DRAFT

MEMORANDUM

Date: January 16, 2001

To: The Honorable Chair and Members
Pima County Board of Supervisors

From: C.H. Huckelberry
County Administrator

Re: **Sonoran Desert Conservation Plan Riparian Vegetation Mapping and Classification**

I. Background

The template for multi-species conservation planning is the vegetation map of the study area. On January 18, 2000, the Board awarded Harris Environmental Group a contract to carry out riparian vegetation mapping, which is one of several tasks related to the biological evaluation. The fact that the Sonoran Desert Conservation Plan requires a detailed and comprehensive riparian vegetation map is a reflection of the importance of riparian habitats to the overall health of the plant and animal community in our region. The biological evaluation workplan defined the riparian mapping task in this way:

A. The consultant shall produce the following:

1. Vegetation maps and a map showing field verification locations as Arc/Info vector coverages or in a format pre-approved by the Pima County Department of Transportation Technical Services GIS Section.

2. A complete reproducible set of mylars registered to 7.5 minute USGS quadrangle maps. Each mylar shall contain a legend, scale, index map, and title block. Each map shall portray the locations of boundaries and the geographic extent of vegetative communities. Each polygon shall be labeled numerically with the vegetation classification. In addition, one mylar index map shall be provided.

3. A report shall be prepared describing the methods, the scale and source of base information used, assumptions made, the nature of any interim products, and a non-statistical assessment of reliability in the mapping in terms of (1) positional accuracy and (2) classification accuracy as it varies by geographic area and by classification category. To the extent thought reliable, existing sources of information shall be used. Information to be reviewed includes but is not limited to the following: [a] PAG maps of perennial, intermittent, and ephemeral streams and shallow groundwater zones (digital); [b] Digital USGS orthophoto quadrangles for portions of Pima County; [c] Unincorporated Pima County riparian habitat maps (digital); [d] Gap Analysis Program vegetation maps (digital); [e] NDVI map for portions of Pima County (digital); [f] PAG 208 maps for non-urban Pima County (paper); [g] Wildlife Habitat Inventory maps for metropolitan Tucson (digital); [h] Organ Pipe Cactus National Monument vegetation map (digital); [I] PAG 208 vegetation and soils data cards (paper); [j] Cienega Creek Natural Preserve vegetation map (paper); [k] USGS and Pima County stream center lines (digital); and [l] USFWS wetland inventory maps (mostly paper).

Emphasis shall be placed on classifying the existing riparian areas as delineated on Pima County's riparian habitat maps, delineating additional riparian areas where no data currently exists, and addressing specific mapping requirements below. Work shall emphasize areas outside existing public reserves.

B. Vegetation Mapping Requirements

1. Discriminate the location of riparian vegetation versus upland vegetation with a minimum map area of 5 acres.

2. Identify physiognomy and dominance, discriminating among leguminous tree forests, broadleaf deciduous forests, tamarisk forests, other riparian forests, emergent marsh, tobosa or sacaton grassland, and riparian scrub. Units should be mapable on a 7.5 minute scale — i.e. 5 acres minimum unit.

3. Map unit classifications should be compatible with the National Vegetation Classification System. The hierarchical classification system used by Brown, Lowe and Pase is acceptable.

C. Procedure

1. Refine and develop a mapping protocol to meet the Science Technical Advisory Team vegetation mapping requirements, budget, and schedule.

2. Design and conduct a pilot vegetation mapping exercise covering several nonadjacent USGS 7.5 minute quadrangles, including field verification. The pilot study areas need to represent the range of vegetation types present in the study area, as well as the variation in available data sources. Evaluate and refine the mapping protocol and classification scheme.

II. Interim Report

On May 8, 2000, an interim report by the Harris Group was forwarded to the Board entitled: *Pima County Riparian Vegetation Mapping Pilot Study.* This study performed a qualitative riparian inventory within several sites in Eastern Pima County, including: (1) the Black Wash in the Brown Mountain area; (2) portions of the Canada del Oro Wash inhabited by the pygmy-owl; (3) portions of the Santa Cruz river that has effluent dominated flow; and (4) floodplain corridors to the southeast of Tucson.

Compared to previous efforts the Harris study classified vegetation communities by the dominant species at a finer level. The pilot study enabled the Harris Group to determine that two existing data sets will be useful for mapping beyond the pilot areas: the Pima County Riparian Habitat Mapping project and the Arizona Game and Fish perennial riparian data base.

III. Final Report

Following the May 2000 pilot study, riparian areas were delineated and vegetation communities at the biome level were identified as reflected in the attached *Sonoran Desert Conservation Plan Riparian Vegetation Mapping and Classification*. The study area for the report consisted of all land within Pima County not under federal or Native American jurisdiction that lacks GAP status as protected land. A total of 2,311,727.39 acres were inventoried for riparian vegetation and are represented in the work product. Technical aspects of the study are discussed for over twenty pages, with results described in pages 23 through 46. Some highlights include:

- "The final database includes 320,180.15 acres of riparian areas, which represents a 157 percent increase in mapped riparian areas from previous existing databases." (P. 23)

- "Riparian vegetation was characterized for 13 naturally existing biomes plus vacant - fallow land. The Sonoran Riparian Deciduous Forest and Woodlands biome was further classified at the series level: Mesquite Series and Cottonwood-willow Series. The most abundant biome is Sonoran Desertscrub. Each of the biomes is described below." (P. 28)

TOTAL ACRES OF RIPARIAN AREAS PER BIOTIC COMMUNITY IN PIMA COUNTY

BIOTIC COMMUNITY	ACRES
Rocky Mountain Montane Conifer Forest	178.55
Madrean Evergreen Forest and Woodland	6,232.45
Relict Conifer Forest and Woodland	103.02
Sonoran Riparian Woodland	560.08
Scrub-Grassland (Semidesert Grassland)	117,106.01
Great Basin Desertscrub	44.38
Chihuahuan Desertscrub	28.09
Sonoran Desertscrub	150,093.51
Rocky Mountain Riparian Deciduous Forest/Woodland	83.05
Interior Southwestern Riparian Deciduous Forest/Woodland	5,833.39
Sonoran Riparian Deciduous Forest and Woodland	25,436.81
Sonoran Deciduous Riparian Scrub	7,751.83
Sonoran Interior Strand	5,336.60
Sonoran Vacant-Fallow Land	1,392.38
TOTAL ACRES	**320,180.15**

IV. Conclusion

The *Sonoran Desert Conservation Plan Riparian Vegetation Mapping and Classification* study represents a significant contribution to (1) the overall planning effort, (2) the ability of Pima County to update and improve mapping that serves as the basis of our current riparian mitigation ordinance, and (3) the community's store of high quality data upon which to base natural resource decision making.

Overall planning effort -- The study identifies approximately 25,000 acres of Sonoran Riparian Deciduous Forest and Woodland known to occur in Pima County. About 88% of this is classified as mesquite woodland. The remainder, some 3116 acres, is cottonwood-willow forest.

The Harris study notes on page 39 that: "Both cottonwood-willow and mesquite-dominated communities are now very much reduced in extent as opposed to the end of the 19th Century when the opposite was true. While Mearns (1907) was conducting the International Boundary Survey between the United States and Mexico between 1892-94, he remarked that 'No tree is more common, more beautiful, nor more valuable as a shade tree than the cottonwood. It grows naturally on almost every stream along the Boundary, and is planted around the houses and along the irrigation 'acequias' of nearly every ranch."

Because of the disproportionate losses, the Science Technical Advisory Team is developing reserve design and restoration goals around these as well as other plant communities.

Update and improve mapping that serves as the basis of our current ordinance -- The polygons from the Harris mapping effort will be used in combination with new satellite imagery to update the classification of hydromesoriparian and xeroriparian vegetation under Pima County's riparian habitat mitigation ordinance. Revisions to hydromesoriparian classification are proceeding in Technical Services using Geographic Information Services. To reclassify hydromesoriparian habitat, we are using the best available information generated by the Sonoran Desert Conservation Plan, consisting of the plant communities from the Harris study and water availability data from Pima Association of Governments. In June of 2000 we will be able to process satellite imagery to update the xeroriparian classifications. The Harris riparian polygon delineations will be used for this effort. Results will be reviewed by the Flood Control District's riparian protection and management staff prior to the formulation of recommendations for adoption by the Board under the riparian habitat mitigation ordinance.

Contribution to the community for natural resource decision making -- The riparian vegetation mapping and classification information is available now to the public and other jurisdictions. Pima County's mapping and records division will have bluelines of the Harris maps available in order to reduce the costs that attach to Geographic Information Service products. These blueline maps are registered to the corners of a United States Geographical Survey topographic quadrangle and are a valuable contribution to the community knowledge base.

RIPARIAN VEGETATION MAPPING AND CLASSIFICATION

SONORAN DESERT CONSERVATION PLAN

CONTRACT # 07-30-H-127196-0100

FINAL REPORT

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DECEMBER 2000

RECOMMENDED CITATION

Harris, L. K., J. A. Wennerlund, and R. B. Duncan. 2000. Riparian vegetation mapping and classification, Sonoran Desert Conservation Plan. Pima County Government, Tucson, Arizona. Contract # 07-30-H-127196-0100. 56 pp.

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1.0 INTRODUCTION

In 1998 the Board of Supervisors of Pima County, Arizona announced their intent to prepare a multi-species conservation plan called the Sonoran Desert Conservation Plan (SDCP). One of the main goals of the SDCP was to comply with Section 10 of the Endangered Species Act (Act) while at the same time meeting the economic needs of the community. For details on the SDCP's purpose and approach see Pima County's web site at http://www.co.pima.az.us/cmo/sdcp/.

As part of the SDCP, Pima County issued a contract to map the county's riparian habitats using aerial photography and geographic information system (GIS) technology to a Tucson based team of biological consultants: Harris Environmental Group, Dames & Moore (now URS Corporation), and R. B. Duncan & Associates. The purpose of the contract was to develop a reasonably comprehensive GIS map of the County's riparian habitat using the BLP (Brown et al.1979) digitized, computer-compatible classification system. The BLP system is grounded on the "biome" concept, which serves as its fundamental organizational unit and provides an ecological basis for classification.

This report is 1 of 2 products prepared for this project. The report presents the results of the Pima County riparian communities mapping project and includes the classification system used and a brief description of each community type that was mapped. The second product consists of maps and GIS electronic data files. The mapping effort was based primarily on aerial photography interpretation of 1:24,000 scale black and white and color infrared U.S. Geological Survey (USGS) orthophotoquads. Fieldwork was conducted on a limited basis, mainly to verify what was present in an area that could not be resolved on the photographs because of the quality of the imagery. Some fieldwork also was conducted for a more detailed mapping effort of riparian habitat dominated by the cottonwood (*Populus fremontii*)-willow (*Salix gooddingii*) and/or mesquite (*Prosopis velutina*) climax series of the Sonoran riparian deciduous forest and woodland community. All fieldwork was non-quantitative. Because of the rarity of these series and

their importance to many species of wildlife, the Scientific and Technical Advisory Team (STAT) to the SDCP requested this more detailed mapping effort.

1.1 Riparian Areas

Lowe (1964) defines riparian vegetation as that which occurs in and along drainage system channels, their margins and/or their floodplains, and is further characterized by different species and/or life forms than those of the immediately surrounding non-riparian (upland) vegetation types. Riparian areas are easily recognizable by the presence of a linear assemblage of trees and shrubs that are denser and taller than the sparse vegetation on the adjacent uplands.

Riparian plants respond by species, site, and abundance to 2 critical features of their drainageway habitat: (1) an unstable substratum with (2) a greater plant-available soil moisture than in surrounding uplands (e.g., Reichenbacher 1984, Asplund and Gooch 1988, Stromberg 1993a, Stromberg1993b, and others cited therein). Historically, riparian habitats in the American Southwest, and elsewhere, have been the primary sites for agriculture, ranching, and urbanization, while through the eons they have been primary habitats for wildlife. Until recently, riparian habitats were often completely ignored in the literature of land management in the Southwest. Since the late 1970s, however, there has grown a burgeoning literature on the ecology, management, and political issues of Southwestern riparian landscapes (e.g., Johnson and Jones 1977, Johnson and McCormick 1978, Brown et al. 1979, Johnson et al. 1985, Warner and Hendrix 1984). Minckley and Brown (1982) present an excellent review of riparian communities in the American Southwest and Tellman et al. (1997) summarize how humans have affected riparian systems in Arizona. A comprehensive searchable database of citations related to Arizona's rivers and riparian areas is available at http://www.ag.arizona.edu/AZWATER/rivhist/rivhist.html.

A riparian community may be composed either of elements generally associated with the riparian characterization, or an extension of a higher, climax association fingering

downward into the drainageway. The latter type has been termed "pseudo-riparian" by Campbell and Green (1968) to distinguish its facultative nature from the obligate nature of purely riparian species. An example of a pseudo-riparian community in Pima County is the extension of oak woodlands, including juniper (*Juniperus* spp.) and Arizona cypress (*Cupressus arizonica*), extending along drainageways into semidesert grasslands and even desertscrub communities at lower elevations. Another regularly observed riparian community of this type is the extension of Arizona Upland desertscrub species such as blue paloverde (*Cercidium floridum*), ironwood (*Olneya tesota*), and saguaros (*Carnegiea gigantea*) along washes within desertscrub dominated by creosotebush (*Larrea tridentata*) in the more arid, lower elevation sites in western Pima County, but mostly in nearby Yuma County.

These primarily linear biomes occupy a limited geographic area that is entirely disproportionate to their landscape importance and immense biological significance in Pima County and elsewhere in Arizona and the American southwest (Shreve 1951, Lowe 1961, Lowe 1964, Carothers 1974, Minckley and Brown 1982, Johnson and Haight 1985, Szaro 1989). Capable of supporting tall, winter deciduous broad-leaf trees that are closely related to those found in the eastern deciduous forest, these communities in Arizona are completely restricted to drainageways and springs that supply the necessary water throughout the growing season to maintain them. One riparian forest in Arizona, the Fremont cottonwood (*Populus fremontii*)-Goodding willow (*Salix gooddingii*) community, has been described as the rarest forest in North America. (Minckley and Brown 1982).

It is not always clear where riparian habitats begin and end, especially at higher elevations and also in desert riparian scrub (xeroriparian) habitats within diverse Arizona Upland Sonoran Desertscrub communities on broad alluvial fans at lower elevation sites. Strictly speaking, riparian habitats are those composed of species, especially deciduous tree species, that are, to some substantial degree, dependent on environments created by streams (Reichenbacher 1984, Szaro 1989). The riparian environment is characterized by

successional dynamics related to the hydraulic activities of surface water movement and by the greater available soil moisture (Reichenbacher 1984, Warner and Hendrix 1984, Asplund and Gooch 1988).

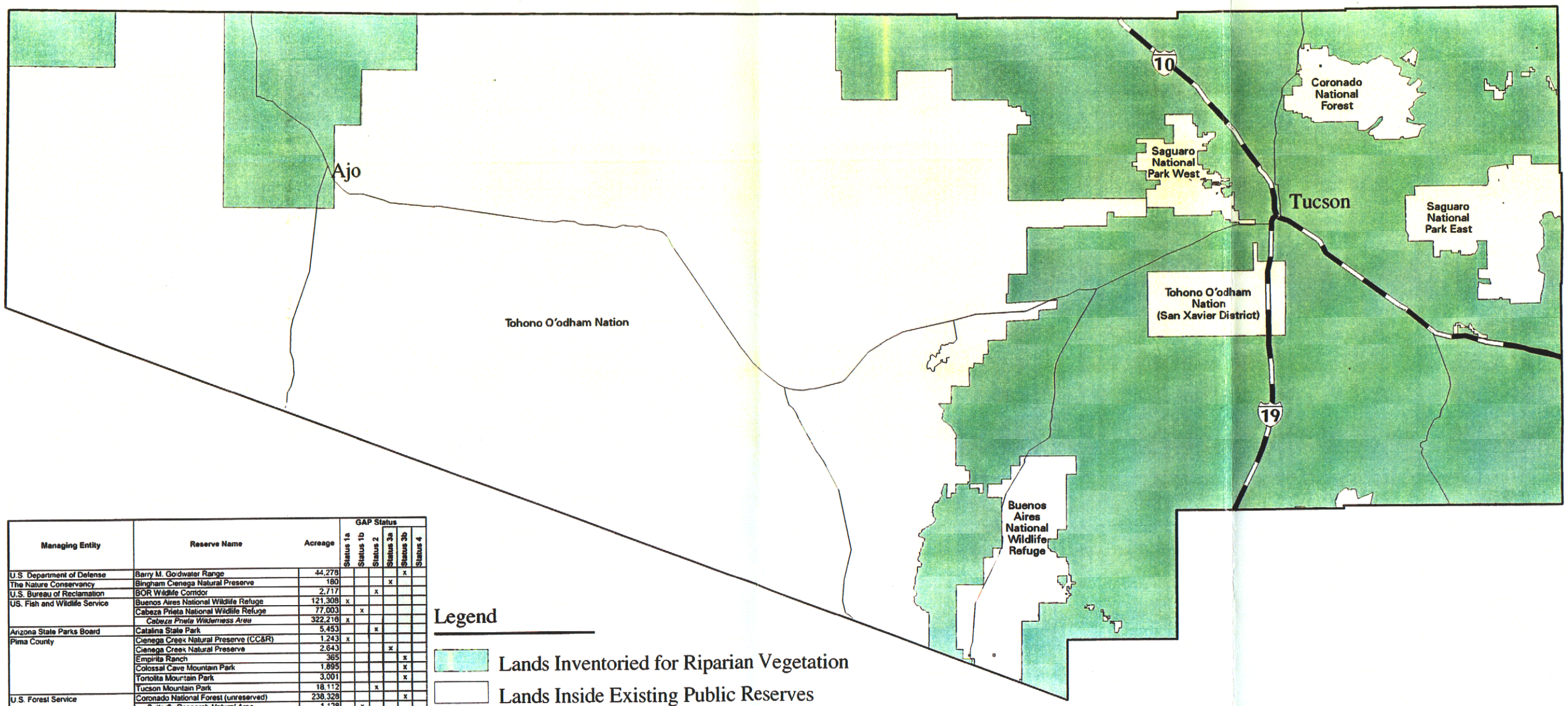
2.0 Study Area

The study area for this project consists of the land within Pima County that is not under federal protection or tribal control (Figure 1). Pima County preserves database was used to identify these areas. The preserves database identifies 6 categories of protective status for various managing entities in Pima County (Table 1). The County considers categories 1a, 1b, and 2 as protected. Categories 3a and 3b are not protected but have some biodiversity management. Category 4 is not protected and has no biodiversity management. We inventoried all private lands and lands in categories 3a, 3b, and 4 in Pima County, with the exception of the Tohono O'Odham and San Xavier Indian Nations. This area comprises 2,311,727.39 acres, and is represented by 108 USGS 7.5-minute quadrangles.

3.0 Methodology

There were 2 phases to the project. The first phase was a pilot study (Appendix A) that developed and refined a mapping methodology that would be efficient and effective in meeting the SDCP's STAT's riparian vegetation mapping requirements. As part of the pilot study, we conducted a GIS gap analysis of existing riparian maps and determined which databases would be integrated into the new effort.

During the pilot study phase of the project we developed a vegetation classification system for the riparian communities of Pima County based on the biome level or 4th level of detail in Brown et al. (1979) (Appendix A). The system (referred to as the BLP system) is based on the biome concept that allows development of a hierarchical, evolutionarily related classification and is well-suited to mapping extensive areas for assessment of animal-plant distributions. Biomes are natural communities of plants and



Managing Entity	Reserve Name	Acreage	GAP Status					
			Status 1a	Status 1b	Status 2	Status 3a	Status 3b	Status 4
U.S. Department of Defense	Barry M. Goldwater Range	44,278					x	
The Nature Conservancy	Bingham Cienega Natural Preserve	180				x		
U.S. Bureau of Reclamation	BOR Wildlife Corridor	2,717			x			
US. Fish and Wildlife Service	Buenos Aires National Wildlife Refuge	121,308	x					
	Cabeza Prieta National Wildlife Refuge	77,003		x				
	Cabeza Prieta Wilderness Area	322,216	x					
Arizona State Parks Board	Catalina State Park	5,453			x			
Pima County	Cienega Creek Natural Preserve (CC&R)	1,243	x					
	Cienega Creek Natural Preserve	2,643				x		
	Empirita Ranch	365					x	
	Colossal Cave Mountain Park	1,895					x	
	Tortolita Mountain Park	3,001					x	
	Tucson Mountain Park	18,112			x			
U.S. Forest Service	Coronado National Forest (unreserved)	238,328					x	
	Butterfly Research Natural Area	1,128		x				
	Santa Catalina Research Natural Area	881	x					
	Mt. Wrightson Wilderness Area	3,903	x					
	Pusch Ridge Wilderness Area	55,992		x				
	Rincon Mountain Wilderness Area	36,992	x					
U.S. Bureau of Land Management	Coyote Mountain Wilderness Area	5,103	x					
	Baboquivari Wilderness Area	2,079	x					
	Empire-Cienega Resource Conservation	31,908					x	
	Waterman Mountains ACEC	3,245			x			
	Silverbell Resource Conservation Area	100,369					x	
The Nature Conservancy	The Nature Conservancy (deeded land)	2,793		x				
	The Nature Conservancy (easements)	68					x	
National Park Service	Organ Pipe Cactus National Monument	13,994			x			
	Organ Pipe Cactus NM Wilderness	317,278	x					
	Saguaro National Park East	8,803		x				
	Saguaro National Park Wilderness Area	56,540	x					
	Saguaro National Park West	10,433		x				
	Saguaro National Park Wilderness Area	12,992	x					
University of Arizona	Santa Rita Experimental Range	51,984					x	
Land Inventoried for Riparian Classification								

Legend

- Lands Inventoried for Riparian Vegetation
- Lands Inside Existing Public Reserves or Inside Tribal Control

Riparian Vegetation Mapping and Classification, Sonoran Desert Conservation Plan Study Area Map

December 2000

Figure 1

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Table 1. Land stewardship and GAP status of protected lands in Pima County, Arizona.

MANAGING ENTITY	RESERVE NAME	ACREAGE	GAP STATUS					
			Status 1a[1]	Status 1b[1]	Status 2[1]	Status 3a[2]	Status 3b[2]	Status 4[3]
U.S. Department of Defense	Barry M. Goldwater Range	44,278						
The Nature Conservancy	Bingham Cienega Natural Preserve	180				x		
U.S. Bureau of Reclamation	BOR Wildlife Corridor	2,717			x			
U.S. Fish and Wildlife Service	Buenos Aires National Wildlife Refuge	121,308	x					
	Cabeza Prieta National Wildlife Refuge	77,003		x				
	Cabeza Prieta Wilderness Area	322,216	x					
Arizona State Parks Board	Catalina State Park	5,453			x			
Pima County	Cienega Creek Natural Preserve (CC&R)	1,243	x					
	Cienega Creek Natural Preserve	2,643				x		
	Empirita Ranch	365						
	Colossal Cave Mountain Park	1,895						
	Tortolita Mountain Park	3,001						
	Tucson Mountain Park	18,112			x			
U.S. Forest Service	Coronado National Forest (unreserved)	238,328						
	Butterfly Research Natural Area	1,128		x				
	Santa Catalina Research Natural Area	881	x					
	Mt. Wrightson Wilderness Area	3,963	x					
	Pusch Ridge Wilderness Area	55,992		x				
	Rincon Mountain Wilderness Area	36,962	x					
U.S. Bureau of Land Mgmt	Coyote Mountain Wilderness Area	5,103	x					
	Baboquivari Wilderness Area	2,079	x					
	Empire-Cienega Resource Conservation	31,906						
	Waterman Mountains ACEC	3,245			x			
	Silverbell Resource Conservation Area	100,369						
The Nature Conservancy	The Nature Conservancy (deeded land)	2,793		x				
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National Park Service	Organ Pipe Cactus National Monument	13,994			x			
	Organ Pipe Cactus NM Wilderness	317,278	x					
	Saguaro National Park East	8,803		x				
	Saguaro National Park Wilderness Area	58,540	x					
	Saguaro National Park West	10,433		x				
	Saguaro National Park Wilderness Area	12,992	x					
University of Arizona	Santa Rita Experimental Range	51,984						
Land Inventoried for Riparian Classification								

[1]Protected lands.
[2]Lands not protected but with some biodiversity management.
[3]Lands not protected and with no biodiversity management.

animals characterized by a distinctive vegetation physiognomy within a formation (forest, woodland, scrubland, grassland, etc.).

One of the first uses of the BLP system was the development of a vegetation classification and map of Organ Pipe Cactus National Monument (OPCNM) in southwestern Pima County produced by Warren et al. (1980). Through extensive fieldwork, this study developed, tested, and applied the prominence value concept for elaboration of the BLP examples into a classification suitable for mapping large areas. The prominence value is a rating that combines estimated dominance, biomass, and commonness. Prominence values are the most important part of vegetation description for classification and mapping (Colorado Plateau Vegetation Advisory Committee 1992). Prominence values are a concept distinct from, but related to, importance values and other qualitative measures described by Daubenmire (1968) and others.

The present study of Pima County's biotic communities resolved vegetation coverage mainly to the biome level for all communities except the Sonoran riparian deciduous forest and woodland type, which was determined to the series level. The prominence value system of Warren et al. (1980) was not used because only a limited amount of fieldwork was conducted. Instead, interpretation of aerial photographs was relied on for determining riparian habitats. This was in keeping with Pima County's criteria of utilizing data that was readily at hand and incorporating these data in a time- and cost-efficient manner.

The general outline of the BLP digitized classification system is as follows (Table 2):

1,000 Biogeographic (Continental) Realm (The numeral in front of the comma is usually cropped for tabular convenience once the realm is identified)

1,100 Vegetation type

1,110 Formation type

1,111 Climatic (Thermal) Zone

1,111.1 Regional formation (biome)

1,111.11 Series (Community of generic dominants)

1,111.111 Association (Community of specific dominants)

1,111.1111 Composition-structure-phase

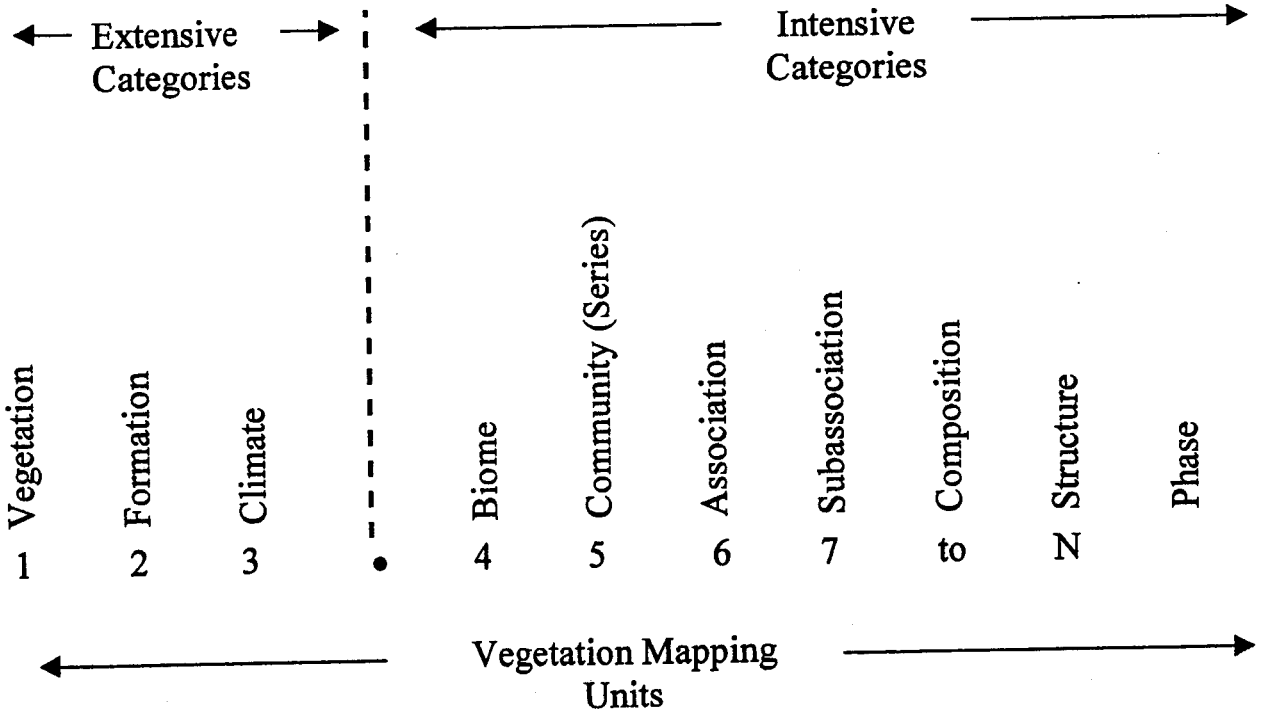

Table 2. Explanation of the digital component in the hierarchy of the Brown et al. (1979) system for vegetation classification. The dashed vertical line indicates the portion of the decimal point that anchors the system (This figure was adopted from Lowe and Brown 1982, Figure 4).

The second phase of the project was to use the methodology developed during the first phase and extend it to the entire county. The goal of the second phase, and the overall project, was to develop a comprehensive Pima County database of riparian areas with their associated plant communities. The final product incorporated relevant existing data and new fieldwork.

3.1 Construction of Database

Development of the new database was initiated by gathering existing digital databases of riparian vegetation in Pima County. During the pilot study phase we evaluated databases for the quality of their line work and attribute information. If attribute information for vegetation was available in the BLP classification system, it was retained to the lowest level originally inventoried. Two databases contained BLP numeric reference: the Cienega Creek Natural Preserve (McGann & Associates 1994) and Organ Pipe Cactus National Monument (Warren et al. 1980). An inventory along the Santa Cruz River (Baker 2000) identified vegetation by name, which was translated to the BLP numeric reference by project biologists. These 3 databases contributed both linear extent and vegetation community to the new inventory.

The Pima County Riparian Habitat Mapping database (Pima County Department of Transportation and Flood Control District, 1994) is the most comprehensive in terms of area covered. It was developed for regulatory purposes (Pima County Floodplain and Erosion Hazard Ordinance 1994- FC-2). However, this data set does not describe vegetation in terms of species; instead, riparian vegetation is classified as mesoriprian or xeroriparian class A, B, C or D. These classifications are related to specific ranges of total vegetation volume. This mapping project focused on eastern Pima County and only includes washes of a certain size and in unincorporated areas.

Wash designation from Cienega Creek, Organ Pipe National Monument, Santa Cruz River, and Pima County riparian habitat mapping project, as well as the National Wetland Inventory (Cowardian et al. 1979), Town of Oro Valley (Harris Environmental Group

2000), and the SDCP riparian pilot study (Phase I of this project) were standardized into 1 digital database. The resulting database was the starting point from which we inventoried the remaining lands outside existing public reserves for riparian vegetation.

3.2 Aerial Photographs

USGS Digital Orthophoto Quarter Quadrangles (DOQQs) were used to establish the geometric base for the development of the new inventory. Digital orthoimagery is a digital representation of an aerial photograph with ground features located in their true map position. Digital orthoimagery combines the image characteristics of an aerial photograph with the accuracy and scale associated with a map. The aerial imagery used to develop the USGS Orthophoto imagery was taken in 1996. This base was chosen as Pima County held a partial inventory of DOQQs. We acquired the outstanding DOQQs necessary to cover the inventory area within the county. As a result of combining existing with new imagery, the imagery used was a mix of black and white and color infrared images. Figure 2 displays the film type of the imagery by 7.5-minute quadrangle.

The imagery was used to generate hard copy maps at 1:24,000 map scale, which were referred to as transcription maps. The transcription maps contained 8 reference databases, the USGS digital orthophoto quarter quadrangles, the 7.5-minute quadrangle boundaries, the County and Forest Service boundaries, perennial and intermittent streams, riparian boundaries from the standardized existing digital databases, and lands currently inside existing public reserves. The transcription maps were used to delineate riparian boundaries and vegetation community type in areas not contained in the standardized database.

3.3 Wash Delineation and Vegetation Classification

All of the riparian areas were delineated based on the presence of a more-or-less linear swath of darker vegetation. Along perennial riparian systems, large tree crowns were

Legend

- Black and White DOQQ Imagery
- Color Infrared DOQQ Imagery

Riparian Vegetation Mapping and Classification, Sonoran Desert Conservation Plan
Digital Orthophoto Quarter Quadrangle Film Types

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Figure 2

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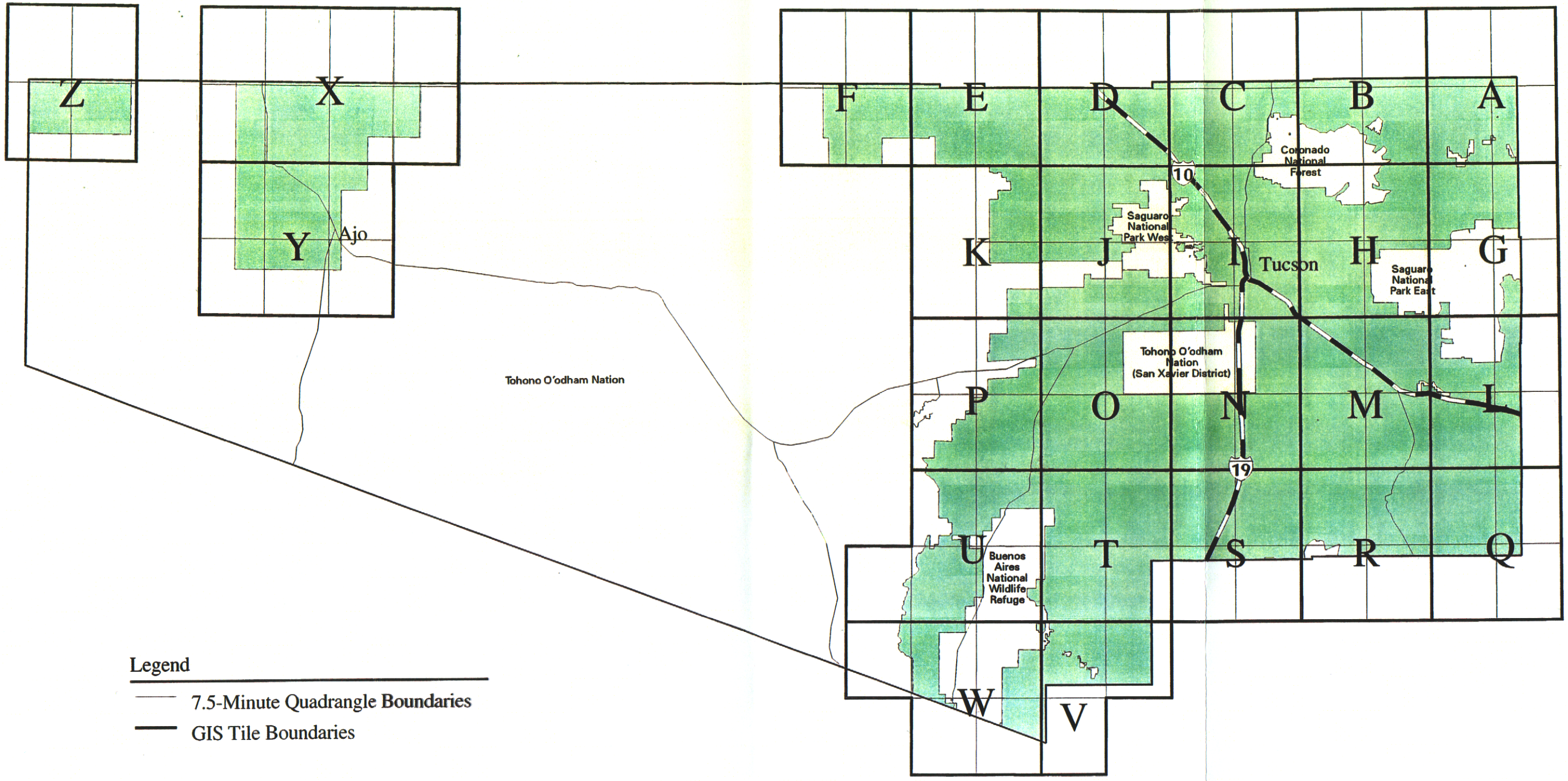
evident on the aerial photographs. Where there was little discernable difference in vegetation size and density, geomorphological evidence of hydrological patterns were used to identify riparian resources. Our goal was to map polygons with a minimum size of 5 acres. In some areas, polygons less than 5 acres were identified.

We delineated the lateral boundaries of riparian areas by drawing polygons directly onto the transcription maps, which already displayed the riparian resources delineated from previous studies. Because riparian systems in nature do not exist within discrete boundaries, any attempt to distinguish between riparian and non-riparian areas involves drawing an artificial boundary across what is actually a natural gradient. To ensure consistency for this project, the same biologist delineated the riparian resources throughout all phases of the project. Each photograph was then compared to its corresponding USGS topographic map to verify the location of washes, springs, canyons, and elevation information. Prior to assigning each polygon a vegetation classification, we reviewed existing data sets that contained riparian information for Pima County (Hendrickson and Minckley 1984, Shaw et al. 1996, Pima Association of Governments 2000).

Using pre-existing data, photo-interpretation and professional knowledge of Pima County riparian systems, we then assigned vegetation classifications to the biome level to each polygon. The exception to this classification level was the Sonoran Riparian Deciduous Forest and Woodlands biome (224.5 BLP code), which was further subdivided to the series level.

3.4 GIS Construction

When delineation was complete, the transcription maps were returned to the GIS to incorporate the data into the digital database. Pima County was divided into 26 tiles based on the USGS 7.5-minute quadrangle index (Figure 3). This division was designed to allow multiple individuals to input and process the data at a single time. It also



Legend

- 7.5-Minute Quadrangle Boundaries
- GIS Tile Boundaries

Riparian Vegetation Mapping and Classification, Sonoran Desert Conservation Plan Geographic Information System Tile Scheme

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Figure 3

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allowed for a measure of computer system backup as tiles were maintained on a network as well as local hard drives. We developed a process to generate the digital database from the transcription maps containing the riparian polygons and vegetation communities. The process was designed to allow for quality review throughout each step. A spreadsheet was developed to track the creation of the database by tile. This enabled us to determine the status of work at any given time. The spreadsheet listed all quadrangles by tile and name, then each step in the process. As each step was completed, staff would initial and date the associated cell on the spreadsheet. The steps of the process were as follows:

- Inventory the transcription map returned by the biologist
- Digitize the riparian polygons into AutoCAD Version 14 program
- Generate a check map to check accuracy of input line work
- Modify any input errors in the Computer Aided Design (CAD) drawing if identified on the check map and reprint a check map to verify accuracy
- Create a .dxf format file from the CAD drawing file
- Translate the .dxf format file to an Arc/Info coverage
- Edit the line work to meet the Arc/Info coverage requirements for topology
- Label all polygons with their associated BLP vegetation classification, BLP2, island, and source values
- Generate a check map to quality check all line and labeling efforts
- Modify any errors identified and reprint a check map to verify accuracy
- Copy completed tile to network server

As an internal quality assurance/quality control (QA/QC) technique, all check maps were verified by a second team member who did not enter the information.

As the inventory progressed, we identified areas classified with the same BLP code but consisting of different plant densities. These areas were identified with an additional attribute, named "island," which received the BLP classification of their surrounding

polygon and a value to identify it as an island within a riparian polygon. Additionally, in a few areas a second BLP attribute was recorded. These were areas where the biologists believed the vegetation composition did not fit well within a single BLP classification. Because of the nature of a GIS layer, only 1 BLP code can be listed as the dominant vegetation type. In these instances the plant communities are listed as "Dominant" and "Supporting." However, in polygons where there is more than 1 vegetation classification, there is no single dominant plant community and the user should understand that multiple vegetation classifications exist within the same polygon.

Upon completion of each tile, a field map was generated for the biologist to review and take into the field for a non-statistical verification of the database. The field maps displayed the USGS 7.5-minute quadrangle with riparian polygons and their associated BLP vegetation classification.

3.5 Classification Verification

As part of verifying the vegetation classification we visited many sites. We visited sites that had been classified as the Sonoran Riparian Deciduous Forest and Woodlands biome (224.5 BLP code) and further described these areas to the series level (Mesquite [224.52] and Cottonwood-Willow [224.53]). We also visited sites that were difficult to classify from the aerial photographs. In addition, we visited numerous other sites to verify that the original classification was correct.

We made an effort to visit various washes in each quadrangle as part of our verification strategy. Site visits primarily were made from vehicular access and hiking. However, because of the inaccessibility of the north and east sides of the Catalina Mountains, we visited these areas with a fixed-wing aircraft provided by the Pima County Sheriff's Department.

During our field visits we recorded several parameters about the riparian resources (Appendix B). In an effort to maximize the efficiency of our field verification, we

recorded minimal information for washes where the original vegetation classification was correct. In other areas, we recorded more detailed information, including the dominant plant species in each vegetation layer.

The locations of each field collection site visited were identified on the map with a unique reference number assigned by the field biologist. Each location was entered into an Arc/Info coverage. The associated field form was scanned, converted into an Adobe Acrobat .pdf format, and assigned a name corresponding to the unique reference number.

Completed field forms have been provided electronically to the County in a separate document.

In addition, we met with members of the STAT who were familiar with riparian areas to review any washes that could not be classified or visited because of time constraints. The STAT reviewed 16 sites on 7 different quadrangles and was able to classify the unknown areas.

3.6 Additional QA/QC

When all field site information was incorporated into the database, the 26 tiles were merged into a single database. Once merged, an overall assessment of the database was made. This overall assessment included generating a table of the frequency of the BLP vegetation classification values, which enabled us to identify any data entry errors that were not found during the review of the check plots. To address edgematching issues generated by the using the 7.5-minute quadrangles as the basis of mapping, check plots were generated for each tile for the next level of review. This tiered review of the riparian classification enabled us to move from a site-specific QA/QC to a regional QA/QC of the database. The tile-level check plots enabled us to adjust transitional boundaries between vegetation classifications at the biome level.

Edgematching polygons between tiles was completed digitally in Arc/Edit, using the DOQQs as a reference to ensure that new boundaries were identified correctly. These areas were reviewed carefully as the digital editing allowed the analysts to display the database at a scale larger than 1:24,000.

4.0 RESULTS

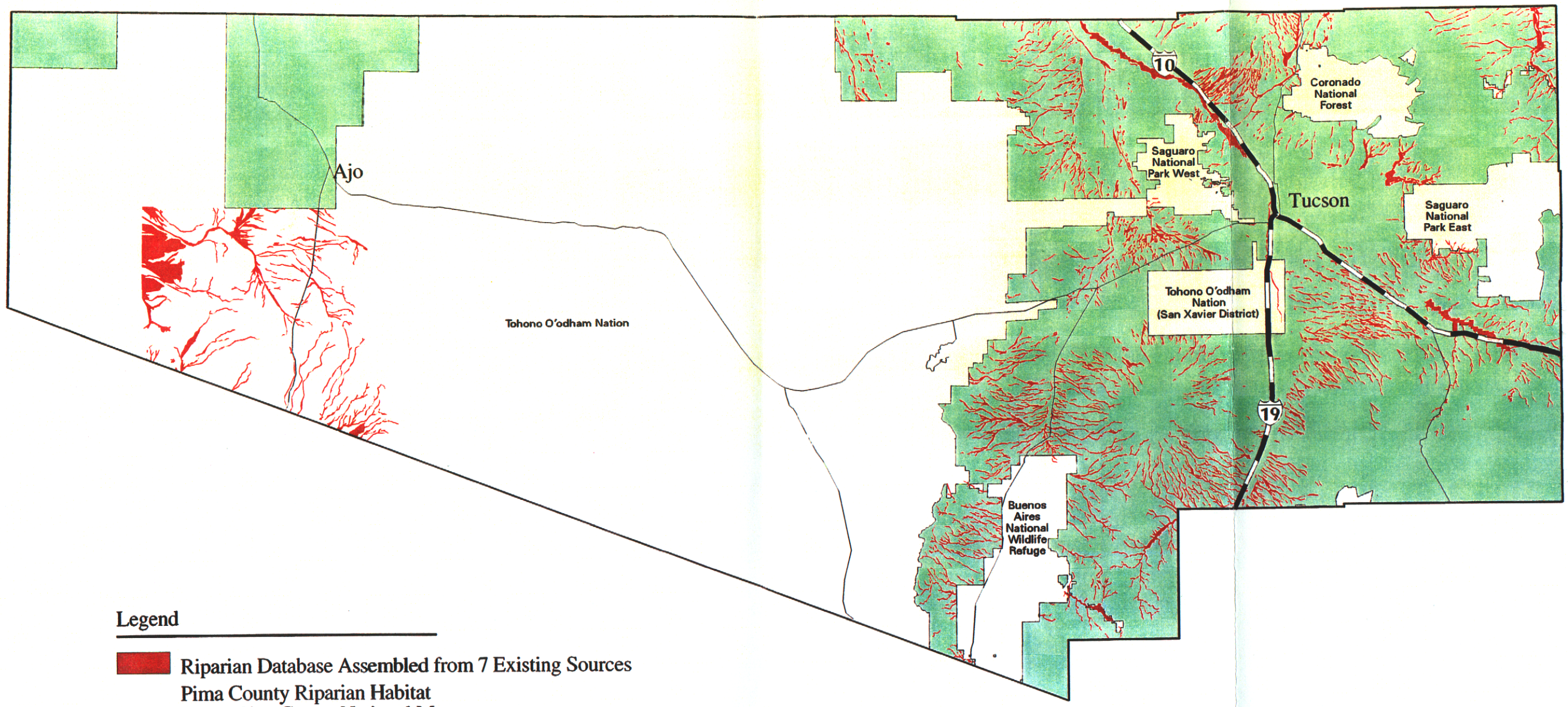
The interim database represented the compilation of already existing databases plus the results of the pilot study. The interim database included products from Pima County riparian habitat (Pima County Department of Transportation and Flood Control 1994), Organ Pipe Cactus National Monument (Warren et al. 1980), Cienega Creek Natural Preserve (McGann & Associates 1994), Oro Valley (Harris Environmental Group 2000), Bureau of Reclamation's Santa Cruz River study (Baker 2000), National Wetland Inventory (Cowardin et al. 1979), and the pilot study data sets. The interim database included 124,464.12 acres of riparian areas (Figure 4).

The final database includes 320,180.15 acres of riparian areas, which represents a 157 percent increase in mapped riparian areas from previous existing databases (Figure 5).

In total, of the 108 quadrangles in the study area, vegetation communities within riparian systems were verified in 97 of the quadrangles. We were unable to visit the remaining portions because of private property boundaries, inaccessible roads, denied access to the Barry M. Goldwater Range, or in instances where only a small part of the area on the quadrangle was within Pima County. The database was verified by conducting 603 field checkpoints (Figure 6).

4.1 Vegetation Summary

Riparian vegetation was characterized for 13 naturally existing biomes plus vacant-fallow land (Table 3). The Sonoran Riparian Deciduous Forest and Woodlands biome (224.5) was further classified to the series level: Mesquite Series (224.52) and Cottonwood-



Legend

Riparian Database Assembled from 7 Existing Sources

- Pima County Riparian Habitat
- Organ Pipe Cactus National Monument
- Cienega Creek Natural Preserve
- Town of Oro Valley
- Bureau of Reclamation's Santa Cruz River Study
- National Wetlands Inventory
- Sonoran Desert Conservation Plan, Pilot Study

Riparian Vegetation Mapping and Classification, Sonoran Desert Conservation Plan Existing Databases

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Figure 4

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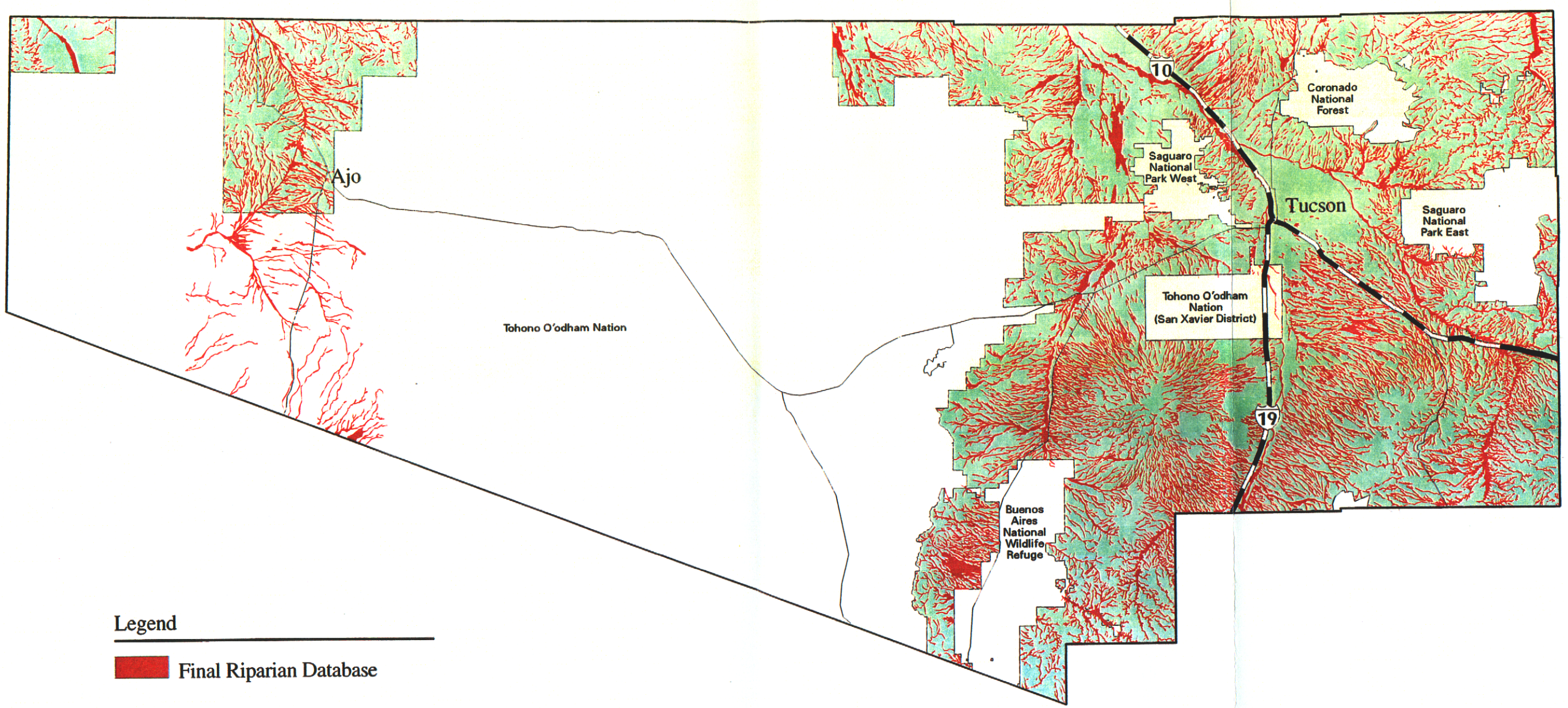

Legend

Final Riparian Database

Riparian Vegetation Mapping and Classification, Sonoran Desert Conservation Plan Final Riparian Database

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Figure 5

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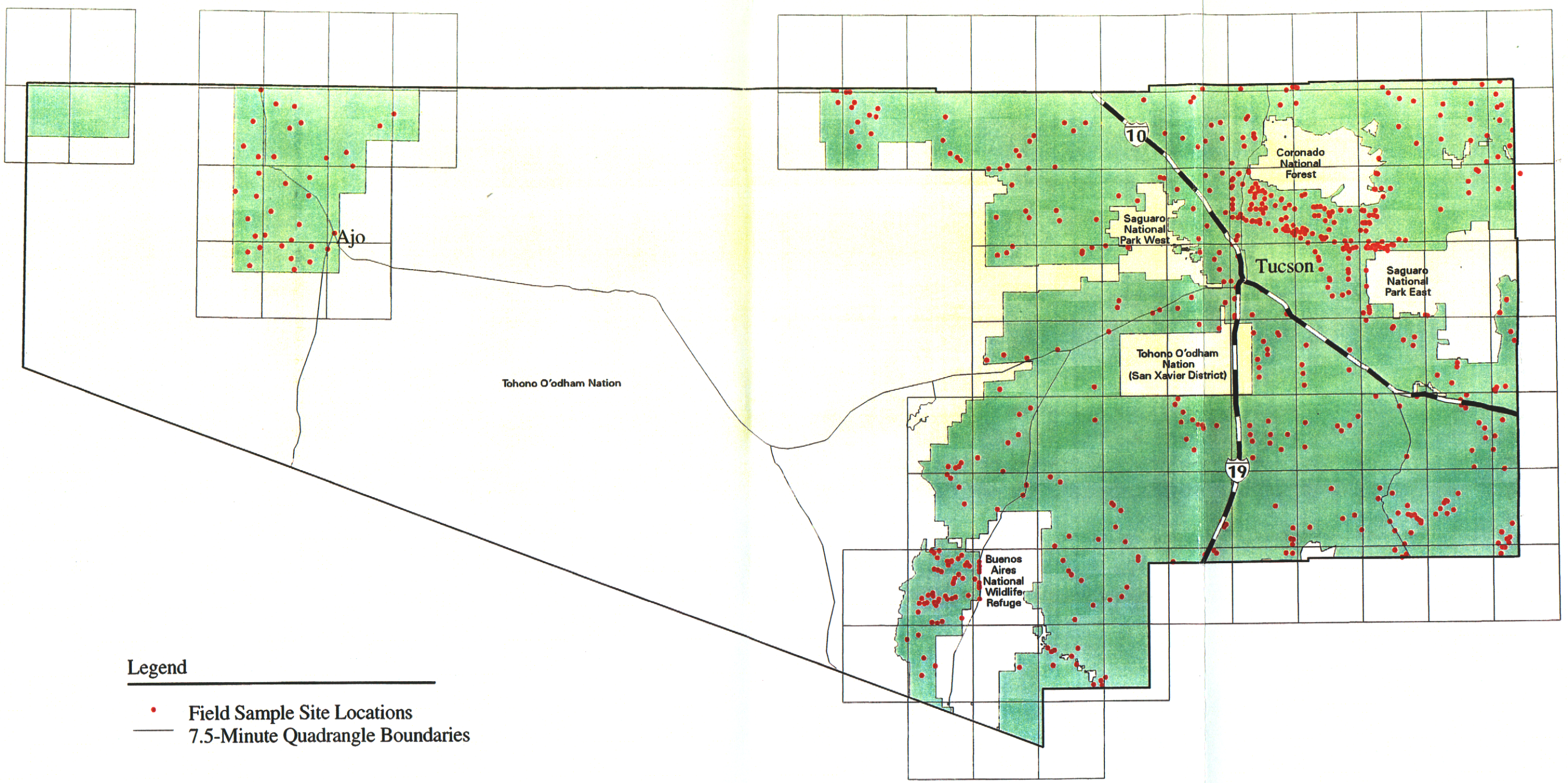

Legend

- Field Sample Site Locations
- 7.5-Minute Quadrangle Boundaries

Riparian Vegetation Mapping and Classification, Sonoran Desert Conservation Plan
Site Visit Locations

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Figure 6

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Table 3. Digitized classification system for Pima County's riparian biotic communities.[1]					
1,100	Nearctic Upland Vegetation (From this point forward in both the upland and wetland communities, the numeral "1" in front of the comma, which represents the Nearctic Realm, is understood and cropped for tabular convenience)				
120	Forests and Woodlands				
	122	Cold Temperate Forests and Woodlands			
		122.3	Rocky Mountain (= Petran) Montane Conifer Forest		
	123	Warm Temperate Forests and Woodlands			
		123.3	Madrean Evergreen Forest and Woodland		
		123.5	Relict Conifer (Cypress) Forest and Woodland		
	124	Tropical-Subtropical Forests and Woodland			
		*124.7	Sonoran Riparian Woodland		
			*124.71	Mesquite Series	
				*124.711R	*Prosopis glandulosa* riparian woodland association
140	Grasslands				
	143	Warm Temperate Grasslands			
		143.1	Scrub-Grassland (Semidesert Grassland)		
150	Desertlands				
	152	Cold Temperate Desertlands			
		152.1	Great Basin Desertscrub		
	153	Warm Temperate Desertlands			
		153.2	Chihuahuan Desertscrub		
	154	Tropical-Subtropical Desertlands			
		154.1	Sonoran Desertscrub		
1,200	Nearctic Wetland Vegetation				
220	Forests				
	222	Cold Temperate Wetlands			
		222.3	Rocky Mountain Riparian Deciduous Forest and Woodland		
	223	Warm Temperate Wetlands			
		223.2	Interior Southwestern Riparian Deciduous Forest and Woodland		
	224	Tropical-Subtropical Wetlands			
		224.5	Sonoran Riparian Deciduous Forest and Woodland		
			224.52	Mesquite Series[2]	
			224.53	Cottonwood - Willow Series[2]	
230	Riparian Scrublands				
	234	Tropical-Subtropical Swamp and Riparian Scrubs			
		234.7	Sonoran Deciduous Riparian Scrub		
250	Strands				
	254	Tropical-Subtropical Strand			
		254.7	Sonoran Interior Strand		
1,300	Nearctic Cultivated and Cultured Land				
360	Vacant-Fallow Land				
	364	Tropical-Subtropical Vacant-Fallow Lands			
		364.1	Sonoran Vacant-Fallow Land		

[1]The classification system follows a modified Brown, D.E., C. H. Lowe, and C. H. Pase. 1979. A digitized classification system for the biotic communities of North America, with community (series) and association examples for the Southwest. J. Arizona-Nevada Acad. Sci. 14 (Suppl. 1):1-16. and Brown, D.E. 1980. A system for classifying cultivated and cultured lands within a systematic classification of natural ecosystems. J. Ariz-Nev Acad. Sci. 15:48-53.

[2]Series examples were mapped and described only for the Sonoran riparian deciduous forest and woodland communities, all others were classified to the biome level only.

*Indicates mapping units used at Organ Pipe Cactus National Monument (OPCNM) after Warren et al. 1980. Vegetation of Organ Pipe Cactus National Monument. National Park Service, Cooperative Park Studies Unit, University of Arizona, Tucson. Coverage provided through Pima County. The coverage for OPCNM was more detailed than the present study because of quantified sampling used to resolve coverage to the vegetation association level (community of specific dominants).

willow Series (224.53). The most abundant biome is Sonoran Desertscrub (154.1) (Table 4). Each of the biomes is described below.

Table 4. Total acres of riparian areas per biotic community in Pima, County, Arizona.

BLP	BIOTIC COMMUNITY	ACRES
122.3	Rocky Mountain Montane Conifer Forest	178.55
123.3	Madrean Evergreen Forest & Woodland	6,232.45
123.5	Relict Conifer Forest & Woodland	103.02
124.7	Sonoran Riparian Woodland	560.08
143.1	Scrub-Grassland (Semidesert Grassland)	117,106.01
152.1	Great Basin Desertscrub	44.38
153.2	Chihuahuan Desertscrub	28.09
154.1	Sonoran Desertscrub	150,093.51
222.3	Rocky Mountain Riparian Deciduous Forest & Woodland	83.05
223.2	Interior Southwestern Riparian Deciduous Forest & Woodland	5,833.39
224.5	Sonoran Riparian Deciduous Forest & Woodland	25,436.81
234.7	Sonoran Deciduous Riparian Scrub	7,751.83
254.7	Sonoran Interior Strand	5,336.60
364.1	Sonoran Vacant-Fallow Land	1,392.38
Total Acres		320,180.15

122.3 Rocky Mountain (Petran) Montane Conifer Forests

Rocky Mountain montane conifer forests are cold-temperate forests, which are composed of medium to large conifers and/or winter deciduous trees (Pase and Brown 1982). In Pima County these forests are found from as low as 5300 feet (1676 m) in elevation to summit areas of 9157 feet (2591 m) in the Santa Catalina Mountains and 8666 feet (2641 m) in the Rincon Mountains. Based on overstory dominants, this forest type is divided into 2 major communities or series—a yellow pine forest and a mixed conifer forest. The yellow pine forest is dominated by ponderosa pine (*Pinus ponderosa*) and also Arizona pine (*Pinus arizonica* = *P. ponderosa* var. *arizonica*), the latter generally being located at lower elevations. Oaks (*Quercus* spp.), both evergreen and winter deciduous species, are commonly associated with the pines. At higher elevations, in canyons and on north-

facing slopes, a cooler mixed conifer forest of Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), southwestern white pine (*Pinus strobiformes*), and locally aspen (*Populus tremuloides*) is dominant. Aspen is a colonizing species that reproduces primarily by root sprouts and often forms homogeneous stands. In Pima County, the Rocky Mountain montane conifer forest biome is located entirely on U.S. Forest Service (Coronado National Forest) and National Park Service (Saguaro National Park) lands. For more detailed descriptions of Rocky Mountain montane conifer forest and subalpine conifer forest see Shreve (1915), Lowe (1961, 1964), Pase and Brown (1982), Niering and Lowe (1984), Bowers and McLaughlin (1987), and references cited therein.

Figure 7. Vegetation Characteristic of the Rocky Mountain Montane Conifer Forest Biome (BLP #122.3).

123.3 Madrean Evergreen Forest and Woodland

This warm-temperate, moist woodland is dominated mainly by short-statured evergreen oaks (*Quercus* spp.), pines (*Pinus* spp.), and junipers (*Juniperus* spp.). In Pima County, Madrean evergreen woodland is well represented on the slopes of the Santa Catalina, Rincon, and Baboquivari mountains from 4400 to 7000 feet (1341 – 2134 m) and higher,

depending on slope aspect. It also is found within those portions of the Santa Rita and Whetstone mountains that are located within Pima County. Authorities generally subdivide this community type into 2 series -- oak woodland (encinal) and pine-oak or oak-pine woodland and forest. The character of the encinal series is generally an open woodland that is dominated by one or more species of oak (e.g., *Q. arizonica, Q. emoryi, Q. hypoleucoides, Q. oblongifolia,* and *Q. rugosa*), junipers (*J. deppeana* and *J. monosperma*), and piñon (*P. discolor*) that are 10 to 20 feet (3 – 6 m) in height. The encinal series also can be chaparral-like with an occasional oak or piñon barely emerging from thickets of manzanita (*Arctostaphylos* spp.). At higher elevations, a pine-oak forest or woodland is prevalent with emergent pines (*P. arizonica* or *P. ponderosa*, and/or *P. leiophylla*) that tower over the oak canopy. For a more detailed description of Madrean evergreen forest and woodland see Marshall (1957) and Brown (1982a), in addition to some of the previously mentioned references.

Figure 8. Vegetation Characteristic of the Madrean Evergreen Forest and Woodland Biome (BLP #123.3).

123.5 Relict Conifer Forest and Woodland

Small groves of Arizona cypress (*Cupressus arizonica*), restricted to cool sheltered north-facing slopes and in canyon bottoms, are found within more temperate Madrean evergreen woodland and also within semidesert grassland in the Santa Catalina Mountains from 4,000 to 6,500 feet (1,220 to 1981 m). These relict (fire-climax) stands

are protected on U.S. Forest Service (Coronado National Forest) system lands in the Bear and Sabino Canyon watersheds (including portions of Rose and Willow canyons) in the Santa Catalina Mountains and are found nowhere else in Pima County. A few stunted individuals can be found in lower Sabino Canyon along with some large Emory oaks (*Quercus emoryi*) just upstream of Sabino Dam at an elevation of 3,000 feet (915 m). The largest individuals are always found along canyon bottoms, typically within Interior Southwestern Riparian Deciduous Forest and Woodland. A large specimen found in Bear Canyon has been identified as the species' champion tree in Arizona. Elsewhere in southeastern Arizona, pockets of cypress are found in the Chiricahua, Dragoon, and Galiuro mountains. For a more detailed description of Relict Conifer Forest and Woodland see Brown (1982b).

Figure 9. Vegetation Characteristic of the Relict Conifer (Cypress) Forest and Woodland Biome (BLP #123.5).

124.7 Sonoran Riparian Woodland

This type was described by Warren et al. (1980) from Organ Pipe Cactus National Monument (OPCNM). For the current project, this riparian woodland type was incorporated into our GIS coverage, as it is a component from OPCNM in southwestern

Pima County. Warren et al. (1980) describe this riparian woodland community as being composed of open stands of trees 15 to 20 feet (5 – 6 m) tall that form continuous corridors along large intermittent drainages (i.e., Growler Wash near Bates Well, Kuakatch Wash near Wall's Well, and near Aguajita Spring). All 3 of these sites are described as having shallow groundwater on level, silty floodplain soil. Characteristic species include western honey mesquite (*Prosopis glandulosa*), blue paloverde (*Cercidium floridum*), canyon ragweed (*Ambrosia ambrosioides*), graythorn (*Ziziphus obtusifolia*), and catclaw (*Acacia greggii*).

Warren et al. (1980) categorized this riparian woodland type as upland vegetation rather than wetland vegetation, perhaps recognizing that it is more characteristic of so-called xeroriparian vegetation as described by Johnson et al. (1984). Xeroriparian habitats are very dense desertscrub thickets bordering dry desert washes with intermittent water supplies and include primarily species from adjoining upland areas. Xeroriparian habitat is equivalent to desert riparian scrub described by Shreve (1951) and Lowe (1964).

143.1 Semidesert Grassland

Semidesert grassland, sometimes called desert grassland, mesquite grassland, or scrub-grassland, is a relatively dry climate grassland that is found on level, rolling, or foothill terrain below 5500 feet (1676 m) in elevation (Brown 1982c). Usually present are mesquite (*Prosopis* spp.), yucca (*Yucca elata*), and several species of cacti and warm-temperate perennial grasses, such as black grama (*Bouteloua eriopoda*), tobosa (*Hilaria mutica*), and other species. Numerous scrub-grassland areas are now characterized by the presence of burroweed (*Isocoma tenuisecta*), snakeweed (*Gutierrezia sarothrae*), and other noxious shrubs, which have replaced the native grasses as a result of overgrazing by livestock. Mesquite also has increased as a result of overgrazing as well as introduced grass species, such as Lehmann's lovegrass (*Erigrostis lehmanniana*). For a more detailed description of semidesert grassland see Brown (1982c).

Figure 10. Vegetation Characteristic of the Semidesert Grassland Biome (BLP #143.1).

152.1 Great Basin Desertscrub

This cold-temperate desert is not found in Pima County. It is the most northerly of the 4 North American deserts and is found in Arizona on the Colorado Plateau in the northeast part of the state, and is often referred to as the "Painted Desert" (Turner 1982; see also map of the biotic communities of the Southwest by Brown and Lowe 1980). It was included as part of the GIS coverage from the OPCNM database. Great Basin Desertscrub is dominated by low shrubs, primarily various species of sagebrush (*Artemisia* spp.) and/or saltbush (*Atriplex* spp.). Other dominant or co-dominant species include blackbrush (*Colegyne ramosissima*), winterfat (*Eurotia lanata*), greasewood (*Sarcobatus vermiculatus*), or rabbitbrush (*Chrysothamnus nauseosus*). This vegetation type is not found in southern Arizona and is probably an error in the OPCNM GIS coverage. For a more detailed description of Great Basin Desertscrub see Turner (1982).

153.2 Chihuahuan Desertscrub

This warm-temperate biome is the major desert vegetation type found in extreme southeastern Arizona and is found in Pima County only in the eastern-most portion of the County. Chihuahuan Desertscrub plant communities are often dominated by an endemic variety of creosotebush, which has 13 chromosomes as compared to 39 in Mohave

Desertscrub and 26 in Sonoran Desertscrub (Brown 1982d). Other dominant plants include mesquite (*Prosopis glandulosa* var. *torreyana*), tarbush (*Florensia cernua*), mariola (*Parthenium incanum*), and whitethorn acacia (*Acacia neovernicosa*), commonly accompanied by yuccas (*Yucca* spp.), agaves (*Agave* spp.), sotol (*Dasylirion wheeleri*), prickly-pear cacti (*Opuntia* spp.), and other leaf and stem succulents. Distinct Chihuahuan Desertscrub communities are often associated with limestone substrates, and a common associate of this substrate is sandpaperbush (*Mortonia scabrella*). Chihuahuan Desertscrub often occurs as a mosaic with semidesert grassland in eastern Pima County, where tobosa (*Hilaria mutica*), a coarse perennial bunch grass, is often prevalent. For a more detailed description of Chihuahuan Desertscrub see Brown (1982d). For a more detailed description of Sonoran Desertscrub see Shreve (1951) and Turner and Brown (1982b).

Figure 11. Vegetation Characteristic of the Chihuahuan Desertscrub Biome (BLP #153.2).

154.1 Sonoran Desertscrub

This tropical-subtropical desert biome covers a large area of Pima County. There are currently 5 major subdivisions (or series) of the Sonoran Desert that are recognized, 2 of which are located in Arizona, the Lower Colorado River Valley Subdivision and the

Arizona Upland Subdivision (Turner and Brown 1982). The Lower Colorado River Valley Subdivision is characterized by creosotebush (*Larrea tridentata*) and white bursage (*Ambrosia deltoidea*) dominated associations on level or nearly level terrain. Arizona Upland is characterized by a diverse assemblage of microphyllous, leguminous trees and a variety of shrubs and cacti, which includes the saguaro (*Carnegiea gigantea*), a columnar cactus that reaches through the various tree and shrub canopy layers. Trees commonly associated with this biome include paloverde (*Cercidium microphyllum* and *C. floridum*), ironwood (*Olneya tesota*), mesquite (*Prosopis* spp.), and cat-claw acacia (*Acacia greggii*). Common shrubs include creosotebush, triangle-leaf bursage (Ambrosia deltoides), ratany (*Krameria* spp.), ocotillo (*Fouquieria splendens*), jojoba (*Simmondsia chinensis*), brittlebush (*Encelia faranosa*), fairy duster (*Calliandra eriophylla*), desert hackberry (*Celtis pallida*), and others. In addition to saguaro, various species of cacti characterize Arizona Upland, including prickly pear and cholla (*Opuntia* spp.), barrel cacti (*Ferrocactus* spp.), hedgehogs (*Echinocereus* spp.), and pincushions (*Mammillaria* spp.).

Riparian habitat found along the normally dry washes within Sonoran Desertscrub is an open to dense, drought-deciduous, microphyllous riparian thorn scrub woodland. This riparian habitat is known as desert riparian scrub (Shreve 1951, Lowe 1964) and xeroriparian scrub (Johnson et al. 1984). These washes typically have braided channels that can substantially rearrange with surface flow flood events. Most of the tree and shrubs species associated with desert riparian scrub are the same found in upland (non-riparian) sites, such as paloverde, mesquite, ironwood, and others. A few shrub species are more prevalent along the washes, e.g., canyon ragweed (*Ambrosia ambrosioides*) and cheesebush (*Hymenoclea salsola*).

Figure 12. Vegetation Characteristic of the Sonoran Desertscrub Biome (BLP #154.1).

222.3 Rocky Mountain Riparian Deciduous Forest and Woodland

This is the principal riparian forest and woodland habitat found along perennial and intermittent streams, and at springs and seeps located at higher elevation sites in the Santa Catalina and Rincon mountains, particularly on north-facing slopes above 7,000 feet (2133 m). Tree and shrub species commonly associated with this riparian community type include bigtooth maple (*Acer grandidentatum*), Arizona alder (*Alnus oblingifolia*), box elder (*Acer negundo*), Rocky Mountain maple (*A. glabrum*), Scouler willow (*Salix scouleriana*) and various scrub willows (*Salix* spp.). Fewer deciduous tree species characterize the montane riparian community; however, the shrub layer is variable, both in species composition and richness. The greatest diversity is found on north-facing slopes. Red-osier dogwood (*Cornus stolonifera*), wax flower (*Jamesia americana*), gooseberry (*Ribes* spp.), thimbleberry and raspberry (*Rubus* spp.), snowberry (*Symphoricarpos oreophilus*), mountain spray (*Holodiscus dumosus*), cow parsnip (*Heracleum sphondylium*), monkey flower (*Mimulus cardinalis*), various ferns (*Athyrium filix-femina, Cystoperis fragilis, Pteridium aquilinum*), sedges (*Carex* spp.), dock (*Rumex* spp.), and various grass species are among the shrub and herbaceous species that are common to this riparian community. Trees from the adjacent uplands are also an important component of the montane riparian community, including white fir, Douglas-

fir, Southwestern white pine, and ponderosa pine. For a more detailed description of Rocky Mountain Montane Riparian Forest and Woodland see Minckley and Brown (1982) and Szaro (1989).

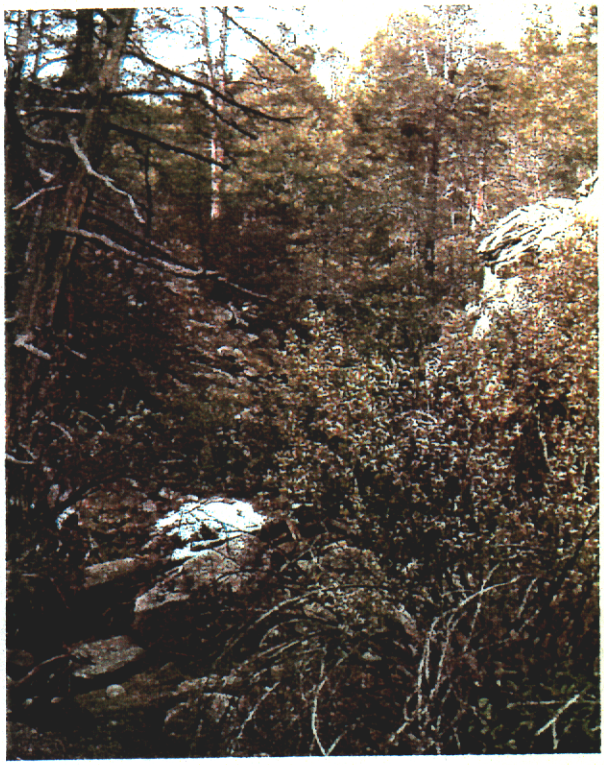

Figure 13. Vegetation Characteristic of the Rocky Mountain Riparian Deciduous Forest and Woodland Biome (BLP #222.3).

223.2 Interior Southwestern Riparian Deciduous Forest and Woodland

This winter deciduous riparian community is diverse because of high elevation species that penetrate downslope to occur among lowland forms. This community is maintained along perennial or seasonally intermittent drainageways and springs, and is divided into 2 major vegetation types (series) in sub-Mogollon Arizona, Cottonwood-willow and Mixed Broadleaf (Lowe 1961, Lowe 1964, Brown and Minckley 1982b). According to Lowe (1964), the most important riparian deciduous trees that make up this community occur in the center of the sub-Mogollon region where Pima County is located, including cottonwood (*Populus* spp.), willow (*Salix* spp.), Arizona sycamore, (*Platanus wrightii*),

velvet ash (*Fraxinus pennsylvannica* var *velutina*), and walnut (*Juglans* major). Often 3 or 4 of these species may occur together, and occasionally all 5 occur together. Occasionally isolated oak trees (e.g., *Q. arizonica, Q. emoryi, Q. hypoleucoides,* and *Q. oblongifolia*) finger down into this deciduous broadleaf riparian community.

Interior Southwestern Riparian Deciduous Forest and Woodland interfaces with Rocky Mountain Riparian Deciduous Forest and Woodland at higher elevation sites and Sonoran Riparian Deciduous Forest and Woodlands at lower elevations.

Figure 14. Vegetation Characteristic of the Interior Southwestern Riparian Forest and Woodland Biome (BLP #223.3).

224.5 Sonoran Riparian Deciduous Forest and Woodlands

These tropic-subtropic winter deciduous riparian forest and woodland communities are tropical in origin and are dominated by 1 or more species of cottonwoods (*Populus* spp.), willows (*Salix* spp.), and/or velvet mesquite (*Prosopis velutina*). They are restricted to peennial or near perennial streams and springs, generally below 3609 – 3937 feet (1100 -- 1200 m) elevation in and immediately adjacent to Sonoran Desertscrub communities (e.g., Shreve 1951, Lowe 1961, Lowe 1964, Minckley and Brown 1982). Both

cottonwood-willow and mesquite-dominated communities are now very much reduced in extent (Minckley and Brown 1982) as opposed to the end of the 19th Century when the opposite was true. While Mearns (1907) was conducting the International Boundary Survey between the United States and Mexico between 1892-94, he remarked that "No tree is more common, more beautiful, nor more valuable as a shade tree than the cottonwood. It grows naturally on almost every stream along the Boundary, and is planted around the houses and along the irrigation "acequias" of nearly every ranch." See Minckley and Brown (1982) for a more detailed description of this community type.

224.52 Mesquite Series

An open to fairly dense, drought-deciduous streamside thorn forest or woodland (bosque [Spanish]) dominated by velvet mesquite (*Prosopis velutina*), which can attain an open, park-like interior maintained by frequent flooding or fire. This community can be very diverse and varies with aspect and water regime. In more mesic areas, this community is comprised of very large mesquite trees and other trees and shrubs in dense, almost impenetrable stands.

Historically, mesquite bosques were open, dominated by annual and perennial grasses and with other woody species scattered throughout the forest. Common associates include catclaw (*Acacia greggii*) and graythorn (*Ziziphus obtusifolia*), and on moister sites, Mexican elderberry (*Sambucus mexicana*) and netleaf hackberry (*Celtis reticulata*). See Minckley and Brown (1982) and Stromberg (1993b) for a more detailed description of this community series type. The mesquite series is associated with washes, streambanks, swales, or outwash plains with substantial near-surface groundwater supplies. Often occurring on higher alluvial terraces away from perennial streams that support cottonwood-willow riparian forests/woodlands closer to water. Intergrades on drier sites with less reliable water supplies with xeroriparian desertscrub. Mesquite bosques are now virtually extirpated by agricultural development, flood control, and ground water depletion.

This community is often found adjacent to or within riparian forest communities representative of Sonoran and Southwestern Riparian Deciduous Forest and Woodland, which are dominated by cottonwood, willow, and other larger trees that tower above the mesquite woodland.

Figure 15. Vegetation Characteristic of the Sonoran Riparian Deciduous Forest and Woodland Biome, Mesquite Series (BLP #224.52).

224.53 Cottonwood - Willow Series

Fremont cottonwood (*Populus fremontii*) and 1or more species of tree willows (e.g., *Salix gooddingii*) dominate this broadleaf woodland. The cottonwood trees attain heights of over 60 feet tall and usually tower over a more visually prominent lower tree layer of *Salix gooddingii* and other shorter trees. Other species commonly found associated with cottonwoods and willows include velvet ash (*Fraxinus pennsylvannica* var. *velutina*), netleaf hackberry (*Celtis reticulata*), velvet mesquite, and the ever increasing exotic tamarisk (*Tamarix chinensis*). In Pima County, eastern cottonwood (*Populus deltoides*) can be found locally with Fremont cottonwood along the San Pedro River. Common shrubs species include graythorn (*Ziziphus obtusifolia*), Burrobush (*Hyemnoclea mongyra*), wolfberry (*Lycium* spp.), desert broom (*Baccahris sarothroides*), and others.

This community requires deep, well-watered, loamy alluvial soils along the near-channel floodplains of perennial desert rivers. According to Asplund and Gooch (1988), Fremont cottonwood is specifically a "strandline," streamside species, particularly of braided aggradations and their associated secondary channels, a microhabitat that depends on both upstream and upslope erosion. Cottonwood requires moist, bare mineral soil for germination and establishment, which is provided after flood waters recede, leading to uniform-aged stands (K. Asplund, pers. comm.). This series intergrades on sites slightly higher above and farther away from the river channels with mesquite dominated woodlands (Bosques).

Cottonwood and willow dominated forests or woodlands once occupied the floodplains and riverbanks of most perennial waterways within Pima County, but has mostly been replaced by disturbance types dominated by exotic species or disclimax riparian scrub communities. Even though this community is now rare, impressive remnant examples of this community type can be found along Arivaca Creek. Cienega Creek, and the San Pedro River in Pima County.

Figure 16. Vegetation Characteristic of the Sonoran Riparian Deciduous Forest and Woodland Biome, Cottonwood – Willow Series (BLP #224.53).

234.7 Sonoran Deciduous Riparian Scrub

A despauperate, moderately tall, up to 5 to 10 feet (1.5 -- 3.0 m) herbaceous riparian scrub community dominated by seep willow (*Baccharis salicifolia*) and others. This early seral community is maintained by frequent flooding, and in the absence of flooding most stands would succeed to cottonwood, willow, mesquite, or other tree dominated community.

These communities usually lack structural diversity found in riparian forest and woodland communities and many of the understory species found in the forests and woodlands are those found in the scrubland. There is evidence for increases in this community type since the turn of the 20th Century, largely at the expense of Sonoran Riparian Deciduous Forest and Woodlands (e.g., Turner 1974, Minckley and Clark 1981, 1984). Species commonly associated with this riparian scrubland type includes catclaw acacia (*Acacia greggii*), mesquite (*Prosopis* spp.), salt cedar (*Tamarix chinensis*), burrobrush (*Hymenoclea monogyra*), desert broom (*Baccharis sarathroides*), seep willow (*Baccharis glutinosa*), saltbush (*Atriplex* spp.), desert hackberry (*Celtis pallida*), desert willow (*Chilopsis linearis*), and other woody perennial and annual herbaceous species. See Minckley and Brown (1982) and Szaro (1989) for a more detailed description of riparian scrub.

Figure 17. Vegetation Characteristic of the Sonoran Deciduous Riparian Scrub Biome (BLP #234.7).

254.7 Sonoran Interior Strands

Sonoran Interior Strands are found along riverine channels that are subject to regular to infrequent submersion (Minkley and Brown 1982, Brown et al. 1998). Strand habitats include areas separated by significant areas that are devoid of perennial vegetation and the vegetative cover is usually less than 50 percent. This habitat is always in a state of flux (i.e. subject to seasonal flood scouring), and as the geomorphology of the channel stabilizes so too does the strand stabilize and increase in cover and thereby begins to form riparian scrub (previously discussed). Species commonly associated with Sonoran Interior Strand include both perennials and annuals, including many of those associated with scrubland communities, such as burrobrush, desert broom, seep willow, saltbush, careless weed or pigweed (*Amaranthus* spp.), sunflowers (*Helianthus* spp.), docks (*Rumex* spp.), nightshades (*Solanum* spp.), buckwheats (*Eriogonum* spp.), common cocklebur (*Xanthium strumarium*), Jimson weed (*Datura* spp.), and others. For a more detailed description of riparian scrub see Minckley and Brown (1982).

Figure 18. Vegetation Characteristic of the Sonoran Interior Strand Biome (BLP #254.7).

364.1 Vacant-fallow lands

This classification follows Brown (1980) for agricultural areas that are unplanted or in the early stages of abandonment or vacant lots within the urban setting within the tropical-subtropical climatic zone of the Nearctic biogeographic realm. Not all areas of this type were mapped because such a task was beyond the scope of this project. Areas in Pima County that were mapped using this classification included a few areas along the Altar Wash, San Pedro River, Sopori Wash, and Cienega Creek, and an area near Three Points. Other areas that we mapped as more-or-less natural riparian habitat surrounded these areas. Some or all of these areas may currently be planted, however, the majority of the areas that were classified as vacant-fallow lands appeared vacant or were not planted at the time the aerial photographs were taken or when the area may have been visited.

The system for classifying cultivated and cultured lands as described by Brown (1980) can easily be adopted for use in Pima County and is fully compatible with natural communities classification for both uplands and riparian communities described by Brown et al. (1979). More detailed fieldwork would be needed to categorize the specific

cultured and cultivated habitats in Pima County with this system. For the interim, the vacant-fallow land category used here is a catchall category for disturbed/agricultural lands.

Figure 19. Vegetation Characteristic of the Sonoran Vacant-Fallow Land Biome (BLP #364.1).

4.2 Project Deliverables

This project included the following 4 deliverables:

1. Pilot Study: The pilot study developed and refined a mapping methodology that was efficient and effective in delineating riparian areas and describing associated plant communities. The study was submitted on 12 April 2000.

2. Interim Database: This database represented the compilation of already existing databases plus the results of our pilot study. The interim database included products from Pima County riparian habitat, Organ Pipe Cactus National Monument, Cienega Creek Natural Preserve, Oro Valley, Bureau of Reclamation's Santa Cruz River study, National Wetland Inventory, and our pilot study data sets. The interim database was submitted on 22 June 2000.

3. Draft Database: This database represented the draft work delineating washes and describing association vegetation communities throughout the study area. The draft database was submitted on 30 October 2000.

4. Final Database and Product Report: This report and accompanying database are the final products for this project. The report describes the methods (including scale and source of base information used, assumptions made, and a non-statistical assessment of reliability in the mapping) and results of the mapping. The database includes (1) field verification locations, including scanned field forms in Adobe Acrobat .pdf format; and (2) the final riparian vegetation mapping and classification database. In addition, a complete reproducible set of mylares registered to 7.5-minute USGS quadrangle maps was included. The final database and project report was submitted on 15 December 2000.

5.0 DISCUSSION

The final riparian communities database for this project includes both our newly collected data combined with data sets from previous studies. As a consequence, any error generated in the data sets from previous studies is present in the new database. For example, in the Cienega Creek data set (McGann & Associates 1994) the polygons did not register exactly with the DOQQ imagery base used for this project. Wherever possible, we smoothed data into the McGann polygons at the perimeter.

Conversely, with the Santa Cruz River data set (Baker 2000), plant community biome definitions were not always consistent with definitions for this project. For example, Baker's (2000) mesquite bosque (224.52) definition was not the same as ours. Our definition of this biome required mesquite woodlands with closed canopies. From aerial photographs and site visits, it appears that Baker's (2000) definition of mesquite bosque included areas that contained sparse mesquite trees and not necessarily closed canopies. In our study, these areas of sparse mesquite trees were described as Sonoran Desertscrub

(154.1) and would not be classified as riparian. We removed some of these outlying polygons from the database.

Describing the plant communities along some riparian areas can be subjective, especially in regions where the overall plant community is in transition between 1 biome and another. Some of the vegetation classifications differ from those described by other authors. One example of this is in the Altar Valley, where there is a transition between Sonoran Desertscrub (154.1) and Semidesert Grassland (143.1). It is often difficult to draw a line separating Semidesert Grassland from Sonoran Desertscrub because plants from 1 coexist with those of the other, thus forming discontinuous, diverse ecotones. Brown et al. (1979) and Brown and Lowe (1980) depicts this area as all Semidesert Grassland and Turner (1974) maps the area as a woody phase of Scrub Grassland. The majority of the woody species are mainly Sonoran Desertscrub species. In the Rincon Valley area the Semidesert Grassland interfaces with both Sonoran Desertscrub and Chihuahuan Desertscrub, which further compounds the problem of mapping discrete units. Lowe (1964), Burgess (1995) and McAuliffe (1995) discuss the complexities of coexisting Desert Grassland and Desert Scrub. However, the Brown and Lowe (1980) map is based on conditions that occurred more than 20 years ago. Desertification and encroachment by woody shrubs and alien grasses into these areas has occurred since that time. In addition, the classification used for this project is based upon several recent field visits to the area and the mapping was conducted at a finer scale than was done in Brown and Lowe (1980). Nevertheless, because patches of grassland occur along this transitional boundary, we have added Semidesert Grassland (143.1) as the secondary BLP code (BLP2) to the Sonoran Desertscrub riparian systems in the area that Brown and Lowe (1980) originally mapped as grassland. Within these riparian areas we include both BLP codes. The Sonoran Desertscrub is listed as the primary BLP code and Semidesert Grassland is listed as the secondary BLP code.

In mountainous areas, we believe the amount of riparian vegetation identified overstates what is actually on the ground. This is a result of the analysts' ability to draw a narrow

enough polygon at our base map scale. The base maps scale (1:24,000) and quality of the imagery was such that it was often difficult to discriminate between true montane riparian habitat dominated by alders and pseudo-riparian dominated by mixed conifer elements.

6.0 Conclusion

The results from this study will be used to model sensitive species habitat and to identify the reserve design for the SDCP. The location of riparian areas and descriptions of the associated vegetation communities are critical factors in biodiversity conservation in Pima County. So many of the County's vulnerable species are dependent on riparian habitat and riparian habitat is limited in supply throughout the County. Furthermore, riparian habitat that exists today (or described here from 1996 aerial photographs) represents a small percentage of what historically occurred prior to groundwater depletion and human development.

7.0 Recommendations

The following recommendations are provided for consideration:

- Conduct a further study of riparian habitat that uses the prominence value technique designed and promoted by Warren et al. (1980) in concert with use of high-resolution color infrared aerial photographs. At a minimum, the study should go beyond the BLP 4th level (biome) to the 6th level (association) or if at all possible to a higher level that includes quantitative techniques to identify species, composition, structure, and phase. In very important riparian areas, the Field Methods for Vegetation Mapping employed by The Nature Conservancy (1994) should be considered. Increasing the level of detail also will improve predictions of biotic vulnerability for the habitat itself and could improve the effectiveness of habitat modeling for special status plant and animal species.

- Map in detail the extent of remaining marshland and aquatic communities, e.g., Sonoran Interior Marshland (BLP 244.7) and Sonoran Inland Submergent (BLP 264.7) communities. Included in the marshland and aquatic categories are ciénegas,

aquatic climax communities that are characterized by permanently saturated, highly organic, reducing soils (Hendrickson and Minckley 1984). Many of these important aquatic habitats have vanished and those that remain are in jeopardy. Ciénega habitat still remains on a local level in Pima County, e.g., along Cienega Creek, Buehman Canyon, San Pedro River, Arivaca Creek, Quitobaquito Springs on Organ Pipe Cactus National Monument, and elsewhere. Such a study would compliment the results of this present study and would allow more accurate habitat modeling for special status invertebrate and vertebrate species in which at least 1of their life stages is directly tied to these wetland communities. An effective way to locate and map such habitats would be to utilize high-resolution color infrared photographs combined with ground surveys. Unfortunately, at the scale of this project, 1:24,000, it is very difficult to describe small areas of marsh land/aquatic habitat. These types of habitat are not readily identifiable on black and white or on color infra-red aerial photographs because they are not large enough to be recorded by the camera. In addition, these vegetation types (marsh land/aquatic areas) contain structural diversity that is not visible on the imagery because the over-hanging canopy obscures it from the camera. Also, the location and size of this habitat is in constant flux depending on hydrological characteristics and rainfall.

- Require developers (both private and governmental) to further document vegetation within riparian habitats that may be impacted by development. Further documentation should include describing the plant community to the 6th BLP level (association) and identifying species, composition, structure, and phase. This information would be used in the planning process so that it is better understood what could be lost and would aid in mitigation strategies. This documentation would be similar to that now conducted for archaeological and historical sites.

- Conduct a similar study (at least to the biome level, if not the association level) of vegetation communities in the upland (non-riparian) areas of Pima County. This study would help conservation of important non-riparian species that are invaluable to

biodiversity in the Sonoran Desert, such as the saguaro cactus (*Carnegiea gigantea*) and agaves (*agave* spp.). Mapping upland habitat also would assist with habitat modeling that will be necessary for special status species being addressed in the SDCP, especially if it is done to the 6th BLP classification level (association).

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APPENDICES

APPENDIX

A. Pima County Riparian Vegetation Mapping Pilot Study

B. Biotic Community Field Verification Form

C. Compact Discs of Final Report and Final Database

PIMA COUNTY
RIPARIAN VEGETATION MAPPING
PILOT STUDY

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INTRODUCTION

On 18 January 2000, Pima County Government, Arizona, contracted with the biological consulting team of Harris Environmental Group, Inc., Dames & Moore, and R. B. Duncan & Associates to conduct a riparian habitat mapping study in Pima County as part of the County's Sonoran Desert Conservation Plan. The first phase of the project was to conduct a pilot study. The purpose of the pilot study was to develop and refine mapping methodology that will be efficient and effective in terms of meeting the Sonoran Desert Conservation Plan's Scientific and Technical Advisory Team's (STAT) riparian vegetation mapping requirements for Pima County.

There have been several vegetation-mapping studies done throughout the County, including those specific to riparian habitats, but few were comprehensive in describing the vegetation communities countywide. The 2 most recent are the Pima County Riparian Habitat Mapping and the U. S. Geological Survey (USGS), Biological Resources Division's Gap Analysis Program.

The Pima County Riparian Habitat Mapping (conducted in the early 1990s) describes the riparian vegetation in unincorporated portions of Pima County and was used for regulatory purposes (Pima County Floodplain and Erosion Hazard Ordinance 1994 – FC-2). This project does not describe vegetation in terms of species; instead riparian vegetation was classified as mesoriparian, or xeroriparian class A, B, or C. These are related to specific ranges of total vegetation volume. This mapping project focused on eastern Pima County and only included washes in the unincorporated areas.

The Gap Analysis Program (GAP) is a scientific method for identifying the degree to which native animal species and natural communities are represented in our

present-day mix of conservation lands. Those species and communities not adequately represented in the existing network of conservation lands constitute conservation "gaps." A preliminary Arizona GAP map has been produced and a final report is due in 2000. The GAP vegetation layer for the State of Arizona, as is the case for all of the United States, was described in terms of species using the National Vegetation Classification System (Anderson et al. 1998, Grossman et al. 1998). However, the STAT has evaluated the GAP map (Draft report dated June 1999) and determined that it was inadequate for the purposes of the Sonoran Desert Conservation Plan's goals.

The current mapping project will be a combination of integrating existing information and conducting new fieldwork. The results of the pilot study will give direction on how this process should be undertaken for the remaining portions of Pima County. As part of the pilot study, we conducted a qualitative riparian inventory within several sites, representing diverse situations in existing mapping information, definition of riparian area, and vegetation classification.

STUDY AREA

Three sites were chosen by Pima County for the pilot study. These areas represented a range of vegetation types present in Pima County. These study areas also represented the variation in available data sources. Given the time-sensitive nature of the overall project, pilot sites were also chosen for their proximity to Tucson (to minimize travel time) and for the availability of aerial photographs processed in a GIS (Geographic Information System) format.

The 3 Pima County riparian mapping pilot study areas are listed as follows by USGS 7.5 minute topographic map quadrangle locations (See Figure 1):

1) *Brown Mountain SE ¼*

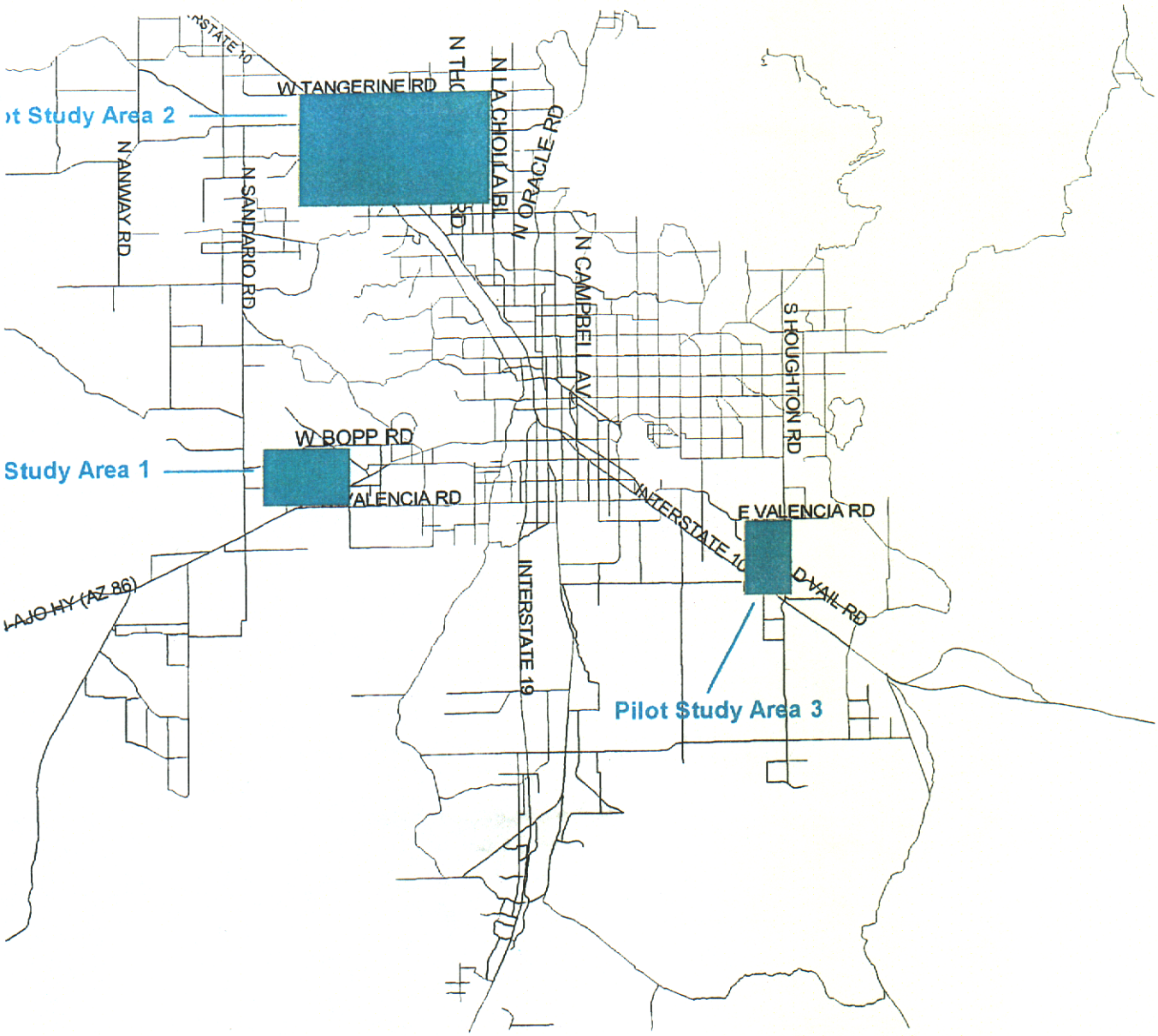
Pilot Study Area 1 includes Black Wash, a developing area thought to include a significant amount of desert riparian scrub and possibly more mesic riparian woodland, and known to have some unique drainage patterns not represented by the other areas.

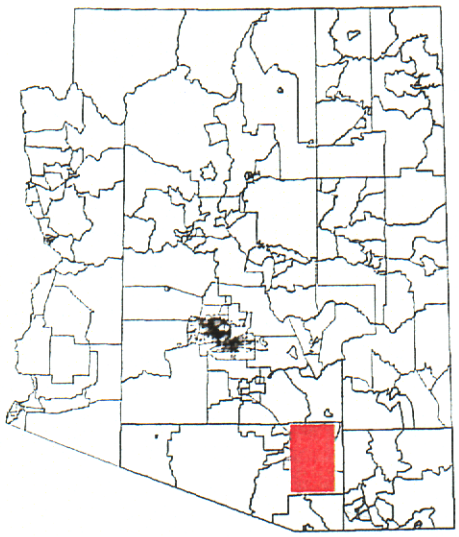
2) *Jaynes NE ¼ and NW ¼ and Ruelas SE ¼ and SW ¼*

Pilot Study Area 2 is located in an area that is inhabited by the federally listed endangered cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*). Riparian vegetation mapping is lacking or inadequate here. This area includes portions of the Cañada del Oro Wash and Santa Cruz River. The reach of the Santa Cruz River that is in this study area has been enhanced by treated effluent discharge.

3) *Tucson Southeast NE ¼*

Pilot Study Area 3 includes broad floodplain corridors containing both desert riparian scrub with shrub-like, perennial bunch grasses. Some of this area is within the jurisdiction of the City of Tucson, where there is no existing riparian vegetation information.





Sonoran Desert Conservation Plan:
Riparian Pilot Study Areas
April 2000

HARRIS ENVIRONMENTAL GROUP INC

METHODOLOGY

We evaluated 9 existing data sets that contain riparian information for Pima County. Data sets reviewed in detail include the GAP analysis, Earth Resources Observation Systems (EROS) Data Center maps, wash centerlines, and the Pima County Riparian Habitat Mapping project. Additional data sets provided by Pima County for evaluation included Cienega Creek, Arizona Game and Fish Department's (AGFD) statewide riparian inventory, Bown, Lowe, and Pace (BLP) natural vegetative communities, The University of Arizona's Wildlife Habitat Inventory Study (WHIPS) BLP layer, and WHIPS land cover layer. The latter referenced data sets were evaluated and eliminated from further investigation based on staff knowledge, extent of the data set outside the pilot sites, and review of the information contained in the data set.

Since species information is important in wildlife conservation, we developed a vegetation classification system based on the Brown, Lowe, and Pase (1979) hierarchical biotic communities classification system (Table 1). The BLP system will be used instead of the vegetative volume classification system used in the previously funded Pima County mapping effort. The BLP system is based on the biome concept that allows development of a hierarchical evolutionarily related classification and is well suited to mapping extensive areas for assessment of animal-plant distributions. Biomes are natural communities of plants and animals characterized by a distinctive vegetation physiognomy within a formation (forest, woodland, scrubland, grassland, etc.).

Since the Pima County Riparian Habitat Mapping project was conducted for regulatory purposes, only certain size washes were included. In an effort to determine the

usefulness of this existing database, we conducted the riparian inventory within the pilot sites without their use so that we would not be biased in our data collection. We then compared our results with the previously documented mapping project.

For delineating the riparian areas and classifying the vegetation within the pilot sites, we used the most current (June 1996) USGS ortho-rectified aerial photographs (1:12,000 scale) and Pima County's non ortho-rectified (1998) aerial photographs (1:400 scale). The non ortho-rectified aerial photographs were used in the field because of their higher resolution and availability when fieldwork began. An Arc Macro Language (AML) program was developed to generate base maps for biologists to transcribe lateral boundaries and type of riparian vegetation from the 1:400 to 1:12,000 scale maps. The base maps contained 4 data layers, the USGS digital ortho-photo quarter quadrangles, the quadrangle boundary, township, range, and section boundaries (from Arizona State Land Department), and lands currently identified as inside existing public reserves, based on the land ownership layer from Arizona State Land Department. Lands identified as inside existing public reserves include Arizona Game and Fish Department, Indian lands, military reservations, National Parks, regional and state parks, U.S. Forest Service, and National Wildlife Refuges. These lands were identified on the maps with a white patch to indicate to the biologist not to inventory in these areas.

Using the non-ortho aerial photographs, we delineated all of the riparian areas based on the presence of a more-or-less linear swath of darker vegetation. Lowe (1964) defined riparian vegetation as that which occurs in and along drainage system channels, their margins and/or their floodplains, and is further characterized by different species

Table 1: Sonoran Desert Conservation Plan
Riparian Pilot Study
Vegetation Categories[1]

154 Tropical-Subtropical Desertlands
- 154.1 Sonoran Desertscrub
  - 154.11 Creosote-Bursage ("Lower Colorado Valley") Series
    - 154.118 *Cercidium spp.-Olneya tesota* riparian Association
    - 154.119 *Cercidium floridum-Prosopis spp.* riparian Association
  - 154.12 Paloverde-Mixed Cacti ("Arizona Uplands") Series
    - 154.127 Mixed shrub-*Cercidium microphyllum-Olneya tesota*-mixed scrub Association
    - 154.128 Mixed shrub-*Cercidium microphyllum-Chilopsis linearis*-mixed scrub Association
  - 154.13 Brittlebush-Ironwood ("Plains of Sonora") Series
  - 154.18 Desertbroom-Burrobush Series

224 Tropical-Subtropical Swamp, Riparian and Oasis Forests
- 224.5 Sonoran Riparian and Oasis Forests
  - 224.52 Mesquite Series
    - 224.521 *Prosopis juliflora velutina* Association
  - 224.53 Cottonwood-Willow Series

234 Tropical-Subtropical Swamp and Riparian Scrub
- 234.7 Sonoran Deciduous Swamp and Riparian Scrub
  - 234.71 Mixed Scrub Series
    - 234.712 *Prosopis juliflora velutina* (mesquite bosque) Association

[1] Brown, D., Lowe, C. H., and C. H. Pase. 1979. A digitized classification system for the biotic communities of North American and community (series) and association examples for the Southwest. J. Arizona-Nevada Academy of Science 14(Suppl.1)1-16.

and/or life forms than that of the immediately surrounding non-riparian (upland) vegetation.

The desert washes dissecting the study area that drain from the adjacent mountain ranges are easily recognizable by the presence of a linear assemblage of trees and shrubs that are denser and taller than the sparse vegetation on the adjacent uplands. Polygons were drawn around these riparian areas. The designation of riparian areas and location of polygon boundaries were internally verified by Dr. Margaret Livingston, The University of Arizona, and Mr. Russell Duncan, R. B. Duncan & Associates.

The base maps were first produced at 1:24,000 map scale. An evaluation of the imagery at this scale determined the resolution to be too small to accurately depict vegetation to the Association level of the BLP vegetation classification system, which was our initial goal for the pilot study. Maps were then enlarged to 1:12,000 map scale. These maps were used in conjunction with the 1:400 aerial imagery to identify the riparian vegetation.

Plant communities were defined, through interpretation of ortho-photo images and field verification. We described the vegetation communities to the Series or Association level. After visiting several areas for confirmation of vegetation classification, field verification eventually consisted of the qualitative assessment of riparian areas. Vegetation polygons were delineated to the minimum mapping unit of 5 acres. The polygon information was then transferred to the ortho-rectified aerial photographs (1:12,000) for digitizing.

Vegetation polygons were digitized and labeled in the *ArcEdit* module of *ARCINFO* (ESRI 1999). GIS analysts reviewed the resulting maps to ensure all polygons

were closed, labeled and that edge matching occurred between quadrangles. Maps were registered to the township/range/section data set. Check plots were generated to verify all boundaries and labels were entered correctly.

Analysts then generated a frequency of the BLP vegetation types. This frequency was a secondary quality assurance/quality control (QA/QC) verification to ensure that all vegetation types were entered correctly into the GIS database. Final maps were generated showing the completed pilot study.

RESULTS AND DISCUSSION

Riparian Area Comparison

We inventoried all existing riparian areas within our pilot sites visible on the 1998 non ortho-rectified aerial photographs (1: 400 scale). In comparison with the 2 previous mapping projects, our coverage was more comprehensive. For example, within pilot study area 2 (Jaynes NE ¼ and NW ¼ and Ruelas SE ¼ and SW ¼), we inventoried 4,312 acres of riparian area, compared to 348 acres in the Pima County's Riparian Habitat Mapping project, and 297 acres in the GAP project. The GAP project showed only 1 riparian area within this pilot site; the Santa Cruz River (See Appendices A & B).

Vegetation Summary

Upland (non-riparian) vegetation of the pilot sites is mainly representative of Sonoran Desertscrub (154.1) but also includes areas dominated by Semidesert Grassland (143.1). Associated mesic riparian communities in the pilot study area (found mainly along the Santa Cruz River and Cañada del Oro Wash) include Sonoran Riparian and

Oases Forests and Woodlands (224.5), Sonoran Deciduous Swamp and Scrub (234.7), and Sonoran Interior Strands (254.7). These riparian communities are present along stream channels and their associated terraces with perennial or near perennial water sources, and in areas where ground water is at a shallow depth. Much of the more mesic riparian habitat along the Santa Cruz River has been enhanced by discharge of treated effluent water. Such habitat would not be present today were it not for the presence of the effluent. Historically this habitat did exist along portions of the Santa Cruz River near Tucson. Much of this riparian habitat in Arizona is now lost, degraded, or highly fragmented due to various human related impacts, including ground water down-pumping.

The existing upland and riparian communities in the Tucson area are a result of a broad range of factors including elevation, topography, temperature, precipitation, geology, soil, fire, and an assortment of anthropogenic effects. A generalized but reasonably accurate vegetation map of the Tucson area was produced by Turner (1974). Detailed descriptions of the aforementioned upland and mesic riparian vegetation communities can be found in Brown 1982, Minckley and Brown 1982, and Turner and Brown 1982.

Included in the pilot study area are desert riparian scrub communities (also known as xeroriparian habitat) composed largely of species from adjacent uplands. These are found along normally dry washes. There is no permanent flow in these washes; instead, flow is intermittent based on seasonal rainfall as well as strength and duration of individual storms. Runoff from the surrounding uplands increases the available water in and adjacent to the washes. This permits growth of plant species not found in the

surrounding open desertscrub and because of the added moisture allows plants also found on upland sites to grow more luxuriantly. Desert riparian scrub species are generally considered facultative riparian species. Facultative species can be observed as dominant vegetation in uplands as often as in desert riparian scrub habitats. Vegetation within each of the pilot study areas is described below.

Pilot Site 1: Brown Mountain SE ¼

Upland habitat was scrub grassland or semidesert grassland (143.155 = Mixed scrub-mixed grass association) and Sonoran Desertscrub, Lower Colorado River Valley Subdivision (154.111) or ecotonal between the two (See Appendix C). Dominant perennial species included *Larrea tridentata*, *Ambrosia deltoidea* and locally *A. dumosa*, *Acacia constricta*, *Prosopis velutina*, *Atriplex canscens*, *Isocoma tenuisecta*, and mixed grasses (in alphabetical order: *Andropogon barbinoidis*, *Aristida* sp., *Chloris virgata*, *Eragrostis* sp. [incl. *E. lehmanniana*], *Erioneuron pulchellum*, *Muhlenbergia porteri*, *Pappophorum mucronulatum*, *Sporobolus* cf. *cryptandrus*, and *Trichachne californica*). *Aristida* sp., *Erioneuron pulchellum*, and *Muhlenbergia porteri* were the most common. Cacti present included mainly *Opuntia fulgida* and also *Ferrocatus wislizenii*, and *Opuntia phaecantha*. *Carnegiea gigantea* was occasionally encountered.

Desert riparian scrub habitat in this area was dominated by *Acacia constricta*, *Prosopis velutina*, *Atriplex canescens*, *Lycium* sp., and mixed grasses. The most common grasses were *Pappophorum mucronulatum*, *Andropogon barbinoidis*, and *Chloris virgata*. Also present was *Cercidium floridum*. *Ambrosia ambrosioides* was found along the larger wash channels.

In some areas of Pilot Study Area 1, it was very difficult to distinguish between upland and riparian habitat because of the braided nature of the washes and the fact that the area seems to be prone to sheet flooding. Where upland habitat was distinct it was clearly characterized as creosote bush dominated desertscrub. The nature of the valley bottom's soil contained a high degree of silts, and here creosote bush was dominant. The more sandy and gravelly sites (usually associated with the wash complex) included *Amborsia deltoidea* and/or *A. dumosa*. *Atriplex* was locally abundant and mostly associated with the riparian habitat.

Pilot Study Area 2: Jaynes NE ¼ and NW ¼ and Ruelas SE ¼ and SW ¼

Here desert riparian scrub was dominated by *Cercidium microphyllum* and *C. floridum, Olneya tesota, Acacia constricta* and *A. greggii, Ambrosia ambrosioides, Hymenoclea salsola, Celtis pallida, Lycium* cf. *andersonii*, and other less common species (See Appendices D & E). The upland community was a "Mixed shrub-*Cercidium microphyllum-Olneya tesota*-mixed scrub association (154.127). *Ambrosia deltoidea* was the most common subshrub and *Larrea tridentata* the most common shrub. Saguaro (*Carnegiea gigantea*) was common and locally abundant throughout. Other species of cacti that were present included *Opuntia acanthocarpa, O. fulgida, O. phaecantha, Ferrocactus wislizenii, Echinocactus engelmannii*, and *Mammillaria microcarpa*. In some places where the washes formed a braided complex it was often difficult to ascertain where the upland and desert riparian scrub habitat began and ended.

Hymenoclea salsola was prevalent and often co-dominant in these difficult to define areas of the alluvial fan.

Pilot Study Area 3: Tucson Southeast NE ¼

In this area desert riparian scrub was dominated by *Prosopis glandulosa*, *Acacia constricta*, and locally *Hilaria mutica* (See Appendix E). Other common species present along the washes included *Atriplex canescens*, *Lycium* cf. *andersonii*, and *Larrea tridentata*. In some areas *Atriplex canescens* appeared co-dominant. *Pennisetum ciliare* was present and locally abundant.

Adjacent upland vegetation was dominated by *Larrea tridentata* and *Prosopis glandulosa* (154.119) with locally abundant and sometimes co-dominant *Zinnia acerosa* and *Tiquilia canescens*. Other species identified in the uplands included *Cercidium microphyllum* (local), *Acacia constricta*, *Psilostrophe cooperi*, *Opuntia fulgida*, *O. versicolor*, *O. phaecantha*, *Ferrocactus wislizenii*, *Fouquieria splendens*, *Muhlenbergia porteri*, *Erioneuron pulchellum*, and *Aristida* sp. Turner (1974) mapped the area as Sonoran Desert, Creosotebush series with a woody phase of desert grassland fingering into the area along the washes in the area of the fairgrounds and racetrack.

In comparison with the other existing mapping projects, we classified the vegetation community by dominant species at the Series or Association level. The Pima County's Riparian Habitat Mapping project classified vegetation by volume, regardless of species composition. The GAP project classified vegetation by species, however,

significant errors have been found. For example, in Pilot Study Area 2 (Jaynes NE ¼ and NW ¼ and Ruelas SE ¼ and SW ¼), GAP showed only 1 riparian area, the Santa Cruz River. GAP classified the vegetation as Mogollon Deciduous Swampforest (Mixed Broadleaf).

This is incorrect, as this type of vegetation does not exist in Pima County. Our fieldwork classified the area as Cottonwood-Willow Series (224.53) of Sonoran riparian deciduous forest and woodland. However, this was based on working from 1:400 scale maps, considerable fieldwork, and extensive knowledge of the area. For the Pima County inventory part of this project we will work from 1:24,000 aerial photos with minimal fieldwork. Classifying vegetation at the Series/Association level will be impractical, if not impossible, at this scale.

Comprehensive Mapping Protocol

The comprehensive riparian inventory for Pima County (excluding already protected lands and lands owned by the Tohono O'odham Nation) will be a combination of existing map data and original work resulting from this pilot study. Results of the pilot study identified 2 useful existing data sets, the Pima County Riparian Habitat Mapping project and AGFD's perennial riparian database. Both data sets identify lateral boundaries of the vegetation reasonably well and will be used in the countywide inventory. In areas where these 2 data sets overlap, the Pima riparian inventory will over ride the AGFD perennial riparian database. We will combine these maps with other existing mapping projects that were conducted for specific areas, such as the Cienega Creek map, Santa Cruz River (portions) map, and the Town of Oro Valley's Sensitive Land Ordinance

(Harris Environmental Group 2000), where vegetation communities were described using the BLP system.

Maps will then be generated at 1:24,000 map scale containing the USGS digital ortho-photo quarter quadrangles, township/range/section lines, quadrangle boundary, lands currently identified as inside existing public reserves, based on the Pima County ownership layer and polygon boundaries from the Pima County riparian and AGFD perennial streams riparian inventories.

Using overlays, we will delineate existing riparian areas that have not been previously identified in our source map database. We will describe the vegetation communities to the biome level, using the BLP (1979) system. We will field check areas where an accurate vegetative description is not possible. The riparian vegetation will be entered in a process similar to the pilot study. The only variation will be to register the maps to the quadrangle boundary instead of the township/range/section layer.

We will present the information to the Sonoran Desert Conservation Plan's Scientific and Technical Advisory Team (STAT) for review and discussion. An important biome community that is associated with many special status species is the Sonoran riparian and oasis forests (224.5), also known as Sonoran riparian deciduous forest and woodland (Brown, Lowe, and Pase 1979, Minkley and Brown 1982). To the extent possible, we will further classify these riparian areas (with input from the STAT) to the Series or Association level. As necessary, we will visit areas unfamiliar to members of the STAT and the project team to describe the vegetation community.

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APPENDICES

1. GAP Data for Jaynes Quadrangle—North Half
2. Gap Data for Ruelas Canyon Quadrangle—South Half
3. SDCP Riparian Vegetation for Brown Mountain Quadrangle—South Half
4. SDCP Riparian Vegetation for Ruelas Canyon Quadrangle—South Half
5. SDCP Riparian Vegetation for Jaynes Quadrangle—North Half
6. SDCP Riparian Vegetation for Tucson SE Quadrangle—North Half

Legend

- Quadrangle Boundary
- Township/Range/Section Boundary
- Mapillion Deciduous Swamp/forest (Mixed Broadleaf)
- Mapillion Deciduous Swamp/forest (Cottonwood-Willow)
- Somerset Riparian and Grass Forest (Cottonwood-Willow)
- Somerset Deciduous Swamp and Riparian Scrub (Mixed Scrub)
- Somerset Interior Marshland (Cattail)

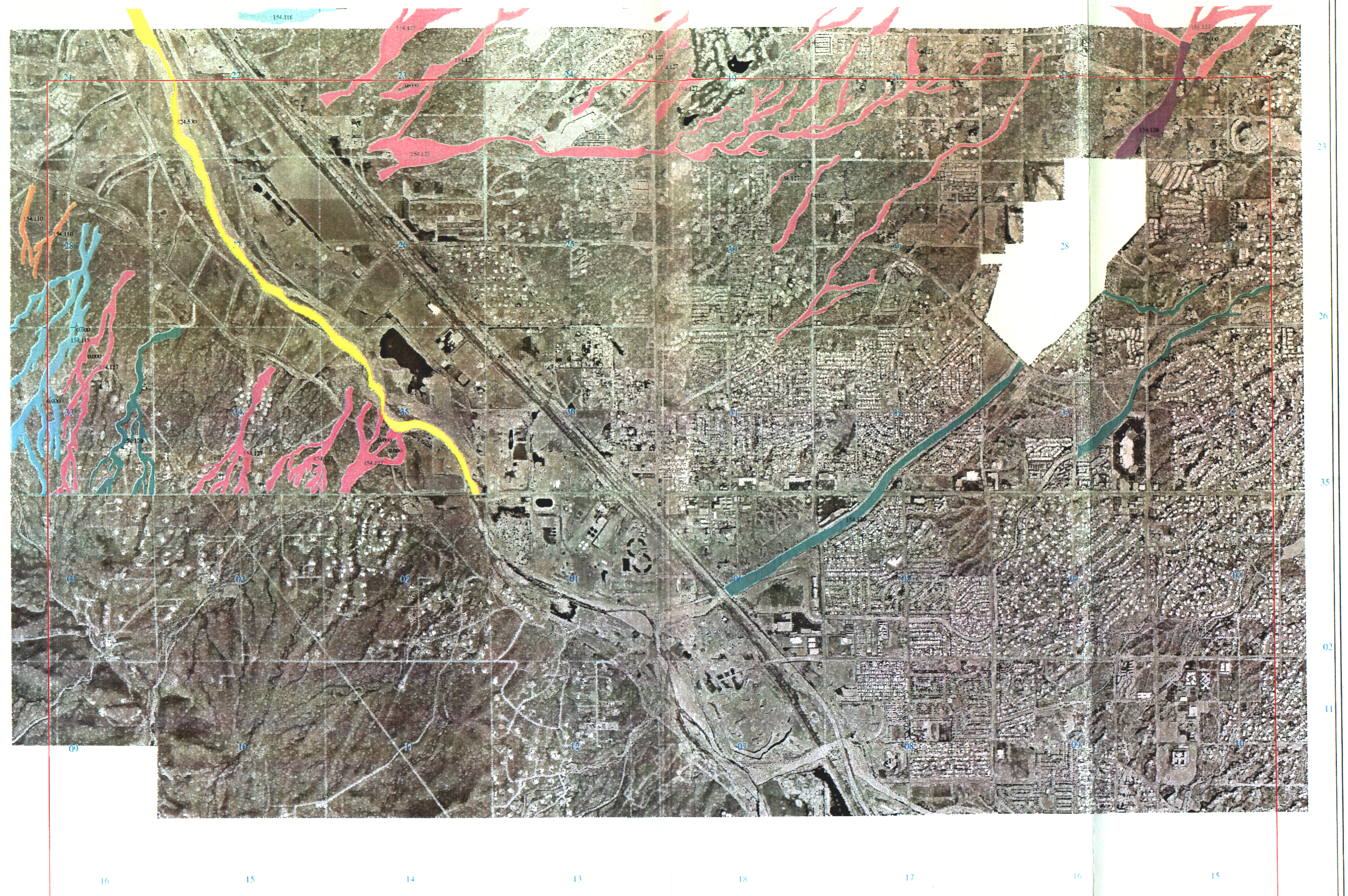
Coordinate Reference:
Projection System UTM Zone 12
Units Meters, North American Datum 1927

0 5000 Feet

0 .5 1 Mile

GAP Data for JAYNES QUADRANGLE –North Half
SDCP Riparian Mapping Pilot Project
April 19, 2000

APPENDIX 1



SDCP Riparian Vegetation for JAYNES QUADRANGLE –North Half

SDCP Riparian Mapping Pilot Project
March 08, 2000
Map Scale = 1:12,000

Legend

- 154.110 Creosote-Bursage ("Lower Colorado Valley") Series
- 154.118 Cercidium spp. –Olneya tesota riparian Association
- 154.119 Cercidium floridum –Prosopis spp. riparian Association
- 154.120 Paloverde-Mixed Cacti ("Arizona Uplands") Series
- 154.127 Mixed Shrub-Cercidium microphyllum-Olneya tesota-mixed scrub Association
- 154.128 Mixed Shrub-Cercidium microphyllum-Chilopsis linearis-mixed scrub Associ
- 224.521 Prosopis juliflora velutina Association
- 224.530 Cottonwood-Willow Series

Quadrangle Boundary
Township/Range/Section Boundary

Coordinate Reference:
Projection System UTM, Zone 12
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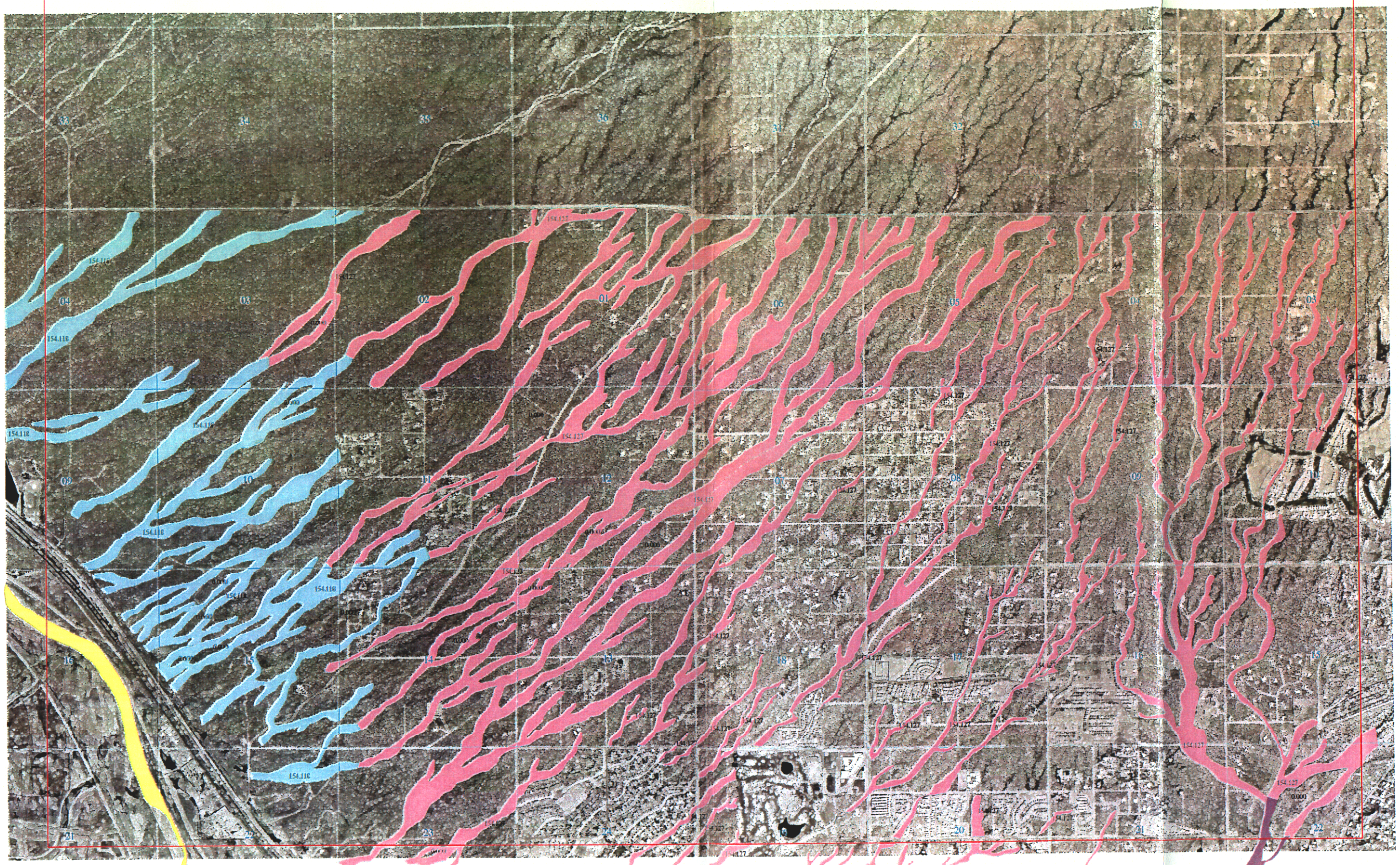
0 — .5 — 1 Mile



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- 154.127 Mixed Shrub-Cercidium microphyllum-Olneya tesota-mixed scrub Association
- 154.128 Mixed Shrub-Cercidium microphyllum-Chilopsis linearis-mixed scrub Assoct
- 224.521 Prosopis pallifora velutina Association
- 224.530 Cottonwood-Willow Series

Quadrangle Boundary
Township/Range/Section Boundary

Coordinate Reference:
Projection System UTM, Zone 12
Units Meters, North American Datum 1927

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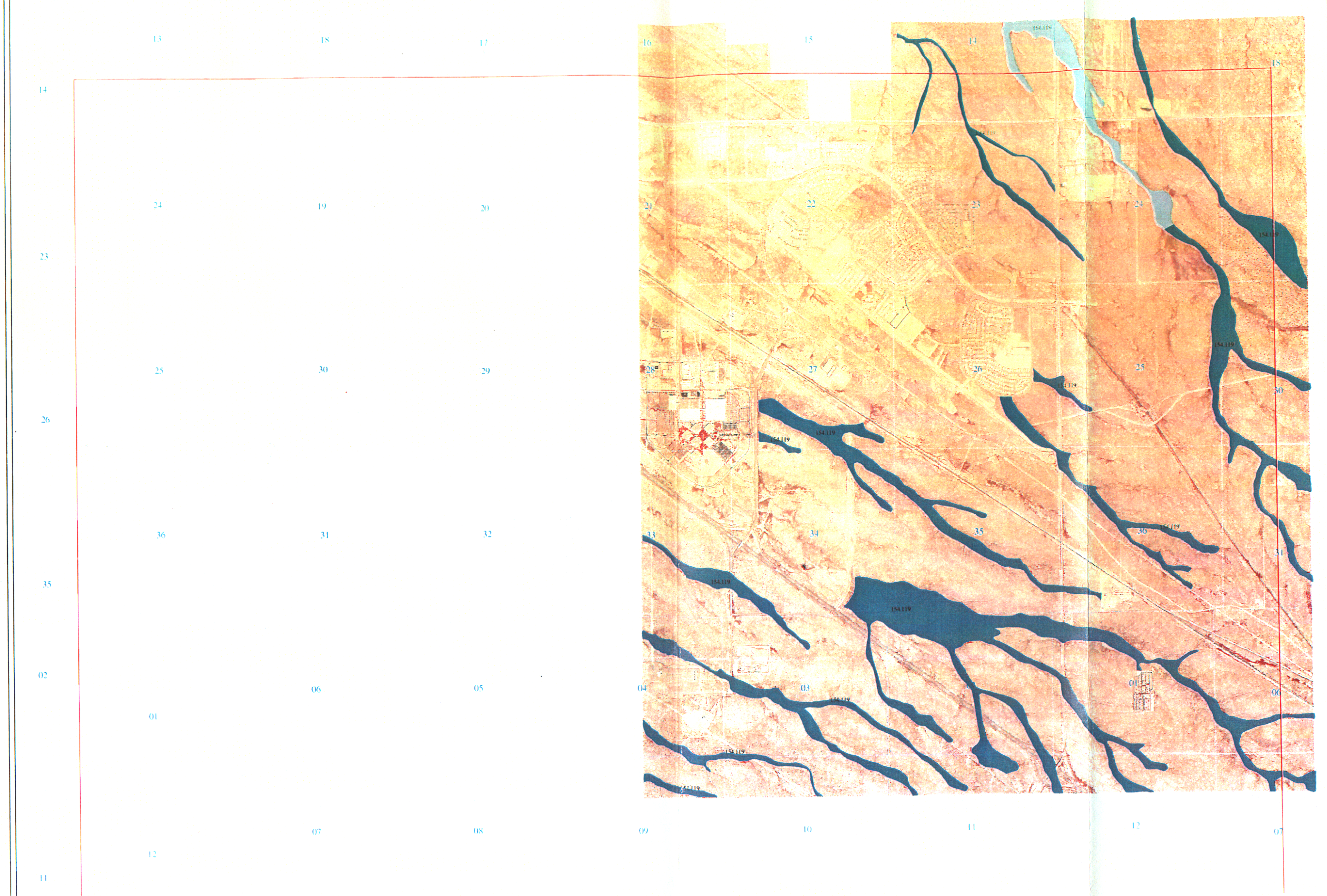
0 .5 1 Mile

SDCP Riparian Vegetation for RUELAS CANYON QUADRANGLE –South Half

SDCP Riparian Mapping Pilot Project
March 08, 2000
Map Scale = 1:12,000

DAVIES & MOORE



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- 154.110 Creosote-Bursage ("Lower Colorado Valley") Series
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- 154.119 Cercidium floridum –Prosopis spp. riparian Association
- 154.120 Paloverde-Mixed Cacti ("Arizona Uplands") Series
- 154.127 Mixed Shrub-Cercidium microphyllum-Olneya tesota-mixed scrub Association
- 154.128 Mixed Shrub-Cercidium microphyllum-Chilopsis linearis-mixed scrub Associ
- 224.521 Prosopis juliflora velutina Association
- 224.530 Cottonwood-Willow Series

Quadrangle Boundary
Township/Range/Section Boundary

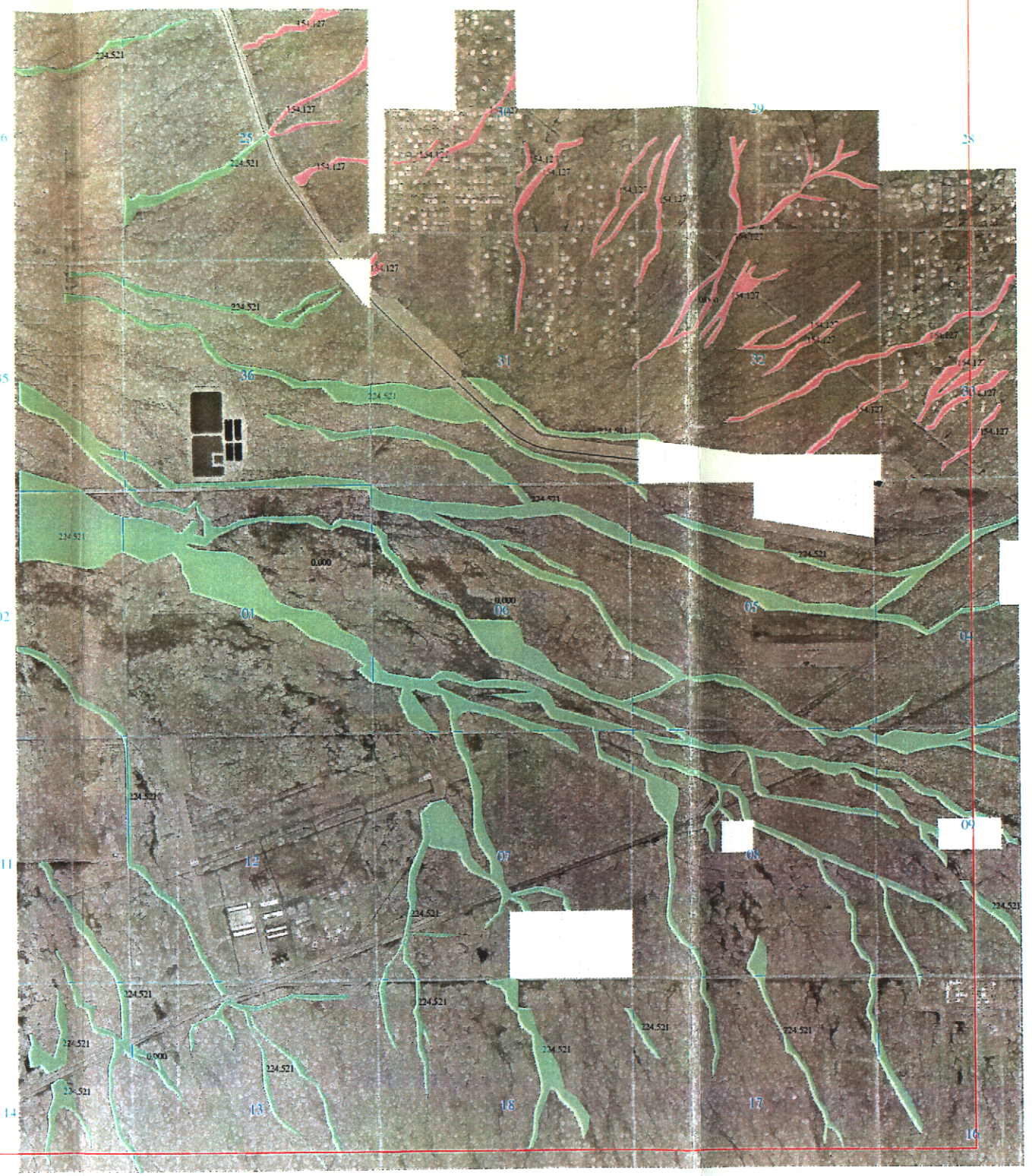
Coordinate Reference:
Projection System UTM, Zone 12
Units Meters, North American Datum 1927

0 5000 Feet

0 .5 1 Mile

SDCP Riparian Vegetation for TUCSON SE QUADRANGLE –North Half

SDCP Riparian Mapping Pilot Project
March 08, 2000
Map Scale = 1:12,000



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- 154.110 Creosote-Bursage ("Lower Colorado Valley") Series
- 154.118 Cercidium spp. –Olneya tesota riparian Association
- 154.119 Cercidium floridum –Prosopis spp. riparian Association
- 154.120 Paloverde-Mixed Cacti ("Arizona Uplands") Series
- 154.127 Mixed Shrub-Cercidium microphyllum-Olneya tesota-mixed scrub Association
- 154.128 Mixed Shrub-Cercidium microphyllum-Chilopsis linearis-mixed scrub Associ
- 224.521 Prosopis pallida-tetutina Association
- 224.530 Cottonwood-Willow Series

Quadrangle Boundary
Township/Range/Section Boundary

Coordinate Reference:
Projection System UTM: Zone 12
Units Meters, North American Datum 1927

0 5000 Feet

0 .5 1 Mile

SDCP Riparian Vegetation for BROWN MOUNTAIN QUADRANGLE –South Half

SDCP Riparian Mapping Pilot Project

March 08, 2000

Map Scale = 1:12,000

DAMES & MOORE

Sonoran Desert Conservation Plan
Riparian Vegetation Mapping Project
(Pima County Contract # 07-30-H-127196-0100)

Biotic Community Field Verification Form

					For Office Use Only						
Site Number (mark on map):					Riparian Community Number (BLP Code):						
	Check if Actual BLP Code Differs from Original				Community Name:						
Date (DD-MMM-YY):					Date Updated:						
Observers:											
Location: AZ, Pima County											
Legal Description:	Township:		Range:		Section:		¼		of	¼	
USGS Map:					UTMx:		UTMy:				
Topography:							Elevation (ft):				
Land Ownership:		Impacts:									
Is Water Present:											

Vegetation Description			
Riparian Community (BLP Code):		Dominant Layer (Ground, Shrub, Tree):	
Adjacent Riparian Community (BLP Code):		Adjacent Upland Community (BLP Code):	
Successional Regeneration of Dominant Species:			
Other similar polygons:			
Weed Species Present:			
Special Status Species Present:			
Photographs (Yes or No):		Roll #		Frame #(s)	

Plant Species Present (Starting with the uppermost stratum, list species that are readily identifiable):
G=Ground (<0.75 m), S=Shrub (0.75 -5.0 m), T=Tree (>5.0 m)

Layer					
G	S	T	Species Identification	Relative Dominance	Final Species Identification

Comments:	