, the annual count has averaged 342 individual raptors a year with a low count of 243 and a high of 445 comprising some 20 species (Jenness 2016a). As more birders visit the Flats the number of species will undoubtedly increase, as additional birds are discovered. For example, the lone record for the Spotted Owl was found during a pre-survey search in preparation for the annual raptor count. The bird was not re-located during the survey period 10 days later.

The annual raptor count has demonstrated some possible population trends. For most species the annual difference is as yet too small to be significant, but the mean number of Crested Caracaras has increased 28% over the 5 years (2011-2015), and we now know that > 100 caracaras inhabit the Flats during the winter months. This species' breeding activity occurs in the native desert environs close to the mountains away from the agricultural areas. Indeed, one of the greatest values of the Flats is for additional such research.

Unfortunately, no other group of birds on the Flats has been studied to the extent as the raptors, so little information is available concerning population changes. One dramatic increase that has been recorded is the population boom of Eurasian Collared-Dove—first documented in Arizona in March 2000 and in Pinal County a year later (Jenness 2005). This bird now numbers in the hundreds on the Flats. Another species, the Ruddy Ground-Dove, which first entered the state in 1981, began appearing in small numbers on the Flats after 2000, particularly around feedlots, and a nest was documented in 2006 in riparian habitat, the first documented nest north of Mexico. Since November 2011, however,

Figure 26. Fledged family of Mexican ducks (*Anas platyrhynchos diazi*) at Tres Rios near where the Santa Cruz River enters the Gila River. DEB, 19 July 2014.

this ground-dove has rarely been reported on the Flats, reflecting the fluctuations of a species at the edge of its range.

Sources and times for bird migrations along the lower Santa Cruz River are varied and complex. Swainson's Hawks moving through south-central Arizona temporarily roost in groves of pecan trees at night and feed in freshly harvested or cultivated fields in daytime. The occupancy period of other migrants is more prolonged, and includes such species as the Mountain Plover, which can forage in cultivated fields, particularly sod farms, for much of the winter. For many species, however, the Flat's paucity of riverine forests and/or aquatic fauna results in a bird's absence due to a lack of suitable habitat. For example, although an average of 200 Common Black Hawks have been seen annually heading north since the spring of 2013 on the Tubac Hawk Watch (HMANA 2016) 145 km (90 mi) upstream along the Santa Cruz River, there are as yet no records of this raptor on the Flats. If present efforts to recover ectotherms in the lower Santa Cruz River succeed the Black Hawk should join those raptors already present.

It is also true that nesting opportunities for some species are fewer now due to habitat alterations over the past century. Sonoran Savanna grasslands are gone for the most part, as are much of the riverine mesquites. Birds that formerly occurred on the Flats include the White-tailed Hawk, a species whose only nesting record for Arizona was at Red Rock (Breninger 1899, Brown and Glinski 2000). Some notable exceptions to the degraded nesting habitat now present include the Mississippi Kite nesting in a pecan grove just south of the Flats near Pinal Airpark in 1983 (Glinski, pers. obs.), and the periodic nesting of White-tailed Kites in a remnant grove of decadent cottonwoods on the Flats in 1983 (Gatz et al.1985), and Tropical Kingbirds nesting in single rows of pecan trees bordering agricultural fields since at least 1990 (Jenness 2015).

We speculate that the Flats at one time afforded habitats for additional species of birds. For example, historic breeding records for Ferruginous Pygmy-Owls along the Agua Fria and Salt rivers north and east of Phoenix suggest that this owl might move along riparian corridors like those provided by the Santa Cruz. If so, it is likely that the number of raptors and passerines migrating along the Santa Cruz may have once been greater than it is today.

Ornithological studies of Bendire's thrasher, Loggerhead Shrike,

Lucy's Warbler and Western Meadowlark will be important in determining the habitat needs of these sensitive species.

The importance of agriculture to the birdlife of the Flats cannot be overstated. Farming contributes to the present bird diversity in the form of cultivated fields, pecan groves, canals, pastures, feedlots, dairies, sod farms, cattle tanks, irrigation ditches, and plantings around buildings. Although a comprehensive list of bird species that historically occurred here is now impossible, indications are that bird diversity in historical native habitats has been much compromised. It is also true however, that native vegetation can be restored to areas that have been farmed. The restoration of native grasslands has been well demonstrated upstream in Avra Valley where abandoned agricultural fields have been acquired for water storage. An example is the former farm fields purchased by the city of Tucson along Brawley Wash west of the Tucson Mountains and managed by Pima County Parks and Recreation Department's Natural Resources Division. Some 20 years of nonuse has shown that eliminating livestock grazing can restore the annual grasses that formerly constituted Sonoran Savanna Grassland. Riparian habitats can not only be restored through the release of treated sewage water, but enhanced as is the case upstream below the Tucson treatment plants.

Unfortunately, housing developments continue to convert both native and agricultural areas into residential communities, and it is likely that the Santa Cruz Flats will suffer the same fate as other agricultural areas in the state. Just a few decades ago hundreds of Swainson's Hawks annually gathered to roost in the pecan groves in Tempe on the broad expanse of farmland that was part of the Salt River Valley. The Flats that occurred along the Salt River were not unlike those that presently exist at the lower reaches of the Santa Cruz River. Hopefully, with a little planning as has taken place in Pima County, we will keep the fates of the two river systems from converging.

Reptiles and Amphibians

Randall D. Babb

Reptile and amphibian surveys were conducted between the months of February and November 2015 and consisted of both night-time road driving and active searching by hiking and turning over debris (both day and night). Additional observations were collected from reliable and experienced amateur herpetologists along with other biologists. Observed animals were noted and those of interest photographed. An effort was made to sample a variety of the Flat's habitats including those summarized in **Appendix C**.

Characteristic Amphibians

Amphibians are chiefly represented by summer breeding anurans (frogs and toads) which emerge from the alluvial Flats and adjacent *bajadas*, prior to, or with the onset of the summer rains. Breeding occurs in stock tanks and ephemeral pools – less often in washes—mostly below 427 m (1400 ft) elevation. Many species spend most of their lives aestivating and are surface active for only a few short weeks, temperatures and moisture permitting. An exception is the Sonoran Desert Toad (*Incilius alvarius*) which emerges weeks prior to the onset of the summer rains during some of the year's driest and hottest conditions (**Figure 27**).

The Woodhouse's toad (*Anaxyrus woodhousei*), breeds almost exclusively in the spring while another species, the red-spotted toad (*Anaxyrus punctatus*), breeds both in the spring and summer. Of these amphibians only this later species ascends the slopes to be encountered along rocky upland bajadas where it breeds in tinajas and anthropogenic water catchments. Occasionally the adults or larvae of western tiger salamanders (*Ambystoma marvortium*) may also be encountered in ponds and stock tanks—the result of human introductions for a variety of reasons including fish bait. These populations may persist for long periods and are often comprised of neotenic animals which may grow to a foot (>300mm) or more in length.

The lowland leopard frog (*Lithobates* [*Rana*] *yavapaiensis*) is the only native ranid and has suffered greatly due to the introduction of exotic species and disease. American bullfrogs (*Lithobates* [*Rana*] *catesbeianus*) may be numerous along the wetter reaches of the Santa Cruz River between Sasco Road and Marana, and in the many stock tanks in the Flats. Originally introduced as a game animal this exotic spread widely and has since been implicated in the declines of native frogs and even some snakes. It would not be surprising if in the near future Rio Grande leopard frogs (*Lithobates* [*Rana*] *berlanderi*), another exotic species, also colonized portions of the lower Santa Cruz River watershed, these amphibians having expanded their range along the Gila River to the western edges of the Phoenix Metropolitan area. Like the bullfrog, they are excellent dispersers capable of traveling surprising distances across inhospitable terrain.

Characteristic Reptiles

The Flats and surrounding mountains support a variety of reptiles—none of them particularly characteristic of the lower Santa Cruz River. Lizards are the most frequently encountered due to their diurnal behavior and active nature. The most common of these include tiger whiptails (*Aspidocelis tigris*), zebra-tailed lizards (*Callisaurus draconoides*), ornate tree lizards (*Urosaurus ornatus*), and side-blotched lizards (*Uta stansburiana*) encountered in their preferred habitats (Brennan and Holycross 2006). Although lizards are scarce during the cooler months, both side-blotched lizards and ornate tree-lizards are active year around and may be seen on any

Figure 27. The Sonoran Desert Toad (*Incilius alvarius*) is one of the most common amphibians throughout the Santa Cruz drainage. Vekol Valley. RDB, 6 August 2016.

warm day. On the Flats proper, one may spot predaceous leopard lizards (*Gambelia wislizenii*) and the equally large but herbivorous desert iguana (*Dipsosaurus dorsalis*). Adjacent mountains such as the West Silverbells support some of the State's best populations of desert tortoise (*Gopherus morafkai*)

The banded gecko (*Coleonyx variegatus*) is the only truly nocturnal native lizard and is common in both alluvial and upland habitats. Two species of exotic geckos are generally associated with man-made structures and have become established in the study area. The Mediterranean gecko (*Hemidactylus turcicus*) is already known to occur in Casa Grande, Eloy, Arizona City, Picacho, and presumably elsewhere along the I-10 corridor. The rough-tailed gecko (*Cyrtopodion scabrum*) has only recently been detected in the state, but is likely to colonize towns along the lower Santa Cruz drainage if it has not done so already (Babb 2014).

A few lizard species are restricted to upland habitats and are largely confined to the mountains and rocky outcrops adjacent to the river. The herbivorous chuckwalla (*Sauromalus ater*) is the largest of these, while two species of collared lizards are separated from each other by the lower Santa Cruz River basin. The Sonoran collared lizard (*Crotophytus nebrius*) inhabits mountains on the west side of the river while the eastern collared lizard (*Crotophytus collaris*) is found in most of the ranges on the east side of the river

The Gila monster (*Heloderma suspectum*) inhabits the entirety of the lower Santa Cruz River basin (**Figure 28**). Although it is most often seen on rocky uplands and bajadas, we have also encountered this animal on the Flats. Diurnal activity is greatest in the spring during the months of March through early June. During the humid monsoon season Gila monsters become chiefly nocturnal. They prey on the young and eggs of ground nesting animals.

Snakes of several species are common the length of the Santa Cruz River. Many varieties frequent agricultural areas and provide a service to farmers by consuming rodents and insects considered agricultural pests. Some of the more common species are rarely seen, however, due to their secretive behavior and/or fossorial nature. Such species include the western threadsnake (*Rena humilis*), Smith's black-headed snake (*Tantilla hobartsmithi*), groundsnake (*Sonora semiannulata*), and variable sandsnake (*Chilomeniscus stamineus*). These species are seldom encountered on the surface but can at times be found beneath plant litter and other debris. Larger snakes

Figure 28. Randy Babb and Gila monster south of Big Tank, reconstituted Sonoran Desert grassland. DEB, 8 August 2013.

including the gopher snake (*Pituophis catenifer*), coachwhip (*Coluber* [*Masticophis*] *flagellum*), and California kingsnake (*Lampropeltis californiae*) are more conspicuous. These serpents occur throughout the lower Santa Cruz drainage inhabiting a variety of anthropogenic and natural habitats. The coachwhip is a diurnal species as is its smaller cousin the western patch-nosed snake (*Salvadora hexalepis*). Several smaller snakes such as the long-nosed snake (*Rhinocheilus lecontei*), glossy snake (*Arizona elegans*), desert nightsnake (*Hypsiglena chlorophea*), western shovel-nosed snake (*Chionactis occipitalis*) and leaf-nosed snakes (*Phyllorhynchus* spp.) are predominately nocturnal but can be regularly found in appropriate habitats throughout their active season.

Three gartersnakes were formerly present in the Santa Cruz drainage: the Mexican gartersnake (*Thamnophis eques*), checkered gartersnake (*Thamnophis marcianus*), and black-necked gartersnake (*Thamnophis cyrtopsis*). The latter species inhabits higher elevation uplands and is not found in the area depicted in **Map 1**. The Mexican gartersnake, formerly found in nearly all of Arizona's major drainages, is now extirpated from most of these including the lower Santa Cruz. The checkered gartersnake is the only species currently inhabiting the lower Santa Cruz where it is commonly encountered in agricultural situations such as canals and pumpback ponds.

The western diamondback (*Crotalus atrox*) is the most commonly encountered of the five rattlesnake species found in the lower Santa Cruz Basin and presumably the most abundant (Jones et al. 2011). It is a generalist inhabiting all habitats along the lower river. Sidewinders (*Crotalus cerastes*) are common on desert flats as are to a lesser extent Mohave rattlesnakes (*Crotalus scutulatus*). Tiger rattlesnakes (*Crotalus tigris*) and black-tailed rattlesnakes (*Crotalus molossus*) inhabit the mountain ranges ringing the lower basin.

Herpetological biogeography

Wetland Species: Few herpetozoa are obligate riparian species even though several utilize stock tanks and farm ponds opportunistically and may even occur in greater abundance there. *Lithobates* [*Rana*] *yavapaiensis*, the lowland leopard frog, is currently absent from the lower Santa Cruz although it does well in portions of the upper reaches. Historically it was also known from the confluence of the Santa Cruz and Gila rivers and may have occurred in select habitats the length of the Santa Cruz River. Bullfrogs (*Lithobates* [*Rana*] *catesbeianus*) currently occupies much of the habitats previously occupied by *Lithobates* [*Rana*] *yavapaiensis* and has replaced this and other native amphibians and reptiles. Even though some wetlands may be restored, predation by American bullfrogs makes restoration of native amphibians unlikely.

In a similar fashion, the native Sonoran mud turtle (*Kinosternon sonoriense*) is found in the upper Santa Cruz River but appears to be absent from the lower river even though common in portions of both the Salt and Gila Rivers. Historically this species likely occupied most all of the State's perennial waters.

Of special interest are those amphibians of Sonoran affinity which extend into Arizona in the watersheds of north-flowing tributaries of the Santa Cruz. Here, in the headwaters of such drainages as Santa Rosa and Vekol Washes on the Tohono O'odham Nation in extreme western Pinal County occur relict populations of the Sonoran green toad (*Anaxyrus retiformis*), Mazatlan narrowmouthed toad (*Gastrophryne mazalatensis*), and lowland burrowing treefrog (*Smilisca fodiens*). Although these species may be abundant on tribal lands, individuals barely enter, if at all, the Santa Cruz Valley where they are today associated with washes and stock ponds located in desert flats. This is unlikely to have always been the case as these are grassland species that formerly occurred in habitats populated by the perennial grasses, *Hilaria mutica* and *Sporobolus* spp. and annual grasses belonging to the genera *Aristida* and *Bouteloua*. It is unknown whether these amphibians are now so limited in range because of the destruction of the fragile Sonoran Savanna

Grasslands or due to their never having been present along the lower Santa Cruz River proper.

Upland Species: The mountains and bajadas ringing the lower Santa Cruz drainages hold few surprises from a herpetological perspective. Here, reptiles and amphibians typical of many Arizona Sonoran desert communities are found (Jones et al. 2011). Of most biogeographic interest is that many species find their eastern or western distribution limits in the study area. This is true of both lowland and upland species, with such reptiles as the sidewinder (*Crotalus cerastes*), spotted leaf-nosed snake (*Phylorhynchus decurtatus*), saddled leaf-nosed snake (*Phyllorhynchus browni*), Western shovel-nosed snake (*Chionactis occipitalis*), Goode's horned lizard (*Phrynosoma goodei*), and desert iguana (*Dipsosaurus dorsalis*) all finding their eastern limits in the flats associated with the Santa Cruz River north and west of Tucson. In like manner the chuckwalla (*Sauromalus ater*), Sonoran collared lizard (*Crotaphytus nebriuis*), and rosy boa (*Lichanura trivirgata*) reach their eastern distributional limits in the mountain ranges bordering the Santa Cruz River west and northwest of Tucson. By way of contrast, the eastern patch-nosed snake (*Salvadora grahamiae*) finds its western limits in the mountains bordering the eastern edges of the lower Santa Cruz basin.

The Santa Cruz Flats is a critically important ecosystem in Arizona with many unique plants and animals connected to the river corridor. With its long history of change, the Lower Santa Cruz River and Flats faces an uncertain future. The U. S. Corp of Engineers is already investigating the potential for additional flood control structures and numerous other projects have been suggested ranging from solar farms to dust abatement measures to high-speed transportation facilities. Our purpose in presenting this natural history summary is to raise awareness of the area's biological values so that municipal, industrial, agricultural, and tribal stakeholders will consider thoughtful conservation strategies for the future.

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Appendix A. Mammals and Habitat Affinities

Notiosorex crawfordi (Desert shrew): Desertscrub flats, riparian associations; lumber piles, debris dumps and other habitats having ample cover.

Didelphis virginiana (Virginia opossum): Along riparian corridor and adjunct thickets, rock piles and dry washes with adequate cover. Poorly established escapee; rare.

Macrotus californicus (California leaf-nosed bat): Desertscrub, year-round resident.

Choeronycteris mexicana (Long-tongued bat): Spring and summer; roosts in caves/ rock fissures.

Leptonycteris yerbabuenae (Long-nosed bat): Rare in late spring and summer, one roost from Picacho Peak.

Myotis yumanensis (Yuma myotis): Found foraging along water courses; open pool habitats favored.

Myotis velifer (Cave myotis): Year-round--forages in desert flats rarely more than a few miles from water source. Roosts in caves and under bridges.

Myotis thysanodes (Fringed myotis): Rare; usually associated with higher elevation habitats.

Myotis californicus (California myotis): Desertscrub; forages yearlong. Roosts in crevices and cracks on canyon walls.

Pipistrellus hesperus (Western pipistrelle): Forages yearlong along riparian corridors and over desertscrub near rocky outcrops and cliffs where species roosts.

Eptesicus fuscus (Big brown bat): Present in desertscrub year-round, travel along the Santa Cruz in route to hibernacula. Roosts in mine shafts, caves, buildings, and saguaro holes.

Lasiurus xanthinus (Yellow bat): Rare, year round resident along riparian corridor. Documented foraging in yuccas.

Lasiurus blossevillii (Red bat): Hypothetical along riparian corridor, particularly in stretches with large trees.

Corynorhinus townsendii (Townsend's big eared bat): Over desertscrub and arid mountains. Roosts mostly in caves and mine tunnels.

Antrozous pallidus (Pallid bat): Open desertscrub; roosts in cliff crevices, old mine tunnels, and rodent burrows.

Tadarida brasiliensis (Mexican free-tailed bat): Desertscrub and foothills; roosts in caves, mines, old buildings and bridges. Common over cotton and other irrigated fields.

Nyctinomops femorosaccus (Pocketed free-tailed bat): Inhabits rocky cliffs and slopes of Arizona Upland subdivision of Sonoran desertscrub. Forages over agricultural fields.

Tadarida macrotis (Big free-tailed bat): Rare in Sonoran desertscrub. Rocky cliffs with crevices and fissures are required for roosting. Flies high above the ground.

Eumops perotis (Western mastiff bat): Roosts in crevices and shallow caves on the sides of cliffs and rock walls.

Sylvilagus audubonii (Desert cottontail): Sonoran desertscrub, riparian forest and scrub, mesquite *bosques*, edges of farm fields where brush present.

Lepus californicus (Black-tailed jack rabbit): Not uncommon in open county within Sonoran desertscrub, open mesquite, barren flats, and open areas adjacent to agricultural fields.

Lepus alleni (Antelope jack rabbit): Common to uncommon with best populations in Sonoran Savanna Grassland and in mesquite bordered *charcos* in southern part of study area. Fewer numbers in Sonoran desertscrub with mesquite, grass and forbs present. This is the signature animal of Santa Cruz Flats, which represents northern portion of range.

Ammospermophilus harrisii (Harris' antelope squirrel): Inhabits Arizona Upland and rocky areas within creosote bush- triangle-leaf bursage communities. Burrows under bushes, among rocks or in cactus thickets. Diurnal

Otospermophilus variegatus (Rock squirrel): Most commonly found in rock-piles. Occasionally found under cottonwood roots and along debris choked agricultural banks.

Xerospermophilus spilosoma (Spotted ground squirrel): Rare and uncommon in relict savanna grasslands with sandy soil and mesquites. Burrows along dry washes and in windblown sands.

Xerospermophilus tereticaudus (Round-tailed ground squirrel): Abundant in savanna grasslands but also common in creosote and saltbush communities where coarse sandy soils are intermixed with pebbles. A major prey species that builds extensive burrow systems in deep soil. Diurnal.

Thomomys bottae (Botta's pocket gopher): Common in underground burrows where soil suitable for digging tunnels and sufficient tuberous roots/plant material are present. Most abundant in riparian corridor and in agricultural fields.

Perognathus amplus (Arizona pocket mouse): Abundant in Sonoran desertscrub with sparse shrubs and open perennial cover; most often found in creosote flats with mesquite, ironwood or paloverde present. Nocturnal burrower.

Perognathus flavus (Silky pocket mouse): Less common than previous species in Sonoran desertscrub/savanna grasslands with mesquite Presence of grass cover important for habitat selection. Burrows.

Chaetodipus baileyi (Bailey's pocket mouse): Desert flats and adjacent slopes interspersed with boulders and Sonoran desert shrubs. Burrows.

Chaetodipus intermedius (Rock pocket mouse): Uncommon. Restricted to rocky slopes of desert mountains in Arizona Upland habitats. Burrows

Chaetodipus penicillatus (Desert pocket mouse): Common in sandy open deserts and savannas where vegetation is sparse; riparian woodland, tamarisk thickets. Burrows.

Dipodomys ordii (Ord's kangaroo rat): Desertscrub and savanna grasslands with gravely soil and scattered mesquites. Rare and documented only in southern portions of Santa Cruz Flats.

Dipodomys spectabilis (Banner-tailed kangaroo rat): Grassy bajadas and savannas > 762 m (2,500 ft) with catclaw, mesquite, and *Opuntia*. Hypothetical in relict grasslands in extreme southern portion of study area. Found in colonies where it burrows.

Dipodomys merriami (Merriam's kangaroo rat): Common in desertscrub, closely associated with mesquite, creosote and cacti, prefers sandy soil with few rocks. Burrows.

Dipodomys deserti (Desert kangaroo rat): Sonoran desertscrub; prefer loose easily digable sands often at the bottom of washes or near wind drifted sands stabilized by creosote. Burrows.

Castor canadensis (Beaver): Flowing waterways and riparian corridors. Extirpated from Santa Cruz River <1800's.

Reithrodontomys montanus (Plains harvest mouse): Desertscrub where there is mesquite, creosote bush, tumbleweeds, or sparse grass. Near cottonwood logs with tall weeds. Rare and uncommon in Santa Rosa Wash watershed.

Reithrodontomys megalotis (Western harvest mouse): Along riparian corridors and in irrigated areas where adequate cover and grasses present.

Peromyscus eremicus (Cactus mouse): Desertscrub among/around cacti, creosote, woodpiles, rocky slopes, and sandy flats. Often lives in abandoned burrows of other mammals.

Peromyscus merriami (Mesquite mouse): Inhabitants of mesquite bosques in forest-like stands, distribution correlates with mesquite and salt-bush bottoms. Rare in study area.

Peromyscus maniculatus (Deer mouse): Common along riparian corridor; near used and abandoned building, and in agricultural areas. Rare in desertscrub.

Onychomys torridus (Southern grasshopper mouse): Sonoran desertscrub and savanna grasslands. Found in areas of mesquite, cacti and digable soils that will not collapse on burrows.

Sigmodon arizonae (Arizona cotton rat): In dense vegetation along riparian corridor, drainages, or well vegetated canals. Occasionally found in grasslands associated with mesquite and tumbleweeds.

Neotoma albigula (White-throated wood rat): Common in desertscrub with cholla or prickly pear; riparian corridors, agricultural areas and buildings having structures to anchor middens.

Rattus rattus (Black rat): Invasive. Found near canals, buildings, barns, and agricultural areas. Tends not to venture far from water.

Mus musculus (House mouse): Invasive. Found in or around houses or other buildings, cultivated fields, disturbed areas.

Erethizon dorsatum (Porcupine): Riparian corridor in thickets of willows, mesquite bosques, desertscrub; rock piles, mine shafts and caves are used for shelter. Very rare—1 specimen reported by Hoffmeister (1984) on Santa Cruz River north of Pima County line.

Canis latrans (Coyote): Found in every habitat having suitable cover nearby: desertscrub, grasslands, riparian, urban, and agricultural.

Canis lupus (Gray wolf): One historic record (Brown 1983) Historically found along the Santa Cruz river corridor and adjacent regions Accidental.

Vulpes macrotis (Kit fox): Sonoran desertscrub and savanna grassland – prefer sandy soils and dunes suitable dens. Common

Urocyon cinereoargenteus (Gray fox): Sonoran desertscrub, riparian corridor, mesquite bosques. Dens are in burrows, rock piles, mine shafts, crevices in cliffs and hollow trees. Common.

Procyon lotor (Raccoon): Common near water at stock tanks riparian corridors, canals, and irrigated agricultural areas.

Bassariscus astutus (Ringtail): Rock walls and boulders in canyons and mountain slopes, caves, mine tunnels, rock piles.

Taxidea taxus (Badger): Sonoran desertscrub and savanna grasslands, bare ground. Associated with high densities of rodents. Burrows. Status unknown as rarely seen.

Spilogale putoris (Western spotted skunk): Along riparian corridors and adjunct thickets, rock piles and dry washes with adequate cover, will take refuge in cliff crevices. Rare.

Mephitis mephitis (Striped skunk): Riparian corridors, artificial water sources, agricultural areas, rock piles and dry washes with adequate cover. Not uncommon.

Mephitis macroura (Hooded skunk): Riparian corridors with heavy growth of weeds and shrubs; rocky slopes, bases of cliffs, rock strewn arroyos. Not common. Shy and seems to avoid human disturbance. Taxonomic status needs investigation.

Puma concolor (Mountain lion): Uncommon but recently increasing in Sonoran desertscrub of *bajadas* having deer; occasionally visits Flats and thick cover of riparian corridor.

Lynx rufus (Bobcat): Not uncommon in Sonoran desertscrub and mesquite bosques; Prefers broken country with rocky outcrops and riparian corridor in desert flats.

Pecari tajacu (Collared peccary): Common in small numbers throughout in Sonoran desertscrub of *bajadas* surrounding Flats; favors dense mesquite thickets, edges of farmlands, and open flats adjacent to washes. Caves or rocky crevices may serve as retreats.

Odocoileus hemionus (Mule deer): Relatively common on *bajadas* of mountains surrounding Flats with some individuals seen on Flats proper. Animals observed or collected were *O. h. eremicus* – the bura deer.

Antilocapra americana (Pronghorn): Formerly occurred throughout Flats with a doe collected near Red Rock (Mearns 1890). Extirpated by 1920-25.

Ovis canadensis (Bighorn sheep): Increasing numbers in mountainous desertscrub surrounding Flats with animals recently seen in Silverbell, Pan Quemado, West Silverbell and Tabletop mountains with individuals expected in Sawtooth, NorthTabletop and Paloverde mountains where extirpated <1970.

Equus ferus caballus (Horse): Abandoned and feral individuals roam Flats near stock tanks.

Appendix B. Bird Species with Abundance and Habitat Affinities

W=Winters
RY=Resident year-round
M= Migrant

SS= Relict Sonoran Savanna, MB=Mesquite bosque, RF=Riparian woodland/forest, SDU=Sonoran Desert Upland, SDLC=Sonora Desert Lower Colorado Subdivision, AG=Agriculture, canals, U=Urban, WT=Wetlands

Species	Habitat	Season of Use	Comments on Status
Greater White-fronted Goose (*Anser albifrons*)	AG, U, WT	M, W	Incidental; early fall migrant on flooded fields and ponds
Snow Goose (*A. caerulescens)*	AG, U, WT	M, W	Incidental
Ross's Goose (*A. rossii*)	AG, U, WT	M, W	Incidental; at least 1 per 5 yrs.
Canada Goose (*Branta canadensis*)	AG, U, WT	M, W	Incidental on flooded fields and ponds
Wood Duck (*Aix sponsa*)	U, WT	M	Rare; very few reports
Gadwall (*Anas strepera*)	AG, U, WT	M, W	Not uncommon on flooded fields
American Wigeon (A. americana)	AG, U	M, W	Not uncommon on flooded fields
Mallard (*A. platyrhynchos*)	AG, U, WT	M, W	Common; some nesting
Mexican Duck (*A. p. diazi*)	AG, U, WT	RY	Nomadic; few residents breed and nest
Blue-winged Teal (*A. discors)*	AG, U, WT	M, W	Rare; shows up in most years.
Cinnamon Teal (*A. cyanoptera*)	AG, U, WT	M, W	Common; a few may breed and nest
Northern Shoveler (*A. clypeata*)	AG, U, WT	M, W	Common
Northern Pintail (*A. acuta*)	AG, U, WT	M, W	Common visitor
Green-winged Teal (*A. crecca*)	AG, U, WT	M, W	Common visitor
Canvasback (*Aythya valisineria*)	U, WT	M, W	Rare to uncommon on ponds
Redhead (*A. americana*)	U, WT	M, W	Not uncommon on ponds
Ring-necked Duck (*A. collaris*)	U, WT	M, W	Common
Lesser Scaup (*A. affinis*)	U, WT	M, W	Rare to uncommon on ponds
Bufflehead (*Bucephala albeola*)	U, WT	M, W	Not uncommon on ponds
Common Goldenye (*B. clangula*)	U, WT	M, W	Rare visitor on urban ponds
Hooded Merganser (*Mergus cucullatus*)	U, WT	M, W	Rare visitor
Common Merganser (*M. merganser*)	AG, U, WT	M, W	Incidental; feeds on fish in canals
Red-breasted Merganser (*M. serrator*)	U, WT	M, W	Casual; possibly 1 every five years at Paradise Lake in Arizona City
Ruddy Duck (*Oxyura jamaicensis*)	U, WT	M, W	Common on ponds
Gambel's Quail (*Callipepla gambelii)*	AG, MB, U, SDLC, SDU	RY	Common to abundant; varies by year
Common Loon (*Gavia immer*)	U, WT	M, W	Incidental, 3 records at Paradise Lake in Arizona City
Pied-billed Grebe (*Podilymbus podiceps*)	AG, WT	M, W	Common on ponds and recreational lakes
Horned Grebe (*Podiceps auritus*)	AG, WT	M	Incidental; 1 record (23 August 2000) at Western Sod farm pond
Eared Grebe (*P. caspicus*)	AG, U, WT	M, W	Common on ponds

Western Grebe (*Aechmophorus occidentalis*)	AG, U, WT	M, W	Uncommon
Clark's Grebe (*A. clarkii*)	U, WT	M	Rare
Neotropic Cormorant (*Phalacrocorax brasilianus*)	U, WT	M	All seasons but not breeding in area; numbers increasing in past years
Double-crested Cormorant (*P. auritus*)	AG, U, WT	M	All seasons but not breeding in area
American White Pelican (*Pelecanus erythrorhynchos*)	AG, U, WT	M, W	Casual
Brown Pelican (*P. occidentalis*)	U, WT	M	Casual in migration
Great Blue Heron (*Ardea herodias*)	AG, RF, WT	M	Common non-nester along canals
Great Egret *(Casmerodius albus*)	AG, RF	M, W	Common in small numbers
Snowy Egret (*Leucophoyx thula*)	AG, RF	M	Uncommon
Cattle Egret (*Bubulcus ibis*)	AG	M	Rare; observed in fields in some years, occasionally in groups during migration
Green Heron (*Butorides virescens*)	RF, WT	RY	Common; likely breeding
Black-crowned Night-Heron *(Nycticorax nycticorax*)	AG, RF	M, W	Common
White-faced Ibis (*Plegadis chihi*)	AG	M	Common migrant
Roseate Spoonbill (*Platalea ajaja*)	AG,WT	M	Incidental, 1 record (23 August 2012)
Black Vulture (*Coragyps atratus*)	ALL	RY	Nests in nearby mountains; common with flocks >100 when not breeding
Turkey Vulture (*Cathartes aura*)	ALL	M	Common migrant and nester in summer; a few beginning to linger in winter.
Osprey (*Pandion haliaetus*)	AG, WT	M	Rare but regular migrant
Mississippi Kite (*Ictinia mississippiensis)*	AG	M	Rare migrant; 1983 nesting record from pecan grove *ca.* 1.5 miles SW of Marana Airpark (RLG)
White-tailed Kite (*Elanus leucurus*)	AG, SS	RY	Rare RY but only 2 reports since 2013; 1st AZ nesting on Flats in 1983 (Gatz et al. 1985)
Bald Eagle (*Haliaeetus leucocephalus*)	AG, U, WT	M, W	Rare winter visitor
Northern Harrier (*Circus cyaneus*)	AG, SS	M, W	Common winter visitor, though numbers may be decreasing
Sharp-shinned Hawk (*Accipiter striatus*)	AG, RF	M, W	Regular but in small numbers
Cooper's Hawk (*A. cooperii*)	AG, MB, RF	RY	Rare nester
Harris's Hawk (*Parabuteo unicinctus*)	AG, MB	RY	Regular but local
Swainson's Hawk (*Buteo swainsoni)*	AG, SS	M	Occasionally seen in summer, nesting not confirmed; roosts in pecan groves and forages in AG fields
White-tailed Hawk (*B. albicaudatus*)	AG, SS		Extirpated, only Arizona nesting record is near Red Rock (Breninger 1899)
Gray Hawk (*Buteo nitidus*)	MB, RF	M	Incidental transient; 1 record (19 September 2015--K. Rosenberg)
Zone-tailed Hawk (*B. albonatus*)	AG, SS	M	Casual migrant, 9 reports since 2006, seven in fall and spring, and two in winter
Red-tailed Hawk (*B. jamaicensis*)	ALL	M, RY	Common nester; large influx of wintering birds in AG fields
Ferruginous Hawk (*B. regalis*)	AG, SS	M, W	Regular winter visitor in small numbers.
Rough-legged Hawk (*B. lagopus*)	AG	M, W	Incidental; 4 records since 2000, all in AG fields
Golden Eagle (*Aquila chrysaetos*)	AG, SS, SDU	RY	Nests on bluffs in surrounding mountains; forages on bajada and Flats. At least 1 reported every winter
Crested Caracara (*Caracara cheriway*)	AG, SDLC, SDU, SS	RY	A few nesting pairs and significant populations of unknown origin in winter

American Kestrel (*Falco sparverius*)	ALL	M, RY	Breeds mainly in SDU adjacent to Flats. Population swells during migration and winter
Merlin (*F. columbarius*)	AG, SS	M, W	Regular winter visitor in small numbers
Peregrine Falcon (*F. peregrinus*)	AG, SDU, SS	M, RY	Nests on mountain bluffs surrounding Flats; wintering birds in AG areas
Prairie Falcon (*F. mexicanus*)	AG, SDU, SS	M, RY	Nests on desert mountain bluffs; wintering birds in AG areas
Sora (*Porzana carolina*)	AG, WT	M	Sparse; at least one reported every year
Common Moorhen (*Gallinula chloropus*)	AG, WT	R	Rare, localized
American Coot (*Fulica americana*)	AG, U, WT	M, W	Common at ponds
Sandhill Crane (*Grus canadensis*)	AG, SS	M	Typically 1 seen/yr; groups of 3 observed in winters of 2014 & 2015. Roosts in *playacitas*?
Black-bellied Plover (*Pluvialis squatarola*)	AG	M	Incidental; 1 record, Evergreen Turf sod farm (October 2015)
American Golden-Plover (*P. dominica*)	AG	M	Incidental; 2 records, sod farms (September 1999, October 2008)
Pacific Golden-Plover (*P. fulva*)	AG	M	Incidental; 1 record, Western Sod Farm (August 1998)
Semipalmated Plover (*Charadrius semipalmatus*)	AG	M	Rare, few reports
Killdeer (*C. vociferous)*	AG	RY	Small breeding population, many migrants and wintering
Mountain Plover (*C. montanus*)	AG	M, W	Regular migrant, wintering flocks >100 at sod farms; no apparent population shifts
Black-necked Stilt (*Himantopus mexicanus*)	AG, U, WT	M, W	Common migrant
American Avocet (*Recurvirostra america*)	AG, WT	M	Uncommon
Spotted Sandpiper (*Actitis macularia*)	AG	M, W	Common migrant
Solitary Sandpiper (*Tringa solitaria*)	AG	M	Common spring and fall migrant
Greater Yellowlegs (*T. melanoleuca*)	AG	M, W	Common winter migrant
Lesser Yellowlegs (*T. flavipes*)	AG	M, W	Common fall and spring migrant
Willet (*Catoptrophorus semipalmatus*)	AG	M	Common migrant, mostly in spring
Upland Sandpiper (*Bartramia longicauda*)	AG	M	Incidental, 3 records , one in early July 2013 was likely early migrant
Whimbrel (*Numenius phaeopus*)	AG	M	Incidental; 1 record (2 March 2011)
Long-billed Curlew (*N. americanus*)	AG	M, W	Common migrant
Marbled Godwit (*Limosa fedoa*)	AG, WT	M	Incidental; 1 record (19 April 2015) Evergreen Turf sod farm
Ruff (*Calidris pugnax*)	AG	M	Incidental, 1 record (8 January 2010), flooded AG field
Dunlin (*C. alpina*)	AG	M	Rare migrant
Baird's Sandpiper (*C. bairdii*)	AG	M	Uncommon migrant, mostly in fall
Least Sandpiper (C. *minutilla*)	AG, WT	M, W	Common migrant and wintering bird
White-rumped Sandpiper (*C. fusicollis*)	AG	M	Incidental, 1 record (11-19 May 2016)
Pectoral Sandpiper (*C. melanotis)*	AG, WT	M	Uncommon migrant
Semipalmated Sandpiper (*C. pusillus*)	AG, WT	M	Incidental; 2 August reports at Western Sod Farm (1995, 2007)
Western Sandpiper (*C. mauri*)	AG, WT	M	Uncommon migrant
Long-billed Dowitcher (*Limnodromus scolopaceus)*	AG	M, W	Common

Wilson's Snipe (*Capella gallinago*)	AG, WT	M, W	Common
Wilson's Phalarope (*Steganopus tricolor*)	AG, U, WT	M	Common
Red-necked Phalarope (*Phalaropus lobatus*)	AG, WT	M	Incidental, 1 record (23 August 2007)
Bonaparte's Gull (*Larus Philadelphia*)	AG, U, WT	M	Uncommon
Heermann's Gull *(L. heermanni*)	U	M	Incidental; 2 records at Paradise Lake in Arizona City (10/2005, 11/2013)
Ring-billed Gull (*L.* d*elawarensis*)	AG, U, WT	M, W	Observed most years at Paradise Lake in Arizona City; occasionally at AG fields
California Gull (*L. californicus)*	AG, U, WT	M, W	Casual, a few reports in past 20 years
Black Tern (*Chlidonias niger*)	U	M	Incidental; 2 reports (9/2002, 8/2007) at Paradise Lake in Arizona City
Forster's Tern (*Sterna forsteri*)	U, WT	M	Rare; usually at Paradise Lake in Arizona City
Rock Pigeon (*Columba livia*)	AG, U	RY	Common around farm buildings
Eurasian Collared-Dove (*Streptopelia decaocto*)	AG, U	RY	Abundant and increasing
White-winged Dove (*Zenaida asiatica*)	AG, MB, RF, SDU	M	Very abundant in fall, especially at cattle feedlot; a few in winter
Mourning Dove (*Z. macroura*)	AG, MB, RF, SDU	M, RY	Abundant in fluctuating numbers yearlong
Inca Dove (*Scardafella inca*)	AG, RF, U	RY	Population fluctuates from numerous to few; past several years there have been fewer
Common Ground-Dove (*Columbina passerina*)	AG, RF	RY	Uncommon in fields and along dirt roads
Ruddy Ground-Dove (*C. talpacoti*)	AG, RF	RY	Mainly winter, but has bred in area; not reported for past 3 years. Attracts birders
Yellow-billed Cuckoo (*Coccyzus americanus*)	RF	M	Transient; few reports
Greater Roadrunner (*Geococcyx californianus*)	AG, MB, RF, SDLC, SDU	RY	Common
Barn Owl (*Tyto alba*)	A, RF, U	RY	Resident, but primarily reported at roosts (willows, tamarisks, paloverdes, hay lofts) in winter; may be declining
Western Screech-Owl (*Otus kennicottia*)	MB, RF, SDU, U	RY	Uncommon; rarely seen or heard in riparian habitat
Great Horned Owl (*Bubo virginianus*)	ALL	RY	Common year-round; nests in barn lofts, saguaros, power poles, etc.
Burrowing Owl (*Athene cunicularia*)	AG, SS	RY	Common; primarily a resident breeding population at margins of fields and in sandy areas; numbers appear stable.
Spotted Owl (*Strix occidentalis*)	AG	W	Incidental, 1 record (8 January 2014) roosting in tamarisk
Northern Saw-whet Owl (*Aegolius acadicius*)	AG	W	Incidental, 1 record (28 December 2007); roosting in tamarisk
Lesser Nighthawk (*Chordeiles acutipennis*)	AG, SDU	RY	Common along canals
Vaux's Swift (*Chaetura vauxi*)	AG	M	Rare migrant, especially in fall
White-throated Swift (*Aeronautes saxatilis*)	AG, RF, WT	M, W	Common
Broad-billed Hummingbird (*Cynanthus latirostris*)	RF	M, W	Common
Black-chinned Hummingbird (*Archilochus alexandr*i)	RF, MB	M	Common
Anna's Hummingbird (*A. anna*)	AG, MB, RF	RY	Common; most expected hummingbird in area

Costa's Hummingbird (*A. costae*)	AG, RF	M, W	Common
Broad-tailed Hummingbird (*Selasphorus platycercus*)	RF	M	Migrant; only 1 report; likely regular, but missed
Rufous Hummingbird (*S. rufus*)	RF	M	Rare
Belted Kingfisher (*Ceryle alcyon*)	AG, WT	M, W	Uncommon; a few reported every year
Lewis's Woodpecker (*Melanerpes lewis*)	AG	M, W	Occasional, not all winters
Acorn Woodpecker (*M. formicivorus*)	AG	W	Occasional, not most winters
Gila Woodpecker (*Centurus uropygalis*)	AG, MB, RF, SDU, U	RY	Abundant
Yellow-bellied Sapsucker (*Sphyrapicus varius*)	AG	M	Incidental; 1 record 19 October 2013
Red-naped Sapsucker (*S. nuchalis*)	AG, RF	M, W	Uncommon
Ladder-backed Woodpecker (*Picoides scalaris*)	MB, RF, SDU	RY	Common
Northern Flicker (*Colaptes auratus*)	AG, MB, RF	M, W	Common in winter, especially in pecan groves
Gilded Flicker (*C. chrysoides*)	SDU	RY	Common year-round
Olive-sided Flycatcher (*Contopus borealis*)	AG, RF	M	Incidental migrant, 2 records
Western Wood-Pewee (*C. sordidulus*)	AG, RF	M	Common migrant
Willow Flycatcher (*Empidonax traillii*)	RF	M	Rare, 3 records
Hammond's Flycatcher (*E. hammondii)*	RF	M, W, SP	Rare
Gray Flycatcher (*E. wrightii*)	RF	M, W	Uncommon
Dusky Flycatcher (*E. oberholseri*)	RF	M, W	Rare
Pacific-slope Flycatcher (*E. difficilis*)	RF	M	Rare
Black Phoebe (*Sayornis nigricans*)	AG, RF, WT	RY	Common
Say's Phoebe (*S. saya*)	AG, MB, RF, WT	RY	Common, especially in winter
Vermilion Flycatcher (*Pyrocephalus rubinus*)	AG, MB, RF, WT	RY	Common
Dusky-capped Flycatcher (*Myiarchus tuberculifer*)	RF	M	Incidental, 1 record (Feb.-March 2011)
Ash-throated Flycatcher (M. cinerascens)	AG, MB, RF, SDU	M	Common in summer and migration, a few remain in winter
Brown-crested Flycatcher *(M. tyrannulus*)	MB, SDU	M	Common nester
Tropical Kingbird (*Tyrannus melancholicus*)	AG	M	Substantial nesting colony in single-row roadside pecan trees
Cassin's Kingbird (*T. vociferans*)	AG, RF	M, W	Regular, but not in large numbers
Thick-billed Kingbird (*T. crassirostris*)	RF	M	Incidental migrant, 1 record (19 May 2014)
Western Kingbird (*T. verticalis*)	AG, MB, RF	M	Common nester, large groups during fall migration
Loggerhead Shrike (*Lanius excubitor*)	AG, SS	RY	Common, mostly wintering, fewer in summer
Bell's Vireo (*Vireo bellii*)	AG, MB, RF	M	Common; nests
Plumbeous Vireo (*V. plumbous*)	AG, RF	M, W	Uncommon
Cassin's Vireo (*V. cassinii*)	RF	M, W	Rare
Hutton's Vireo (*V. huttoni*)	RF	M, W	Uncommon
Warbling Vireo (*V. gilvus*)	RF	M	Uncommon

American Crow (*Corvus brachyrhyncos*)	AG	M, W	Occasional, not every winter
Chihuahuan Raven (*C. cryptoleucus*)	AG	W	Occasionally reported, but status not well known
Common Raven (*C. corax*)	AG, MB, SDU	RY	Abundant
Horned Lark (*Eremophila alpestris*)	AG, SS	M, W	Abundant in winter, but breeding status unknown
Purple martin (*Progne subis*)	AG, RF, SDU	M	Uncommon
Tree Swallow (*Iridoprocne bicolor*)	AG, RF, WT	M	Abundant migrant, some early migrants in summer
Violet-green Swallow (*Tachycineta thalassina*)	AG, RF, WT	M	Common migrant
Northern Rough-winged Swallow (*Stelgidopteryx ruficollis*)	AG, RF, WT	M	Common migrant; some nesting
Bank Swallow (*Riparia riparia*)	AG, WT	M	Uncommon
Cliff Swallow (*Petrochelidon pyrrhonota*)	AG, WT	M	Abundant migrant and nester
Barn Swallow (*Hirundo rustica*)	AG, WT	M	Common nester
Verdin (*Auriparus flaviceps*)	AG, MB, RF, SDU	RY	Common
White-breasted Nuthatch (*Sitta carolinensis*)	AG	W	Incidental, 1 record (18 Feb 2011)
Cactus Wren (*Campylorhynchus brunneicapillus*)	MB, SDU	RY	Common
Rock Wren (*Salpictes obsoletus*)	AG	W	Uncommon in winter
Bewick's Wren (*Thryomanes bewickii*)	RF	M, W	Uncommon locally
House Wren (*Troglodytes aedon*)	RF	M, W	Rare migrant and wintering
Marsh Wren (*Telmatodytes palustris*)	AG, RF, WT	M, W	Regular migrant and wintering at farm ponds
Blue-gray Gnatcatcher (*Polioptila caerulea*)	AG, RF	M, W	Rare migrant
Black-tailed Gnatcatcher *(P. melanura*)	MB, SDU	RY	Common
Ruby-crowned Kinglet (*Regulus calendula*)	AG, RF	M, W	Common in migration and wintering
Western Bluebird (*Sialia mexicana*)	AG	M, W	Erratic, some winters common, other winters none
Mountain Bluebird (*S. currucoides*)	AG	M, W	Erratic, some winters common in large flocks, other winters none
Swainson's Thrush (*Hylocichla ustulata*)	AG	M	Incidental, 2 reports, both in May
Hermit Thrush (*H. guttata*)	RF	M, W	Uncommon migrant and wintering
Rufous-backed Robin (*Turdus rufopalliatus*	AG	W	Incidental, 2 records
American Robin (*T. migratorius*)	AG, RF	M, W	Rare migrant
Northern Mockingbird (*Mimus polyglottos*)	AG, MB, SDU	RY	Common
Sage Thrasher (*Oreoscoptes montanus*)	AG, SDU	M, W	Rare, mostly seen in spring migration
Bendire's Thrasher (*Toxostoma rufum*)	AG, SDU	RY	Uncommon resident; status of population is unclear; target for many birders
Curve-billed Thrasher (*T. curvirostre*)	AG, MB, RF, SDU	RY	Common
LeConte's Thrasher (*T. lecontei*)	SDLC, SDU		Incidental, at least 1 record; transient
European Starling (*Sturnus vulgaris)*	AG, SDU	RY	Common, especially around farm yards, but also in nesting colonies in saguaros
American Pipit (*Anthus rubescens*)	AG, SDU, SS	M, W	Common in transit and winter

Sprague's Pipit *(A. spragueii)*	AG	W	2 winters, 2014-15 and 2015-16; status unclear may have been previously present but not observed
Cedar Waxwing (*Bombycilla cedrorum*)	RF	M	Rare
Phainopepla (*Phainopepla nitens*)	MB, RF	M, W	Common in nonbreeding season, but few summer reports
Chestnut-collared Longspur (*Calcarius ornatus*)	AG	W	Rare
Lapland Longspur (*C. lapponicus*)	AG	W	Incidental (2 reports) at sod farm
McCown's Longspur (*Rhynchophaens mccownii*)	AG	W	Rare
Orange-crowned Warbler (*Vermivora celata*)	RF	M, W	Common in winter and migration
Nashville Warbler (*V. ruficapilla*)	RF	M	Incidental; 2 spring reports
Lucy's Warbler (*V. luciae*)	MB, RF	M	Common nester
Northern Parula *(Parula americana*)	AG, RF	M	Rare; typically at least one a year
Yellow Warbler (*Dendroica petechia*)	RF	M	Common nester
Black-throated Blue Warbler (*D. caerulescens*)	AG	W	Incidental, 1 record
Palm Warbler (*D. palmarum*)	RF	W	Incidental, 1 record (7 February 2015)
Yellow-rumped Warbler (*D. auduboni*)	AG, MB, R	M, W	Common, wintering and migrant
Black-throated Gray Warbler (*D. nigrescens*)	RF	M, W	Several reported every year
Townsend's Warbler (*D. townsendi*)	RF	M, W	Rare migrant
Hermit Warbler (*D. occidentalis*)	RF	M	Rare migrant
Yellow-throated Warbler (*Setopohaga dominica*)	U	M	Incidental, 1 record, November 2008 at Paradise Lake in Arizona City
Black-and-white Warbler (*Mniotilta varia*)	RF	M, W	At least one every year
American Redstart (*Setophaga ruticilla*)	AG	W	Incidental, 2 records (1 in December 1998, 1 December-March 2014-15)
Lousiana Waterthrush (*Seiurus motacilla*)	RF	W	Incidental, 1 record, December 2015
Northern Waterthrush (S. *noveboracensis*)	RF	M	Incidental, 2 records, both May
MacGillivray's Warbler (*Oporornis tolmiei*)	AG	M	Uncommon migrant
Common Yellowthroat (*Geothlypis trichas*)	AG, RF	M	Nests in riparian habitat; occasional wintering
Wilson's Warbler *(Wilsonia pusilla*)	AG, RF	M	Common migrant
Yellow-breasted Chat (*Icteria virens*)	RF, WT	M	Common nester
Summer Tanager (*Piranga rubra*)	AG, RF	M	Uncommon breeding; 1 winter record
Western Tanager (*P. ludoviciana*)	AG, RF	M	Rare migrant, 1 summer record
Green-tailed Towhee (*Chlorura chlorura*)	AG, MB, RF	M, W	Uncommon
Spotted Towhee (*Pipilo erythrophthalmus*)	AG, RF	W	Rare, only seen during migration
Canyon Towhee (*P. fuscus*)	SDU	RY	Uncommon
Abert's Towhee (*P. aberti*)	AG, RF	RY	Common
Rufous-winged Sparrow (*Aimophila carpalis*)	MB, SS	M, W	Locally rare; status not well known

Chipping Sparrow (*Spizella passerina*)	AG	W	Uncommon in winter
Clay-colored Sparrow (*S. pallida*)	AG, SS	M, W	Casual, 3 known reports (1 in September, 2 in winter)
Brewer's Sparrow (*S. breweri*)	AG, SDU	M, W	Common in winter
Vesper Sparrow (*Pooecetes gramineus*)	AG, RF	M, W	Abundant migrant and winter visitor
Lark Sparrow (*Chondestes grammacus*)	AG, SDU	M, W	Abundant migrant and winter visitor
Black-throated Sparrow (*Amphispiza bilineata*)	SDLC, SDU	RY	Uncommon
Sagebrush Sparrow (*A. belli*)	SDLC	M, W	Locally uncommon; principally in saltbush flats; attraction for birders
Lark Bunting (*Calamospiza melanocorys*)	AG, SD, SS	M,W	Abundant in flocks in most winters; a few in some winters.
Savannah Sparrow *(Passerculus sandwichensis)*	AG, SS	M, W	Abundant
Grasshopper Sparrow *(Ammodramus savannarum)*	AG	M, W	3 records
Song Sparrow (*Melospiza melodia*)	AG, RF	RY	Common; breeds in riparian habitat and farm pond marshes
Lincoln's Sparrow (*M. lincolnii*)	AG, MB, RF	M, W	Common
Swamp Sparrow (*M. georgiana*)	AG	W	Accidental, 1 record (17 January 2009)
White-throated Sparrow (*Zonotrichia albicollis*)	AG, RF, SDU	M, W	Rare migrant; 3 records
Harris's Sparrow (*Z. querula*)	AG	M, W	Incidental; 1 or 2 records
White-crowned Sparrow (*Z. leucophrys*)	AG, MB, RF, SDU	M, W	Abundant in winter and migration
Dark-eyed Junco (*Junco hymalis*)	AG, RF	M, W	Rare; < 1/yr.
Northern Cardinal (*Cardinalis cardinalis*)	MB, RF	RY	Common
Pyrrhuloxia (*C. sinuatus)*	MB, SDU	RY	Uncommon
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	RF	M	Incidental, 2 records
Black-headed Grosbeak *(P. melanocephalus*)	RF	M	Uncommon migrant
Blue Grosbeak (*Guiraca caerulea*)	AG, MB, RF	M	Common breeding bird
Lazuli Bunting (*Passerina amoena*)	AG, RF	M	Common migrant
Indigo Bunting (*P. cyanea*)	AG	M	Incidental: 1 record (10 May 2014)
Dickcissel *(Spiza americana*)	AG	F, M	Casual, with at least 1 report every year.
Bobolink (*Dolichonyx oryzivorus*)	AG	M	Accidental, 1 record (21 October 1998) in cotton field
Red-winged Blackbird (*Agelaius phoeniceus*)	AG, WT	M, RY	Although some nest around farm ponds, most are wintering migrants
Eastern Meadowlark (*Sturnella magna*)	AG	M,W	Sparse; a few reported each winter, though many likely misidentified
Western Meadowlark (*S. neglecta*)	AG, SS	M,W	Abundant in winter; occasionally breeds if in suitable pasture or fallow field.
Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)	AG, WT	W, SP, F	Locally abundant in winter; roosts in marshes
Brewer's Blackbird (*Ephagus cyanocephalus*)	AG	M, W	Abundant in winter
Great-tailed Grackle (*Cassidix mexicanus*)	AG, U	RY	Locally common to abundant

Bronzed Cowbird (*Tangavius aeneus)*	AG	M	Uncommon in spring
Brown-headed Cowbird (*Molothrus ater*)	AG, SDU, U	M, RY	Large wintering population; smaller breeding population is likely migratory
Hooded Oriole (*Icterus cucullatus*)	MB, RF, SDU, U	M	Uncommon
Bullock's Oriole (Icterus *bullockii*)	AG, RF	M	Uncommon
House Finch (*Carpodacus mexicanus*)	AG, MB, RF, SDU	RY	Common
Pine Siskin (*Spinus pinus*)	AG	M	Occasional migrant; 1 report (28 February 2015)
Lesser Goldfinch (*S. psaltria*)	AG, RF	RY	Common
Lawrence's Goldfinch (*S. lawrencei*)	AG, MB	M,W	Seen some years
House Sparrow (*Passer domesticus*)	AG, U	RY	Common

Appendix C. Reptiles and Amphibians with Habitat Affinities

Western tiger salamander or waterdog (*Ambystoma marvotium*): Introduced to some of the larger stock ponds or *charcos.*

Couch's spadefoot toad (*Scaphiopus couchii*): Ephemeral pools, manmade ponds, bends in washes, associated with Lower Colorado subdivision of Sonoran Desert.

Mexican spadefoot (*Spea multiplicata*): Ephemeral pools, manmade ponds, bends in washes associated with Lower Colorado subdivision of Sonoran Desert Scrub.

Mazatlan narrow-mouthed toad (*Gastrophryne mazalatensis*): Ephemeral pools, manmade ponds, bends in washes, associated with Lower Colorado subdivision of Sonoran desertscrub. Restricted in study area to Santa Rosa Wash watershed on Tohono O'odham Nation and Vekol wash.

Great Plains toad (*Anaxyrus cognatus*): Ephemeral pools, manmade ponds, bends in washes, associated with Lower Colorado subdivision of Sonoran Desert.

Red-spotted toad (*Anaxyrus punctatus*): Bajadas, rocky slopes, tinajas, permanent and ephemeral pools, manmade ponds, bends in washes, in upland and desert flats communities. Breeds in spring and summer.

Woodhouse's toad *(Anaxyrus woodhousei*): Ephemeral pools, manmade ponds, bends in washes, breeds in the spring, associated with Lower Colorado subdivision of Sonoran Desert in study area.

Sonoran green toad (*Anaxyrus retiformis*): Ephemeral pools, manmade ponds, bends in washes, associated with Lower Colorado subdivision of Sonoran Desert Scrub. Restricted in study area to lower Santa Rosa Wash watershed on Tohono O'odham Nation, Vekol Wash, and Rainbow Valley.

Sonoran desert toad (*Incilius alvarius*): Ephemeral pools, manmade ponds, bends in washes; associated with Lower Colorado subdivision of Sonoran desertscrub.

Lowland leopard frog: (*Lithobates* [*Rana*] *yavapaiensis*): Extirpated from the lower river; requires permanent water, riparian, manmade ponds.

American bullfrog (*Lithobates* [*Rana*] *catesbeianus*): Introduced. Permanent waters; riparian, manmade ponds; associated in study area with Lower Colorado subdivision of Sonoran desertscrub. Common in Santa Cruz River below Marana.

Sonoran desert tortoise (*Gopherus morafkai*): *Bajadas,* mountain slopes, banks of incised washes

Sonora mud turtle (*Kinosternon sonoriense*): Rare in stock tanks; hypothetical in Santa Cruz river above Sasco Road. Pools and slow runs of river.

Rough-tailed gecko (*Cyrtopodion scabrum*): Likely to be found in urban situations in study area.

Western banded gecko (*Coleonyx variegatus*): Found throughout on desert flats, bajadas, and mountain slopes.

Mediterranean house gecko (*Hemidactylus turcicus*): Introduced. Confined to anthropogenic structures, mainly buildings. Not to be expected outside of urban areas or home sites. Sometimes occurs in trash piles.

Tiger whiptail (*Aspidocelis tigris*)*:* Desert flats, bajadas, and mountain slopes.

Desert iguana (*Dipsosaurus dorsalis*): Desert flats and lower bajadas generally associated with creosote communities in Lower Colorado subdivision of Sonoran desertscrub.

Chuckwalla (*Sauromalus ater*): Rocky bajadas, and mountain slopes. Generally associated with Arizona Upland Subdivision of Sonoran Desert.

Eastern collared lizard (*Crotophyus collaris*): Rocky bajadas and mountain slopes associated with Arizona Upland subdivision of Sonoran Desert.

Sonoran collared lizard (*Crotophytus nebrius*): Rocky bajadas and mountain slopes in southwestern Pinal County associated with Arizona Upland subdivision of Sonoran Desert.

Long-nosed leopard lizard (*Gambelia wislizenii*): Desert flats and lower bajadas. A sparsely occurring species most often associated with Lower Colorado subdivision of the Sonoran Desert.

Zebra-tailed lizarad (*Callisaurus draconoides*): Desert flats and lower bajadas; usually associated with dry washes. Common to abundant.

Ornate tree lizard (*Urosaurus ornatus*): Common in situations that provide vertical habitat and escape cover including rocky bajadas, mountain slopes, and trees such as ironwood and mesquite that occur along washes, and anthropogenic structures such as wooden corrals and buildings.

Long-tailed brush lizard (*Urosaurus graciosus*): Predominately found on trees along desert washes but also utilizes creosote and other shrubs in flat Sonoran habitats.

Common side-blotched lizard (*Uta stansburiana*): Often numerous near old trash piles on flats, bajadas, and mountain slope in Sonoran habitats.

Desert spiny lizard *(Sceloporus magister*): Desert flats (generally inhabiting trees along washes), bajadas, and mountain slopes, also anthropogenic structures such as corrals or old buildings.

Goode's horned lizard (*Phrynosoma goodei*): Desert flats and lower bajadas generally associated with Lower Colorado subdivision of Sonoran desertscrub south of Gila River.

Regal horned lizard (*Phrynosoma solare*): Desert flats, lower bajadas, and to a lesser degree mountain slopes associated with Arizona Upland subdivision of Sonoran Desert.

Gila monster (*Heloderma suspectum*): Not uncommon on desert flats, bajadas, and mountain slopes associated with Arizona Upland subdivision of Sonoran Desert and mesquite communities in the flats.

Western threadsnake (*Rena humilis*): Probably common on desert flats, bajadas, and mountain slopes. Nocturnal and subterranean.

Smith's black-headed snake *(Tantilla hobartsmithi*): Rocky bajadas, and mountain slopes within Arizona Upland subdivision of Sonoran Desert. Also in riparian communities.

Western shovel-nosed snake (*Chionactis occipitalis*): Not uncommon in desert flats and in lower bajadas associated with Lower Colorado subdivision of Sonoran Desert.

Variable sandsnake *(Chilomeniscus stramineus*): Look for this snake in washes in desert flats and lower bajadas.

Groundsnake (*Sonora semiannulata*): Desert flats and lower bajadas within Sonoran desertscub and savannas. Not uncommon in rural and urban situations. Often encountered beneath surface debris.

Saddled leaf-nosed snake (*Phyllorhynchus browni*): Mostly lower bajadas, predominately Arizona Upland subdivision of Sonoran desertscrub Frequently associated with large washes in bajada situations.

Spotted leaf-nosed snake (*Phyllorhynchus decurtatus*): Desert flats and lower bajadas generally associated with Lower Colorado subdivision of Sonoran Desert.

Desert nightsnake (*Hypsiglena chlorophaea*): A habitat generalist, may be encountered in all habitats found in the study area.

Western lyresnake (*Trimorphodon biscutatus*): Rocky bajadas, and mountain slopes. Generally within Arizona Upland subdivision of Sonoran Desert.

California kingsnake (*Lampropeltis californiae*): A generalist that frequents riparian and agricultural areas but also inhabits desert flats and upland situations.

Long-nosed snake (*Rhinocheilus lecontei*): *Widely disturbed on d*esert flats and in lower bajadas.

Glossy snake (*Arizona elegans*): Desert flats and lower bajadas. Most often associated with Lower Colorado subdivision of the Sonoran Desert.

Gopher snake (*Pituophis catenifer*): A generalist commonly found in upland and flats communities as well as agricultural and riparian situations.

Western patch-nosed snake (*Salvadora hexalepus*): Most often associated with bajadas, and mountain slopes in Arizona Upland subdivision of Sonoran Desert.

Coachwhip (*Coluber* [*Masticophis*] *flagellum*): Widely represented in desert flats, bajadas, and mountain slopes.

Sonoran whipsnake (*Coluber* [*Masticophis*] *bilineatus*): Local on bajadas and mountain slopes in Arizona Upland situations.

Checkered gartersnake (*Thamnophis marcianus*): Irrigated areas and riparian habitats with water.

Mexican gartersnake (*Thamnophis eques*): Extirpated.

Black-neckedgarter snake (*Thamnophis cyrtopsis*): Rare. To be looked for in riparian habitats along the eastern edge of Santa Cruz basin.

Sonoran coralsnake (*Micruroides euryxanthus*): Most commonly encountered on bajadas and mountain slopes in Arizona Upland subdivision of Sonoran Desert but also found on flats and in riparian habitats.

Western diamond-backed rattlesnake (*Crotalus atrox*): A habitat generalist. Commonly found in both upland and Flats communities including agricultural and riparian habitats.

Western black-tailed rattlesnake (*Crotalus molossus*): An upland species found on rocky bajadas and mountain slopes. Generally associated with Arizona Upland subdivision of Sonoran Desert.

Mohave Rattlesnake (*Crotalus scutulatus*): Desert flats and lower bajadas. Most often associated in study area with Sonoran savanna grassland and Lower Colorado subdivision of Sonoran Desert.

Tiger rattlesnake (*Crotalus tigris*): An upland species that inhabits rocky bajadas and mountain slopes. Generally associated with Arizona Upland subdivision of Sonoran Desert.

Sidewinder (*Crotalus cerastes*): Desert flats and rarely lower bajadas. Most often associated with Lower Colorado subdivision of the Sonoran Desert

Several impressive monsoon rain events made for exceptional growth on the upper Santa Cruz Flats in 2016. The herbaceous vegetation along this small wash includes robust forms of *Amaranthus palmeri*, *Aristida ternipes*, *Kallstroemia grandiflora*, and *Tidestroemia lanuginosa*. EM, 6 September 2016.