The Phoenix Four Rivers Flora,

Maricopa County, Arizona

by

Darin Jenke

A Thesis Presented in Partial Fulfillment
of the Requirements for the Degree
Master of Science

Approved April 2011 by the
Graduate Supervisory Committee:

Kathleen B. Pigg, Co-Chair
Leslie R. Landrum, Co-Chair
Elizabeth Makings

ARIZONA STATE UNIVERSITY

May 2011

ABSTRACT

The Phoenix Four Rivers Flora is an inventory of all the vascular plants growing along the Salt, Gila, New and Agua Fria Rivers, and their tributaries in the Phoenix Metropolitan Area during the years of the study (2009-2011). This floristic inventory documents the plant species and habitats that exist currently in the project area, which has changed dramatically from previous times. The data gathered by the flora project thus not only documents how the current flora has been altered by urbanization, but also will provide a baseline for future ecological studies.

The Phoenix Metropolitan Area is a large urbanized region in the Sonoran Desert of Central Arizona, and its rivers are important for the region for many uses including flood control, waste water management, recreation, and gravel mining. The flora of the rivers and tributaries within the project area is extremely diverse; the heterogeneity of the systems being caused by urbanization, stream modification for flood control, gravel mining, and escaped exotic species. Hydrological changes include increased runoff in some areas because of impermeable surfaces (e.g. paved streets) and decreased runoff in other areas due to flood retention basins. The landscaping trade has introduced exotic plant species that have escaped into urban washes and riparian areas. Many of these have established with native species to form novel plant associations.

DEDICATION

I dedicate my thesis to James Michael Jenke and Wade Jenke, whose support during the long years of graduate school made it possible to make it through.

ACKNOWLEDGMENTS

A number of people assisted, supported, and encouraged me in the completion of this thesis. I would like to thank Dr. Leslie R. Landrum for the many years of mentorship and Dr. Kathleen B. Pigg for assistance with editing and advice during graduate school. Elizabeth Makings helped with plant identification and field work. I thank Wade Jenke for his assistance with field work, hours of plant collecting, and rides to field sites.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

INTRODUCTION

This study, “The Phoenix Four Rivers Flora (PFR),” is a floristic inventory of all the vascular plants presently growing along the Salt River channel and its tributaries, the Agua Fria, and New Rivers, Cave Creek, and minor urban streams, of the Phoenix Metropolitan Area (PMA). Figure 9 is a map of the project area. (Two areas in the eastern part of the PMA, Indian Bend Wash and Queen Creek were not included as part of the flora project). This area is managed by the Maricopa County Flood Control District and the Tres Rios Project (TRP) with the participants and stakeholders being the cities of Phoenix, Scottsdale, Tempe, and Avondale. One major component of the system is the Phoenix 91st Ave. Treatment Plant which purifies metro waste water and releases effluent into the Salt River bottom, creating a riparian habitat. Before the Salt River was dammed and diverted for irrigation and urban water use, there were extensive riparian habitats in the Phoenix area but now they have been reduced to small remnants (Calvin 1946). The effective management of these remaining riparian ecosystems requires an extensive understanding of the environment.

One of the most important elements in ecosystem function is the plant life. Plants contribute to ecosystem functions in a variety of ways: by playing an important role in controlling nutrient cycling, mitigating erosion, and by being the primary producers and thus supporting animals, fungi, and micro-organisms. Biodiversity studies are critical to ecological research because they provide the baseline data that can be used for future comparisons. This study is one of the few to focus on an arid, urban riparian system. As preservation and restoration become increasingly important to scientists, biological inventories are valuable management tools in the context of impact assessment, restoration, evaluation, and ecosystem management.

The rivers in the PFR are important drainages of the Phoenix Metropolitan Area for flood control, waste water management, recreation, and gravel mining. The rivers are located in a dynamic area of the Southwest where the urban fringe and desert meet. The water for the Tres Rios Project is provided by ephemeral flow from the three rivers, storm drains, agricultural field drains, and effluent outflow from the city of Phoenix 91st Avenue Water Treatment Plant. The goal of this project is to identify the plant species that presently occur in the area. This flora will complement future interdisciplinary studies in urban riparian ecology. Government agencies, private organizations, and the TRP will benefit from this study. The information will be made available to the public as a pamphlet on the common plants, their ethno-botanical uses, along with a history of the project area. Thus this research will advance awareness and appreciation of the flora at the confluence of four major desert rivers of Central Arizona.

Chapter 2

HISTORY

History of the Phoenix Metropolitan Area (PMA). The Phoenix Four Rivers Flora (PFR) is located at the confluence of two major rivers in the state of Arizona, the Salt and Gila Rivers. They are two of the most important water sources for Central Arizona. Early humans fished, hunted big game, and collected food here during the last Ice Age (Robichaux, 1999). However, a slow progression of climate change caused Arizona to become more arid (Holmgren, 2006). Given this change the rivers must have become an important water source for the inhabitants of Central Arizona.

The nomadic tribes known as the Hohokam settled in between 500 - early 1000's AD (Ross, 1946; Grimm et al., 2008) and started farming the Arizona valleys. Their methods varied from dry land farming of chollas and agaves to irrigating field crops with an advanced canal system. The Hohokam built this system of canals to divert water from the Salt and Gila Rivers to their fields. These canal systems reached over 400 miles in length during the 1200's (Calvin, 1946). The primary crops grown were corn, squash, and cotton in the summer, while in winter wild greens were collected from the fields. The Hohokam disappeared during the 1400's and their canal systems were mostly abandoned.

The next chapter in Arizona began in the late 1700s when Spanish missions were established in southern Arizona. The missionaries discovered the peaceful Pima and Maricopa tribes who lived and farmed near the confluence of the Salt and Gila Rivers just like the previous Hohokam (Emory and Fremont, 1849).The Pimas and Maricopa's obtained wheat and cattle from the Spanish. Wheat becomes an important crop for the tribes in Arizona because it essentially filled the fallow winter season with a multi-functional crop (Calvin, 1946).

In 1846, during the Mexican-American War, an expedition called the Army of the West was sent to California to take control of that region. The expedition was led by General Stephen W. Kearny with two thousand soldiers, dragoons, and wagons (Emory and Fremont, 1849). The soldiers walked from Fort Leavenworth, Kansas to San Diego, California. According to Emory and Fremont (1849) General Kearny peacefully conquered New Mexico without any major violence against the New Mexicans. Kearny's kind treatment was significant because prior to this the local people were subjected to mistreatment by the Mexican government and its cruel governor. In California there was significant resistance from the Mexicans but the Americans were victorious.

On this expedition Lieutenant William H. Emory was a soldier but, more importantly, also a scientist (Emory and Fremont, 1849). Emory's primary duties were to record latitude and longitude at different points along the way and convert these data into maps. The expedition's progress recorded on maps showing their route and important geographic features. As a scientist Emory also collected data on native people, plants and animals. Emory was one of the first trained scientists to visit the Southwest and as a result many plants are named after him. Emory's notes on the confluence of the Salt and Gila are interesting because he gives detailed firsthand accounts of what he saw. Emory provided a window of detail into what the PMA was like on November 12, 1846 noting that the Pimas had extensive farm fields along the Gila and Salt Rivers and that their primary crops were winter wheat, corn, beans, and squash. Wheat was the most important crop because of its high production and trade value with the new European settlers. The Pima's canal system used water from the Gila River, but most of the water was unused and returned to the river. The Salt and Gila Rivers during the 1840's were substantial; the confluence measured 100 to 500 feet across and was 4-5 feet deep, and the flow of the Gila continued all the way to the Colorado River at present-day Yuma. The Gila River was wild and natural with extensive cottonwoods, willows, and “cane” (*Pluchea sericea)* (Emory and Fremont, 1849). Emory is credited with discovering many new species of plants (Calvin, 1946). Overall the work of Emory was valuable because it established a solid scientific and historical baseline for future research efforts.

Phoenix was established in the 1880s when Jack Swelling started a canal company by repairing and widening the old Hohokam canals (SRP, 2011). With irrigation systems in place farmers moved to the valley and Phoenix grew rapidly to become the territorial capital in 1888. Small farming towns were founded across the valley that would later become important cities. For instance, the city of Tempe was founded at a ferry crossing of the Salt River near Hayden Butte. Few people today could imagine that a boat was once needed to cross the Salt River. By 1900, Mesa was a small Mormon farming town, and was the first city in Arizona to have a Temple built (Calvin, 1946). Few people could have predicted that the fragmented and scattered settlements of the Salt River Valley would grow together to create one large nearly continuous city.

The Salt River Project (SRP) was founded to build dams to control the destructive floods of the Salt and Gila Rivers. In 1911 Roosevelt Dam was built to the northeast of the Valley, resulting in the beginning of the dewatering and containment of the PFR area. Arizona became a State on Valentine’s Day 1912 in part due to the rapid growth of the PMA. The SRP grew and the Valley of the Sun became a major agriculture producer. Water diversion for farming caused the Salt and Gila Rivers soon to run dry in the valley, but downstream small amounts of agriculture field runoff were returned to the Gila (SRP, 2011).

Fredrick Irish, who served as football coach and biology professor at Arizona Normal School (now Arizona State University) collected *Prosopis pubescens* and *Cephalanthus occidentalis* along the then flowing Salt River. These early collections from around 1906 and included plants that currently no longer occur naturally in the PFR. The Irish collections are one of the few records of what grew along the Salt River before it was dewatered (Arizona State University Vascular Plant Herbarium records). The water diversion was so complete that from the1930's onward the Salt and Gila River beds were usually dry (Calvin, 1946).

In 1957 the City of Phoenix built a small sewage treatment plant near 91st Ave. and the Salt River, an area also known as Tres Rios Project (TRP). The treatment plant along with small amounts of agricultural runoff helped fill the dry river bed. Upstream however the Salt River usually remained dry and was used for dumping trash, unmanaged recreation, and the mining of rock and gravel. In fact, TRP only had flowing water throughout the system during wet El Nino years. This was because water from the SRP dams was released only during floods, after which the riverbeds soon returned to a dry state. Over the years the treatment plant was expanded to meet the increased needs of the growing city and the increase in effluent release along with periodic flooding created the possibility for cottonwood-willow recruitment. In the 1990s large tracts of cottonwood-willow forest were established in the TRP area (Corkran, 1996). Tamarisk woodlands became established along the Gila River, as a result of this plant's tolerance of salty conditions, it thrives with other halophytes in the agricultural runoff that enters the river. These woodlands created a prime environment for wildfires that have recently burned, causing poor air quality across the urban valley.

In 1996 the city of Phoenix built the TRP demonstration wetland, as a way to treat sewage. The wetlands attracted birds and other wildlife, and soon became popular with bird watchers. In 2007 TRP received a grant to build extensive wetlands that were expected to be completed by 2010 (TRP website). Very little was known about the flora of the proposed project area and only a floristic study on the nearby Sierra Estella Park had been conducted. However the focus of that flora was on the mountain range, not the Gila River. Thus there was a significant need for a floristic inventory to be conducted at TRP, and the PFR of the PMA in general.

In summer 2007, I started the study of the flora of TRP with the help of the ASU herbarium and the permission of the TRP. At that point in time there had been a 10 year drought and the prospect of wet years seemed unlikely. However the Salt and Gila Rivers had ample water due to effluent and agriculture runoff, which was fortunate because the presence of water made conducting a flora project practical. One of the benefits was that there would be plants growing in the riparian areas even in a drought as exemplified by the hot and dry summer of 2009 (Table 1). From 2007 to 2009 I conducted many field trips at TRP and collected a plethora of plant species for my project. Many summer annuals were discovered along with a *Cyperus* species new to the state of Arizona. In summer 2009 I began to collect on the tributaries of the Salt and Gila Rivers to make a comparison with TRP area and to add to the greater understanding of the flora of Phoenix. Many different species were found, especially escaped horticultural species. Thus my project evolved to include the Four Rivers of the PMA.

Historical plant collectors:

There have been many plant collectors over the last one hundred years documenting species within the PFR area. Most have concentrated on local mountain ranges, such as Sierra Estrella Regional Park (Sundell, 1968), White Tank Mountains Regional Park (Keil, 1973), South Mountain (Daniel and Butterwick, 1992), McDowell Mountains Regional Park (Lane, 1981), Lake Pleasant Regional Park (Lehto, 1970), Hassayampa Preserve (Wolden et al.1995), and the Phoenix flora (Damrel, 2010). Relatively few have included riparian areas. The Sierra Estrella flora focused on the mountains but Sundell (1968) collected a few plants from the Gila River bed. The Lake Pleasant flora included part of the lower Agua Fria River just below the New Waddell Dam (Lehto, 1970). These two projects contributed information on the nature of the PMA river flora, but barely overlap with it. Most plant collections within the PMA have been associated with ecological studies, with no concentrated effort to document the plants.

As mentioned above, F.M. Irish was an important collector in the early 20th Century. McLellan and Stitt collected from about 1930 to 1950. Many of the plants that they collected along the Salt River no longer occur in the region's flora. For example: *Nasturtium officinale*, *Marrubium vulgare*, *Orobanche cooperi*, *Prosopis pubescens, Dimorphocarpa wislizeni,* and *Cephalanthus occidentalis.* In the late 20th century A. Rea, D.J. Pinkava, and E. Lehto were important collectors. In the early 21st century ecologists Jenica Pozik and Jacqueline White conducted seeds bank studies of soils from the Salt River. Seed banks often have interesting species from the upper watershed like *Hedeoma oblongifolia,* and escaped exotic garden plants like *Solanum lycopersicum.* The past plant collectors have contributed important information on previous occurrences of plant species that can be compared to collections made in the present study to serve as evidence for floristic change over time. The present study of species in PMA will aid future generations in understanding the changing nature of the flora.

Chapter 3

CLIMATE

The PMA is a riparian ecosystem located in central Arizona's arid Salt River Valley, which has a bi-seasonal pattern of precipitation (Cerveny, 1996). In the winter PMA is affected by cold fronts that bring gentle rains that originate in the western Pacific Ocean. This winter precipitation may last days with each passing cold front bringing cool temperatures, and this extended duration of rain allowing for deep penetration of water into the soil. This is an important aspect of the winter season because this duration has a direct effect on the number of germinating ephemeral plants. In the spring after heavy rains ephemeral plants can carpet vast areas of the PMA. The winter's rains are variable and often fail due to the changing conditions in the Pacific called El Nino and La Nina. Winter precipitation can be above average during El Nino because higher sea temperatures in the eastern Pacific feed extra moisture into frontal system entering the Southwest USA. During La Nina the eastern Pacific is cooler than normal and causes drought conditions in the Southwest (Cerveny, 1996).

The summer rains are called the North American Monsoon and have a complex origin. In the summer, high pressure forms over the Four Corners area (where the states of Arizona, Colorado, New Mexico and Utah meet). The circulation of the air around the high pressure draws in moist air from the Gulf of California and the Gulf of Mexico. In the Gulf of California low pressure forms due to intense daytime heating and it brings in the majority of moist air into Arizona. These two sources provide enough moisture via the monsoonal flow to generate thunderstorms due to daytime heating. Thunderstorms are intense but spotty with only small areas receiving rain on a given day (Cerveny, 1996). For instance, precipitation from one summer thunderstorm was 1.93" (August 2, 2005) on the east fork of Cave Creek (Maricopa Flood control, 2011).

Sometimes one storm can produce up to 3 inches of rain causing flash floods in small streams (personal observation). The summer rains, if plentiful enough, can produce abundant ephemerals, but these conditions rarely occur in low desert. In a dry monsoon ephemerals are rare and found widely scattered across the landscape. For example, in PMA I discovered that summer ephemerals were abundant in 2008 but were rarely observed in other years (Table 1).

Some authors have described the climate of PMA as having six seasons based on temperature and bi-seasonal precipitation pattern (Robichaux, 1999). 1) <u>Winter</u>: December-January average temperatures of 52 F. The mild winters allow subtropical plants to thrive but about every 10 years a hard frost below 25 F can kill frost-sensitive plants. Typically PMA experiences mild frosts which usually occur in December, January or February. The urban heat island effect has reduced the risk of frost and the urban center rarely experience temperatures below 25 F (Svoma & Brazel 2010). 2 <u>Spring</u>: February through March and up to April is usually dry with mild temperatures, but late spring can be hot with temperatures above 100 F. Sometimes the spring season can bring wet and cool weather due largely to the El Nino. 3) <u>Pre Summer</u>: May-June typically tends to be hot and dry with the first 100 F days. 4) <u>Summer Monsoon</u>: June 15 – September 15 is hot with high temperatures sometimes averaging above 110 F and lows in the 90's F. Nature can be forgiving in the desert with the monsoon clouds and thunderstorms moderating the intense heat. 5) <u>Post Summer:</u> September 15- October 15. This season tends to be hot with highs in the 100's F and dry much like May and June but the nights are pleasant with temperatures below 80 F. 6) <u>Fall</u>: October- November. The days are warm with highs in the 80's with cool nights in the 60's, temperatures moderate by mid-season due to passing cold fronts and the shortening of the days (Robichaux, 1999). Most rains falls in the winter and summer monsoon seasons.

Table 1.			
"Water year" (October to September) precipitation totals in inches	2008	2009	2010
Station name			
Laveen	8.46	4.57	6.30
East Fork of Cave Creek	8.46	4.09	7.13
New River and Bell Road	7.24	3.74	9.53
New River and Glendale Ave.	7.36	3.66	8.82

(Maricopa County flood control, 2011)

Chapter 4

HYDROLOGY

The PMA hydrology is defined by the Basin and Range topography of fault block mountain ranges and deep valleys filled with alluvium. The PMA is made up of several deep sub basins interconnected by a common aquifer. The depth to the water table varies across the basin due to ground water pumping. The shallowest depth is 27 feet near the Salt-Gila River confluence and the deepest near Luke Air force base at 483ft. Natural ground water recharge for the PMA is 24,000 acre feet a year, annual withdraw is 200,000 acre feet a year (ADWR, 2008).

Natural ground water flows is in the direction of the southwest toward the Gila River, but due to pumping many large cone depressions have formed near Luke Air Force base and South Scottsdale. The perennial reaches of the Salt and Gila Rivers may be dewatered as ground water flows towards the cone depression near Luke Air Force base. The perennial reach of the Salt and Gila water source is effluent from the 91st Ave Treatment Plant, agriculture runoff, and the naturally high water table. The Aqua Fria is a losing stream because of the water tables great depth due to excessive ground water pumping in the west Salt River sub basin (ADWR, 2008). The small urban streams are perennial for short distances near large storm drains, and other water sources. The influx of water into the otherwise intermittent stream creates many mesic microhabitats. Shade created by large bridges is also a factor and these tend to be located near storm drains.

The Rio Salado project is located near Central Ave. and the Salt River. The project transformed dry sections of the Salt River into perennial flowing riparian areas by pumping ground water and importing water from the Central Arizona Project Canal.

The hydrology of the PMA has been greatly affected by urbanization. The effects of urbanization include: soil compaction, impermeable surfaces, increased runoff into riparian areas, decreased runoff due to terminal flood retention basins, stream bed incision, ground water withdrawal and recharge, and introduction of exotic plants and animals. The combination of these effects has created an urban ecosystem that is unique to the PMA.

Chapter 5

METHODS

Collections:

Field collecting for the present study of plants along the urban PFR system began in May 2007, and includes the Salt River channel and adjacent areas from 91st Avenue west to the Gila River and to the confluence of the Gila and Agua Fria River. Collections on the Agua Fria River watershed inside the Urban PMA were conducted from May 2009-present. Eight hundred and sixty specimens have been collected and the total number of species found is 347.

Plants have been identified to using the Arizona Flora by Kearney & Peebles and collaborators (1960), treatments for Vascular Plants of Arizona project (http://www.canotia.org/vpa_project.html), Southwest Environmental Information Network, SEINet (accessed 2007-2011),and appropriate revisions of the Flora of North America (http://www.fna.org/). In general, nomenclature follows the United States Department of Agriculture's National Plant Database (USDA, 2000).

Voucher specimens.

Herbarium voucher specimens have been made as part of the TRP collection and placed in the Arizona State University Herbarium. Duplicates will be sent to other herbaria around the world for exchange.

Species abundance:

Classifications are useful tools for communicating various vegetation patterns. The flora provides information on the abundance of each species in distinct plant associations. An approach relying on dominant or indicator species was used to show stand similarities. Vegetation was classified into types as was appropriate within practical limits. The associations or patch types was defined as a plant community of definite floristic composition, uniform habitat conditions, and uniform physiognomy (Szaro, 1989). I have subjectively determined abundance of taxa in association types. Each species was be categorized as follows:

"Rare" was used to indicate 50 or fewer individuals occurring in the Flora area.

"Occasional" described species found in few associations, never dominating any one association or patch type.

"Common" represented species found at many patch types, occasionally dominating.

"Abundant" was used to describe plant species found in over half of the associations, often dominating.

Species traits:

The following information was included for each species: phenology (flowering time), life span (perennial, annual, biennial), form (tree, shrub, sub-shrub, succulent, graminoid, or herb), native/exotic status, and wetland indicator ranking following Reed (1988).

Site characterization:

Literature reviews of climate data, flood/drought dynamics, soils, and geography were conducted.

Photography

Photographs were taken of many plants for presentations and addition to the ASU herbarium image library online.   Rare species were scanned by herbarium staff at 300 dots per square inch, some with close-ups of important reproductive and/or vegetative parts.

Arizona State University administers and maintains a database of life science collections on the World Wide Web(SEINet 2011). I plan to add the PFR to this website.

GIS

The voucher specimens were georeferenced mostly with Google Earth (Google Inc. 2009.) In some cases these data were augmented with a handheld GPS unit. The latitude and longitude was recorded for every collection.

Chapter 6

GEOGRAPHIC INFORMATION

Study Area

The urban riparian flora of the Phoenix Metropolitan Area (PMA) encompasses watersheds of the lower Salt, middle Gila, New and Agua Fria Rivers. The flora project focuses on two main areas: the TRP Wetlands and the greater watershed of the tributary streams in the PMA (figure 9). TRP is situated in the southwestern Salt River Valley, at the confluence of Salt, Gila, and Agua Fria Rivers. The rivers now are ephemeral with the exception of areas where there is runoff from agriculture, storm drains, and the outflow from the 91st Avenue sewage treatment plant. The Agua Fria watershed within the PMA contains many small streams located mostly in the western part of the basin. Before the building of dams along these rivers, water probably flowed continuously along the Salt, Gila, and possibly the Aqua Fria. The river bed has been subject to environmental degradation from the nearby urban areas in a variety of man-made ways: illegal dumping, All Terrain Vehicle use, homeless squatters, feral dog packs, target shooting, and crime.

Despite the abuse of the river bed at the TRP there are many notable species of plants : 1) escaped cultivars (*Vitex agnus-castus, Morus alba, Cucumis sativa,* and *Colocasia esculenta);* 2) species nearly new to Arizona *(Cyperus elegans, Cyperus eragrostis, Cyperus pygmaeus);* 3) recent range expansions from the Colorado River *(Sesbania herbacea)*; 4) unexpected species, *(Cylindropuntia fulgida*, and *Platystemon californicus),* both rarely found at the low elevations of the TRP. There are also some missing species, such as *Prosopis pubescens, Lycium torreyi, and Cephalanthus occidentalis,* that were collected in the past, but have not been collected in over 40 years.

Geographic information

The Phoenix Metropolitan Area, often called the Valley of the Sun, is situated within the Basin and Range Province of Western North America (Robichaux, 1999; see Fig. 9). This Province is characterized by fault block mountain ranges that separate basins filled by alluvium, forming flat valleys. The PMA is ringed by a series of mountain ranges including the Sierra Estrella and South Mountain to the south, White Tanks to the northwest, Bradshaws to the north, New River Mountains to the northeast, the McDowells and Superstitions to the east.

At the TRP the river bed is composed of different patches of substrate such as river cobble, sand, silt, and clay. The active river bed ranges from cobble to fine gravel. River terraces just above the active channel are typically sandy. The river bank adjacent to the active channel is composed of silt to clay loams. Soil organics are low except in perennial pools where algae and other aquatic organisms gather. Some plants are associated with particular substrate types, although many are found in all types depending on soil moisture. The soils are the result of young alluvium being deposited by floods of the Salt and Gila Rivers. The oldest are located on the upper terraces and were deposited during previous centuries. There are two granite buttes located in TRP. They have typical desert mountain soils of unconsolidated gravels, silts and clays. The soils are shallow and rocky, lacking soil organics and have a high pH (Corkran, 1996).

The Agua Fria watershed within the PMA has been altered for flood control purposes. The addition of levees, construction of low flow channels, grade leveling, removal of woody vegetation, and channel cementing, are some examples of stream alteration. The streams vary from small desert and urban washes to large, sandy river beds. Stream alteration within the PMA has changed the function of the stream to create new habitats unique to the PMA.

Habitats

Plant communities (listed in Table 6 for mesic and xeric riparian) within the PFR vary with respect to water source and depth, depth to water table, substrate, and disturbance, and include the following:

I. Mesic Riparian:

(A) Cottonwood-Willow Forest

(B) *Prosopis* Woodlands

(C) *Tamarix* Woodlands

(D) Tree Tobacco-Castor Bean Thickets

(E) Agricultural land.

II. Xeric Riparian:

(A) River cobble to grave;

(B) Sand bars

(C) Silty river banks and terraces

III. Desert Mountain

IV. Urban Xeric-Mesic Riparian Streams

V. Quarry Lakes and Marshes

VI. Flood Control Dams and seasonally flooded lakes

VII. Flood retention basins

I. Mesic Riparian Habitats

(A). Cottonwood-Willow Forest (CWF): The forest is made up of *Populus fremontii, Salix gooddingii*, and understory of shrubs and herbs. CWF is rich in grasses, and other herbaceous plants. The CWF is limited to the main effluent channel, and is dependent on surface flows (Sarzo 1989).

(B). *Prosopis* Woodlands: The woodlands have a scattered distribution with the largest remnants located at TRP along Baseline Road west of Phoenix International Race Track. The woodlands are made up of *Prosopis, Atriplex spp.*, and variety of shrubs. *Prosopis* woodlands merge with *Tamarix* woodlands depending on substrate, soil salinity, and depth of water table. *Prosopis* forms the most extensive stands on upper dry terraces, and *Tamarix chinensis* dominates on silty low areas with halophytes.

(C). *Tamarix* Woodlands: These woodlands are found throughout the TRP varying in density from sparse shrubs to thick woodlands. The density and productivity of *Tamarix* stands is dependent on depth of the water table. Numerous stands develop on a number of different soil types from silt loams to clay loam with varying levels of water availability from surface water to shallow water tables. Sparse shrubby stands can develop with surface flows of water from floods and survive without access to ground water. *Tamarix* can occur in mixed stands with *Populus and Salix, Prosopis* and *Atriplex*, or in pure, thick stands. Shrub and herbaceous plants are minimal to absent. Groundcover is sometimes a thick thatch layer of *Tamarix* leaves. *Tamarix aphylla* is a minor associate reproducing by cloning or sprouting from broken limbs washed downstream from a parent plant.

(D). Tree Tobacco-Castor Bean Thickets: This habitat, associated with disturbed areas within the active channel, is composed of *Nicotiana glauca* and *Ricinus communis* 5-10 m in height. The understory is rich in shrubs and herbs, most commonly *Pluchea odorata* and *P. sericea*, and herbaceous plants such as *Nicotiana obtusifolia*, and *Eclipta prostrata*.

(E). Agricultural Land: Before the construction of the TRP wetlands the upper river terraces had farm fields. Depending on season the fields grew wheat, barley, alfalfa, sorghum, corn, or millet. Farms are present on the margins of the PMA and merge with the city. Common agriculture weeds in these areas include *Ipomoea purpurea*, *Cyperus rotundus*, *Polygonum aviculare,* and *Malva parviflora*.

II. Xeric Riparian Habitats

The Xeric Riparian Habitats occur from just beyond the active channel to the upper river terraces. This habitat is defined by a seasonal presence of water. Flows occur during floods caused by heavy rain storms. This habitat is similar to xeric desert washes except it occurs along a major river course (see Fig. 10).

(A) River cobble to gravel: The species that characterize this habitat include *Ambrosia eriocentra*, *Hymenoclea monogyra,* and *Stephanomeria pauciflora*. Among herbaceous components are *Cryptantha* spp., *Chamaesyce* ssp., and *Bouteloua barbata.*

(B) Sand bars: Annual herbaceous plants found in sandy areas are *Abronia angustifolia, Oenothera californica, Helianthus annuus,* and *Chenopodium album.*

(C) Silty river banks and terraces: Common species are *Parkinsonia* spp., *Prosopis* spp., and species of Chenopodiaceae. Soils can be salty and salt-loving plants like *Allenrolfea occidentalis* occur in some areas.

III. Desert Mountain Habitat and plains

There are two buttes within the TRP, both of which have typical Arizona Uplands plants. Because the buttes are isolated from larger mountain ranges, they are similar to islands where the flora is expected to be impoverished in comparison to larger mountain ranges such as the South Mountains or the Sierra Estrellas. Both buttes are also impacted by heavy recreational use and one of them is the site of a granite quarry. Two species which only occur on their slopes and not in riparian habitats of PMA watershed are *Carnegiea gigantea* and *Hilaria rigida.*

IV. Urban Xeric-Mesic Riparian Streams

The washes, creeks, and rivers of the Valley of the Sun have been greatly altered by urbanization. Flood control structures, such as the cementing of river beds have changed stream grade and water infiltration rates. Ground water pumping has caused the dewatering of some reaches of the Agua Fria and New Rivers. Waste water from agriculture runoff is received by some reaches of the Agua Fria and New Rivers which creates perennial stretches for short distances. The flow regimes have been significantly changed by pulses of storm runoff from impermeable streets.

The storm drains introduce an urban flora of escaped horticulture species and novel plant associations are created. These include *Eucalyptus-Acacia* forests, Ash-Elm woodlands, and *Prosopis* woodlands. Overall biodiversity is increased by the escaped horticultural species, which often do better in the altered urban riparian sites than native plants.

The New River, Agua Fria River, Cave Creek, and Skunk Creek have been altered for flood control purposes with cemented banks and leveled stream beds. Every mile the streambed has a drop off, followed by a leveling and the middle of the river bed has a low flow channel 1-3ft deep that in some reaches is cemented. Figures 5-8 are photos of the habitats with these stream alterations. When heavy rain falls on the urban watershed the water rushes from the storm drains and creates short periods of flood waters. When the flood waters breach the low flow channel the water slowly flows over the level stream bed. The slowly moving flood waters are similar in their effect to flood irrigation and grasses and mostly herbaceous species later cover the stream bed.

Maricopa County's practices for flood control management of the river beds have been to remove trees, and mow the grass and weeds. The result is that in some places a meadowland of *Cynodon dactylon* has formed. On reaches where flood control does not remove trees thick woodlands of *Prosopis-Acacia-Parkinsonia* form. Xeric desert wash vegetation occurs in dewatered reaches that lack storm drain or agriculture runoff. These are typically characterized by *Baccharis sarothroides, Prosopis spp., Parkinsonia spp.,* and *Rhus lancea*.

Perennial reaches of these rivers occur for short distances near large storm drains and agricultural runoff. Mesic habitats are dominated by cottonwood-willow, *Acacia-Prosopis-Parkinsonia*, and rarely *Tamarix.* Wetland species such as *Cyperus eragrostis, Schoenoplectus acutus, Juncus torreyi,* and many others occur in the perennial reaches. The New River has three perennial reaches located near Pinnacle Peak Road, the confluence with Skunk Creek, and near the Glendale Airport. The Agua Fria River has a short perennial reach near the I-10 Bridge crossing and just below the New Waddell Dam. The unique ecology of urban streams is fascinating and needs to be studied in the future.

V. Quarry Lakes and Marshes

Gravel quarries are a major industry within the PMA. There are two main types of quarries: sand-gravel, and granite rock. Sand-gravel quarries are located near or within flood plains, and use the sand for aggregate in cement. Flooded quarries are an important habitat for birds. The pits can be very deep and in areas of high water tables perennial lakes and marshes can form. One Quarry near the confluence of the Agua Fria and Gila Rivers is over 10 feet deep (personal personal observation, 2009). Large dredges floating on barges are used to mine the aggregates. The quarry lakes can be several acres in size and if protected with levees will not fill with sediment over time.

Shallow quarry lakes along the urban rivers capture seasonal flood waters creating ephemeral lakes and marshes. Figures 2-4 are air photos of quarry lake habitat from Google Earth; this habitat is often difficult to find on the ground. The use of Google Earth allowed me to find many quarry lakes. At Pinnacle Peak road and the New River a large flooded quarry exists and is a fine example. A large pit was dug about fifty feet into the river bed. The quarry site was abandoned and flood waters from the New River are captured after heavy rains forming a large lake about 2 acres in diameter. Over a period of months the water seeps into the ground and also evaporates away. As the lake shrinks riparian and marsh plants establish along the shore. The lake dries up leaving behind large muddy areas covered in marsh plants. The quarry lake reforms after every large flood, but eventually it will fill with sediment and disappear. This reach of the New River is xeric riparian but supports wetland species that occupy the margins of the lake. Species present include *Typha domingensis*, *Cyperus pygmaeus*, and *Veronica peregrina*.

VI. Flood control dams and seasonally flooded lakes

The Maricopa Flood Control District constructed several large flood control dams on the edge of the PMA. The dams prevent large scale flooding by capturing flood waters and slowly releasing managed flows downstream. The effect of the dams has essentially altered the downstream flood regime, while upstream the dams have also created ephemeral lakes. These lakes are only present for a matter of weeks but create riparian habitat similar to a flooded quarry lake. The lake beds are large flat areas and have several different habitats such as delta, lake shore, and silt-clay lake bed. This habitat can be seen in fig. 1, a quarry lake on the Agua Fria River.

A. Deltas form where the stream enters the lake and sediments accumulate. Course sand builds up at the base of the delta and Bermuda grass dominates this area, while at the foot of the delta fine silt/clay sediment is present and supports *Chenopodium spp*.

B. The lake shore constantly changes as flood waters fill the basin or drain away. Herbaceous plants colonize the shore and can cover the dry lake bed.

C. Lake bed is made of fine silt/clay and can be barren or densely covered in annual plants depending on how long ago the lake bed was flooded. A common plant is pig weed: *Amaranthus palmeri*. Mesquite trees can form woodlands along the high water mark of the lake. Trees can grow on the lower lake bed but are commonly killed by flood waters. The ephemeral lakes created by the flood control dams are an interesting habitat because seasonally flooded lakes are uncommon in the Sonoran Desert. The New River, Skunk Creek, and Cave Creek have good examples of this habitat.

VII. Flood retention Basins

Flood control options in the PMA often include the construction of small retention basins to capture runoff from urban areas. These basins are often terminal and water disperses by seeping into the ground and evaporating away. The retention basins are usually small and constructed in association with parking lots or housing developments. The small retention basins provide water for landscaping trees like *Acacia* and *Prosopis*. Larger basins are used as recreation areas for residents of the nearby housing developments. The main effect of the many retention basins is a reduction of water flow into urban streams. The private retention basins are usually landscaped and maintained by a home owner association.

Reach 11 retention basin is located in Northwest Phoenix and is a terminal flood retention basin built to protect the Central Arizona Project canal. The basin is 17 miles long by ½ mile wide and features recreation trials. Reach 11 retention basin has extensive xeric riparian wash habitat. *Prosopis-Acacia-Parkinsonia* woodlands occur along washes. Reach 11 also has a small seasonal stock tank fed by the many washes that empty into the terminal basin.

Non-terminal flood retention basins retain water that is not released. These basins are scattered across the PMA and are often larger than the small private terminal basins. The non-terminal retention basins are linked to urban streams by pipe systems. These basins are smaller urban analogs to larger flood control basins of the major rivers of the PMA. Public parks are often built in these basins and feature turf areas and landscaping trees like *Prosopis, Acacia, Quercus,* and *Fraxinus*. The basins that are linked to urban streams could be a source of exotic tree species.

Chapter 7

RESULTS

The flora of the PFR, including the TRP area, and the tributaries of the Salt and Gila Rivers of the Phoenix Metropolitan area was collected over a four year period from 2007-2010. The purpose was to increase the understanding of the region's riparian flora. The data from the urban tributaries provided a comparison of how the distribution of native and escaped horticulture species varies across the urban river system. Species found growing upstream of Tres Rios Project area could have seeds transported by floods downstream. The distribution of species varies from one river to another due to the effects of urbanizations.

The species found in urban streams appear to have three origins: native, escaped horticultural species, and agricultural weeds. Native species are those such as *Populus fremontii* that have persisted through the changes to the urban river environment. Escaped species originated from cultivated species in city landscaping by three dispersal agents; animals (biotic dispersal), wind (amenochory), and water (hydrochory). Species spread by animals often have burs that stick to fur in order to be transported to a new area, or juicy fruit like *Lantana camera* that are consumed, with the seeds transported to a new area. Wind dispersal species have seeds that are small and sometimes fluffy like grass species. Hydrochorous species dispersal occurs when heavy rains wash seeds off the streets into storm drains that empty into river beds. Escaped species are often found in close proximity to storm drains for a variety of reasons. Each storm drain has its own watershed with a unique flora of cultivated species; however several species are common to most of these assemblages.

In a study of the dispersal mechanisms on the Hassayampa River animal dispersal was the most common method, followed by wind and water (Drezner et al., 2001). Similar modes of dispersal are found in the Phoenix riparian areas. Water dispersal may be more important because of the frequency of storm drains that reach river beds. River bed sites provide a good environment where windblown and hydrochorous seeds can germinate.

Urban streams of the PMA have developed novel species associations composed of both native and escaped species. Riparian species are preadapted to disturbance regimes of rivers and thrive in these areas. The mixture of native and escaped species may seem odd at first glance but when the life histories of the species are examined it is clear that they are occupying habitats with similar environmental parameters as those of their native range. For example *Eucalyptus microtheca* forms woodlands in dry washes and is associated with *Acacia farnesiana*, *Parkinsonia spp.*, and *Rhus lancea*. *Eucalyptus microtheca* in Australia grows along seasonally flooded watercourses (Chippendale, 1988), a habitat very similar to the seasonally flooded washes in urban Phoenix. Other escaped horticultural species have become established in the river bottoms because it is the only mesic environment in an otherwise arid landscape. Examples include: *Ulmus pariflora*, *Schinus terebinthifolius*, and *Melalueca viminalis.*

The urban streams of the PMA are a unique assemblage of species and habitats found nowhere else in the world. The factors that formed these habitats were urbanization and stream alteration. As the PMA urban environment expanded, new horticultural species from around the world were introduced as landscaping plants for new housing developments. The landscape plants are native to arid parts of Australia, Africa, Eurasia, and Latin America and the conditions of the PMA riparian system are similar to their native habitats.

The urban streams of the PMA probably receive more water from runoff than natural systems because of the impermeable surfaces of the city surroundings. In desert systems much of the runoff is absorbed before it reaches the main channels of the tributaries. The effect of increased long lasting water flow and stream alteration has created new habitats prime for colonization by both native and escaped plants.

Anthropogenic alteration to streams is similar to disturbance in natural streams. The common example in the PMA is when a stream grade is leveled and vegetation is removed. After grading, the streams have bare substrate ready for recruitment of disturbance tolerant plants. Plant associations will change as succession processes For example, annual grasses often form meadow like areas in early successional areas, but are replaced by woody plants over time. Areas that have not been graded for many years form dense woodlands of *Parkinsonia*, *Prosopis,* and *Acacia*.

At the confluence of the New River and Skunk Creek the stream bed was graded and the river bed and channelized for flood control. This reach of the New River has mixtures of both native and escaped exotic species. Exotic species included: *Eucalyptus microtheca*, *Acacia farnesiana*, *Parkinsonia aculeata, and Lythrum hyssopifolium.* The seed source of these exotics was the urban flora growing in the watershed that entered through storm drains. Native plants were either already present in the seed bank or were washed down stream during large flood events. Natives included many typical xeric riparian species like *Hymenoclea monogyra*, *Parkinsonia florida*, and *Chilopis linearis*. There are also many native mesic plants like *Schoenoplectus maritimus, Cyperus eragrostis, Lythrum californica, Veronica peregrina*, and *Juncus torreyi*.

The occurrence of the mesic species is interesting because the pre-modified stream was xeric riparian wash. Urbanization changes including stream bed modifications, increased runoff from the urban watershed, and Arizona canal overflow water, have apparently provided conditions favorable for the establishment of mesic species. The combination of changes to the stream bed, watershed, and exotic and seed sources have created several unique urban riparian habitats. For example, Cave Creek just west of the confluence with its East Fork has dense woodlands of *Eucalyptus microtheca*, *Eucalyptus camaldulensis*, *Parkinsonia aculeata*, and *Acacia farnesiana*, approximately from 19th Ave east to the confluence with the East Fork of Cave Creek. The dense stands of *Eucalyptus* recently developed after a levee was constructed for a new shopping center. Vegetation was removed and the bare ground was colonized by seeds washed down from storm drains and plants upstream. *Eucalyptus microtheca* occurs upstream on the East Fork of Cave Creek but there are only a few scattered trees. The seeds that produced this Cave Creek grove may have been washed in through storm drains, were windblown, or carried by animal from nearby landscaping trees. The grove of trees is interesting because it appears to be the densest stand of *Eucalyptus* trees in the PMA. There are also scattered trees of *Eucalyptus* that occur throughout the streams of the PMA. *Eucalyptus microtheca* was introduced ca. 25 years ago to the PMA as a landscape tree. In contrast, most escaped specimens appear less than ten years old. It will be interesting in the future to see how successful these trees will become in the urban riparian habitat of the PMA.

The Salt-Gila River reach of the PMA is a perennial stream dominated by effluent flow from the 91st Ave treatment plant. The Salt-Gila River reach was initially the primary focus of my botanical exploration effort and understanding of urban riparian ecology. This reach is influenced by both the urban and rural landscapes of the PMA, but the degree of influence of the urban environment is less than the upstream tributaries. The banks of this reach are lined with farm fields growing many different types of crops, and the exotic species found in this area are mostly weeds from these agricultural fields versus escaped cultivars. Seed sources for escaped exotics are upstream and only a few species have been found during the project. For example *Acacia salicina* is frequently found on the New River, and on the Salt River at the Rio Salado project area. This species has only one occurrence on the Salt-Gila reach. Escaped agriculture plants are common on this reach and include alfalfa, wheat, barely, and pearl millet. One of the important components of the flora is weeds both native and escaped agricultural. Common weedy species include *Cynodon dactylon*, *Sorghum halepense*, *Cyperus rotundus*, and *Enchinochloa colona*.

The Agua Fria River from below Lake Pleasant to the confluence with the Gila River is a large, dry desert river bed. The Agua Fria River has one perennial reach just below New Waddle dam in a small canyon. The perennial reach has *Tamarix* woodlands, and wetland plants along the active channel. Below the perennial reach the river is intermittent. The river has a broad sandy channel about a half mile to quarter mile wide. The river has been modified by the construction of levees, bridges, and gravel quarries. Vegetation consists of widely scattered *Prosopis*, *Chilopsis linearis*, and *Parkinsonia florida*. The river is a large wash for most of its length in the PMA. Microhabitats near storm drains and under bridges have more mesic species such as *Fraxinus uhdei*, and *Ulmus parvifolia*. Gravel quarries located within the river bed capture flood waters and form ephemeral ponds and marshes. In areas of high water table, deep quarry pits can be perennial lakes or marshes, depending on the quarry pit depth. Quarry lakes and marshes are common throughout the PMA and represent a major habitat for marsh plants and birds.

An interesting comparison can be made between the urban riparian systems of the mesic eastern city of Baltimore and the PMA (Grimm et al., 2008). The mesic streams experience hydrologic drought due to the effects of urbanization. City streets create large areas of impermeable surfaces that increase runoff into streams causing flash floods. The floods incise streams beds and lower water tables (Groffman et al.). The riparian species of the mesic east coast of the United State are ill adapted to drought and suffer from the loss of water. The effects of urbanization in the PMA are similar to Baltimore with respect to the physical changes to the urban watershed but with different results. Urban streams in the PMA experience an increase water flow because runoff from urban impermeable surface runs into stream channels and sometimes the stream channel itself is paved. In the PMA many smaller streams have intermittent flows and are often losing streams due to natural low water tables. Under natural conditions water running into these streams would have often been absorbed by desert soils. The increased water into the urban streams benefits the drought adapted xeric riparian species and also benefits more mesic riparian species, both native and exotic, that would have not been present in a pre-urban stream.

The Hassayampa River just northwest of the PMA perhaps provides a glimpse of the Agua Fria before urbanization. Its watershed is similar in size, but has not been as greatly affected by humans. The lower reach of Hassayampa River west of the White Tank Mountains sits on a broad plain and is an intermittent stream with xeric riparian vegetation such as *Baccharis, Hymenoclea*, and *Prosopis*. A comparison of the two rivers floras is interesting because it's an indicator of the change urbanization may bring to a xeric river. The Agua Fria has many wetland mesic species that do not occur along the dry reach of Hassayampa River west of the White Tank Mountains, including: *Cyperus eragrostis, Schoenoplectus acutus*, *Veronica peregrina*, *Ulmus parvifolia, and Fraxinus uhdei.*. Their presence in the PMA and absence along the Hassayampa may indicate that urbanization has increased water availability enough for these species to thrive in a habitat that would have been too dry in its pre-urban state. *Ulmus* and *Fraxinus*, being urban trees, are less likely to have established along the Hassayampa.

Chapter 8

CONCLUSIONS

The known flora of the rivers of the PMA includes 347 species with the important families listed in Table 2. The most important families are Asteraceae with 43 species, Poaceae with 33 species, and Cyperaceae with 15 species. Regionally, the flora is most similar to Sierra Estrella Park (Sundell, 1974) with 162species in common. Table 3 shows the flora is least similar to Seven Springs with 96 species in common, a higher elevation area in the New River Mountains (Doan, 2002).

Table 4 notes the records of new and/or recently recorded species for the Arizona flora, many of which are horticultural cultivars that are apparently persisting. The two escaped *Acacia* species from Australia, were common landscaping plants in the late 20th Century. They are found as young trees along urban streams and in abundance on the Agua Fria watershed. The new *Cyperus* species pose an interesting question: have these species been here for many years, but have gone unnoticed until now? *Cyperus* species are often misidentified and/or avoided for collection by botanists due to the difficulty in identification.

The discovery of several new species for Arizona may be the result of the intense botanical exploration of the project area or perhaps these species were just overlooked by previous botanist's investigations. For example, the first collections of the old world species *Cyperus pygmaeus* were on the Salt and Agua Fria Rivers in 1998 but were not correctly identified until much later. The Agua Fria plants were collected just below New Waddell dam where a flora was conducted many years earlier by Elinor Lehto in her flora of Lake Pleasant Park (Lehto 1970). The Lake Pleasant Flora was published in 1970 by Lehto and would have most likely recorded the new *Cyperus* if it were present at the time. *Cyperus pygmaeus* must have escaped and become established between 1970 and 1998.

The escaped horticulture species are found more often at urban sites and less frequently at rural sites in the Flora area. For example, the New River has many escaped species like *Eucalyptus* but the more rural site of the TRP does not. TRP is on the fringe of the urban area where seeds from landscape plants have yet to establish.

The flora of the PFR has expanded the known flora of the state by vouchering horticultural species that have become established in the area, and by adding new several state records. New species are not included in keys for the region were especially challenging. For example *Acacia salicina* was identified to genus with local reference material, then to species by comparison to cultivated herbarium records. Identification to species is often the most difficult step due to variety of reasons such as specimen quality. Sometimes unknown plants must be confirmed by experts. For example, *Cyperus pygmaeus* was confirmed in this manner. The theme of the urban river system is anthropogenic change and introductions of plant species. The main difference between urban riparian ecosystem and the unaltered pre-urban streams is increased biodiversity and heterogeneity of habitats. The ecosystem services these highly altered riparian systems provide remain important and include for example, habitat for wildlife, recreation, water filtration, aquifer recharge, scenic beauty, erosion and flood control. The urban streams of the PMA are dynamic and fascinating systems that will continue to produce novel associations of plants and should be explored on a regular basis.

REFERENCES

Arizona Department of Water Resources. 2008. http://www.azwater.gov/azdwr/StatewidePlanning/WaterAtlas/ActiveManagementAreas/documents/Volume_8_PHX_final.pdf .

Calvin, R. (1946). River of the sun; stories of the storied Gila. Albuquerque: University of New Mexico Press.

Cerveny, R.S. 1996. Climate of Phoenix Arizona. Online version. http://www.public.asu.edu/~aunjs/ClimateofPhoenix/phxwx.htm.

Chippendale, G. M. 1988. Eucalyptus. Pp. 1--448 in A. S. George (ed.), Flora of Australia 19, Astralian Government Publishing Service, Canberra.

Corkran, D. F. (1996). Native riparian vegetation of the lower Salt and middle Gila rivers: Status and restoration. *M.S. thesis.* Arizona State University, Tempe.

Damrel, D.Z., 2010. http://swbiodiversity.org/seinet/checklists/checklist.php?cl=22&proj=1.

Daniel, T. F. and M. L. Butterwick. 1992. The flora of the South Mountains of south-central Arizona. Desert Plants 10: 99-119

Drezner, T. D., Fall, P. L., & Stromberg, J. C. 2001. Plant distribution and dispersal mechanisms at the Hassayampa River Preserve, Arizona, USA. Global Ecology and Biogeography, 10(2): 205-217.

Doan, S. 2002. Flora of the Seven Springs Region, Tonto National Forest, Maricopa County, Arizona. M.S. thesis. Arizona State University, Tempe.

Emory, W. H., & Fremont, J. C. (1849). Notes of travel in California; comprising the prominent geographical, agricultural, geological, and mineralogical features of the country; also, the route to San Diego, in California, including parts of the Arkansas, Del Norte and Gila Rivers. Dublin: J. M'Glashan.

Google Inc. 2009. Google Earth (Version 5.2.1.1588) [Software]

Grimm, N.B., J. M. Grove, S. T. A. Pickett, and C. L. Redman. 2008 Integrated approaches to long-term studies of urban ecological systems. 123-142 in: Urban ecology. An international perspective on the interactions between humans and nature. Marzluff, J. M., E. Shulenberger, W. Endlicher, M. Alberti, G. Bradley, C. Ryan, U. Simon, C. ZumBrunnen, eds. Springer Science + Business Media, New York.

Groffman, P. M., et al. 2003. Down by the riverside: Urban riparian ecology. *Frontiers in Ecology and the Environment,* 1(6):315-321.

Holmgren, C. A., J.L. Betancourt., and K.A. Rylander. 2006. A 36,000-yr vegetation history from the peloncillo mountains, southeastern arizona, USA.*Palaeogeography, Palaeoclimatology, Palaeoecology, 240*(3-4), 405-422. doi:DOI: 10.1016/j.palaeo.2006.02.01

Kearney, T. H., R.H. Peebles and collaborators. 1960. *Arizona flora, ed. 2.* Berkeley, University of California Press.

Keil, D. J. 1973. Vegetation and flora of the White Tank Mountains Regional Park, Maricopa County, Arizona. *Journal of the Arizona Academy of Science,* 8(1):35-48.

Flora of North America Editorial Committee, eds. 1993-2003. *Flora of North America north of Mexico.* 10+ vols. New York and Oxford.

Lane, M. A. 1981. Vegetation and flora of the McDowell Mountains Regional Park, Maricopa County, Arizona. Journal of the Arizona-Nevada Academy of Science 16(VOL?): 29-38.

Lehto, E. 1970. Floristic Study of Lake Pleasant Regional Park, Maricopa County, Arizona. M.S. thesis. Arizona State University, Tempe.

Maricopa County Flood Control, 2011. http://www.fcd.maricopa.gov/Rainfall/Raininfo/raininfo.aspx . Accessed 2011

Reed, P.B., Jr. 1988. National list of plant species that occur in wetlands: Southwest (Region 7). U.S. Fish and Wildlife Service Biological Report 88(26.7).

Robichaux, R. H. (1999). Ecology of Sonoran desert plants and plant communities. Tucson: University of Arizona Press.

Salt River Project Website, 2011. http://www.srpnet.com/about/history/water.aspx Accessed 2011

SOUTHWEST ENVIRONMENTAL INFORMATION NETWORK SEINet). 2007-2011.SEINet. http://swbiodiversity.org/seinet/index.php. Accessed January 2007 to April 2011.

Sundell, E.G. 1974. Vegetation and Flora of the Sierra Estrella Regional Park, Maricopa County, Arizona. M.S. thesis. Arizona State University, Tempe.

Svoma, B. M., and A. Brazel. 2010. Urban Effects on the Diurnal Temperature Cycle in Phoenix, Arizona. *Climate Research* 41(1):21-29.

Szaro, R. C. 1989. *Riparian forest and scrubland community types of Arizona and New Mexico*. Desert Plants 9(3-4):70-138.

Tres Rios wetlands http://phoenix.gov/TRESRIOS/index.html. Accessed 2008-2010

United State Department of Agriculture, NRCS 2000. The Plants Database http://www.plants.usda.gov/plants. National Plant Database Center, Baton Rouge, LA 70874-4490, U.S.A.

Wolden, L. G., J. C. Stromberg and D. T. Patten. 1995. Flora and vegetation of the Hassayampa River Preserve, Maricopa County, Arizona. Journal of the Arizona-Nevada Academy of Science 28: 76-111

APPENDIX A

PLANT LIST

Family	Scientific name	Author	Common name	Collector #	Native/introduced	Habitat	Wetland indicator	Site	Notes
Acanthaceae	*Ruellia brittoniana*	Leonard	Britton's wild petunia	DJ 572	Intro	Mesic riparian	N/A	Tres Rios-Salt River	Subshrub with purple flowers. Rare
Acanthaceae	*Ruellia nudiflora*	(Engelm. & A. Gray) Urban	Violet wild petunia	DJ 689	Native	Mesic riparian	N/A	New River-Skunk Creek	Subshrub with purple flowers. Rare
Aizoaceae	*Mesembryanthemum crystallinum*	L.	Ice plant	DJ 47	Intro	Mesic riparian	N/A	Tres Rios-Salt River	Ice plant a small prostrate herb, yellow flowers. Cultivated
Aizoaceae	*Sesuvium verrucosum*	Raf.	Verrucose seapurslane	DJ 490	Intro	Mesic riparian	FACW	All	Marsh plant, small prostate herb along rivers. Common
Aizoaceae	*Trianthema portulacastrum*	L.	Desert horsepurslane	DJ 20, 45, 121, 136, 157, 172, 515.	Native	Mesic riparian	N/A	All	Herb grows in disturbed soils. Common
Amaranthaceae	*Amaranthus albus*	L.	Prostrate pigweed	DJ 35, 55.	Native	Mesic riparian	FACU	All	Herb grows in disturbed soils. Common
Amaranthaceae	*Amaranthus fimbriatus*	(Torr.) Benth. ex S. Wats.	Fringed amaranth	DJ 519. 561.	Native	Xeric riparian	N/A	All	Herb grows on disturbed soils. Occasional
Amaranthaceae	*Amaranthus palmeri*	S. Wats.	Careless weed	DJ 133, 472,477, 533.	Native	Xeric riparian	FACU	All	Herb. Occasional
Amaranthaceae	*Tidestromia lanuginosa*	(Nutt.) Standl.	Woolly tidestromia	DJ 81,117, 203, 479.	Native	Xeric riparian,	N/A	All	Herb that grows in sandy soils. Common
Anacardiaceae	*Rhus lancea*	L.f.	African sumac	DJ 695, 728, 745.	Intro	Mesic to Xeric riparian	N/A	All	Tree that escapes into urban streams. Occasional
Anacardiaceae	*Schinus molle*	L.	Peruvian peppertree	DJ 570	Intro	Mesic riparian	N/A	Tres Rios-Salt River	Tree that escapes into urban streams. Rare

Anacardiaceae	*Schinus terebinthifolia*	Raddi	Brazilian peppertree	DJ 792	Intro	Mesic riparian	N/A	New River-Skunk Creek	Tree that escapes into urban streams. Rare
Apiaceae	*Bowlesia incana*	Ruiz & Pav.	Hoary bowlesia	DJ 254, 262, 369, 612, 775.	Native	Desert mountian and Riparian areas	UPL	All	Herb. Common
Apiaceae	*Hydrocotyle verticillata*	Thunb.	Whorled marsh pennywort	DJ 53.	Native	Mesic riparian	OBL	Tres Rios-Salt River	Herb of marshlands. Common
Apiaceae	*Spermolepis echinata*	(Nutt. Ex DC.) Heller	Bristly scale seed	DJ 829	Native	Mesic riparian	N/A	New River-Skunk Creek	Herb. Rare
Apocynaceae	*Nerium oleander*	L.	Oleander	DJ 716	Intro	Mesic to Xeric riparian	N/A	New River-Skunk Creek	Shrub. Rare
Araceae	*Colocasia esculenta*	(L.) Schott	Taro	DJ 86, 181, 191	Intro	Mesic riparian	OBL	Tres Rios-Salt River	Herb with edible tuber
Arecaceae	*Phoenix dactylifera*	L.	Date palm	Makings 3611	Intro	Mesic riparian	N/A	Salt River at Tres Rios, and Loop 202	Tree. Rare
Arecaceae	*Washingtonia filifera*	(Linden ex Andre) H. Wendl.	California palm tree	Observed at Cave Creek at 19th Av. And New River near Thunderbrid rd.	Native	Mesic riparian	FACW	New River-Skunk Creek	Tree. Occasional
Arecaceae	*Washingtonia robusta*	H. Wendl.	Palm tree	DJ 740	Intro	Mesic riparian	N/A	All	Tree that escapes into urban streams. Occasional
Asclepiadaceae	*Asclepias subulata*	Dcne.	Rush milkweed	DJ 139	Native	Xeric riparian to desert mountains	N/A	Tres Rios-Salt River	Native plant that is grown as a cultivated plant in this area.

Asclepiadaceae	*Sarcostemma cynanchoides*	Dcne.	Fringed twinevine	DJ 625	Native	Xeric riparian.	FAC	All	Desert vine, sprawls over trees, shrubs and herbs. Common
Asteraceae	*Ambrosia ambrosioides*	(Cav.) W.W. Payne	Ambrosia leaf bur ragweed	DJ 78	Native	Xeric riparian, sandy soils	N/A	All	Shrub with large ragweed like leafs. Common
Asteraceae	*Ambrosia dumosa*	(A. Gray) W.W. Payne	Burrobush	DJ 617,	Native	Desert mountain	N/A	All	Shrub that grows on mountain slopes. Rare
Asteraceae	*Ambrosia eriocentra*	(A. Gray) W.W. Payne	Woolly fruit bur ragweed	DJ 75, 100, 395.	Native	Xeric riparian, sandy soils	N/A	Tres Rios-Salt River	Shrub bur like fruit. Common
Asteraceae	*Baccharis salicifolia*	(Ruiz & Pav.) Pers.	Seep willow	DJ 1	Native	Mesic riparian	FACW	All	Shrub with willow like leaves and white flowers. Common
Asteraceae	*Baccharis sarothroides*	A. Gray	Desertbroom		Native	Xeric riparian	FAC-	All	Shrub. Common
Asteraceae	*Baileya multiradiata*	Harvey & A. Gray ex A. Gray	Desert marigold	DJ 42, 808	Native	Xeric riparian	N/A	All	Herb with yellow flowers. Occasional
Asteraceae	*Bebbia juncea*	(Benth.) Greene	Sweatbush	DJ 57, 99, 396	Native	Xeric riparian, sandy soils	N/A	All	Desert shrub. Common
Asteraceae	*Brickellia coulteri*	Ell.	Coulter's brickellbush	DJ 656	Native	Desert hills and Sandy Xeric riparian	N/A	Tres Rios-Salt River	Desert shrub. Occasional
Asteraceae	*Calycoseris wrightii*	A. Gray	White tackstem	DJ 638	Native	Xeric riparian	N/A	All	Herb. Occasional
Asteraceae	*Centaurea melitensis*	L.	Maltese star thistle	DJ 702, 706	Intro	Xeric riparian	N/A	All	Herb. Occasional
Asteraceae	*Chaenactis stevioides*	Hook. & Arn.	Esteve's pincushion	DJ 594, 618, 641, 772	Native	Xeric riaprian	N/A	All	Herb. Occasional
Asteraceae	*Conyza canadensis*	(L.) Cronq.	Canadian horseweed	DJ 169	Native	Mesic riparian	FACU	All	Herb. Common

Asteraceae	*Dicoria canescens*	A. Gray	Desert twinbugs	DJ 153, 585	Native	Xeric riparian, sandy soils	N/A	All	Shrub. Occasional
Asteraceae	*Dieteria asteroides*	Torr.	Fall Tanyaster	DJ 446, 481, 421	Native	Xeric riparian	N/A	All	Herb. Occasional
Asteraceae	*Dimorphotheca sinuata*	Berg.	Glandular Cape marigold	DJ 230	Intro	Xeric riparian	N/A	All	Herb. Occasional
Asteraceae	*Dyssodia pentachaeta*	(DC.) B.L. Robins.	Fiveneedle pricklyleaf	DJ 714	Native	Xeric riparian	N/A	All	Herb. Occasional
Asteraceae	*Eclipta prostrata*	(L.) L.	False daisy	DJ 152, 160, 468	Intro	Mesic riparian	FAC	All	Herb. Common
Asteraceae	*Encelia farinosa*	A. Gray ex Torr.	Brittlebush	DJ 59, 257, 463	Native	Desert hills and Sandy Xeric riparian	N/A	All	Desert perennial shrub. Common
Asteraceae	*Filago californica*	Nutt.	California cottonrose	DJ 223, 281	Native	Xeric riparian to desert mountains	N/A	All	Herb. Occasional
Asteraceae	*Helenium thurberi*	A. Gray	Thurber's sneezeweed	DJ 682	Native	Mesic riparian	OBL	New River-Skunk Creek	Herb. Rare
Asteraceae	*Helianthus annuus*	L.	Common sunflower	DJ 49, 176, 385, 471, 551, 574	Native	Mesic riparian	FAC-	All	Herb with yellow flowers and edible seeds. Common
Asteraceae	*Heterotheca subaxillaris*	(Lam.) Britt. & Rusby	Camphorweed	DJ 166, 552	Native	Mesic riparian	UPL	All	Tall herb with yellow flowers. Common
Asteraceae	*Hymenoclea monogyra*	Torr. & A. Gray ex A. Gray	Singlewhorl burrobush	DJ 189, 206	Native	Xeric riparian	N/A	All	Shrub common in riparian areas. Occasional
Asteraceae	*Hymenoclea salsola*	Torr. & A.Gray	Burrobush	DJ 356, 397	Native	Xeric riparian	N/A	All	Shrub common in riparian areas. Occasional

Asteraceae	*Isocoma acradenia*	(Greene) Greene	Alkali goldenbush	DJ 192	Native	Xeric riparian	N/A	All	Desert perennial shrub. Occasional
Asteraceae	*Lactuca serriola*	L.	Prickly lettuce	DJ 503, 540	Intro	Xeric riparian	FAC	All	Herb. Common
Asteraceae	*Laennecia coulteri*	(A. Gray) G.L. Nesom	Coulter's horseweed	DJ 11, 14, 178, 413, 419	Native	Mesic riparian	FAC	All	Herb. Common
Asteraceae	*Machaeranthera pinnatifida*	B.L. Turner & Horne	Arid tansyaster	DJ 652	Native	Xeric riparian desert mountain	FAC	All	Desert perennial shrub. Occasional
Asteraceae	*Malacothrix glabrata*	(A. Gray ex D.C. Eat.) A. Gray	Smooth desertdandelion	DJ 210, 317, 321, 327, 355, 358	Native	Desert mountain	N/A	All	Herb. Occasional
Asteraceae	*Monoptilon bellioides*	(A. Gray) Hall	Mohave desertstar	DJ 319, 325, 372	Native	Desert mountain	N/A	All	Herb. Occasional
Asteraceae	*Oncosiphon piluliferum*	(L. f.) Kallersjo	Stinknet	DJ 6, 205	Intro	Desert mountain	N/A	All	Herb with yellow flowers. Common
Asteraceae	*Pectis papposa*	Harvey & A. Gray	Manybristle cinchweed	DJ 512	Native	Desert mountain	N/A	All	Herb. Occasional
Asteraceae	*Perityle emoryi*	Torr.	Emory's rockdaisy	DJ 607, 653, 661	Native	Desert mountain	N/A	Tres Rios-Salt River	Herb. Occasional
Asteraceae	*Pluchea odorata*	(L.) Cass.	Sweetscent	DJ 69, 107, 202	Native	Mesic riparian	FACW	All	Shrub. Common
Asteraceae	*Pluchea sericea*	(Nutt.) Coville	Arrowweed	DJ 108, 116, 119, 812	Native	Mesic riparian	FACW	All	Shrub. Common
Asteraceae	*Pseudognaphalium canescens*	(DC.) W.A. Weber	Wright's cudweed	DJ 719	Native	Xeric riparian	UPL	All	Herb. Occasional
Asteraceae	*Pseudognaphalium luteoalbum*	(L.) Hilliard & Burtt	Jersey cudweed	DJ 498, 722, 832	Native	Mesic riparian	FAC	All	Herb. Occasional
Asteraceae	*Rafinesquia neomexicana*	A. Gray	New Mexico plumeseed	DJ 279, 322, 334, 789	Native	Desert mountain	N/A	All	Herb. Common

Asteraceae	*Sonchus asper*	(L.) Hill	Spiny sowthistle	DJ 449	Intro	Mesic riparian	FACW	All	Herb. Common
Asteraceae	*Sonchus oleraceus*	L.	Common sowthistle	DJ 164, 183, 213, 214, 374, 410, 459	Intro	Desert mountain	UPL	All	Herb. Common
Asteraceae	*Stephanomeria pauciflora*	(Torr.) A. Nels.	Brownplume wirelettuce	DJ 60, 114, 188	Native	Xeric riparian	N/A	All	Shrub with small pink flowers. Common
Asteraceae	*Symphyotrichum divaricatum*	(Nutt.) G.L. Nesom	Southern annual saltmarsh aster	DJ 541, 548	Native	Xeric riparian	N/A	All	Herb. Occasional
Asteraceae	*Verbesina encelioides*	(Cav.) Benth. & Hook. f. ex A. Gray	Golden crownbeard	DJ 31, 271, 333, 336, 403, 412	Native	Mesic to Xeric riparian	FAC	All	Herb. Common
Asteraceae	*Xanthium strumarium*	L.	Rough cocklebur	DJ 120, 122, 177	Native	Mesic riparian	FAC	All	Herb. Common
Bignoniaceae	*Chilopsis linearis*	(Cav.) Sweet	Desert willow	DJ 26, 62, 746	Native	Xeric riparian	UPL	All	Tree. Occasional
Boraginaceae	*Amsinckia menziesii*	(Lehm.) A. Nels. & J.F. Macbr.	Menzies' fiddleneck	DJ 253, 266, 272, 273, 508, 616, 781, 787	Native	Desert mountain and xeric riparian	N/A	All	Herb. Common
Boraginaceae	*Cryptantha angustifolia*	Lehm. ex G. Don	Panamint cryptantha	DJ 61, 242, 245, 247, 328, 365, 386, 408, 510, 635	Native	Desert mountain and xeric riparian	N/A	All	Herb. Common
Boraginaceae	*Cryptantha barbigera*	(A. Gray) Greene	Bearded cryptantha	DJ 58, 265, 367, 390, 392	Native	Desert mountain and xeric riparian	N/A	All	Herb. Common
Boraginaceae	*Cryptantha maritima*	(Greene) Greene	Guadalupe cryptantha	DJ 357, 391, 393, 601, 654,784	Native	Desert mountain and xeric riparian	N/A	All	Herb. Occasional

Boraginaceae	*Cryptantha muricata*	(Hook. & Arn.) A. Nels. & J.F. Macbr.	Pointed cryptantha	DJ 252, 354, 366	Native	Desert mountain and xeric riparian	N/A	All	Herb. Occasional
Boraginaceae	*Cryptantha pterocarya*	(Torr.) Greene	Wingnut cryptantha	DJ 264, 611, 614, 662	Native	Desert mountain and xeric riparian	N/A	Tres Rios-Salt River	Herb. Occasional
Boraginaceae	*Heliotropium curassavicum*	L.	Salt heliotrope	DJ 13, 32, 46.	Native	Mesic riparian	FACW	All	Prostrate spreading herb with white flowers. Common
Boraginaceae	*Pectocarya heterocarpa*	(I.M. Johnston) I.M. Johnston	Chuckwalla combseed	DJ 240, 241, 270	Native	Desert mountain and xeric riparian	N/A	All	Herb. Common
Boraginaceae	*Pectocarya platycarpa*	(Munz & Johnston) Munz & Johnston	Broadfruit combseed	DJ 243, 243, 244, 246	Native	Desert mountain and xeric riparian	N/A	All	Herb. Common
Boraginaceae	*Pectocarya recurvata*	I.M. Johnston	Curvenut combseed	DJ 208, 274, 398	Native	Desert mountain and xeric riparian	N/A	All	Herb. Common
Boraginaceae	*Tiquilia plicata*	(Torr.) A. Richards .	Fanleaf crinklemat	DJ 74	Native	Xeric riparian and desert	N/A	All	Herb. Occasional
Brassicaceae	*Brassica tournefortii*	Gouan	Asian mustard	DJ 249	Intro	Mesic riparian	N/A	All	Herb. Common
Brassicaceae	*Capsella bursa-pastoris*	(L.) Medik.	Shepherd's purse	DJ 235	Intro	Mesic riparian	FAC	All	Herb. Occasional
Brassicaceae	*Descurainia pinnata*	(Walter) Britton	Western tansymustard	Lehto 17533	Native	Desert mountain and xeric riparian	N/A	All	Herb. Not collected during this study

Brassicaceae	*Dimorphocarpa wislizeni*	(Engelm.) Rollins	Touristplant	Irish s.n., Lehto 17991	Native	Desert mountian and Riparian areas	N/A	Tres Rios-Salt River	Herb. Not collected during this study
Brassicaceae	*Draba cuneifolia*	Nutt. ex Torr. & A. Gray	Wedgeleaf draba	DJ 593	Native	Desert mountain and xeric riparian	N/A	All	Herb. Occasional
Brassicaceae	*Eruca vesicaria ssp. sativa*	(P. Mill.) Thellung	Rocketsalad	DJ 783, 830	Intro	Desert mountain and xeric riparian	N/A	New River-Skunk Creek	Herb. Occasional
Brassicaceae	*Guillenia lasiophylla*	(Hook. & Arn.) Greene	California mustard	DJ 251, 597, 599, 619, 779, 786	Native	Desert mountian and Riparian areas	N/A	All	Herb. Common
Brassicaceae	*Lepidium lasiocarpum*	Nutt.	Shaggyfruit pepperweed	DJ 222, 232, 238, 239, 359, 603, 636	Native	Desert mountian and Riparian areas	N/A	All	Herb. Common
Brassicaceae	*Lesquerella gordonii*	(A. Gray) S. Wats.	Gordon's bladderpod	DJ 276	Native	Desert mountain and xeric riparian	N/A	All	Herb. Occasional
Brassicaceae	*Raphanus sativus*	L.	Radish	D.J. Pinkava 10116	Intro	Mesic riparian	N/A	Gila River	Herb. Rare
Brassicaceae	*Sisymbrium irio*	L.	London rocket	DJ 182	Native	Mesic riparian	N/A	All	Herb. Abundant
Buddlejaceae	*Buddleja marrubiifolia*	Benth.	Wolly butterflybush	DJ 457	Intro	Mesic riparian	N/A	Tres Rios-Salt River	Subshrub cultivated. Rare
Cactaceae	*Cylindropuntia fulgida*	(Engelm.) Knuth	Chainfruit cholla	DJ 190	Native	Desert mountain	N/A	Tres Rios-Salt River	Shrub/Tree. Rare
Cactaceae	*Opuntia sp.*	P. Mill.	Prickly-pear	DJ 577	Native	Desert mountain	N/A	Tres Rios-Salt River	Shrub. Rare

Cactaceae	*Opuntia engelmannii var. engelmannii*	Salm-Dyck	Prickly-pear	DJ 89	Native	Desert mountain	N/A	Tres Rios-Salt River	Shrub. Rare
Campanulaceae	*Nemacladus glanduliferus var. orientalis*	Mc Vaugh	Glandular threadplant	Pinkava 11817	Native	Mesic riparian	N/A	Papago Park	Herb.. Not collected during this study
Capparidaceae	*Polanisia trachysperma*	Torr. & Gray	Sandyseed clammyweed	DJ 12, 30	Native	Mesic riparian	FAC	All	Tall herb with yellow flowers. Common
Capparidaceae	*Wislizenia refracta*	Engelm.	Spectacle fruit	Lehto 18276, Sundell 546	Native	Mesic riparian	FACW	Gila River	Herb.. Not collected during this study
Caprifoliaceae	*Sambucus nigra ssp. caerulea*	(Raf.) Bolli	Blue Elderberry	DJ 5, 28, 36, 193, 433	Native	Mesic riparian	FAC	Tres Rios-Salt River	Small tree or shrub. Occasional
Caryophyllaceae	*Spergularia salina*	J.& K. Presl	Salt sandspurry	DJ 623, 659, 705	Native	Mesic riparian	OBL	Tres Rios-Salt River	Herb. Common
Chenopodiaceae	*Allenrolfea occidentalis*	(S. Wats.) Kuntze	Iodine bush	DJ 626	Native	Mesic riparian	FACW	Tres Rios-Salt River	Shrub. Rare
Chenopodiaceae	*Atriplex canescens*	(Pursh) Nutt.	Fourwing saltbush	DJ 655	Native	Xeric riparian	UPL	All	Shrub. Common
Chenopodiaceae	*Atriplex elegans*	(Moq.) D. Dietr.	Wheelscsle saltbush	DJ 516, 555	Native	Xeric riparian	N/A	All	Herb. Common
Chenopodiaceae	*Atriplex lentiformis*	(Torr.) S. Wats.	Big saltbush	DJ 18, 87, 126, 554	Native	Xeric riparian	FACW	All	Shrub. Common
Chenopodiaceae	*Atriplex polycarpa*	(Torr.) S. Wats.	Cattle saltbush	DJ 204	Native	Xeric riparian	FACU	All	Shrub. Occasional
Chenopodiaceae	*Atriplex semibaccata*	R. Br.	Australian saltbush	Lehto 427	Intro	Xeric riparian	FAC	Agua Fria River	Shrub. Not collected during this study
Chenopodiaceae	*Atriplex wrightii*	S. Watson	Wright's saltbush	McLellan 81	Native	Xeric riparian	N/A	Agua Fria River	Herb.. Not collected during this study.

Chenopodiaceae	*Bassia hyssopifolia*	(Pall.) Kuntz	Fivehorn smotherweed	Rhea 1193	Intro	Xeric riparian	FACW	Agua Fria River	Herb. Not collected during this study.
Chenopodiaceae	*Chenopodium sp.*	L.	Goosefoot	DJ 54, 216, 261	Native	Xeric riparian	N/A	All	Herb. Common
Chenopodiaceae	*Chenopodium album*	L.	Lambsquarters	DJ 199	Native	Xeric riparian	FAC	All	Herb. Common
Chenopodiaceae	*Chenopodium berlandieri*	Moq.	Pitseed goosefoot	DJ 217, 320, 404, 409	Native	Xeric riparian	N/A	All	Herb. Common
Chenopodiaceae	*Chenopodium leptophyllum*	(Moq.) Nutt. ex S. Wats.	Narrowleaf goosefoot	DJ 383	Native	Xeric riparian	FACU	All	Herb. Common
Chenopodiaceae	*Chenopodium murale*	L.	Nettleleaf goosefoot	DJ 19, 220, 418, 535, 550, 651, 816	Native	Xeric riparian	NO	All	Herb. Common
Chenopodiaceae	*Dysphania ambrosioides*	(L.) Mosyakin & Clemants	Mexican tea	DJ 171, 175, 452, 586	Native	Xeric riparian	FAC	All	Herb. Common
Chenopodiaceae	*Monolepis nuttalliana*	(J.A. Schultes) Greene	Nuttall's povertyweed	DJ 326, 388	Native	Xeric riparian	FAC	All	Herb. Occasional
Chenopodiaceae	*Salsola tragus*	L.	Prickly Russian thistle	DJ 77, 102	Intro	Xeric riparian	FACU	All	Herb. Common
Chenopodiaceae	*Suaeda moquinii*	(Torr.) Greene	Mohave seablite	DJ 93, 197, 580	Native	Xeric riparian	N/A	Tres Rios-Salt River	Herb. Common
Convolvulaceae	*Ipomoea X leucantha*	L.	Morning-glory	DJ 534, 590	Intro	Xeric riparian	N/A	Tres Rios-Salt River	Herb. Rare
Crassulaceae	*Crassula connata*	(Ruiz & Pav.) Berger	Sand pygmweed	DJ 268, 295, 324, 339, 361, 637	Native	Xeric riparian	FACW	All	Herb. Common
Cucurbitaceae	*Cucumis sativus*	L.	Garden cucumber	DJ 184, 221	Intro	Xeric riparian	N/A	Tres Rios-Salt River	Herb. Rare
Cucurbitaceae	*Cucurbita digitata*	A. Gray	Fingerleaf gourd	Sundell 356	Native	Xeric riparian and desert	N/A	Gila River	Vine. Occasional
Cuscutaceae	*Cuscuta campestris*	Yuncker	Dodder	DJ 717	Native	Xeric riparian and desert	N/A	All	Herb, parasite. Occasional

Cuscutaceae	*Cuscuta salina*	L.	Saltmarsh dodder	DJ 499, 834, 842	Native	Xeric riparian and desert	N/A	All	Herb parasite. Occasional
Cyperaceae	*Cyperus sp.*	L.	Faltsedge	DJ 97, 524, 713	Native	Mesic riparian	OBL	All	Herb. Common
Cyperaceae	*Cyperus difformis*	L.	Variable flatsedge	DJ 162, 560, 566, 764	Intro	Mesic riparian	OBL	All	Herb. Common
Cyperaceae	*Cyperus elegans*	L.	Royal flatsedge	DJ 591, 707, 711, 734	Native	Mesic riparian	OBL	Gila River, Salt River	Herb. Occasional
Cyperaceae	*Cyperus eragrostis*	Lam.	Tall flatsedge	DJ 435, 589, 678, 712, 736	Native	Mesic riparian	OBL	New River-Skunk Creek	Herb. Common
Cyperaceae	*Cyperus erythrorhizos*	Muhl.	Redroot flatsedge	DJ 148, 158, 434	Intro	Mesic riparian	OBL	Gila, Salt Rivers	Perennial. Occasional
Cyperaceae	*Cyperus involucratus*	Rottb.	Umbrella plant	DJ 51, 215	Intro	Mesic riparian	FACW	All	Perennial. Occasional
Cyperaceae	*Cyperus odoratus*	L.	Fragrant flatsedge	DJ 124, 145, 147, 149, 187, 423, 426, 427, 495, 497, 504	Native	Mesic riparian	OBL	All	Herb. Abundant
Cyperaceae	*Cyperus pygmaeus*	Rottb.	Dwarf flatsedge	DJ 526, 708, 723	Intro	Mesic riparian	OBL	All	Small annual herb. Common
Cyperaceae	*Cyperus rotundus*	L.	Nutgrass	DJ 528	Intro	Mesic riparian	OBL	All	Herb. Occasional
Cyperaceae	*Eleocharis sp.*	R. Br.	Spike rush	DJ 675, 709	Native	Mesic riparian	OBL	All	Herb. Occasional
Cyperaceae	*Eleocharis geniculata*	(L.) Roemer & J.A. Schultes	Canada spikesedge	DJ 161, 525	Native	Mesic riparian	OBL	All	Herb. Occasional
Cyperaceae	*Eleocharis parishii*	Britt.	Parish's spikerush	DJ 67, 718	Native	Mesic riparian	FACW	All	Herb. Occasional
Cyperaceae	*Schoenoplectus acutus*	(Muhl. ex Bigelow) A.& D. L÷ve	Hardstem bulrush	DJ 22, 430, 487, 730, 733	Native	Mesic riparian	OBL	All	Perennial. Occasional

Cyperaceae	*Schoenoplectus americanus*	(Pers.) Volk. ex Schinz & R. Keller	Chairmaker's bulrush	DJ 432	Native	Mesic riparian	OBL	All	Perennial. Occasional
Cyperaceae	*Schoenoplectus californicus*	(C.A. Mey.) Palla	California bulrush	Lehto 5082	Native	Mesic riparian	OBL	Agua Fria River, Papago Park	Perennial. Occasional
Cyperaceae	*Schoenoplectus maritimus*	(Pers.) Volk. ex Schinz & R. Keller	Cosmopolitan bulrush	DJ 23, 64, 159, 163, 428, 429, 432, 476, 492, 493, 757	Native	Mesic riparian	OBL	All	Perennial. Common
Dryopteridaceae	*Nephrolepis exultata var. bostoniensis*	Davenp.	Boston fern	Sundell 394	Intro	Mesic riparian	N/A	Gila River	Perennial. . Not collected during this study
Euphorbiaceae	*Argythamnia neomexicana*	Mull. Arg.	New Mexico silverbush	Lehto 5139, McLellan 656	Native	Xeric riparian	N/A	All	Herb. Occasional
Euphorbiaceae	*Chamaesyce sp.*	S.F. A. Gray	Sandmat	DJ 156	Native	Xeric riparian	N/A	All	Herb. Occasional
Euphorbiaceae	*Chamaesyce albomarginata*	(Torr. & A. Gray) Small	Whitemargin sandmat	DJ 34, 818	Native	Xeric riparian	N/A	All	Herb. Occasional
Euphorbiaceae	*Chamaesyce arizonica*	(Engelm.) Arthur	Arizona sandmat	DJ 436	Native	Xeric riparian	N/A	All	Herb. Occasional
Euphorbiaceae	*Chamaesyce hyssopifolia*	(L.) Small	Hyssopleaf sandmat	DJ 755	Native	Xeric riparian	N/A	All	Herb. Occasional
Euphorbiaceae	*Chamaesyce maculata*	(L.) Small	Spotted sandmat	Makings 3606	Native	Xeric riparian	N/A	All	Herb. Occasional
Euphorbiaceae	*Chamaesyce setiloba*	(Engelm. ex Torr.) Millsp. ex Parish	Yuma sandmat	DJ 155, 579	Native	Xeric riparian	N/A	All	Herb. Occasional
Euphorbiaceae	*Ricinus communis*	L.	Castor bean	DJ 10, 127, 134, 576	Intro	Mesic riparian	FAC	All	Small tree or shrub. Common

Fabaceae	*Acacia farnesiana*	(L.) Willd.	Sweat acacia	DJ 666, 842	Native	Mesic riparian	FACU	New River-Skunk Creek	Tree. Occasional
Fabaceae	*Acacia greggii*	A. Gray	Catclaw acacia	DJ 480	Native	Xeric riparian	UPL	All	Tree. Occasional
Fabaceae	*Acacia salicina*	Lindl.	Cooba	DJ 649, 665, 747, 801	Intro	Xeric riparian	N/A	New River-Skunk Creek	Tree. Occasional
Fabaceae	*Acacia schaffneri*	(S. Wats.) F.J. Herm.	Schaffner's wattle	DJ 687, 698	Intro	Xeric riparian	N/A	New River-Skunk Creek	Tree. Occasional
Fabaceae	*Acacia stenophylla*	A. Cunn. ex Benth.	Dalby myall	DJ 664	Intro	Xeric riparian	N/A	New River-Skunk Creek, Gila River	Tree. Occasional
Fabaceae	*Alhagi maurorum*	Medik.	Camelthorn	Makings 3601	Intro	Xeric riparian	N/A	Salt River at Loop 202	Shrub with sharp thorns. Occasional
Fabaceae	*Calliandra eriophylla*	Benth.	Fairyduster	DJ 137	Native	Mesic riparian	N/A	Tres Rios-Salt River	Shrub. Occasional
Fabaceae	*Dalea mollis*	Benth.	Hairy prairie clover	DJ 630	Native	Desert mountains	N/A	All	Subshrub. Common
Fabaceae	*Gleditsia triacanthos*	L.	Honeylocust	DJ 679	Intro	Mesic riparian	FAC	New River-Skunk Creek	Tree. Rare
Fabaceae	*Leucaena leucocephala*	(Lam.) de Wit	White leadtree	DJ 453	Intro	Mesic riparian	N/A	Tres Rios-Salt River	Tree. Occasional
Fabaceae	*Lotus salsuginosus*	Greene	Coastal bird's-foot trefoil	DJ 2, 604, 771	Native	Desert mountains	N/A	All	Herb. Occasional
Fabaceae	*Lupinus sparsiflorus*	Benth.	Coulter's lupine	DJ 280, 307, 609, 776	Native	Desert mountains	N/A	All	Herb. Common
Fabaceae	*Lysiloma watsonii*	Rose	Littleleaf false tamarind	Makings 3605	Intro	Mesic riparian	N/A	Salt River at Loop 202	Tree. Rare
Fabaceae	*Medicago sativa*	L.	Alfalfa	DJ 458, 530	Intro	Mesic riparian	N/A	Tres Rios-Salt River	Herb. Occasional
Fabaceae	*Melilotus alba*	Medikus	White clover	DJ 726	Native	Mesic riparian	FAC	All	Herb. Common
Fabaceae	*Melilotus indicus*	(L.) All.	Annual yellow sweatclover	DJ 407	Native	Mesic riparian	FAC	All	Herb. Common
Fabaceae	*Nasturtium officinale*	W.T. Aiton	Watercress	Irish	Intro	Mesic riparian	OBL	Salt River near what is now TempeTown Lake	Perennial herb. . Not collected during this study

Fabaceae	*Parkinsonia aculeata*	L.	Mexican paloverde	DJ 21, 444, 833, 845	Native	Xeric riparian	FAC	All	Tree. Abundant
Fabaceae	*Parkinsonia florida*	(Benth. ex A. Gray) S. Wats.	Blue paloverde	DJ 91, 379	Native	Xeric riparian	N/A	All	Tree. Occasional
Fabaceae	*Parkinsonia microphylla*	Torr.	Foothills paloverde	DJ 209	Native	Desert mountains and xeric riparian	N/A	All	Tree. Occasional
Fabaceae	*Prosopis sp.*	L.	Mesquite	DJ 741, 742,743,751, 754, 800, 807, 838, 841, 844,	Native	Xeric riparian	N/A	All	Trees of hybrid swarms. Abundant
Fabaceae	*Prosopis alba*	Griseb.	White mesquite	DJ 90	Intro	Xeric riparian	N/A	All	Tree. Occasional
Fabaceae	*Prosopis pubescens*	Benth.	Screwbean mesquite	DJ 24	Native	Mesic riparian	FACW	Tres Rios-Salt River	Tree cultivated. Rare
Fabaceae	*Prosopis velutina*	Woot.	Velvet mesquite	DJ 37, 88, 381	Native	Xeric riparian	FAC	All	Tree. Common
Fabaceae	*Sesbania herbacea*	Urb.	Bigpod sesbania	DJ 72, 96	Native	Mesic riparian	FACW	Tres Rios-Salt River	Tall herb with yellow flowers. Common
Fabaceae	*Senna artemisioides*	Gaud. Ex DC.	Silver senna	DJ 803	Intro	Xeric riparian	N/A	New River near Glendale Ave.	Shrub. Occasional
Fabaceae	*Senna covesii*	A. Gray	Coves senna	DJ 83	Native	Xeric riaprian	N/A	All	Shrub. Occasional
Fabaceae	*Vigna caracalla*	(L.) Verdc.	Snailflower	DJ 41, 454	Intro	Mesic riaprian	N/A	Tres Rios-Salt River	Vine. Occasional found in cultivations
Fouquieriaceae	*Fouquieria splendens*	Engelm.	Ocotillo	DJ 138	Native	Desert mountain	N/A	Tres Rios-Salt River	Large Shrub. Occasional
Gentianaceae	*Eustoma exaltatum*	(L.) Salisb. Ex G. Don	Catchfly praire gentian	Makings 3591	Native	Mesic riparian	OBL	Salt River at Loop 202	Herb of salty soils. Rare
Geraniaceae	*Erodium cicutarium*	(L.) L'HΘr. ex Ait.	Redstem stork's bill	DJ 248, 394	Native	Xeric riparian	N/A	All	Herb with small pink flowers. Abundant

Haloragaceae	*Myriophyllum brasiliense*	Camb.	Parrot feather watermilfoil	DJ 185	Intro	Mesic riparian	OBL	Tres Rios-Salt River	Aquatic herb. Occasional
Hydrophyllaceae	*Emmenanthe penduliflora*	Benth.	Whisperingbells	DJ 338	Native	Xeric riparian	N/A	All	Herb. Occasional
Hydrophyllaceae	*Eucrypta micrantha*	(Torr.) Heller	Dainty desert hideseed	DJ 592, 610, 780, 785	Native	Xeric riparian	N/A	All	Herb. Common
Hydrophyllaceae	*Nama demissum*	A. Gray	Purplemat	DJ 231, 318, 337, 360, 389, 416, 509, 640, 667	Native	Xeric riparian	N/A	All	Herb. Common
Hydrophyllaceae	*Phacelia crenulata*	Juss.	Cleftleaf wildheliotrope	DJ 332, 657	Native	Xeric riparian	N/A	All	Herb. Common
Hydrophyllaceae	*Phacelia distans*	Benth.	Distant phacelia	DJ 278, 600, 602, 620, 770, 777, 782	Native	Xeric riparian	N/A	All	Herb. Common
Juncaceae	*Juncus torreyi*	Coville	Torrey's rush	DJ 691, 737, 804	Native	Mesic riparian	OBL	New River-Skunk Creek	Wetland herb. Occasional
Lamiaceae	*Hedeoma oblongifolia*	(A. Gray) A. Heller	Oblongleaf false pennyroyal	Jacqueline White s.n.	Native	Mesic riparian	N/A	Salt River near Central Ave.	Perennial herb. Not collected during this study.
Lamiaceae	*Marrubium vulgare*	L.	Horehound	McLellan 660, 34	Intro	Mesic riparian	FAC+	Salt River near what is now TempeTown Lake	Perennial Herb
Lamiaceae	*Teucrium cubense*	Jacq.	Small coastal germander	Nelson 11204a	Native	Mesic riparian	FAC	Gila River	Perennial herb. Species not found in flora area.
Lemnaceae	*Lemna gibba*	L.	Swollen duckweed	DJ 753	Native	Mesic riparian	OBL	All	Aquatic herb. Occasional
Lemnaceae	*Lemna minor*	L.	Common duckweed	DJ 154	Native	Mesic riparian	OBL	All	Aquatic herb. Occasional
Liliaceae	*Dichelostemma capitatum*	(Benth.) Wood	Bluedicks	DJ 769	Native	Desert hills.	N/A	All	Herb with purple flowers. Occasional

Loasaceae	*Mentzelia affinis*	Greene	Yellowcomet	DJ 335	Native	Xeric riparian	N/A	All	Herb with yellow flowers. Common
Loasaceae	*Mentzelia multiflora*	(Nutt.) A. Gray	Adonis blazingstar	DJ 9, 415, 465	Native	Xeric riparian	N/A	All	Small shrub. Occasional
Loasaceae	*Petalonyx thurberi*	A. Gray	Thurber's sandpaper plant	DJ 73, 475,501, 699, 720.	Native	Xeric riparian, sandy washes.	N/A	Agua Fria River and Salt River	Shrub with rough leafs and yellow flowers. Occasional
Lythraceae	*Ammannia coccinea*	Rottb.	Valley redstem	DJ 164	Native	Mesic riparian	OBL	All	Herb with pink flowers, rare in most of flora area but common in Tempe reach of the Salt River
Lythraceae	*Lythrum californicum*	Torr. & A. Gray	California loosestrife	Lehto L-6695, Makings 3596, McLellan 520.	Native	Mesic riparian	OBL	New River	Shrub. Occasional
Lythraceae	*Lythrum hyssopifolium*	L.	Hyssop loosestrife	DJ 806, 810, 827, 837	Intro	Mesic riparian	OBL	New River	Herb. Common
Malvaceae	*Abutilon theophrasti*	Medik.	Velvetleaf	DJ 581	Native	Mesic riparian	N/A	Tres Rios-Salt River	Herb common in farm fields. Occasional
Malvaceae	*Alcea rosea*	L.	Hollyhock	Makings 3614	Intro	Mesic riparian	N/A	Salt River at Loop 202	Biennial perennial herb. Rare
Malvaceae	*Gossypium hirsutum*	L.	Upland cotton	DJ 557	Native	Mesic riparian	N/A	Tres Rios-Salt River	Herb. Rare
Malvaceae	*Malva parviflora*	L.	Cheeseweed mallow	DJ 65, 135, 210	Native	Mesic riparian	N/A	All	Herb. Common
Malvaceae	*Sphaeralcea sp.*	St.-Hil.	Globemallow	DJ 343	Native	Xeric riparian and desert mountain	N/A	All	Herb. Common
Malvaceae	*Sphaeralcea ambigua*	St.-Hil.	Desert globemallow	DJ 445, 521, 633, 658	Native	Xeric riparian and desert mountain	N/A	All	Shrub. Common

Malvaceae	*Sphaeralcea coulteri*	(S. Wats.) A. Gray	Coulter's globemallow	DJ 275, 384, 400, 650	Native	Xeric riparian and desert mountain	N/A	All	Herb. Common
Martyniaceae	*Proboscidea parviflora*	(Woot.) Woot. & Standl.	Devilsclaw	DJ 567, 569	Native	Xeric riparian and desert mountain	N/A	Tres Rios-Salt River	Herb. Occasional
Meliaceae	*Melia azedarach*	L.	Chinaberry	DJ 690, 762, 798	Intro	Mesic riparian	N/A	New River-Skunk Creek, Agua Fria River at I-10	Tree. Occasional
Moraceae	*Morus alba*	L.	White Mulberry	DJ 128, 485, 568, 725	Intro	Mesic riparian	N/A	All	Tree. Rare
Myrtaceae	*Callistemon salignus*	(Sm.) Sweat	Stonewood	DJ 685, 668, 761, 790, 793	Intro	Mesic riparian	N/A	New River-Skunk Creek, Agua Fria River at I-10	Tree. Occasional
Myrtaceae	*Eucalyptus camaldulensis*	Dehnhar dt	Redriver gum	DJ 539, 646, 674	Intro	Mesic riparian	N/A	New River-Skunk Creek, Cave Creek.	Tree. Occasional
Myrtaceae	*Eucalyptus microtheca*	F. Muell.	Coolabah	DJ 647, 673, 694, 756, 835	Intro	Xeric riparian and Mesic riparian.	N/A	Salt River near Airport, Cave Creek, New River-Skunk Creek	Tree. Occasional
Myrtaceae	*Eucalyptus polyanthemos*	Schauer	Redbox	DJ 571	Intro	Xeric riparian	N/A	Tres Rios-Salt River	Tree, cultivated. Rare
Najadaceae	*Najas marina*	L.	holly-leaved water nymph.	DJ 167	Native	Mesic riparian	OBL	Tres Rios-Salt River	Aquatic herb. Occasional
Nyctaginaceae	*Abronia angustifolia*	Greene	Purple sand verbena	DJ 226, 236, 340	Native	Xeric riparian, sandy soils	N/A	Tres Rios-Salt River	Herb with purple flowers, common in sandy river bottoms. Occasional
Nyctaginaceae	*Boerhavia coccinea*	L.	Scarlet spiderling	DJ 76, 115, 375, 523, 546	Native	Mesic riparian	N/A	All	Herb. Common

Nyctaginaceae	*Boerhavia intermedia*	L.	Fivewing spiderling	DJ 543, 544, 545, 547	Native	Mesic riparian	N/A	All	Herb. Common
Nyctaginaceae	*Bougainvillea spectabilis*	Willd.	Bougainvillea	DJ 573	Intro	Mesic riparian	N/A	Tres Rios-Salt River	Shrub. Common cultivated plant
Oleaceae	*Fraxinus uhdei*	(Wenzig) Lingelsh.	Shamel ash	DJ 697	Intro	Mesic riparian	N/A	Agua Fria at I-10, Salt River at Loop 202.	Tree. Rare
Oleaceae	*Fraxinus velutina*	Torr.	Velvet ash	DJ 92, 681	Native	Mesic riparian	FAC	New River-Skunk Creek.	Tree. Occasional
Onagraceae	*Camissonia californica*	(Nutt. ex Torr. & A. Gray) Raven	California suncup	DJ 224, 225, 228, 605	Native	Xeric riparian	N/A	All	Herb. Occasional
Onagraceae	*Clarkia epilobioides*	(Nutt. Ex Torr. & A. Gray) A. Nelson & J.F. Macbr.	Canyon Clarkia	Harrison 3951	Native	Xeric riparian	N/A	Agua Fria River	Herb Not collected in current study
Onagraceae	*Gaura mollis*	James	Velvetweed	DJ 677, 688, 701, 765	Native	Mesic riparian	N/A	New River-Skunk Creek	Herb. Occasional
Onagraceae	*Ludwigia erecta*	(L.) H. Hara	Erect primrose-willow	Makings 3594	Native	Mesic riparian	OBL	Salt River at Loop 202	Herb, new state record. Rare
Onagraceae	*Ludwigia peploides*	(Kunth) Raven	Floating primrose-willow	DJ 85, 186, 494, 759	Native	Mesic riparian	OBL	All	Herb. Common
Onagraceae	*Oenothera arizonica*	(Munz) W.L. Wagner	Arizona evening primrose	Loomis 6709, Rhea 585, 790	Native	Xeric riparian, sandy soils.	N/A	Gila River	Herb. Not collected in current study. Occasional
Onagraceae	*Oenothera californica*	(S. Wats.) S. Wats.	California evening primrose	DJ 227, 233, 329, 402, 693	Native	Xeric riparian, sandy soils.	N/A	Tres Rios-Salt River	Herb. Occasional
Onagraceae	*Oenothera speciosa*	Nutt.	Pinkladies	DJ 676, 828	Intro	Mesic riparian	N/A	New River-Skunk Creek	Herb. Occasional

Orobanchaceae	*Orobanche cooperi*	(A. Gray) A. Heller	Broomrape	Howard Rice s.n. , Irish s.n.	Native	Mesic riparian	N/A	Gila River	Herb. Not collected during this study
Papaveraceae	*Eschscholzia californica ssp. mexicana*	(Greene) C. Clark	Golden poppy	DJ 267, 277, 331, 629, 773	Native	Xeric riparian	N/A	All	Herb. Occasional
Papaveraceae	*Platystemon californicus*	Benth.	Tidytips	DJ 371	Native	Xeric riparian	N/A	Tres Rios-Salt River	Herb. Rare
Passifloraceae	*Passiflora caerulea*	L.	Passionvine	DJ 455	Intro	Xeric riparian	N/A	Tres Rios-Salt River	Vine. Occasional found in cultivation
Pinaceae	*Pinus halepensis*	P. Mill.	Alleppo pine	DJ 549	Intro	Xeric riparian	N/A	Tres Rios-Salt River	Cultivated tree. Rare
Plantaginaceae	*Plantago ovata*	Forsk.	Plantago	DJ 606, 634 788	Native	Xeric riparian	N/A	All	Herb. Occasional
Platanaceae	*Platanus wrightii*	S. Wats.	Arizona Sycamore	DJ 25	Native	Xeric riparian	N/A	Tres Rios-Salt River	Cultivated tree. Rare
Poaceae	*Aristida adscensionis*	L.	Sixweeks threeawn	DJ 56	Native	Xeric riparian	N/A	All	Grass. Occasional
Poaceae	*Aristida purpurea*	Nutt.	Purple threeawn	DJ 299, 598	Native	Xeric riparian	N/A	All	Perennial grass. Occasional
Poaceae	*Arundo donax*	L.	Giant reed	DJ 489, 553	Intro	Mesic riparian	FACW	Gila River	Giant reed. Occasional
Poaceae	*Avena fatua*	L.	Wild oat	DJ 378	Intro	Desert	N/A	All	Oat grass. Common
Poaceae	*Bothriochloa barbinodis*	(Lag.) Herter	Cane bluestem	DJ 536	Native	Mesic riparian	N/A	All	Perennial grass. Occasional
Poaceae	*Bothriochloa ischaemum*	(L.) Keng	Yellow bluestem	DJ 672, 710, 826	Native	Mesic riparian	N/A	All	Perennial grass. Abundant
Poaceae	*Bouteloua aristidoides*	(Kunth) Griseb.	Needle grama	DJ 146, 179, 370, 517	Native	Desert	N/A	All	Grass. Occasional
Poaceae	*Bouteloua barbata*	Lag.	Sixweeks grama	DJ 518	Native	Desert	N/A	All	Grass. Occasional
Poaceae	*Bromus catharticus*	Vahl	Rescuegrass	Lehto 18060	Intro	Mesic riparian	N/A	Agua Fria River	Perennial grass. Not collected during this study. Occasional

Poaceae	*Bromus diandrus*	Roth	Ripgut brome	DJ 700	Intro	Desert	N/A	All	Grass. Rare
Poaceae	*Bromus rubens*	L.	Red brome	DJ 377, 660	Intro	Desert	N/A	All	Grass. Occasional
Poaceae	*Cynodon dactylon*	(L.) Pers.	Bermudagrass	DJ 382, 825	Intro	Mesic riparian	FACU	All	Perennial grass. Abundant
Poaceae	*Dasyochloa pulchella*	(Kunth) Willd. ex Rydb.	Low woollygrass	DJ 631	Native	Desert	N/A	All	Perennial grass. Occasional
Poaceae	*Digitaria sanguinalis*	(L.) Scop.	Hairy crabgrass	Makings 3612	Native	Mesic riparian	FACU	New River	Grass. Occasional
Poaceae	*Echinochloa colona*	(L.) Link	Jungle rice	DJ 144, 532	Native	Mesic riparian	FACW	All	Grass. Common
Poaceae	*Echinochloa crus-galli*	(L.) Beauv.	Barnyardgrass	DJ 500, 823	Native	Mesic riparian	FACW	All	Perennial grass. Common
Poaceae	*Eragrostis echinochloidea*	Stapf	African lovegrass	DJ 724, 848	Intro	Desert mountain	N/A	Salt River at Central Ave, New River.	Perennial grass. Occasional
Poaceae	*Eriochloa aristata*	Vasey	Bearded cupgrass	DJ 537	Native	Mesic riparian	FACW	All	Grass. Occasional
Poaceae	*Hordeum murinum ssp. leporinum*	(Link) Arcang.	Hare barley	DJ 260, 399	Intro	Desert mountain	N/A	All	Grass. Common
Poaceae	*Hordeum pusillum*	Nutt.	Little barley	DJ 791	Native	Desert mountain	FAC	New River-Skunk Creek	Grass. Rare
Poaceae	*Hordeum vulgare*	L.	Common barley	DJ 229, 644	Intro	Desert mountain	N/A	Cave Creek at 19th Ave, and Salt river at 91st Ave.	Grass. Rare
Poaceae	*Leptochloa fusca ssp. uninervia*	Beauv.	Mexican sprangletop	DJ 44, 50, 98, 531, 538	Native	Mesic riparian	FACW	All	Grass. Abundant
Poaceae	*Lolium perenne*	L.	Perennial ryegrass	DJ 732, 739, 824	Intro	Mesic riparian	FACU	All	Perennial grass. Abundant
Poaceae	*Paspalum distichum*	L.	Knotgrass	Johnson 3912	Native	Mesic ripariann	OBL	New River-Skunk	Perennial grass. Occasional

Poaceae	*Pennisetum ciliare*	(L.) Link	Buffelgrass	DJ 380, 482,502, 632, 847	Intro	Xeric riparian	N/A	All	Perennial grass. Occasional
Poaceae	*Phalaris minor*	Retz.	Littleseed canarygrass	DJ 364	Intro	Mesic riparian	N/A	All	Grass. Common
Poaceae	*Pleuraphis rigida*	Thurb.	Big galleta	DJ 621	Native	Desert mountains	N/A	Tres Rios-Salt River	Perennial grass. Occasional
Poaceae	*Poa annua*	L.	Annual Bluegrass	Sundell 196	Intro	Mesic riparian	FAC-	New River-Skunk	Grass. Occasional
Poaceae	*Poa bigelovii*	Vasey & Scribn	Bigelow's bluegrass	DJ 596, 613, 778	Native	Desert mountain	N/A	New River	Grass. Occasional
Poaceae	*Polypogon monspeliensis*	(L.) Desf.	Annual rabbitsfoot grass	DJ 68, 362, 822	Intro	Mesic riparian	FACW	All	Grass. Abundant
Poaceae	*Schismus arabicus*	Nees	Arabian schismus	DJ 4, 237	Intro	Xeric riparian	N/A	All	Grass. Abundant
Poaceae	*Setaria macrostachya*	Kunth	Large-spike bristle grass	DJ 715	Native	Xeric riparian	N/A	Salt River at Central Ave	Perennial grass. Rare
Poaceae	*Sorghum bicolor*	(L.) Moench	Sorghum	DJ 563, 588, 627, 758	Native	Mesic riparian	N/A	Tres Rios-Salt River	Grass. Occasional
Poaceae	*Sorghum halepense*	(L.) Pers.	Johnsongrass	DJ 170, 520, 738, 819	Intro	Mesic riparian	FACU	All	Perennial grass. Common
Poaceae	*Triticum aestivum*	L.	Wheat grass	DJ 431, 794	Intro	Mesic riparian	N/A	Tres Rios-Salt River	Wheat. Rare
Poaceae	*Vulpia octoflora*	(Walt.) Rydb.	Sixweeks fescue	Sundell 90	Native	Desert	N/A	All	Grass. Occasional
Polemoniaceae	*Eriastrum eremicum*	(Jepson) Mason	Desert woollystar	DJ 387, 401	Native	Desert mountain	N/A	Tres Rios-Salt River	Herb. Occasional
Polemoniaceae	*Gilia stellata*	Heller	Star gilia	DJ 347	Native	Desert mountain	N/A	Tres Rios-Salt River	Herb. Occasional
Polemoniaceae	*Linanthus*	Benth.	Linanthus	DJ 346, 348	Native	Desert mountian	N/A	Tres Rios-Salt River	Herb. Occasional
Polygonaceae	*Antigonon leptopus*	Hook. & Arn.	Coral vine	DJ 40	Intro	Mesic riparian	N/A	Tres Rios-Salt River	Vine. Occasional found in cultivation.

Polygonaceae	*Chorizanthe rigida*	(Torr.) Torr. & A. Gray	Devil's spineflower	Sundell 128	Native	Desert mountain	N/A	All	Herb.Not collected during this study.
Polygonaceae	*Eriogonum deflexum*	Torr.	Flatcrown buckwheat	DJ 150, 578	Native	Desert mountain	N/A	All	Herb. Common
Polygonaceae	*Polygonum aviculare*	L.	Prostrate pigweed	DJ 529, 622, 813, 820	Native	Mesic riparian	FACW	All	Perennial herb. Common
Polygonaceae	*Polygonum lapathifolium*	L.	Curlytop knotweed	DJ 82, 424, 438, 451, 491, 496, 511, 582, 750, 763	Native	Mesic riparian	OBL	All	Herb. Occasional
Polygonaceae	*Polygonum pensylvanicum*	L.	Pennsylvania smartweed	DJ 470	Native	Mesic riparian	OBL	All	Herb. Occasional
Polygonaceae	*Polygonum persicaria*	L.	Spotted ladysthumb	DJ 437, 483, 583, 814	Native	Mesic riparian	FACW	All	Perennial herb. Occasional
Polygonaceae	*Rumex dentatus*	L.	Toothed dock	DJ 16, 43, 104, 218, 255, 406, 417, 425, 447, 727, 817, 827	Native	Mesic riparian	OBL	All	Herb. Abundant
Pontederiaceae	*Heteranthera dubia*	(Jacq.) MacMill .	Grassleaf mudplantain	Irish s.n., McLellan 597, Rhea 1482, Sauck 1.	Native	Mesic riparian	OBL	Agua Fria River	Perennial herb. Not collected during this study.
Portulacaceae	*Portulaca oleracea*	L.	Little hogweed	DJ 505, 527, 799	Intro	Mesic riparian	FAC	All	Herb. Occasional
Potamogetonaceae	*Stuckenia pectinatus*	(L.) Boeiner	Sago pondweed	Taylor T67-123	Native	Mesic riparian	OBL	Tres Rios-Salt River	Herb. Not collected during this study
Primulaceae	*Androsace occidentalis*	Pursh	Western rockjasmine	Lehto 11780	Native	Mesic riparian	FACU	Gila River	Herb.Not collected during this study.
Proteaceae	*Grevillea robusta*	A. Cunning ham ex R. Br.	Silkoak	DJ 575	Intro	Mesic riparian	N/A	Tres Rios-Salt River	Tree found at old homestead. Common in cultivation

Punicaceae	*Punica granatum*	L.	Pomegranate	DJ 558, 797	Intro	Mesic riparian	N/A	New River-Skunk Creek, Tres Rios	Shrub/tree that escaped into the New River and found at an old homestead on the Salt River. Rare
Ranunculaceae	*Ranunculus sceleratus*	L.	Cursed buttercup	DJ 752	Native	Mesic riparian	OBL	Tres Rios-Salt River	Herb. Rare
Resedaceae	*Oligomeris linifolia*	(Vahl) J.F. Macbr.	Lineleaf whitepuff	Lehto 426, Sundell 107	Native	Xeric riparian	N/A	Gila River	Herb. Species not found in Flora area.
Rhamnaceae	*Ziziphus obtusifolia*	(Hook. ex Torr. & A. Gray) A. Gray	Lotebush	DJ 94	Native	Xeric riparian	N/A	All	Spiny small tree. Occasional
Rosaceae	*Rosa*	L.	Rose	DJ 141	Intro	Mesic riparian	N/A	Tres Rios-Salt River	Cultivated shrub. Rare
Rubiaceae	*Cephalanthus occidentalis*	L.	Common button bush	Irish 1904 s.n.	Native	Mesic riparian	OBL	Salt River at Tempe	Tree. Not collected during this study
Salicaceae	*Populus fremontii*	S. Wats.	Fremont's cottonwood	DJ 234, 256, 258	Native	Mesic riparian	OBL	All	Tree. Common
Salicaceae	*Salix exigua*	Nutt.	Narrowleaf willow	DJ 680	Native	Mesic riparian	OBL	New River-Skunk Creek	Shrub. Rare
Salicaceae	*Salix gooddingii*	Ball	Goodding willow	DJ 52, 130, 174, 663, 671	Native	Mesic riparian	OBL	All	Tree. Common
Saururaceae	*Anemopsis californica*	(Nutt.) Hook. & Arn.	Yerba mansa	DJ 84	Native	Mesic riparian	OBL	Tres Rios-Salt River	Herb. Rare
Scrophulariaceae	*Mimetanthe pilosa*	(Benth.) Greene	false monkeyflower	DJ 448, 473	Native	Mesic riparian, sandy soils	FACW	All	Herb with yellow flowers. Occasional
Scrophulariaceae	*Orthocarpus purpurascens*	Benth.	Indian paintbrush	DJ 323, 330	Native	Xeric riparian	N/A	All	Herb with pink flowers. Occasional

Scrophulariaceae	*Penstemon parryi*	(A. Gray) A. Gray	Parry's beardtongue	DJ 140	Native	Mesic riaprian	N/A	Tres Rios-Salt River	Perennial garden plant with pink flowers. Rare
Scrophulariaceae	*Stemodia durantifolia*	(L.) Sw.	Whitewoolly twintip	DJ 71, 462, 584, 670	Native	Mesic riparian	OBL	All	Herb with small purple flowers. Occasional
Scrophulariaceae	*Veronica anagallis-aquatica*	L.	Water speedwell	DJ 15, 48, 66, 103, 123, 129, 198, 363, 422, 450	Native	Mesic riparian	OBL	All	Herb. Abundant
Scrophulariaceae	*Veronica peregrina*	L.	Neckweed	DJ 669, 805	Native	Mesic riparian	OBL	All	Herb. Common
Simaroubaceae	*Ailanthus altissima*	(P. Mill.) Swingle	Tree of heaven	DJ 696	Intro	Mesic riparian	FACU	Agua Fria River at I-10	Tree. Rare
Simaroubaceae	*Castela emoryi*	(A. Gray) Moran & Felger	Crucifixion thorn	Landrum 7045	Native	Xeric riparian on slity soils.	N/A	Gila River	Tree/shrub. Not collected during this study
Simmondsiaceae	*Simmondsia chinensis*	(Link) Schneid.	Goatnut	DJ 760	Native	Mesic riparian	N/A	Agua Fria River at I-10	Shrub. Rare
Solanaceae	*Calibrachoa parviflora*	(Juss.) D'Arcy	Seaside petunia	DJ 173, 349, 405, 411, 464	Native	Mesic riparian	FACW	All	Herb. Common
Solanaceae	*Datura discolor*	Bernh.	Desert thorn-apple	DJ 513, 559, 565, 587	Native	Xeric riparian	N/A	All	Herb with tubular flowers. Occasional
Solanaceae	*Datura wrightii*	Regel	Sacred thorn-apple	DJ 131, 168, 564	Native	Xeric riparian	N/A	All	Perennial with large white flowers. Common
Solanaceae	*Lycium andersonii*	A. Gray	Water jacket	DJ 300, 624	Native	Xeric riparian	N/A	All	Shrub with red berries. Occasional
Solanaceae	*Lycium californicum*	Nutt. Ex A. Gray	California wolfberry	Lehto 424	Native	Xeric riparian	N/A	Gila River	Shrub. Not collected during this study

Solanaceae	*Lycium fremontii*	A. Gray	Fremont's wolfberry	DJ 132,195,207,259,263,642.	Native	Xeric riparian on slity soils.	N/A	All	Desert shrub, red berries. Common
Solanaceae	*Lycium torreyi*	A. Gray	Torrey's wolfberry	Pinkava 7793	Native	Xeric riparian	N/A	Gila River	Shrub. Not collected during this study
Solanaceae	*Nicotiana glauca*	Graham	Tree tobacco	DJ 3, 414	Intro	Xeric riparian	FAC	All	Small tree or shrub with yellow flowers. Abundant
Solanaceae	*Nicotiana obtusifolia*	Mertens & Galeotti	Desert tobacco	DJ 8, 420, 474	Native	Xeric riparian	FACU	All	Perennial herb. Abundant
Solanaceae	*Physalis acutifolia*	(Miers) Sandw.	Sharpleaf groundcherry	DJ 507, 562, 729, 843	Native	Mesic riparian	N/A	All	Herb. Occasional
Solanaceae	*Physalis angulata*	L.	Cutleaf groundcherry	DJ 461, 506, 522, 542, 556	Native	Mesic riparian	N/A	All	Herb. Occasional
Solanaceae	*Solanum americanum*	P. Mill.	American black nightshade	DJ 17, 27, 105, 142, 219, 469, 484, 639, 469, 628, 639, 749,	Native	Mesic riparian	FAC	All	Subshrub/herb. Common
Solanaceae	*Solanum elaeagnifolium*	Cav.	silverleaf nightshade	DJ 125, 211, 212, 33.	Intro	Xeric riparian	N/A	All	Subshrub/herb. Common
Solanaceae	*Solanum lycopersicum*	L.	Garden tomato	Jenica Poznik s.n.	Intro	Mesic riparian	N/A	Gila and Salt River	Herb. Rare
Tamaricaceae	*Tamarix aphylla*	(L.) Karst.	Athel tamarisk	DJ 194	Intro	Xeric riparian	FACW	Tres Rios-Salt River	Tree. Rare
Tamaricaceae	*Tamarix chinensis*	Lour.	Five-stamen tamarisk	DJ 101, 143, 79, 80	Intro	Xeric riparian	FACW	All	Tree to shrub. Common
Typhaceae	*Typha domingensis*	Pers.	Cattail	DJ 63	Native	Mesic riparian	OBL	All	Perennial herb. Abundant
Ulmaceae	*Celtis pallida*	Torr.	Spiny hackberry	DJ 342	Native	Xeric riparian	FAC	All	Small tree or shrub with juicy fruit. Occasional

Ulmaceae	*Celtis reticulata*	Torr.	Netleaf hackberry	DJ 95	Native	Mesic to Xeric riparian	UPL	Tres Rios-Salt River	Tree with small fruit. Rare in Flora area
Ulmaceae	*Ulmus parviflora*	Jacq.	Elm tree	DJ 686, 796	Intro	Mesic riparian	N/A	New River-Skunk Creek, Salt River at Loop 202	Tree that escapes into urban streams. Rare
Urticaceae	*Parietaria hespera*	Hinton	Rillita pellitory	DJ 595	Native	Desert mountain	N/A	All	Herb. Occasional
Urticaceae	*Parietaria pensylvanica*	Muhl. ex Willd.	Pennsylvania pellitory	DJ 368, 615, 774	Native	Desert mountain	N/A	All	Herb. Occasional
Verbenaceae	*Glandularia gooddingii*	(Briq.) Solbrig	Southwestern mock vervain	DJ 456, 811	Native	Mesic riparian	N/A	All	Herb. Occasional
Verbenaceae	*Lantana camara*	L.	Lantana	DJ 38, 39, 684	Intro	Xeric riparian	N/A	New River	Shrub that escapes into urban streams. Rare
Verbenaceae	*Verbena bracteata*	Lag. & Rodr.	Bigbract verbena	DJ 721	Native	Xeric riparian	FAC	New River	Herb. Occasional
Verbenaceae	*Verbena neomexicana*	Benth.	Mint vervain	DJ 683, 795	Native	Mesic riparian	N/A	New River-Skunk Creek	Herb. Occasional
Verbenaceae	*Vitex agnus-castus*	L.	Lilac chastetree	DJ 29, 106, 467	Intro	Mesic riparian	N/A	All	Shrub or small tree thatescapes into urban streams. Occasional
Zannichelliaceae	*Zannichellia palustris*	L.	Horned pondweed	DJ 735	Native	Mesic riaprian	OBL	Tres Rios-Salt River	Aquatic Herb, Occasional
Zygophyllaceae	*Larrea tridentata*	(SessΘ & Moc. ex DC.) Coville	Creosote bush	DJ 118	Native	Xeric riparian	N/A	All	Desert perennial shrub. Rare in Riparian areas
Zygophyllaceae	*Tribulus terrestris*	L.	Puncturevine	DJ 460, 478, 514	Native	Xeric riparian	N/A	All	Herb, seeds sharply pointed. Occasional

APPENDIX B

TABLES AND FIGURES

Table 2	Poenix Four River Flora
Family	# Species
Asteraceae	43
Poaceae	33
Fabaceae	28
Cyperaceae	15
Solanaceae	14

Table 3 Flora comparisons		
Flora	Number of Species	Number of Species in common
Lake Pleasant	364	148
Sierra Estrella	316	162
Seven Springs	239	96
Hassayampa	284	143
PMA	329	

Table 4	New plants records for Arizona		
Acacia salicina	Gila River, New River	*Fraxinus uhdei*	Found on the Agua Fria River
Acacia schaffneri	New River	*Ludwigia erecta*	Salt River and Loop 202
Acacia stenophylla	New River	*Lythrum hyssopifium*	New River
Alcea rosea	Hollyhocks found at loop 202 and Salt River	*Melaleuca viminalis*	I-10 and Agua Fria River, and New River Skunk Creek
Cucumis sativus	Tres Rios	*Melia azedarach*	Chinaberry common escaped tree in wet rivers
Cyperus elegans	Salt River, and Gila River	*Punica granatum*	New River Skunk Creek
Cyperus ergrostis	New River	*Ulmus parviflora*	Elm tree found on the Salt and New River
Cyperus pygmaeus	Tres Rios, Salt River, New River, and Agua Fria River	*Senna artemisioides*	New River

Table 5 List of Acronyms	
Phoenix Four Rivers Flora	PFR
Phoenix Metropolitan Area	PMA
Tres Rios Project	TRP
Salt River Project	SRP

Table 6.	
Mesic and Xeric riparian	**Important Species present**
I. Mesic Riparian:	
(A) Cottonwood-Willow Forest	Forest of *Populus fremontii*, *Salix gooddingii*, and herbs.
(B) *Prosopis* Woodlands	Woodlands of *Prosopis*, *Atriplex spp*
(C) *Tamarix* Woodlands	Woodlands of *Tamarix*.
(D) Tree Tobacco-Castor Bean Thickets	Brush thickets of *Nicotiana glauca* and *Ricinus communis* 5-10 m in height.
(E) Agricultural land.	Farm with cotton, wheat, and other crops on river banks.
II. Xeric Riparian:	
(A) River cobble to gravel.	*Ambrosia eriocentra*, *Hymenoclea monogyra*, and *Stephanomeria pauciflora.*
(B) Sand bars	*Abronia angustifolia*, *Oenothera californica*, *Helianthus annuus*, and *Chenopodium album.*
(C) Silty river banks and terraces	*Parkinsonia* spp., *Prosopis* spp., and *Atriplex spp.*

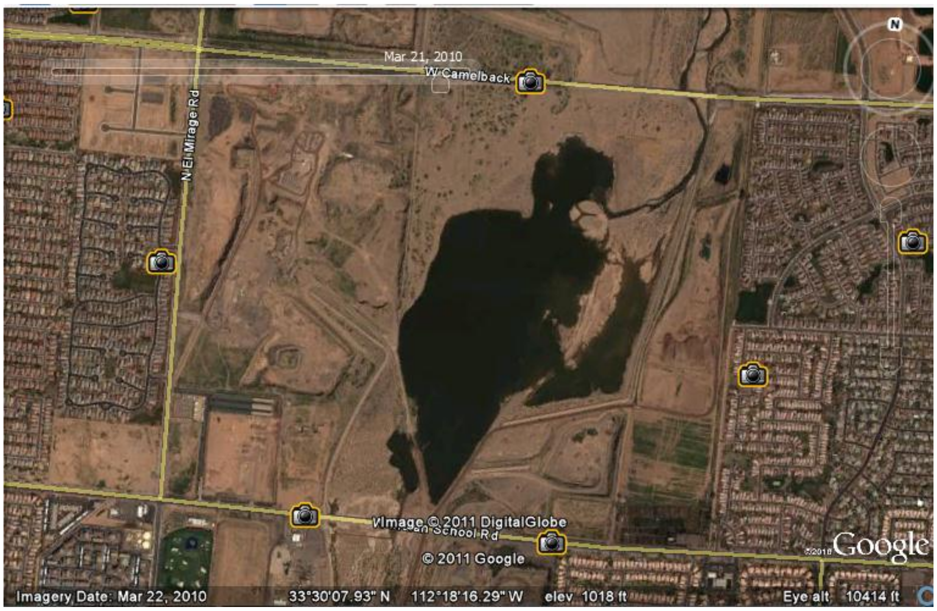

Figure 1. A quarry Lake on the Agua Fria River (Google Earth, 2011)

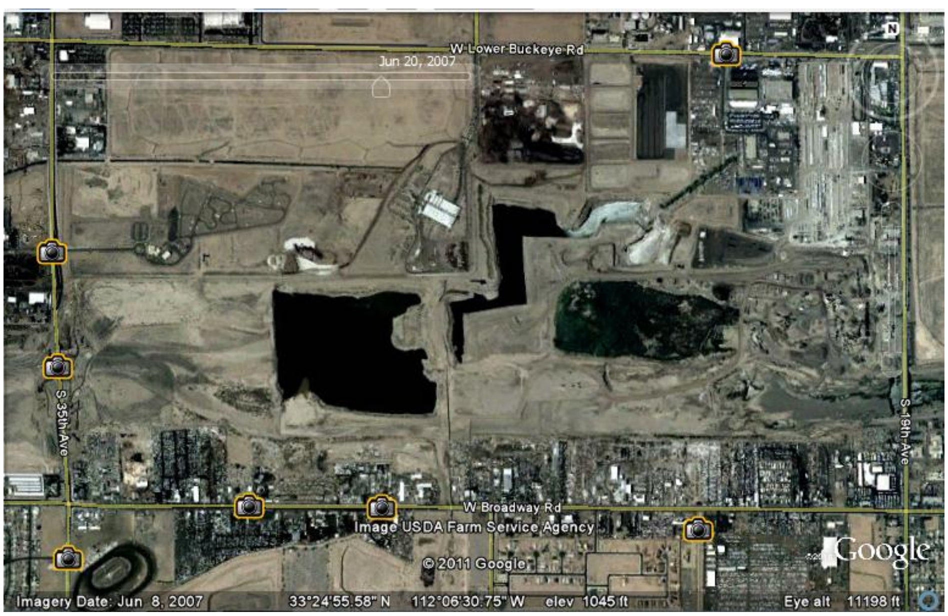

Figure 2. Quarry lakes on the Salt River (Google Earth, 2011)

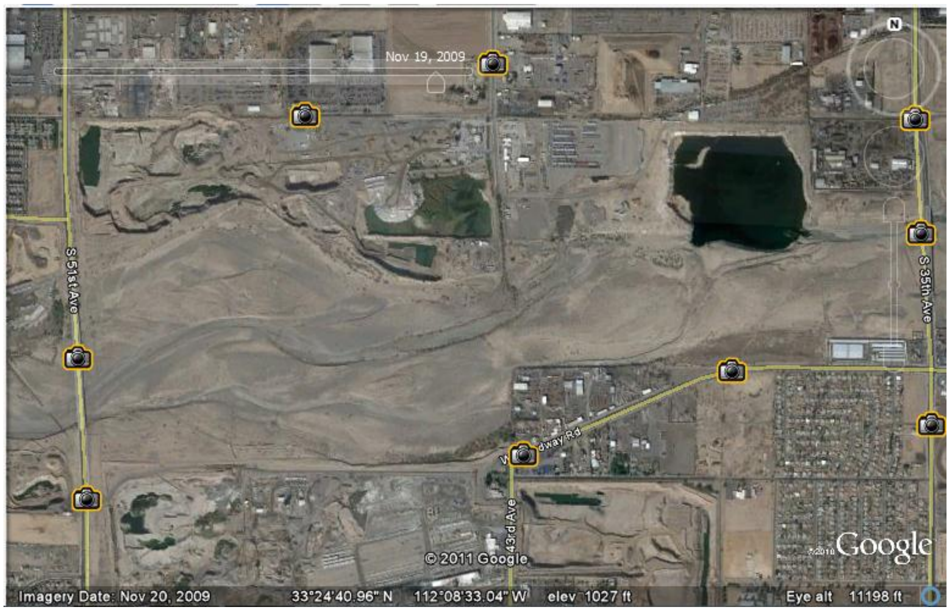

Figure 3. Quarry lakes # 2 on the Salt River (Google Earth, 2011)

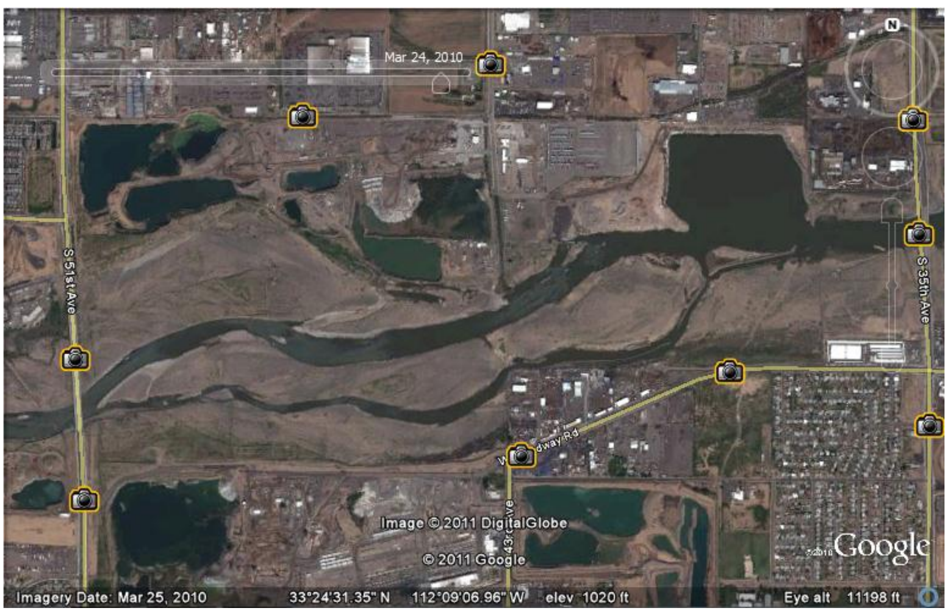

Figure 4. Quarry lakes fill up with water when the Salt River floods during a wet spring in 2010. (Google Earth, 2011)

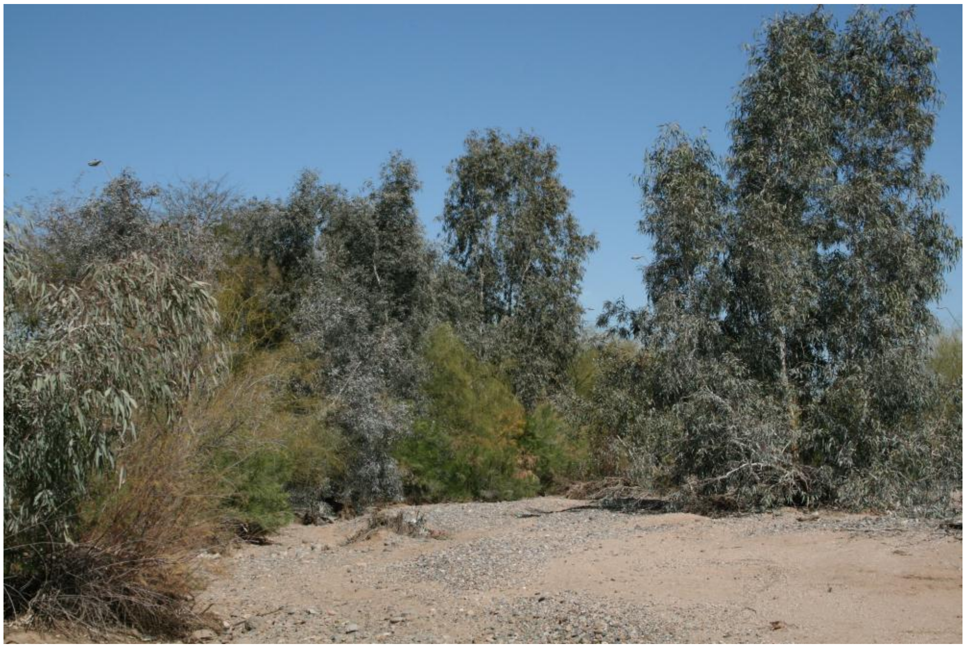

Figure 5. Cave Creek at 19th Ave. Xeric riparian habitat with Eucalytus microtheca, Parkinsonia spp., and Acacia spp.

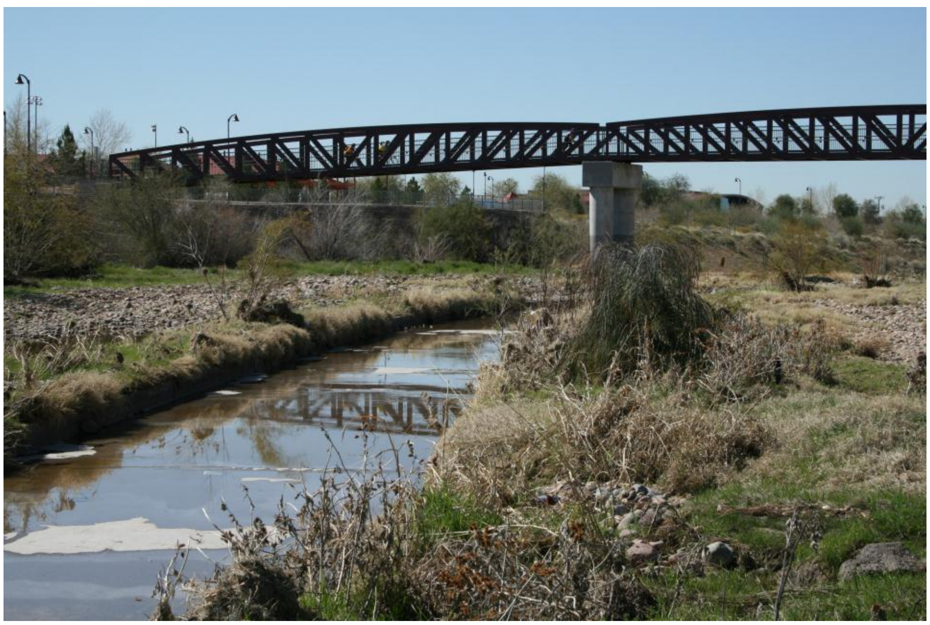

Figure 6. Mesic riparian section of the New River confluence with Skunk Creek, *Acacia stenophylla*, *Cyperus eragrostis*, and *Lythrum hyssopifium* are present.

Figure 7. Mesic Riparian habitat on Skunk Creek, ***Salix spp*****.** ***Ulmus parviflora*****,** ***Juncus torreyi*****, and** ***Fraxinus*** **velutina are present.**

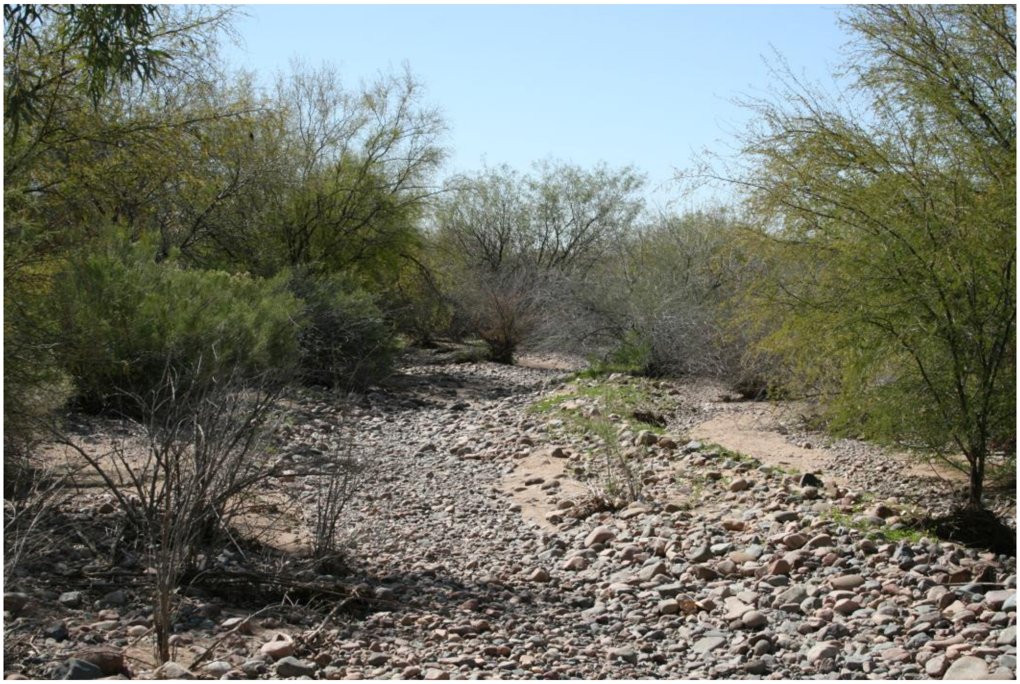

Figure 8. Xeric Riparian habitat on the East Fork of Cave Creek, *Prosopis spp, Parkinsonia spp., Chilopsis linearis, and Hymenoclea monogyra.*

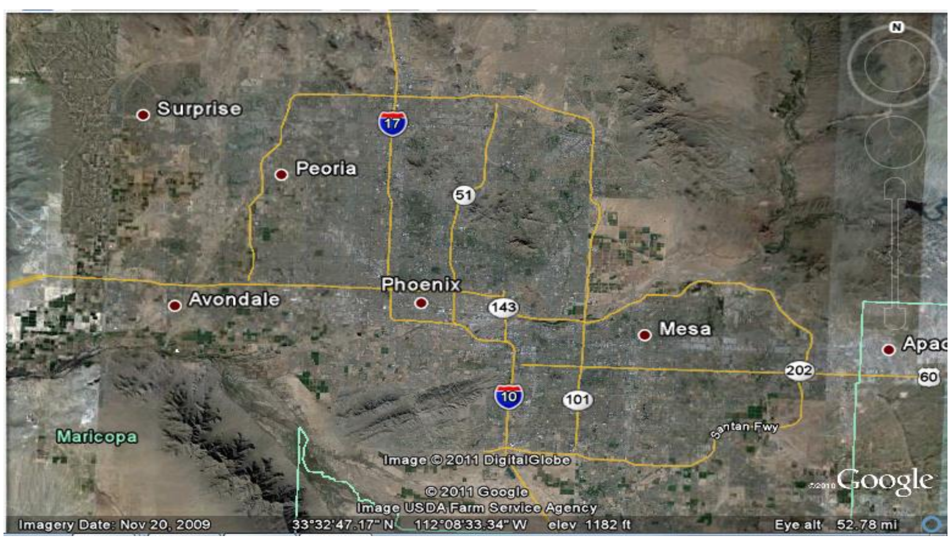

Figure 9. Map of the Phoenix Metropolitan Area. (Google Earth, 2011)

Figure 10. Xeric Riparian habitat at Tres Rios, ***Ambrosia eriocentra, Hymenoclea monogyra, and Lycium fremontii*****. Woodlands of** ***Prosopis*** **and** ***Tamarix*** **are visable in the background.**