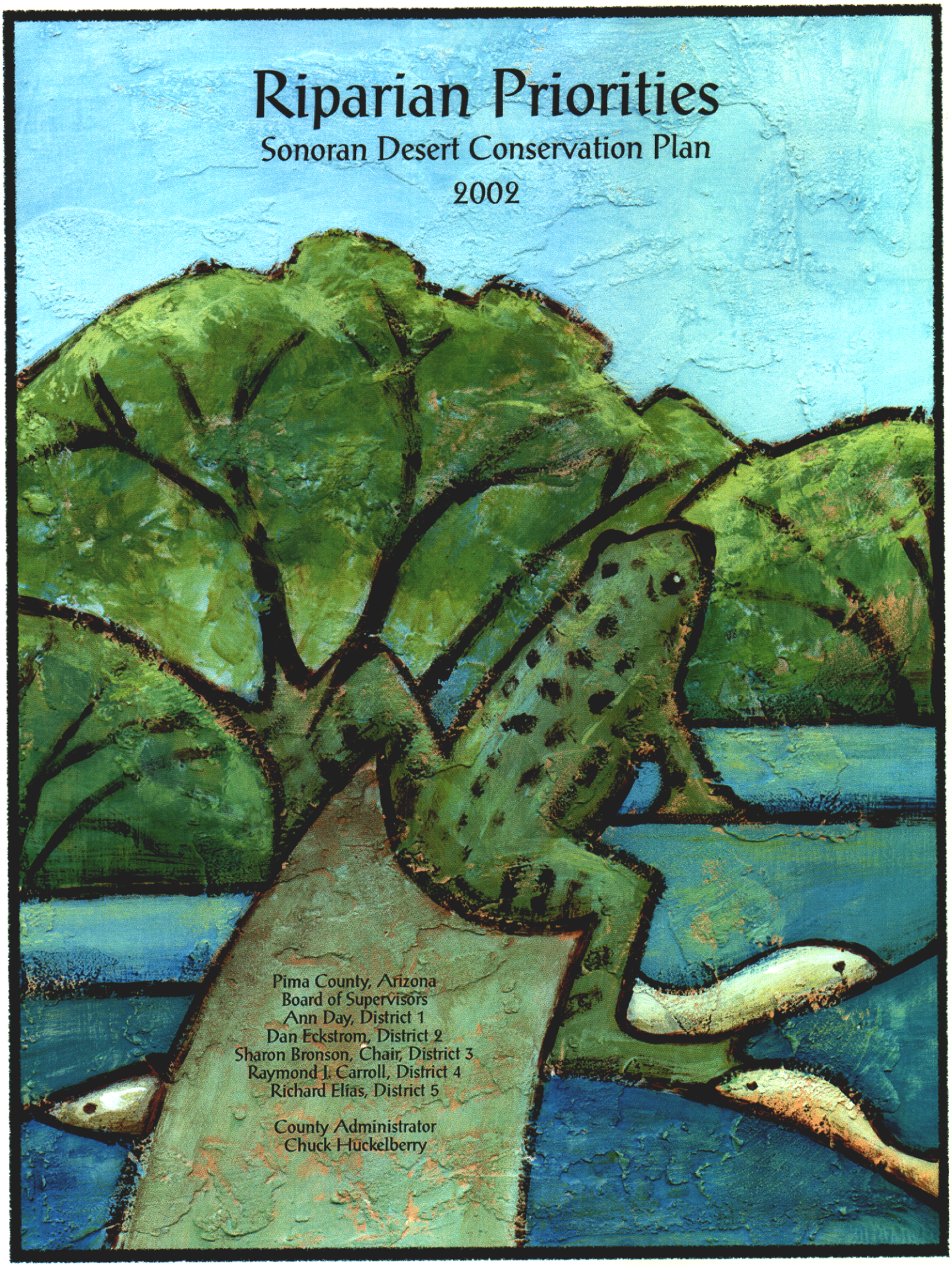
Riparian Priorities

Sonoran Desert Conservation Plan

2002



MEMORANDUM

Date: August 21, 2002

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

From: C.H. Huckelberry
County Administrator

Re: **Riparian Priorities**

The attached study on riparian priorities recommends where riparian land acquisitions would be most effective in serving as mitigation for a Section 10(a) permit that would cover all priority vulnerable species identified in the Sonoran Desert Conservation Plan. Priority is given to reaches of watercourses which:

1. are large in size, in and of themselves;
2. are part of larger, essentially natural adjoining lands;
3. have relatively undeveloped watersheds;
4. have relatively few, irreversible impairments to biological and hydrological functions;
5. are unlikely to be greatly diminished during the time period needed to acquire the reserved lands;
6. have large, existing populations of priority vulnerable species;
7. have suitable habitat for priority vulnerable species;
8. are unconstrained or less likely to be constrained by conflicting expectations created by easements, land use plans, land use history or tenure, etc; and
9. are low in cost relative to the biological benefits.

To help evaluate which areas best meet these guidelines, analyses of the distribution of high-potential species habitats, priority conservation areas, vegetation density, ecological condition and other data and observations are presented and discussed.

Recommendations are made in terms of each subarea, as well as the entire study area. Priority stream reaches include Cienega Creek, Davidson Canyon, Posta Quemada Wash, San Pedro River, Agua Verde Wash, Sabino Creek near Coronado National Forest, Bear Canyon, Buehman Canyon, Altar Wash near Buenos Aires National Wildlife Refuge, Sopori/ Papalote Wash, Arivaca Creek, Sutherland Canyon, Tanque Verde Wash near Saguaro National Park, Agua Caliente Wash upstream of Prince Road, Rincon Creek near Saguaro National Park, Paige Canyon, Madera Canyon near Coronado National Forest, Wakefield Canyon, Cedar Canyon (confluence with Sopori), Espiritu Canyon and Youtcy Canyon.

Attachment

Background

This report has been prepared to help the Steering Committee evaluate acquisition options for a Section 10(a) permit application under the Endangered Species Act. The proposed acquisition alternatives were described in a May 23 document entitled *Cost Model for Section 10 Endangered Species Act Compliance for All Impacts in the Unincorporated Area of Pima County.*

The *Cost Model* estimated that the land needed to offset the biological impacts of urban land conversion in unincorporated Pima County over the next 20 years could be around 20,400 acres. Alternative strategies for acquiring mitigation lands that were proposed in the *Cost Model* include ranch acquisition, mountain park acquisition, acquisitions in the Northwest Tucson Basin, and riparian land acquisitions. A combination of strategies could be used, but any alternative must achieve long-term species conservation and be acceptable to U. S. Fish and Wildlife Service.

Riparian Land Acquisition in Context

To provide an historical context for discussing future riparian land acquisitions, a chronology of actions specifically undertaken for riparian conservation has been prepared for this report (Appendix A). "Riparian" (literally "streamside") refers to those areas of higher moisture along watercourses and springs of any type, whether flow is ephemeral, intermittent or perennial.

In Pima County, riparian land acquisition began under the auspices of watershed protection, with the establishment of the national forest reserves at the turn of the century (Figure 1). The Coronado National Forest includes many perennial and intermittent streams in Pima County, and efforts to enhance and protect riparian resources along those streams continue today. In 1929, mountain park acquisitions began with the establishment of Tucson Mountain Park. Locally funded park acquisitions have preserved many desert washes, principally those in mountain areas and sometimes extending into the upper bajada or foothills.

Our community's long history of developing farmland in broad, alluvial valleys and preserving mountain ranges as open space left most valley floor riparian areas in Pima County unprotected until the 1980's, when a series of ranches were acquired by the federal government for endangered species and open space purposes, beginning with Buenos Aires National Wildlife Refuge, and continuing with Empire-Cienega Ranch.

Local government began land purchases for riparian benefits in 1986, when the Pima County Board of Supervisors established the Cienega Creek Natural Preserve specifically for its riparian habitat values (Appendix A). This also marked the first use of flood control taxes toward protecting riparian resources. With the passage of the legislation authorizing Flood Control Districts in 1973, state legislators had clearly envisioned land acquisition as a tool for riparian preservation. According to the 1973 legislation, the purposes for which lands might be acquired by Flood Control Districts included to "enhance wildlife and recreation values where appropriate by preserving riparian vegetation in "green belts" along watercourses and floodplains."

The chronology illustrates that land acquisition is just one of many strategies available to conserve resources along streams and springs. Other strategies used for riparian area conservation by various entities are also described in Appendix A. These include improved land management of private and public lands, public information and education, rezoning requirements on new development, in-stream flow water rights, groundwater conservation, and modifications of specific construction projects to avoid or reduce impacts. More recently, there have been efforts to control invasive non-native plants in riparian areas, to restore natural processes, and to re-establish native plants and animals.

Purpose

The purpose of this report is to identify high priority acquisitions for long-term riparian and aquatic ecosystem protection and restoration, for the purpose of a Section 10 permit issued to Pima County and Pima County Flood Control District.

To most people, acquisition brings to mind fee-simple purchases of the full bundle of property rights inherent in land. For this report, the term "acquisition" may include conservation easements or other mechanisms, if conservation goals can be achieved through obtaining a more limited set of property rights. The biological goal of such actions is to ensure the **long-term** persistence of the full range of plants and animals indigenous to Pima County. (Persistence refers to the continuing ability to survive in an area.) Because the goal is long-term, acquisitions of property rights must provide enduring benefits, not limited to the 20-year term of a permit.

The biological goals of the Sonoran Desert Conservation plan will not be achieved by mitigation acquisitions alone. Given the historic losses of riparian areas in Pima County, and the fact that the Section 10 permit would allow continued biological impacts upon those areas, we cannot "mitigate" ourselves into a scenario which ensures long-term persistence of such species as the Gila topminnow, the lowland leopard frog, the yellow-billed cuckoo, and many other species.

This report does not envision that riparian acquisition alone would be sufficient for addressing permit needs. Measures to repair damages to ecosystem structure and function and re-establish or otherwise secure vulnerable species populations will also be needed to reverse historical trends and the biological goals of the Sonoran Desert Conservation Plan. A number of previous SDCP reports describe how and where one might restore riparian plant communities or re-establish native plants, fishes and frogs.

Assumptions

This report will not address acquisitions along washes which may be needed for urban trail and parks needs, cultural resource protection, or many other functions which stream-side lands may address. Nor will this report explore related mitigation questions, such as mitigation ratios, banking provisions, and in-situ project mitigation.

Furthermore, for this report, I assume that the Section 10 permit is for the full range of priority vulnerable species using riparian areas. Biological impacts and therefore mitigation needs might be different if permit were restricted to a few species.

I also assume that the Section 10 permit is for urban/suburban development in unincorporated Pima County, rather than grazing or mining. The location and nature of the impacts would be different for other activities, and thus mitigation needs might also differ.

For purposes of brevity and lack of better information, acquisition of partial property rights (grazing, water, land, mineral) within existing reserves (GAP status 1, 2 or 3) is not considered in this report. Acquisitions of limited property rights within existing reserves could yield great riparian conservation benefits; these should be investigated in detail as reserve management plans are updated.

Previous Work

The biological significance of riparian lands is embodied in the Conservation Land System (CLS). The CLS is largely based on suitability of habitat for priority vulnerable species, many of which were riparian obligate or riparian facultative species, and consideration of special landscape elements.

Within the CLS, the Science Technical Advisory Team has identified their top priorities for riparian conservation as "important riparian areas" (IRAs). Specifically,

> *these are areas defined by meso-riparian and xero-riparian vegetation having higher water availability, denser vegetation, and high biological productivity. In addition to the inherent biological value of these water-related vegetation communities, important riparian areas and the adjacent uplands provide a framework for linkages and landscape connection. These important riparian areas are extremely important elements in this Conservation Land System and every effort should be made to protect, restore and enhance the structure and functions of these areas, including hydrological, geomorphic and biologic functions.*

These designations supercede those identified in an April 2000 report entitled *Prioritization of Streams for Conservation in Pima County*. The 2000 report predated the availability of improved SDCP data and mapping for riparian vegetation communities, vegetation density, water resource availability and species distributions.

Prioritization Issues

Riparian areas are part of a larger landscape. At a landscape scale, important riparian areas are considered as the top priority for landscape-level protection and management in the Conservation Land System (CLS). There are a total of 158,221 acres of Important Riparian Areas in the CLS, out of a total of 2,006,028 acres in the CLS. But the question now before us is how and where to select a much smaller set of lands specifically to meet Section 10 needs. These acquisitions have been estimated to be 20,400 acres in the *Cost Model* (2002).

The CLS does not consider which conservation methods are most appropriate for conserving important riparian resources at a given area. While the environmental element of the *Comprehensive Plan* (Pima County, 2002) sets guidelines for riparian area conservation for urban development, neither the CLS nor *Comprehensive Plan* evaluates where acquisitions are to be preferred over regulation, dedication, restoration or other mechanisms.

Because the biological goal of the Sonoran Desert Conservation Plan is to assure the long-term persistence of native species through preserving ecosystem structure and function, differences in the long-term prospects for maintaining species and ecosystem processes within the lands to be acquired must be considered. Biological issues such as fragmentation, edge effects, lack of connectivity, and social expectations have diminished the usefulness of lands acquired for other Section 10 permits (Scott and Sullivan, 2000). Riparian acquisition strategies are particularly vulnerable, as compared to ranch and mountain park acquisitions. Riparian resources are distributed in a linear and often discontinuous distribution, which makes them inherently more susceptible to fragmentation, edge effects, and disruption of continuity. In addition, the shade, water and denser vegetation that characterizes many riparian areas makes them attractive for many social uses other than mitigation.

Ecological integrity of riparian areas within existing and future preserves is an important consideration when choosing mitigation lands. Integrity refers to the health of the riparian system, relative to the key ecological factors that sustain the biological features of interest. Integrity can be defined by measures of *ecological condition, landscape context* and *size* (Anderson et al., 1999).

Size is a measure of the area or abundance of the vegetation community or species population.

In general, sites in which the plant community size is greater than the typical natural disturbance mechanism (fire, flooding, insect infestations) affecting them offer superior persistence opportunities. The issue of size relative to persistence was explored in detail for the cottonwood-willow forest by Fonseca et al. (2001), which recommended that preferable sites will have the fluvial processes, water availability and biotic interactions needed to maintain patches of forest at least 20 acres in size, embedded in riparian areas of 200 acres in size.

Ecological condition can include factors such as biological composition, vegetation structure, geomorphic conditions of channels and hillslopes throughout the watershed, and biotic interactions. At varying levels of scale, options for comparing ecological condition will be constrained by the data available. For this effort, the presence of native fish and frogs, and

hydromesoriparian conditions are factors which indicate some degree of integrity, since so many streams have already lost these components. The presence of non-native fish and bullfrogs is a type of biotic interaction that may affect long-term prospects for native vertebrates, particularly in the absence of a natural flooding regime. The presence of a variety of the younger life stages of riparian trees would be a useful indicator of ecological conditions necessary for recruitment. However, the only systematic information on the structure of vegetation which is available for all of Pima County's riparian areas is that necessary to differentiate grassland, woodland, scrubland and forest.

Landscape context refers to the dominant ecological process that establish and maintain the target occurrence. Impairments to natural flooding processes in the contributing watershed can greatly affect ecological processes such as flood frequency and magnitude, recharge, and sediment transport. Landscape fragmentation adjoining the riparian site is suggested as another key measures for riparian areas, because it can so greatly affect wildlife movement and persistence, and can impose stress to riparian systems. For riparian forest and sacaton, groundwater availability is another key ecological factor needed for recruitment and maintenance. Landscape complexity, include variation in geology, soils, topography, and the presence of large tributaries, can contribute to persistence of species by maintaining a wide range of soil moisture regimes, vegetation cover, and stream flow conditions during times of drought, fire and flooding.

Species occurrences are another important type of information for considering mitigation lands. Potentially suitable habitat may not actually have the species, or all of the habitat features needed for the species. For the Section 10 permit, U. S. Fish and Wildlife Service will consider the likelihood that the mitigation site provides habitat for each species covered under the permit, along with other factors.

For most plants and animals, there is relatively little information about population size and distribution, and the size of the area needed to sustain the animals. Our information about the size of essential habitat features needed for certain species like fish is better, as is the information about the size of riparian plant communities. For fish, leopard frogs, and pygmy-owls, most of the large populations are identified in reports such as the *Sonoran Aquatic Vertebrate Conservation Report* (Rosen, 2000) and *Priority Vulnerable Species* (RECON, n.d.).

Actual species occurrence and abundance for some species are quite limited, so potentially suitable habitat for each species is also considered. Potentially suitable habitat areas were developed for the SDCP's priority vulnerable species using GIS-based models. Biologists have prioritized areas within the models that must be in a reserve system based on their knowledge of the animal's or plant's distribution, abundance or occurrence. These are referred to as Priority Conservation Areas (PCA1s). (Lower ranking designations were called PCA2, PCA3 and PCA4).

Cost is also an important consideration. Funds for acquisition will be limited, and distributed over time. Acquisitions which maximize biological benefits will help achieve biological goals more rapidly. In this report, we attempt to maximize the biological effectiveness of expenditures by considering ecological condition, species occurrences and likely species richness, as described above. Once this is done, then acquisition costs can be considered in

relation to expected biological benefits. Another type of cost is the management cost. Lands which can be managed as a part of another larger unit often cost less to manage than smaller or isolated tracts. On the other hand, isolated tracts with few uses and few expectations for changes in condition can have extremely low management costs.

Methods

Several tools developed for the SDCP are used to further prioritize acquisitions into areas which serve the needs for the greatest number of species for which the permit would be obtained. We begin by differentiating hydromesoriparian areas from xeroriparian plant communities using information about vegetation structure, plant species, and water availability. Using the Brown, Lowe and Pase classification system, the 200-series of plant communities are those which are known to have obligate or preferential riparian plants. All 200-series vegetation is considered hydromesoriparian. In addition, areas of sacaton grassland are considered hydromesoriparian. In addition, where shallow groundwater, perennial or intermittent flow conditions exist, the polygon representing the riparian plant community is considered hydromesoriparian. This includes polygons lacking preferential riparian plants. By including 100-series vegetation associated with these water resources, this approach is conservative of riparian habitats.

The remaining areas are considered xeroriparian, "xero" meaning "dry". In general, although the woody perennial vegetation of these areas is similar to upland vegetation, the xeroriparian zone will often have greater density, productivity and herbaceous species diversity.

Differences among "xeroriparian" areas can be differentiated using Normalized Difference Vegetation Index (NDVI) values, which provide some consistent, relative data about vegetative conditions along streams. NDVI values are related to the reflectance of land and vegetation features on the landscape, as sensed by satellites. In Pima County, the NDVI values have been found to relate to the vegetation leaf volume along riparian areas (SWCA, 1993). Vegetation volume is an indicator of plant productivity and also has been correlated to breeding bird densities (SWCA, 1993). Structural information is not provided by the NDVI values.

Figure 2 displays all hydromesoriparian and xeroriparian areas in eastern Pima County. Xeroriparian areas are further classified into condition categories A, B, C and D, based on NDVI values. Higher vegetation volumes, associated with Class A, imply more productivity than classes B, C and D. Hydromesoriparian areas may have any range of NDVI values, because of the classification criteria previously described. The Important Riparian Areas (IRAs) of the Conservation Land System include all hydromesoriparian areas, as well as some of the xeroriparian areas.

Next, all of the high potential habitat suitability grid cells of the 41 priority vulnerable species models were summed and examined relative to Important Riparian Area (IRA) boundaries (Figure 3). This differs somewhat from the approach used for developing the CLS, which considered habitat thought to have moderate to high suitability. Also, only the grid cells which fall inside an IRA is depicted, not the data for the entire landscape.

All of the priority conservation areas (PCA1s) identified by biological experts were summed and overlaid upon IRAs (Figure 4). PCA1s are those areas which biologists recommended must be in a reserve system for that species. This is the highest class of PCA identified in the SDCP. Again, for this analysis, the data are shown relative to IRAs rather than the entire landscape.

Species occurrences for several taxa of priority vulnerable species are singled out for special attention: pygmy owls and native fish and leopard frogs. Pygmy owl distribution is scrutinized separately because its importance to the regional Section 10 permit; native fish and leopard frogs are used as indicators of aquatic ecosystems not already diminished by non-native fauna and other resource impairments.

Cost per acre, using assessed value, is considered only generally. The cost per acre for each parcel located within an important riparian area has been calculated using full cash value based on the County Assessor's data. Although these values are generally lower than market value, they are used here as a relative comparison on land values across a large landscape, and reflect differences in value due to lot splitting, development, and proximity to infrastructure. The results are categorized in Figure 4.

To describe ecological integrity, the landscape context, size, and condition of watercourse reaches outside existing reserves are described in narrative terms .

Priority is given to riparian lands which:

- are large in size, in and of themselves
- are part of larger, essentially natural adjoining lands
- have relatively undeveloped watersheds above them
- have relatively few, irreversible impairments to biological and hydrological functions
- are unlikely to be greatly diminished during the time period needed to acquire the reserved lands
- have large, existing populations of priority vulnerable species
- have suitable habitat for priority vulnerable species
- are unconstrained or less likely to be constrained by conflicting expectations created by easements, land use plans, land use history or tenure, etc.
- are low in cost relative to the biological benefits

Results

Hydromesoriparian and Xeroriparian Vegetation Classifications

Hydromesoriparian areas are not evenly distributed. They are almost exclusively located in eastern Pima County (Figure 2). Arivaca Creek, Tanque Verde Creek, San Pedro River, and Cienega Creek are examples of some of the larger hydromesoriparian corridors.

Class A xeroriparian areas are very limited in extent, in part because most of the areas with high NDVI values (and hence high vegetation volume) are already classified as hydromesoriparian, Most of the Class A xeroriparian areas are located in the headwaters of streams in the Coronado National Forest. Class A xeroriparian areas exist at lower elevations along some of the west-side tributaries of Altar Wash, along tributaries of Sabino Canyon, and several other locations.

Class B riparian areas are more extensive. Most of the large areas exist in the Altar Valley. Class C is also extensive, but more broadly distributed than B. Class D, the category with the lowest NDVI values are found principally along the overbank floodplain of Brawley Wash, the Rillito, and the Santa Cruz River upstream of the Roger Road Wastewater Treatment Facility outfall.

Species Richness using Potential Suitability Models for Priority Vulnerable Species

High potential habitat suitability cells for sum of the species models are shown relative to IRAs (Figure 3). The grid analysis makes it difficult to depict colors accurately on such a small scale. There are a few areas which lack high potential suitability habitat for any priority vulnerable species. These areas occur on a short reach of the Rillito, and even shorter reaches of washes in the Tortolita piedmont. The next lowest category of species richness is shown in yellow and represents high suitability for a single species. Large areas in this lowest category are found along the Santa Cruz River upstream of Roger Road Wastewater Treatment Facility's discharge, and portions of the Rillito, and tributaries in the southern Tortolita and northern Tucson Mountains piedmonts.

The area of IRAs having high suitability for 2 to 5 priority vulnerable species is much more extensive (~370,000 acres). These are shown in dark blue-green. The largest areas are located along Brawley and Blanco Wash, and portions of Altar Wash and its tributaries in and near Buenos Aires National Wildlife Refuge.

Areas having high suitability for 6 to 10 priority vulnerable species are also extensive (~225,000) acres) shown in purple. Many streams fit this category, but the largest areas exist along Altar Valley and the lower Santa Cruz River.

Areas having high suitability for 11 to 25 species are limited in distribution, comprising ~57,000 acres. Large, contiguous areas are located along the San Pedro River, Arivaca Creek, and Cienega Creek, but there are many other locations likely to provide habitat for many priority vulnerable species. While most of the highest category of species richness is associated with intermittent or perennial water, there are important exceptions.

For instance, priority vulnerable species richness is likely to be very high in unprotected, ephemeral portions of Davidson Canyon and several watercourses northwest of the Whetstone Mountains. Also, some segments of flowing water offer great variations in species richness. For instance, the lower portions of Agua Caliente Wash are predicted to be associated with lower species richness than the upper portions.

Important Riparian Areas within Designated Species Priority Conservation Areas

IRAs relative to top priority conservation areas that biologists believed must be in the reserve system (PCA1s) are shown in Figure 3. The perennial and intermittent reaches of Cienega Creek garnered the highest number of priority designations from biologists, up to 16. Altar Wash near and within Buenos Aires National Wildlife Refuge, Agua Verde Wash, Tanque Verde Creek near Saguaro National Park, Box Canyon, Sopori Wash, Arivaca Creek, portions of Cienega Creek, and tributaries near Cienega Creek ranked next.

The San Pedro River, Santa Cruz River, Tanque Verde Creek, Sabino Canyon, and Rincon Creek did not rank especially high for PCA1s, with 2 to 4 recommendations along each. Most of the Brawley, Blanco, and washes of the Tortolita and Tucson Mountain piedmont had 1 PCA each. However, the lowermost portions of the washes in the Tortolita and Tucson piedmonts, near where they enter the Santa Cruz River, had 2 to 4 PCA1 recommendations.

Cost of Important Riparian Areas

Most parcels in IRAs have full cash values below $10,000 per acre. Land values above $10,000 per acre are found along the Santa Cruz River downstream of Valencia Road and upstream of Avra Valley Road, the Tucson Mountains, the Tortolita piedmont outside the alluvial fan flood hazard zone, Sabino Canyon, Sutherland Wash, Big Wash, Canada del Oro, Agua Caliente Wash, Tanque Verde Creek. Values in excess of $100,000 are found along watercourses in the Catalina Foothills, such as Pima Canyon, Finger Rock Wash, Ventana Wash, Sabino Canyon, Agua Caliente and Soldier Canyon. Some areas along washes in the Tucson Mountains foothills and the Tortolita piedmont outside the alluvial fan flood hazard zone also have parcels with full cash values in excess of $100,000 per acre.

The *Cost Model* (2002) identified tradoffs among financial costs among different types of acquisition strategies using previously recorded acquisition costs. In general, the results are consistent with the trends in assessed value described above. The report estimated a value of $2000 per acre for ranch lands, and $20,000 per acre for lands in the Tortolita piedmont.

Ecological Integrity and Species Occurences in IRAs

The vegetation, species occurrences and ecological integrity for over 90 Important Riparian Areas are described in Appendix B. Ecological integrity is discussed in terms of changes to bottomland vegetation, bank stability and hydrology, and developments in the watershed.

This information is used in conjunction with cost, priority conservation areas and species richness to suggest acquisition priorities below.

Discussion of Priorities by Subarea

Middle San Pedro: This subarea has many undeveloped riparian corridors, and one very large, broad riparian corridor, the San Pedro River. Given the pattern of existing protected areas, acquisitions which would secure the Buehman Canyon corridor outside the existing City-owned open space lands are paramount.

Acquisitions, including conservation easements, along Edgar Canyon could help secure an important source of water for Bingham Cienega, but the threat of development in Edgar Canyon is considered lower than Buehman. Acquisition of small, isolated tracts along the San Pedro should be considered lower priority, as well. Acquisitions contiguous to the existing City and County-owned lands along the San Pedro should be considered top priority if the bottomland vegetation is intact.

Existing threats are low for Espiritu and Youtcy Canyons, too, but someday acquisition might be needed to assure conservation of these streams.

Soza Wash has an unusually extensive xeroriparian corridor, and should be considered as a potential acquisition target. Acquisition of xeroriparian land along Redfield Canyon in Pima County should be considered only in the context of larger upland acquisitions since the existing channel has been extensively modified and provides poor vegetative resources compared to Soza Wash and many other tributaries of the San Pedro River.

Cienega-Rincon: This subarea has many well-watered streams and a disportionate share of biological resources, compared to other subareas. The top priority for acquisition in this subarea should be the conservation of the mainstem of Cienega Creek. Species richness, priority conservation areas, ecological condition, and species occurrences are high in these areas. Acquisitions which contribute to protection of the mainstem include:

- State lands along Cienega Creek valley adjacent to the existing Cienega Creek Natural Preserve and in "the Narrows" just north of the Empire Ranch.

- a one-acre inholding and associated water rights within the Cienega Creek Natural Preserve.

- uplands located between the Cienega Creek Natural Preserve and Marsh Station Road, where clay mining creates bullfrog habitat and increases discharges of clay to the tributaries. Most of this is state land.

- land south of J6 Ranch, if the source of water for its development would be from Cienega Creek.

- the site of Northwest Reservoir (a stock pond) at the foot of the Whetstone Mountains, a bullfrog source popolation which is jeopardizing downstream populations of native aquatic wildlife.

A second priority should be accorded to minimizing fragmentation due to development of state lands in and around Cienega Creek. BLM/State land trades might be useful to secure these areas.

A third priority is protecting major hydromesoriparian areas along tributaries through purchase of State and private lands along Posta Quemada (largely completed), Agua Verde, Wakefield, and Davidson Canyon, giving preference to large tracts in proximity to the existing reserves. Conservation easements might be appropriate to consider in areas where ranchland is already being split into lots for residential development.

A fourth tier of acquisitions could be considered along Gardner Canyon, upper Rincon Creek, if conservation easements for the "ranchettes" could serve mitigation purposes. Conservation easement language should restrict both land cover modification, surface water developments, and groundwater pumping.

Upper Santa Cruz subarea

This subarea lacks many well-watered riparian areas, compared to some other subareas within the county. Acquiring and protecting hydromesoriparian areas outside of existing reserves should be the top priority in this subarea. These occur along a short reach of Madera Canyon adjacent and downstream of the National Forest, along Papalote Wash and Sopori Wash, upstream of Elephant Head Road along the Santa Cruz River, and at a few small springs located between the National Forest and the Santa Rita Experimental Range.

Papalote Wash is less disturbed and developed than is Sopori Wash, and has a less incised channel with sacaton. For that reason, Papalote Wash should be considered to have higher ecological integrity than Sopori Wash. Certain tracts along Sopori Wash have better developed riparian forest, however, and had a higher number of recommendations for inclusion in the reserve system.

A secondary priority should be accorded protecting xeroriparian areas that provide connectivity across Interstate Highway 19 near Canoa, and to the more dense xeroriparian areas in the southern piedmont of the Sierrita Mountains.

Although there is no current threat, acquisition might someday to be needed to assure the conservation status of Florida Canyon, now in University of Arizona ownership.

Middle Santa Cruz

Although many of the riparian areas in this subarea have been degraded by agricultural and urban developments, there are many streams and springs which have a high availability of water and important biological resources. Sabino Creek, Bear Canyon, Agua Caliente Wash and Tanque Verde near the National Forest boundary have higher resource values than other watercourses in the subarea. The upper stream reaches have higher ecological integrity than areas downstream.

Conservation easements along the middle reach of Sabino Creek, which are already subdivided, would be of value. The Nature Conservancy has several existing easements and their conservation program for this area should be encouraged.

Santa Cruz River effluent-dominated reach has a great deal of the remaining cottonwood-willow forest in the Tucson Basin. Maintaining the discharges from the wastewater treatment facilities is critical to the biological resource values. Land acquisition will not contribute toward that objective, but it can help minimize the disturbance and encroachment of the river corridor.

Tortolita Piedmont

Compared to other subareas of eastern Pima County, this subarea has many areas degraded by agricultural and urban development. Within the subarea, Sutherland Wash ranks highly for its species richness, dense vegetation and ecological integrity.

Acquisitions of land adjacent to the discharge of effluent into the Santa Cruz River will be of conservation value to many species, even though the Santa Cruz is less intact ecologically than many other streams of the Tortolita piedmont, as long as effluent discharges continue. Honey Bee Wash is another area rich in biological resources, but the ecological integrity of the watershed is greatly compromised by adjacent development.

Although watercourses of the Tortolita piedmont do not offer as high a value for many priority vulnerable species, they are necessary for the existing pymgy-owl population of the Northwest side. Biologists will consider all habitat needs of the pygmy owl in selecting lands for mitigation purposes in the Tortolita piedmont, rather than just considering which watercourses might be more hydrologically or vegetatively intact. Another need is that of connectivity across landscape barriers such as the CAP canal and Interstate Highway 10.

Altar Valley

Compared to other subareas, the Altar Valley offers several hydromesoriparian areas and many relatively densely vegetated xeroriparian areas which are extensive and relatively undeveloped. Many of these areas occur in the mid-piedmont zone, rather than being restricted to the mountain canyons or valley floor, as is common in most other subareas.

Acquisitions along Arivaca Creek are the top priority for providing the highest biological benefits to priority vulnerable species.

The first four miles of Altar Wash north of Buenos Aires should be considered the next priority, because it ranked higher among biologists than most other riparian watercourses for inclusion in a reserve system. Most of Altar Wash is not recommended as a high priority within this subarea due to its degraded nature and lesser species richness, compared to its tributaries. Along Altar Wash itself, ignoring the tributaries, the distributary flow reach downstream of Ajo Highway would be next priority.

In general, tributary watercourses west of Altar Wash are more densely vegetated than watercourses east of Altar Wash. Also, the rangeland health of the southwestern tributary watersheds is better than the tributaries north and east of Altar Wash. Of the xeroriparian watercourses, acquisitions along Mendoza Canyon, La Osa Wash, San Luis Wash, Bajillo de las Chivas, Fraguita Wash and San Juan Wash might provide benefits for cactus ferruginous pygmy-owl as well as other species. Los Encinos Canyon, Thomas Canyon, Brown Canyon, Sabino Canyon and Yellow Jacket Wash are notable for having hydromesoriparian areas.

Avra Valley

Compared to other subareas of eastern Pima County, the Avra Valley subarea is relatively arid and degraded by agricultural use and water resource developments. Within this area, acquisitions of existing mesquite woodlands and forests, which are a relatively limited resource, would be a priority, if the hydrology upon which they depend can be conserved. Generally, Brawley Wash north of Three Points to the Garcia Strip ranked higher for PCAs and species richness than other parts of Brawley Wash. Blanco Wash, Los Robles Wash, and tributaries of Los Robles Wash ranked lower for species richness than Brawley north of Three Points.

Black Wash ranked lower for species richness and priority conservation areas, and has more problems associated with ongoing urbanization than these other watercourses. However, Black Wash has some of the denser and most extensive mesquite thickets in the subarea. Black Wash should continue to be a target for the Flood Control District's land acquisition program, to minimize future flood damages.

Aguirre Valley

Compared to other subareas, Aguirre Valley is not predicted to have high species richness. Much of the riparian land is already within the Ironwood Forest National Monument, but the mesquite woodlands that lie outside the boundaries might be logical areas to prioritize.

Western Pima County

Compared to other subareas, riparian areas in western Pima County do not have the higher species richness and many overlapping priority conservation areas. Within the subarea, the Rio Cornez/Sikort Chuapo system has consistent, moderately high vegetation densities, and probably deserves the highest priority for conservation in western Pima County. Some of this land is already owned and managed by the Pima County Natural Resources, Parks and Recreation Department. Some is privately owned, and some might become privately owned through a federal land trade involving the Department of Defense. The rest is managed by Bureau of Land Management.

Prioritization of Acquisitions across Subareas

If the objective is to maximize benefits to the full range of priority vulnerable species, then acquisitions along unprotected portions of watercourses with high predicted species richness as indicated on Figure 2 should generally be higher priority than reaches with low species richness. If the scope of the Section 10 Permit were restricted to a few species, then the stream priorities might need revisions.

Giving preference to large size, better ecological condition, landscape context, and land values, the streams with high predicted species richness outside of existing reserves can be further divided into two tiers.

TABLE 1

Priority Stream Reaches for Acquisition in Pima County, Arizona

"A" list
Cienega Creek
Davidson Canyon
Posta Quemada Wash
San Pedro River
Agua Verde Wash
Sabino Creek near Coronado NF
Bear Canyon
Buehman Canyon

"B" list
Arivaca Creek
Sutherland Canyon
Tanque Verde Wash near Saguaro NP
Agua Caliente Wash (upstream of Prince Road)
Rincon Creek near Saguaro NP
Edgar Canyon
Paige Canyon
Madera Canyon near Coronado NF
Wakefield Canyon
Cedar Canyon (confluence with Sopori)
Espiritu Canyon
Youtcy Canyon
Sopori/ Papalote Wash
Altar Wash adjacent to Buenos Aires National Wildlife Refuge

The effluent-dominated Santa Cruz River below Tucson is not listed as a priority stream, despite the predicted high species richness, due to its lack of a groundwater table to sustain flows. Honey Bee Canyon is not a priority for Section 10 mitigation, for different reasons. The reach with high predicted species richness is small and isolated, the land is costly, and the area around it is largely developed. Although it is not recommended as a top priority for Section 10 mitigation, Honey Bee Canyon is worth conserving, and bonds have been authorized for open space acquisitions. Anderson Canyon is not listed because of its low value for fish and frogs, and small size. There are a number of other small riparian systems not listed due to small size.

Sopori, Papalote and Altar Wash near Buenos Aires rank lower for biological considerations than the other watercourses, but are included herein due to their more numerous recommendations by biologists for inclusion in the reserve system (as indicated by PCA1s).

Some of the streams listed as priorities also have high land costs (Sabino, Agua Caliente), impaired hydrology due to dams (Bear Canyon, Arivaca), or have intensive development (Tanque Verde) next to them, but the author suggests that factors such their biological resources, size and proximity provide sufficient counterbalance to the negative factors.

Relationship to Existing Acquisition Programs

This section addresses how top priorities for biological benefits mesh with existing acquisition programs of various organizations. To summarize, there are no existing acquisition programs for conserving resources along Madera Canyon downstream of the National Forest, Cedar Canyon, Paige Canyon, Sopori/Papalote Wash, and much of upper Agua Verde and Rincon Creek.

Pima County bonds are already authorized for open space acquisitions along Cienega Creek, upper Honeybee Canyon, Agua Caliente Creek, Sabino Canyon, Sutherland Wash, and Tanque Verde Creek. Most of Posta Quemada Wash has already been acquired.

Pima County has acquired land through the subdivision development process and intends to continue to do so. This is likely to affect areas undergoing development such as Rincon Creek, Tanque Verde Creek, Agua Caliente Wash, Sabino Canyon and many others.

Floodprone lands are being acquired by Pima County Flood Control District along Tanque Verde Creek, lower Agua Verde Creek, and Cienega Creek, as well as many other stream reaches which are not high priority for Section 10 mitigation, such as Black Wash and Brawley Wash.

City of Tucson has acquired open space lands along Youtcy, Espiritu, San Pedro River and Tanque Verde Creek. For this report, it was assumed that those lands remain in conservation status. City of Tucson has no known intentions to acquire additional riparian lands for conservation purposes.

Oro Valley has acquired lands along Honey Bee Wash through the development platting process, and is investigating transferral of ownership to Pima County.

The Nature Conservancy has acquired land or conservation easements along Sabino Canyon, Buehman Canyon, and San Pedro River. It is not known whether there are plans to continue acquisitions.

BLM has acquired lands along Cienega Creek and its tributaries, and intends to acquire additional lands in the Cienega watershed pursuant to the legislation which created Las Cienegas National Conservation Area.

USFWS has acquired lands along Arivaca Creek, and intends to acquire additional lands there. USFWS has acquired lands along Altar Wash, but has no ongoing program to extend acquisitions northward.

University of Arizona has stewardship of Florida Canyon within the Santa Rita Experimental Range.

U. S. Bureau of Reclamation recently acquired portions of Posta Quemada Wash, which largely complete the potential acquisitions along this watercourse.

Riparian Acquisition Program Considerations

High priority Section 10 acquisitions could serve various needs. In a few cases, the primary biological need could be to assure that surface water features are constructed and managed to protect native aquatic wildlife. This generally means removal of non-native fish and frogs, monitoring and management of the water source for periodic drying. This type of acquisition could conceivably be handled through a special type of conservation easement with private owners.

In some cases, the primary need might be to prevent ranchland conversion or further lot splitting. Purchase of development rights alone would address this, but not other activities that might affect the habitat or ecological processes upon which vulnerable species depend.

Fee acquisition or specially-written conservation easement provisions would address a wide range of activities that can affect biological resources. These activities could include livestock grazing levels, animal or plant re-establishment activities, preventing modifications of bottomland vegetation and floodplain hydrology, and constraints on use of non-native species, groundwater pumping, roadway access improvements, and hydrologic modifications.

Pima County has no conservation easement program at this time. Staffing elements of a conservation easement program would include personnel to define conservation needs, negotiate terms, value the easements, and monitor that terms of the easements are met over time. If conservation easements or purchase of development rights cannot serve to offset damages done by the activities covered under the Section 10(a) permit, then fee acquisitions. For areas which are already split into small lots, fee acquisitions would generally be more difficult and more costly to administer.

There are also substantial tracts of state trust land which could be acquired along high priority streams for mitigation purposes. Nearly all of Wakefield and Espiritu Canyon is on state trust land, and significant portions of Cienega Creek and Davidson Canyon are as well. Smaller tracts of State Trust lands occur along many others. State lands might be acquired through land trades, in addition, to outright acquisition. On state land, fee acquisitions would likely be needed. In general, leases or easements to achieve long-term biological conservation are not available at this time. Under the existing state constitution, State lands are to be managed for maximizing revenue to the school system.

This report has considered biological issues at a broad scale. Many site-specific factors can affect the desirability of a particular acquisition. Adjacent and on-site land uses, land use history, management costs, utility easements and other encumbrances, the potential for partnerships with other cooperators, and many other issues will need to be considered on a site-specific basis.

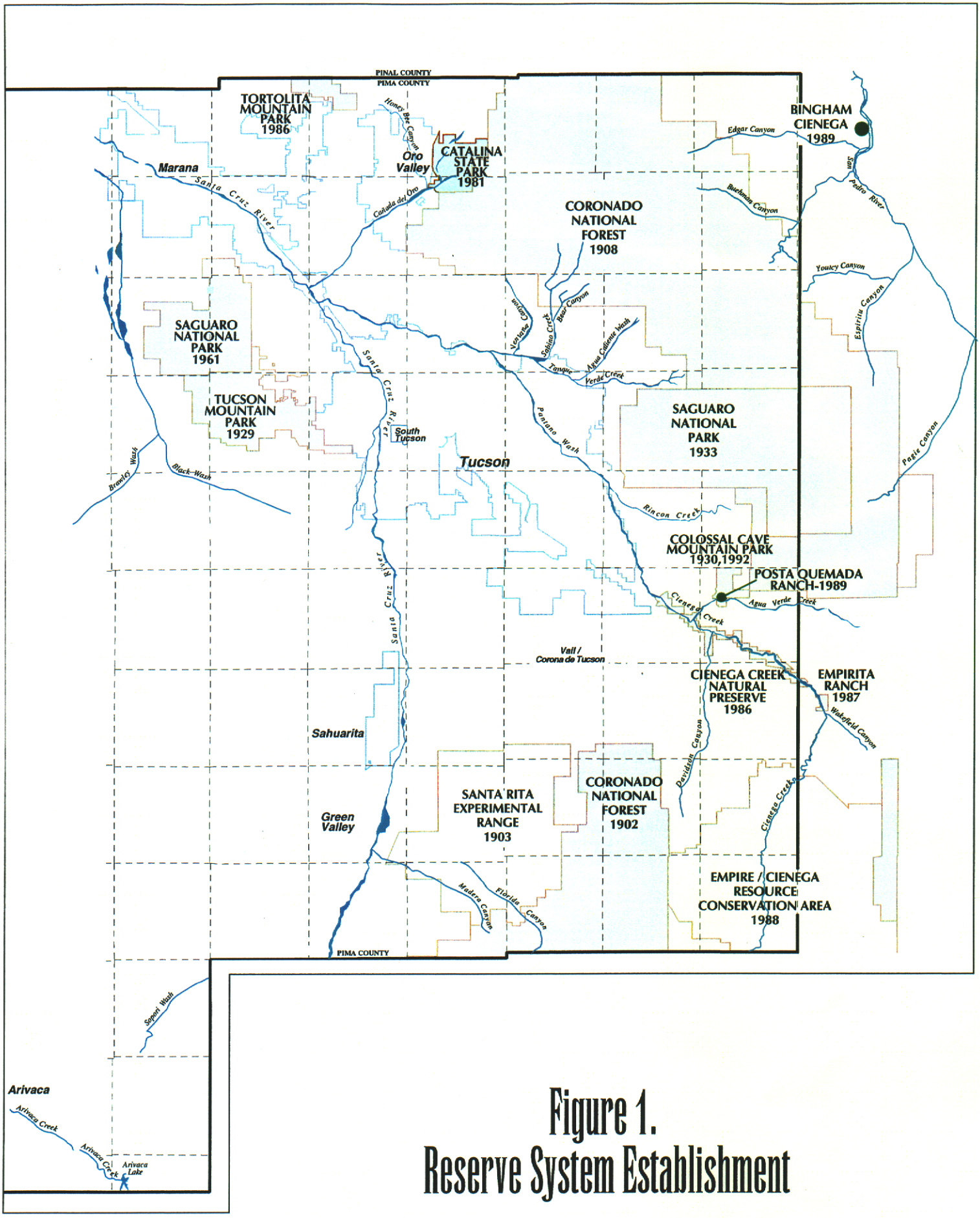
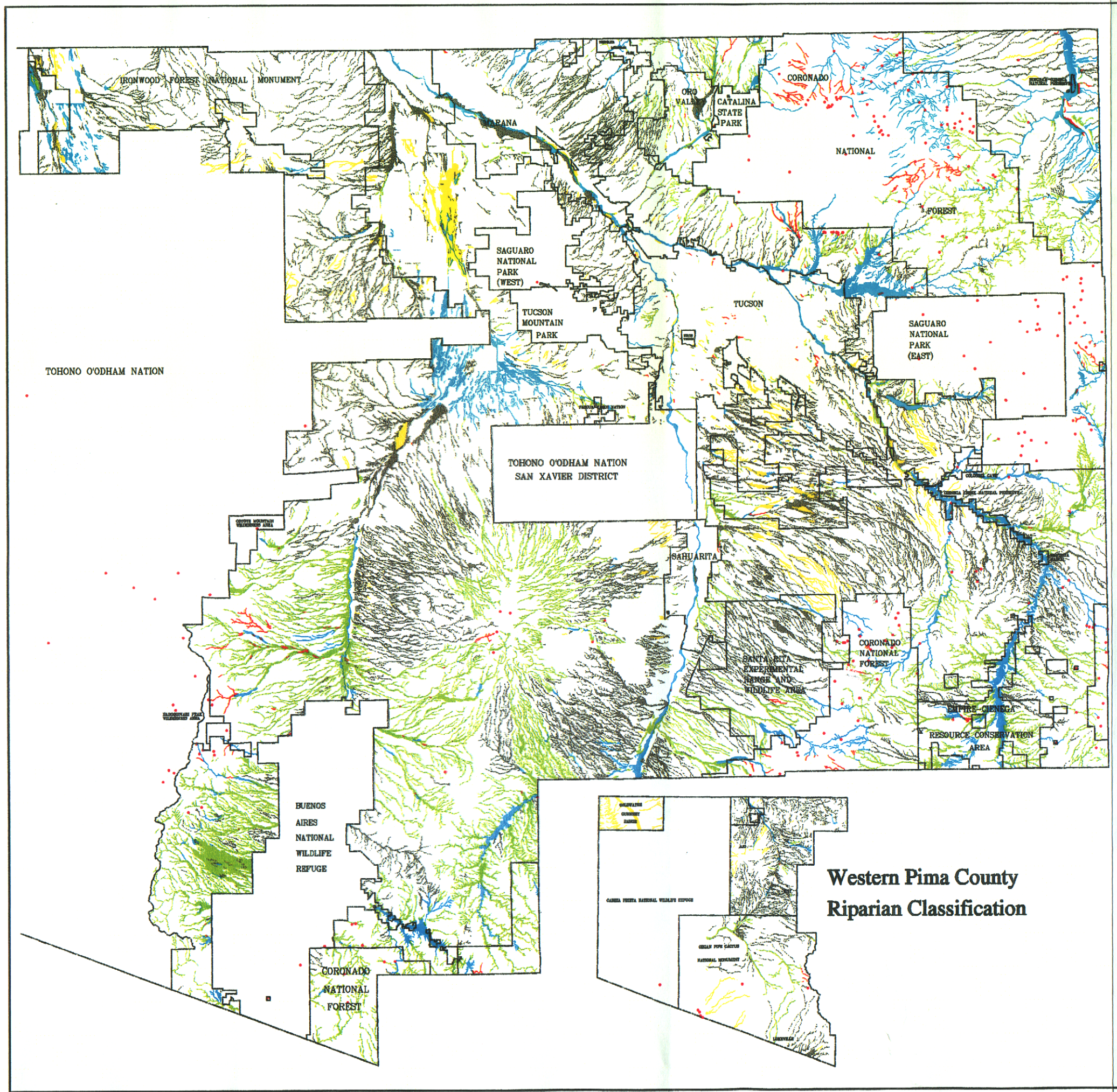


Figure 1.
Reserve System Establishment

Pima County Graphic Design Up-dated 07/02gm

Figure 2
Riparian Classification
Eastern Pima County



- Administrative Boundaries
- Hydromeso Riparian Habitat
- Class A Xeroriparian Habitat
- Class B Xeroriparian Habitat
- Class C Xeroriparian Habitat
- Class D Xeroriparian Habitat
- Springs (Hydromeso Riparian Habitat)

Pima County Index Map

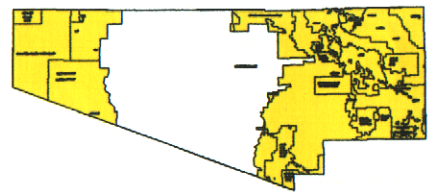


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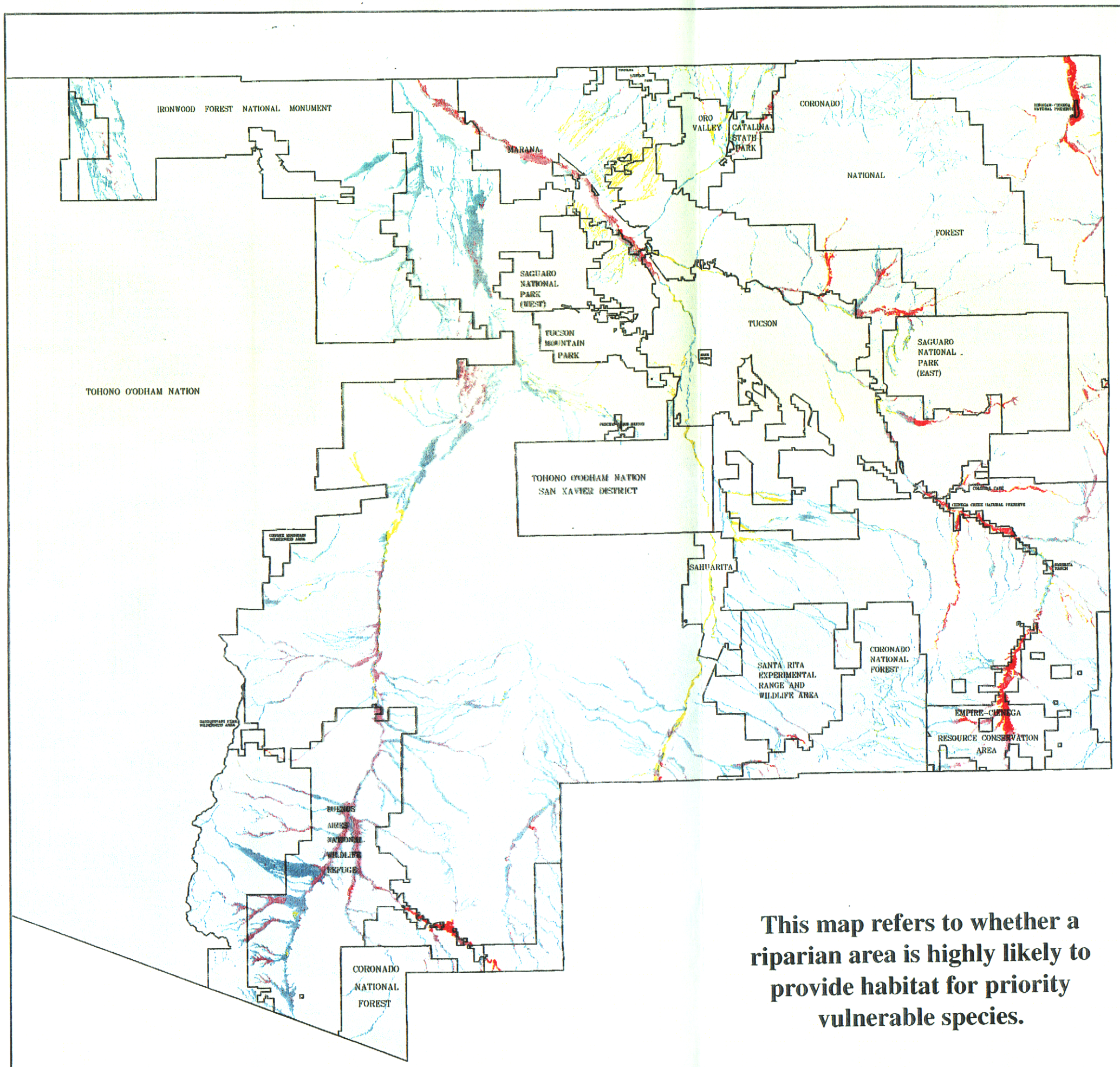
Figure 3
Predicted Species Richness In Important Riparian Areas



No Species in Important Riparian Areas (28,456,995 cells)

1 Species in Important Riparian Areas (48,128 cells)

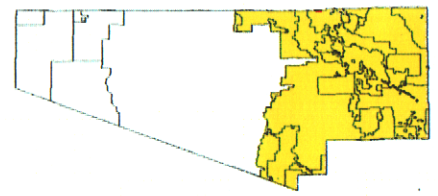
2 to 5 Species in Important Riparian Areas (412,279 cells)

6-10 Species in Important Riparian Areas (250,504 cells)

11-25 Species in Important Riparian Areas (63,307 cells)

This map refers to whether a riparian area is highly likely to provide habitat for priority vulnerable species.

Pima County Index Map



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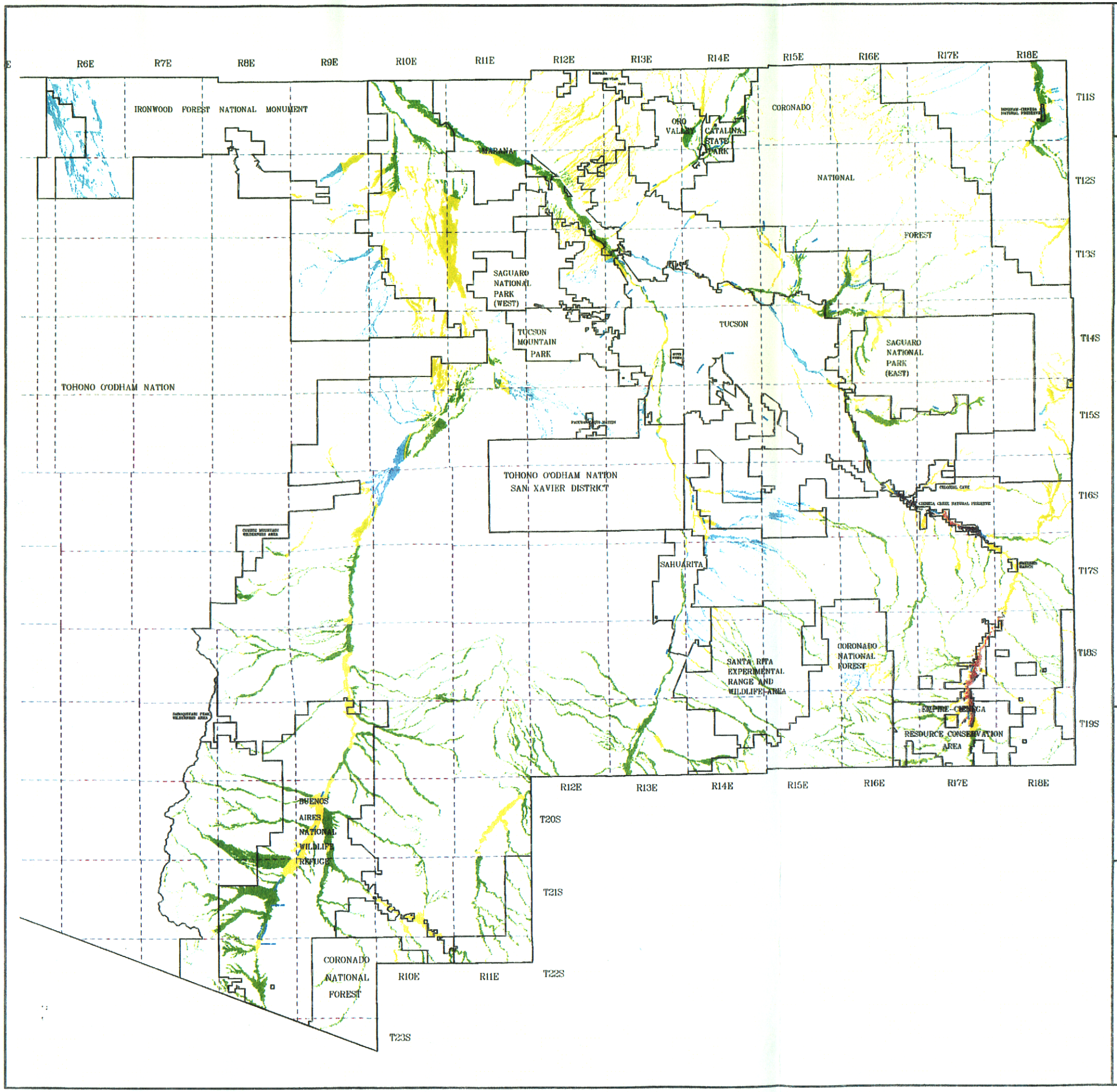
Plotted: 7/10/02

Figure 4

Species Priority Conservation Areas Within Important Riparian Areas

Eastern Pima County



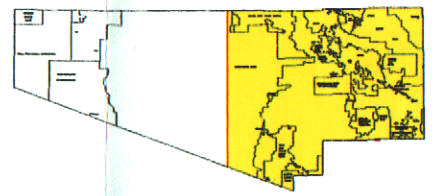
Township and Range

Administrative Boundaries

0	PCA1s
1	PCA1s (35,718 Cells)
2 - 4	PCA1s (94,183 Cells)
5 - 7	PCA1s (14,254 Cells)
8 - 10	PCA1s (1,498 Cells)
11 - 13	PCA1s (1,823 Cells)
14 - 16	PCA1s (2,581 Cells)

PCA1 Is An Area Which Biologists Recommended Must Be In A Reserve System For That Species.

Pima County Index Map



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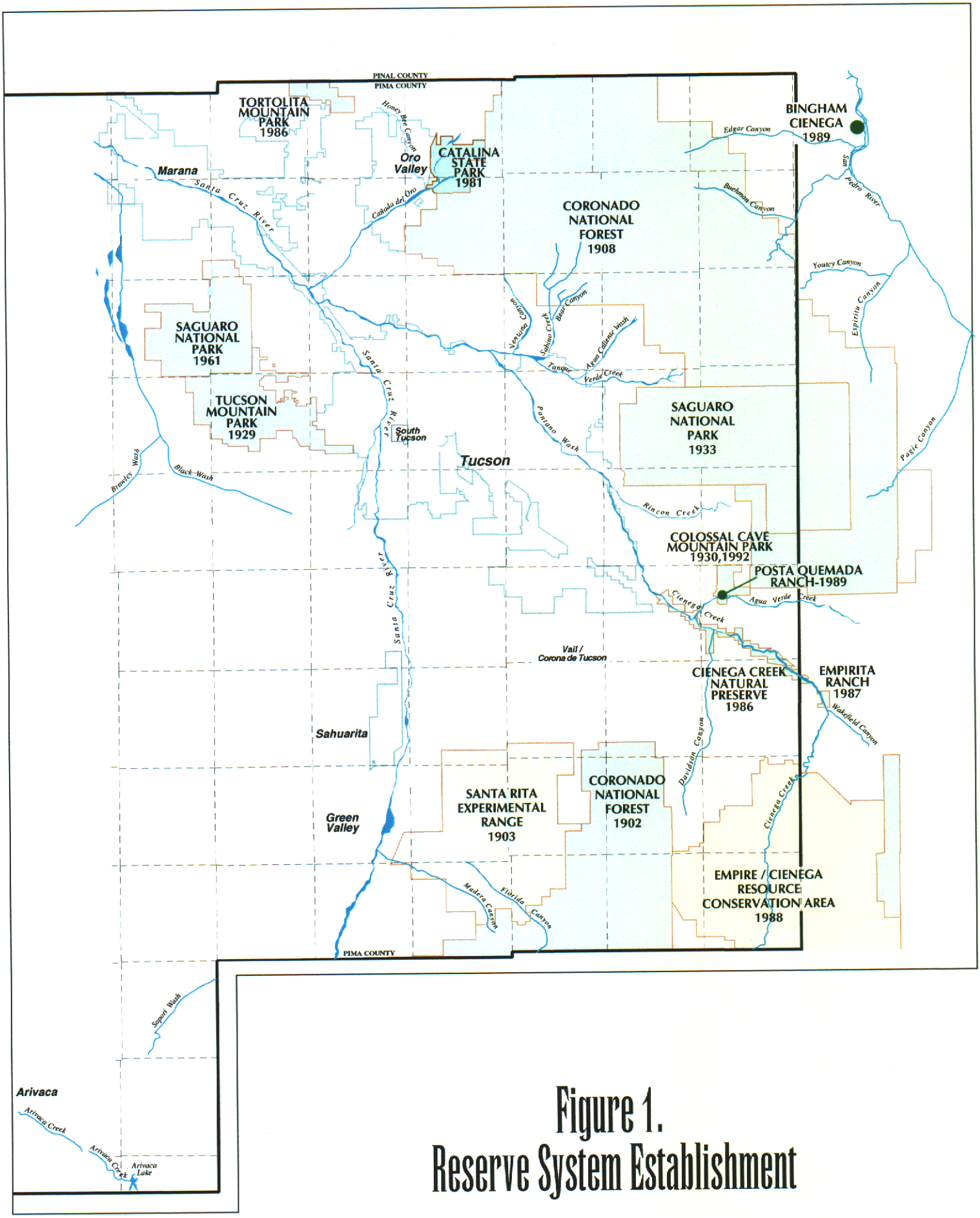

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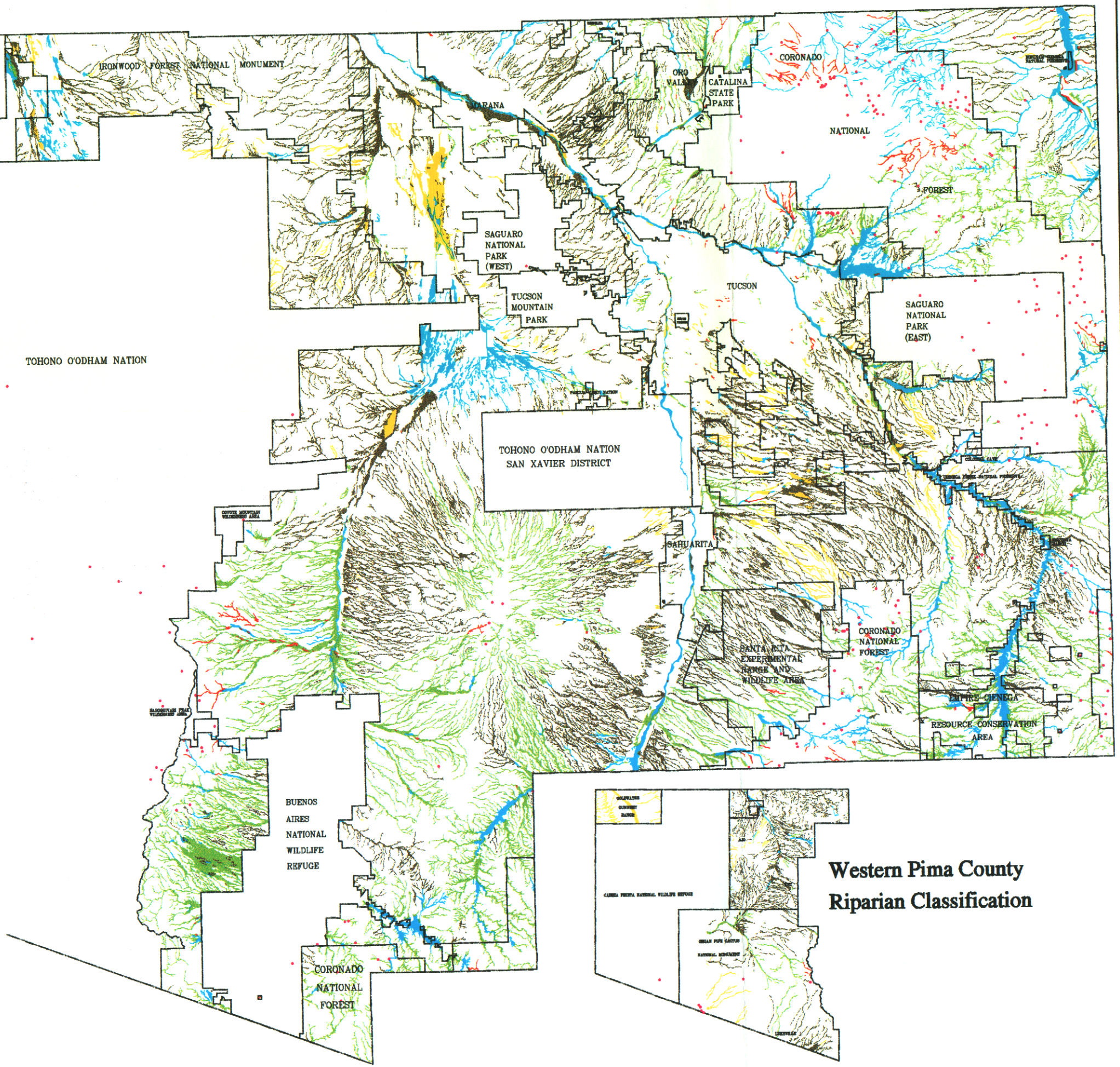

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Western Pima County
Riparian Classification

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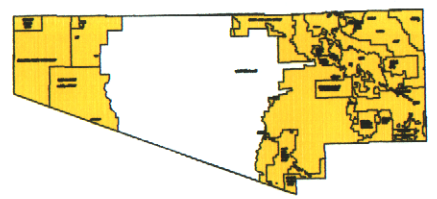

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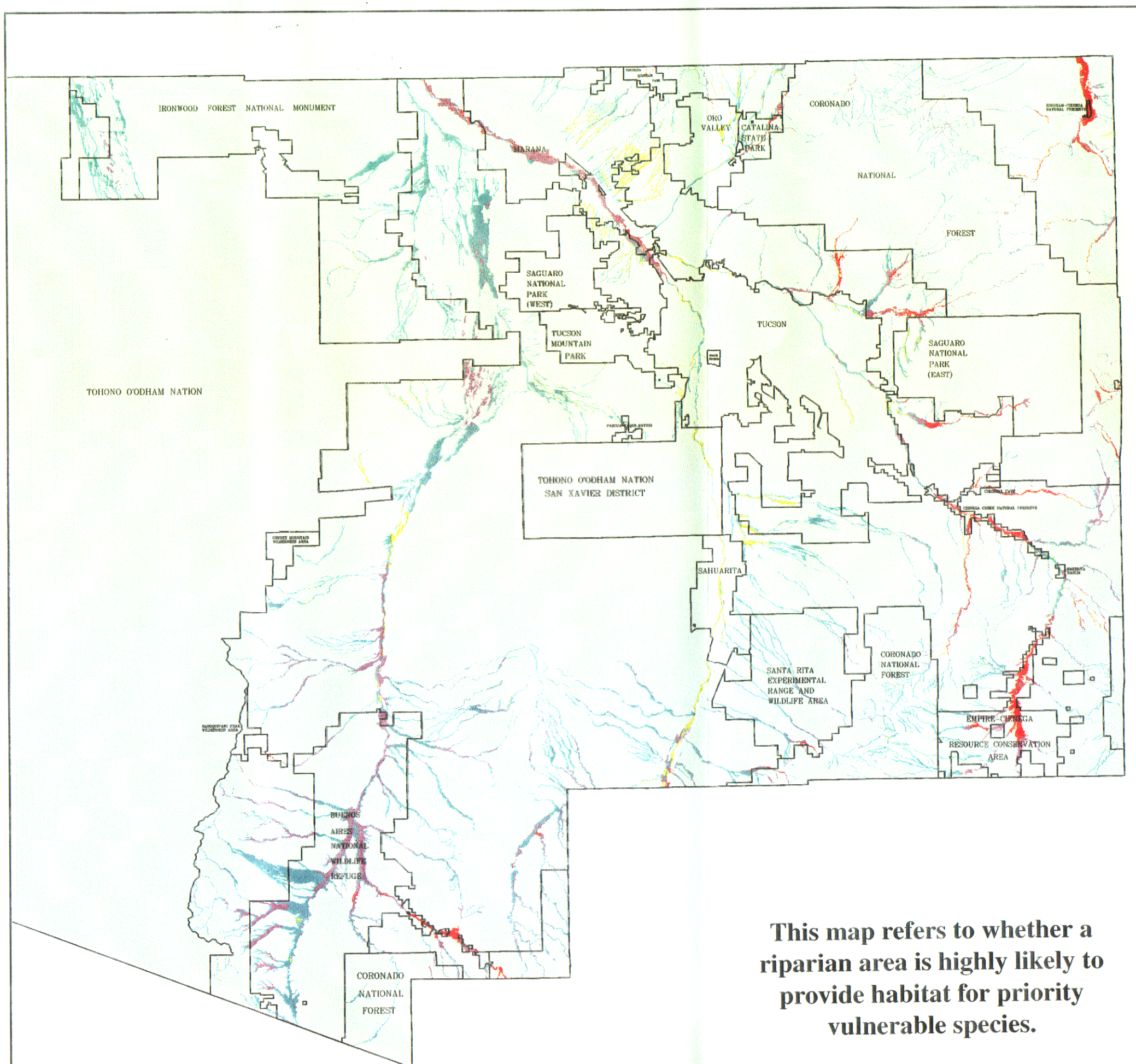

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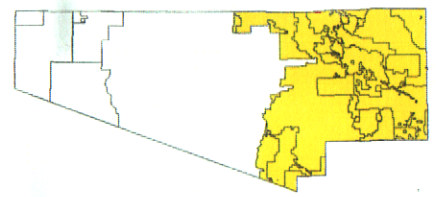

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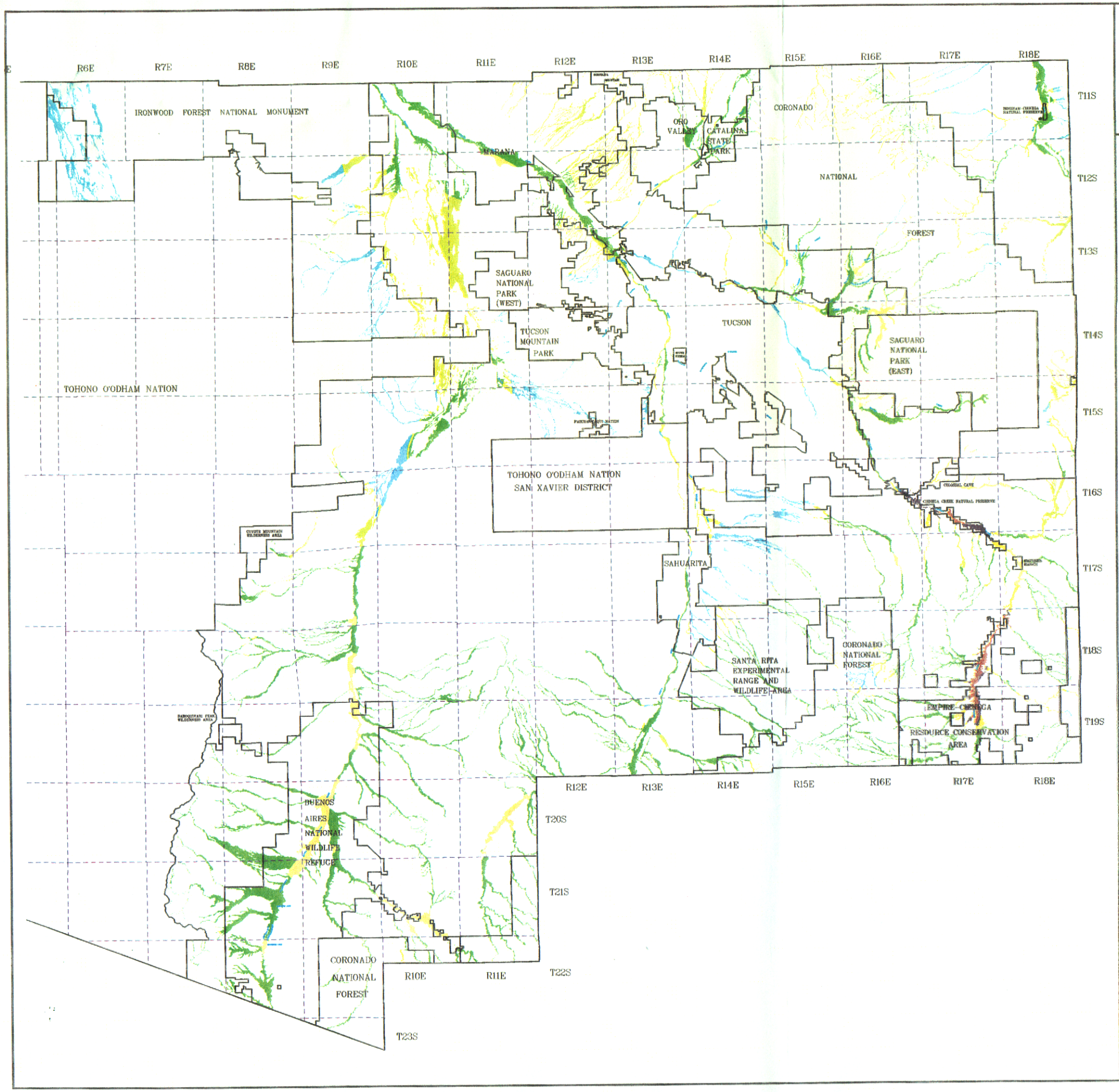
Figure 4

Species Priority Conservation Areas Within Important Riparian Areas

Eastern Pima County



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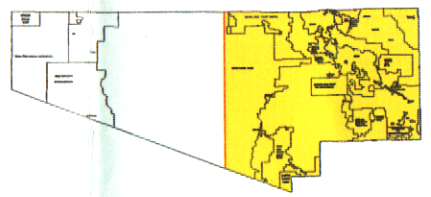

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Appendix A

A Brief Chronology of Riparian Protection in Pima County, Arizona

Compiled by Julia Fonseca, Program Manager

This chronology focuses on actions which actually resulted in some level of riparian protection. These achievements often are based on the acts of those many citizens and policy-makers who fought earlier battles for areas that were subsequently developed or degraded. Those many painful losses are not recorded below. The scope of this brief chronology is further limited to actions motivated by a specific concern for protection of water and water quality, plants or animals associated with streams and springs in Pima County. Many open space and cultural resource protection activities which resulted in incidental but substantial benefits for riparian resources are known, but not included herein.

1902-1908 National Forest Reserves established to protect watersheds in Santa Catalina and Santa Rita Mountains.

1979 The Arizona Nature Conservancy files in-stream water rights requests to Arizona Department of Water Resources (ADWR) for four watercourses, including Thomas Canyon in the Baboquivari Mountains. In response, ADWR develops an in-stream flow program.

1984 City of Tucson and Pima County negotiate the acquisition of Agua Caliente Ranch for a public park. The acquisition spares 100 acres of land from conversion to a subdivision. The spring and ponds in the park are an aesthetic amenity and wildlife habitat, especially for migratory birds.

1984 Pima County voters authorize bonds to buy flood-damaged housing and relocate residents affected by the 1983 flood. Previously, flood and erosion control had been accomplished only through the construction of structures such as bank protection, channels, and levees.

1985 Financing for the floodprone land aquisition program is expanded to include preservation of undeveloped floodplains, funded by an annual allocation from Flood Control Distict tax revenue.

1986 Pima County voters authorize expenditures of $20 million for acquiring vacant, floodprone lands using general obligation bonds. Purposes include "natural flood storage and management, groundwater recharge and natural riverine habitat preservation".

1986 Cienega Creek Natural Preserve established by Pima County Board of Supervisors through initial acquisition, adoption of preserve boundaries, and establishment of covenants, conditions and management principles for the new preserve. Subsequent acquisitions included the purchase of Empirita Ranch, state lands adjoining Cienega Creek, and private lands along Agua Verde Wash.

1986 Critical and Sensitive Wildlife Habitats in eastern Pima County are identified by School of Renewable Resources, University of Arizona, on contract to Pima County Department of Transportation and Flood Control District. The map is widely distributed, and provides a basis for many subsequent decisions to preserve riparian lands during the development process.

1986 Provisions of Section 404 of the 1977 Clean Water Act are first imposed on a project involving waters of the U.S. in Pima County.

1988 Bureau of Land Management acquires the Empire-Cienega Ranch from Anamax, thwarting development of a satellite city in the Cienega Creek watershed, and preserving the most viable native fishery in Pima County.

1989 U. S. Fish and Wildlife Services embarks upon land acquisitions along Arivaca Creek, despite great opposition.

1989 Pima County Flood Control District acquires Bingham Cienega and signs 25-year management agreement with The Nature Conservancy.

1990 The Pima County Board of Supervisors adopts the Buffer Overlay Zone Ordinance. The ordinance arose in the aftermath of a court ruling which stopped a citizen-led initiative to impose restrictions upon development adjacent to public preserves. One provision of the ordinance requires a percentage of natural open space along watercourses to be preserved.

1990 City Council orders Tucson Water to limit groundwater pumping in Tanque Verde Valley.

~1990 U. S. Forest Service begins to implement reduction in livestock utilization in all watersheds and especially along riparian areas through individual allotment plans.

1990 City Council adopts Environmental Resource Zone.

1991 City Council adopts Watercourse Amenities, Safety and Habitat Ordinance.

1992 Arizona Game and Fish Department closes Cienega Creek to fishing to protect native fish species.

1993 Pima County Flood Control District obtains an in-stream flow certificate for Cienega Creek, the fifth ever issued in the State of Arizona.

1994 Pima County Flood Control District adopts riparian maps and requirements for riparian habitat mitigation.

1996 Nature Conservancy acquires Buehman Canyon, in the wake of skirmishes with mining companies.

1996 With support of local agencies, environmentalists and ranchers, ADEQ designates Buehman Canyon a Unique Water of the State of Arizona, which imposes higher water quality standards to protect aquatic animal life.

1999 Arizona Game and Fish Department and U. S. Forest Service remove sunfish from Sabino Canyon to protect the Gila chub.

1999 Bureau of Land Management re-establishes flow path of Cienega Creek at Cienega Ranch using Arizona Water Protection Funds.

1999 Tucson Audubon Society initiates program of restoration along the Santa Cruz River on Tucson City Water land known as North Simpson Farm, using section 404 mitigation money.

2000 Forest Service drains Rose Canyon Lake, a step toward managing for both trout and native fish resources in Bear Canyon watershed.

2001 The Nature Conservancy revegetates abandoned farm lands at Bingham Cienega with native plants, using Arizona Water Protection Funds.

2001 Las Cienegas National Conservation Area established, permanently withdrawing lands along Cienega Creek and its tributaries from disposal.

Appendix B

Notes on Ecological Integrity and Species Occurrences in some Important Riparian Areas of Pima County, Arizona

Locations are grouped alphabetically within the following SDCP subareas: Middle San Pedro, Cienega-Rincon, Upper Santa Cruz, Middle Santa Cruz, Tortolita Piedmont, Altar Valley, Avra Valley, Aguirre Valley, Western Pima County. The topologic relationships among most watercourses discussed herein are depicted in Figures B1, B2 and B3. Figure B1 covers the Middle San Pedro subarea. Figure B2 covers the Cienega-Rincon, Middle Santa Cruz and Upper Santa Cruz subareas. Figure B3 covers the Altar and Avra Subareas.

Unless otherwise noted, watershed and vegetation descriptions are based on observations by Julia Fonseca. Species occurrence data reported herein are limited to those native fish, cactus ferruginous pygmy-owl, Chiricahua leopard frog, and lowland leopard frog occurrences mapped in *Priority Vulnerable Species* (RECON n.d.), unless otherwise noted. Dates are provided for field observations.

Middle San Pedro Subarea

Alder Canyon, Santa Catalina Mountains (AGFD, 2000). There are spotty stands of cottonwoods in this canyon. A few small galleries are located in the upper section of the canyon. These include alder, sycamore, and soapberry. When considered with Atchley Canyon, this watershed has one of the largest areas of mixed broadleaf riparian forest in Pima County (Fonseca and Regan, 2001). No recent fish, pygmy owl or leopard frog occurrences are known.

Ash Creek, Rincon Mountains (2002). Bottomland vegetation is intact; hydrology is unaltered. This creek is paralleled by the Happy Valley Road and receives high levels of motorized recreational vehicles. There is some evidence of bank instability. Vegetation includes multigenerational ash and walnut. Canyon treefrogs are known from this site, which might also support small pockets of lowland leopard frogs. No recent fish, pygmy owl or leopard frog occurrences are known.

Bingham Ciénega. A grove of ashtrees, cattail-bulrush ciénega, and mesquite bosques in several successional stages are present. During the period 1989 to 1992, Goodding willow established in the ciénega. Fires burn the cienega occasionally. Recruitment of hackberry and mesquite have also occurred, particularly along the eastern margin of the ciénega. A sacaton grassland was recently established by The Nature Conservancy. The site is not grazed. Leopard frogs and fish are known to exist. No recent pygmy owl observations are known, however, pygmy owl calls have been reported in the 1980s (T. Tibbitts, pers. comm.).

Buehman Canyon, Santa Catalina Mountains (2000). Most of this watershed is undeveloped, and likely to remain so, although there has been some disturbance related to minerals exploration. An extensive and dense mesquite forest is present along the valley

floor where this stream meets the San Pedro River. Because of its proximity to roadways, this area is vulnerable to future residential development. Upstream, the canyon contains a mixed broadleaf forest (Harris, 2000) of ash, cottonwood, willow and sycamore (PAG, 2000), but roadway access is poor. An extensive, dense cottonwood, sycamore, and ash gallery with perennial water is located in the section of land that is for sale below the Nature Conservancy property in Buehman; this would make an excellent acquisition (AGFD, 2000). Leopard frogs and fish are known to exist (PAG 2000). No recent pygmy owl observations are known. In 2002, a fire burned in much of the watershed.

Bullock Canyon. Most of this watershed is undeveloped. A rough road follows much of the channel, destabilizing sediment and vegetation. The watercourse contains a mixed broadleaf forest (TNC, 2000). Evidence of ash and sycamore recruitment is present (Fonseca, 2000).Small cottonwood, sycamore, and ash gallery present 1-2 miles above confluence with Buehman Canyon at Bullock spring (AGFD, 2000). No recent pygmy owl occurrences are known. Native fish and frogs present (PAG, 2000).. In 2002, a fire burned in much of the watershed.

Edgar Canyon, Santa Catalina Mountains. The dominant tree in middle Edgar Canyon forest is sycamore, with ash and willow as common associates (J. Bill, pers. comm., 2000) There is potential for improved forest quality (TNC, 2000). Edgar has some excellent cottonwood and willow galleries in the middle and upper portions of the canyon where overgrazing has not occurred (AGFD, 2000). Road access is poor. Fish and frogs have been reported (PAG, 2000), but no pygmy owl observations. In 2002, a fire burned in much of the watershed.

Espiritu Canyon, Santa Catalina Mountains. This site and its watershed is almost entirely undeveloped, except for a rough road on a stream terrace. The terrace has fire rings and evidence of wood-cutting. Vegetation includes ash, hackberry, cottonwood. This site has supported lowland leopard frogs and may be suitable for native fish (Rosen, 2000). It currently has sunfish. There are no recent native fish or pygmy owl occurrences.

Gessaman Canyon, Santa Catalina Mountains. This stream has occasional stands of cottonwoods and sycamores (AGFD, 2000). No recent fish, pygmy owl or leopard frog occurrences are known.

Miller Creek, Rincon Mountains (S. Schorr, 1999). As of 1995, ASARCO owned three mining claims in Happy Valley: near the confluence of Miller and Paige Creeks, the Turkey Creek trailhead area, and near the confluence of Turkey and Paige Creeks (mostly in Cochise Co.). These parcels were included in the proposed land swap for the Rosemont Ranch area. (ASARCO 1995, The Rosemont Ranch Land Exchange.) Vegetation is dense oak and broadleaf deciduous forest. No recent pygmy owl or fish occurrences are known.

Paige Canyon (2002). Outside the San Pedro River, this area has some of the densest riparian vegetation in the subarea. At the confluence of Turkey and Paige Creeks, >1 mile downstream of the trailhead next to the Clopton Ranch, there are sycamores, along with some cottonwood, ash, and willow trees. There is evidence of past bank instability and incision. The banks are healing over in the wetter stream reaches; the incision has

desiccated the confluence area so that young Arizona cypress are coming up under the mature sycamores.

According to Rosen (2000): "This area supports lowland leopard frogs and some kind of fish, perhaps native fish. I believe a key area for the natives at a well and pond site high in the main drainage has sunfish, which ought to be eliminated if possible. This is a large enough stream to support one or possibly several species of native fishes, though in relatively limited numbers. Pima County should pursue the matter of exotic species removal, as well as developing a collaborative relationship with the local ranchers, or at least purchase of in-holdings or conservation easements therein."

Redfield Canyon. The portion downstream of the San Pedro River Road has been channelized and supports very little vegetation. Upstream, the wash vegetation is xeroriparian desert scrub. There are no recent fish, frog, or pygmy owl occurrences along this ephemeral reach.

San Pedro River (1990-2001). The bottomland vegetation, bank stability and hydrology of this watercourse have been substantially altered by agriculture, surface water diversions, fire effects, elimination of beaver and grazing. Where not cleared for agriculture, pasture, or homes, the floodplain contains a large mesquite bosque with the densest vegetation anywhere in Pima County. A County-maintained roadway provides access. The channel is mostly open riparian scrub. Much bank erosion occurred during the 1993 flood, as a result of sediment moved into the mainstem from Buehman and Edgar Canyons. Since then, many of the sand bars have become stabilized with vegetation. In places, tamarisk, Goodding willows and cottonwood trees are established, many of the latter following the 1993 flood. Most of the San Pedro River is grazed. Water is diverted from the channel just upstream of the Cochise County line. Leopard frogs and fish are known to exist. No recent pygmy owl observations are known. Feral hogs, exotic fish and bullfrogs are a concern.

Soza Canyon (2000). This tributary of the San Pedro River has an extensive mesquite bosque. It is outside any existing reserves, but upstream tributaries Youtcy and Espiritu Canyon remain largely undeveloped, roadway access is poor, and the upper watershed is managed for livestock and open space purposes by lessees of City of Tucson's A7 Ranch.

Stratton Canyon, Santa Catalina Mountains). A small stand of sycamores and ash are in the upper portion of the canyon between the U Circle Ranch and the Forest boundary (AGFD, 2000). Mesquite bosque is present. No recent fish, pygmy owl or leopard frog occurrences are known.

Turkey Creek, Rincon Mtns, downstream of FS boundary, at the Turkey Creek trailhead (S. Schorr, 1999). There is a large stand of mature and old sycamores at the trailhead, with an occasional mature or old ash. The area is used intensively for recreation. Large groups of people camp there for multiple days with constant motorcycle, truck, and other OHV traffic on and off the roads. There are signs of past grazing. Presumably, due to vehicular traffic, there is no recruitment occurring at the trailhead/parking area. However, next to the parking area, there are young sycamores and ash along and within the creek bed. The

bases of the trees at the trailhead are buried by sediment, so flood events may have played a hand in wiping out the young trees in the area. Recruitment of cottonwood, ash, and sycamore was observed upstream of the trailhead, where vehicular traffic and grazing is prohibited.

Youtcy Canyon, Santa Catalina Mountains. This undeveloped watershed has supported lowland leopard frogs and is suitable for fish, possibly longfin dace (Rosen, 2000). Roadway access is poor. There are no recent fish or pygmy owl occurrences.

Cienega-Rincon Subarea

Agua Verde Creek, Rincon Mountains (2000). Contains an extensive but short-statured mesquite bosque with isolated cottonwoods. The middle reach has the highest vegetation volume. The bottomland and uplands are grazed and beginning to be fragmented by low density, single-lot development. Leopard frogs and fish are known to exist. No recent pygmy owl observations are known.

Anderson Wash. This undeveloped watershed enters Cienega Creek at Empirita Ranch. Vegetation is xeroriparian, and probably included sacaton grassland at its confluence, prior to agricultural development. There are no recent pygmy owl, fish or leopard frog occurrences known.

Box Canyon. This tributary to Rincon Creek has a largely undeveloped watershed. Outside the National Park, the riparian corridor is broad, densely vegetated and unincised. Residential development increasingly fragments the bottomland vegetation. There are no recent fish or leopard frog occurrences known, but pygmy owl occurrences are known within the watershed.

Lower CiénegaCreek, downstream of the Narrows (1986-2002. The uplands are beginning to be fragmented by rural subdivisions and roadways. The bottomland includes extensive mesquite bosques and cottonwood-willow forest with some of the highest vegetation volumes anywhere in Pima County. The floodplain is constricted by the construction of a railroad embankment in several locations. Depth of channel incision increases downstream, and there is evidence of bank instability. Bottomland vegetation has been disturbed by historic pasture clearing in several places, but there are large areas of intact native plant communities. The largest cottonwood grove is located just upstream of the diversion dam, where perennial flow is diverted into a pipeline for the Del Lago golf course. This impairment could be easily reversed by acquiring the surface water right and restoring flows to the channel below.

Leopard frogs and fish are known to exist. No recent pygmy owl observations are known.

Threats to the existing resources are the potential groundwater withdrawals at the well adjacent to the diversion dam, and at Empirita Ranch, where the Empirita Partnership has the right to withdraw up to 1600 af per year, pursuant to the Empirita Ranch acquisition contract with Pima County.

Upper CiénegaCreek, upstream of the Narrows (1990-2001). Bottomland vegetation is largely intact and includes sacaton, mesquite bosque and the largest area of contiguous cottonwood-willow forest in Pima County. Vegetation volume ranks among the highest anywhere in Pima County. Bank stability and hydrologic functions are intact, although there is evidence of excessive sedimentation from tributaries. The Bureau of Land Management has removed livestock from the channel, minimized roadway impacts, and recently restored the flow path of the channel. The latter is an action which is likely to assist in restoration of a large agricultural clearing over time.

According to Rosen (2000), "This is the wetland gem of Pima County, with lowland leopard frogs (rare or extinct), Chiricahua leopard frogs (now rare), bullfrogs (rare), Mexican garter snakes (apparently still widespread and probably not uncommon), Sonoran mud turtles (abundant), longfin dace (abundant), and Gila chubs and Gila topminnows (both superabundant)."

Cumero Canyon (1999). Mesquite-hackberry forest occurs within a very productive grassland. Relatively little development occurs within the watershed, and road access is poor. No recent pygmy owl, fish or leopard frog occurrences are known.

Davidson Canyon, from Cienega Creek to National Forest (2000). Occasional small stands of young ash, willow, cottonwood and tamarisk trees or isolated old cottonwoods, ash and willow are found within the arroyo walls, but the majority is riparian scrub (broom, burrobrush) and mesquite. Walnuts, yew-leaved willow and hackberry trees are also present. Arizona Highway 83 borders the riparian area, and a number of houses have recently been constructed at the margins of the valley. Davidson Canyon is an important source of underflow for Cienega Creek, and it is considered one of the few locations where terrestrial wildlife can safely cross the Interstate Highway. Groundwater wells are being installed to provide for rural domestic uses. Grazing is permitted upstream of I-10. There is a proposed copper mine in the National Forest. Lowland leopard frogs and long-fin dace fish are known to exist. No recent pygmy owl observations are known.

Gardner Canyon, Northern Santa Rita Mountains (and West Sawmill, Cave, Little Fish Canyons). Gardner Canyon receives relatively high levels of recreation. A road parallels the creek, and a paved highway crosses it. Vegetation includes desert willow and sycamore. Wildfires burned much of the riparian corridor in the past. According to Rosen (2000), "the set of canyons with Chiricahua leopard frogs is not entirely in Pima County, but these probably function as a loose metapopulation, or two metapopulations. Thus, they should be treated as a unit for management purposes. In addition to the listed sites, individual Chiricahua leopard frogs have been found in Florida Canyon and Box Canyon, again pointing to substantial dispersal and thence, to potential metapopulation dynamics." No recent fish or pygmy owl occurrences are known.

Mescal Wash (1986-2000). The uplands are beginning to be fragmented by rural subdivisions. The bottomland includes sacaton in the upstream reaches, mesquite, hackberry and walnut in the lower reach. The floodplain is somewhat constricted by the construction of a railroad. Interstate Highway 10 is nearby. Depth of channel incision increases downstream. No recent pygmy owl, fish or leopard frog occurrences are known.

Pantano Wash (1986-2002). This watercourse is a wide, incised, sand-bed channel dominated by the riparian scrub (burrobrush, seepwillow) plant community. Vegetation upstream of Rincon Creek is much denser than vegetation downstream. The channel has been extensively modified by gravel mines in the upper reaches. Bank stabilization and floodplain encroachments have recently been constructed at Vail Valley. In places, motorized recreation levels are high. Lowland leopard frogs and bullfrogs have been recently reported, but not fish or pygmy owls.

Posta Quemada Creek, Rincon Mountains (2000). Developments include campground residential structures, and roadways associated with Colossal Cave Park and livestock-related infrastructure within the Coronado National Forest. This watershed receives a high level of recreation. Nearly all of the watercourse is publically owned or accessible. Vegetation includes cottonwood gallery forest, a small cienega, and mesquite bosque, as well as cave resources. Lowland leopard frogs and fish are known to exist. A pygmy owl observation is known within the National Forest, but there are no known breeding populations.

Rincon Creek, Rincon Mountains. The bottomland vegetation, bank stability and hydrology of this watercourse have been substantially altered by agriculture, grazing, and gravel mining. Urban development of the Rocking K area will also result in changes to floodplain hydraulics, due to construction of levees and channelization of tributaries. A developer will plant and irrigate 118.5 acres of the floodplain to offset damages under Section 404 of the Clean Water Act. Walnut was historically a dominant riparian tree (Briggs, pers. comm., n.d.), which today is absent. Upstream of Rocking K is a mesquite bosque with hackberry, blue palo verde and desert willow (Briggs, pers. comm., 1999). Sycamores are the most common broadleaf deciduous tree, but the full complement of broadleaf trees is present. On a tributary located behind the fire station is a stand of mature cottonwoods and willow trees (1997). If the developers make a lake here, they may drown the trees. Groundwater pumping is also a concern (PAG 2000, Baird et al., 2001). Lowland leopard frogs and fish are known to exist. No recent pygmy owl observations are known.

Road Canyon, 1999. This little-developed watershed is a tributary of Cienega Creek, most notable for the presence of bullfrogs. A key acquisition need is the elimination of habitat conditions for bullfrogs at Northwest Reservoir. BLM has attempted to eradicate bullfrogs on its lands downstream, but a source population remains at Northwest Reservoir, which has year-round water and is located on private lands.

Wakefield Canyon, 1999. Vegetation ranges from dense xeroriparian to hydromesoriparian. It includes sycamore gallery forest, in-channel bulrush marshes, deergrass, seepwillow and Goodding willow. There is very little development or impairment in the watershed. Road access is very poor. Grazing is locally intense at one supplementary feeding area, but some of the upper watershed is in an exclosure. This is an important breeding area for lowland leopard frog (D. Turner, pers. comm.). No recent pygmy owl occurrences are known. An earlier effort to introduce topminnow failed. Dace were observed in 1994 in the lower reaches, but were no longer present by 1999.

Middle Santa Cruz Subarea

Agua Caliente Wash (1986-2002). The upper watershed includes several cattle tanks that hold year-round water, and one feature known as "The Lake" near the Bellota Ranch headquarters. The watershed outside the National Forest includes low density subdivisions with relatively high amounts of natural cover, transitioning to denser residential uses adjacent to flood control channels and soil-cement bank stabilization. Bank stability downstream of Limberlost is low, and the historic extent of flow has been altered.

Vegetation volume (inferred from NDVI) is higher in the lower reaches. At its lower end, a few ash and walnut trees mix into the Tanque Verde bosque in a large diverse distributary flow zone. There was evidence of recent recruitment in 1999. However, the tiny seedlings could have been disturbed by natural forces or recreational traffic since then. Between the Forest Boundary and Soldier Trail are occasional isolated cottonwood, sycamore, walnut or ash trees. Ash trees become more frequent near the Forest boundary and there is evidence of recruitment. The 6 to 15-foot high saplings had brown, dry leaves or browning leaves in August 2000. No recent pygmy owl occurrences are known. Lowland leopard frogs were known in the National Forest watershed into the early 1990's. Sunfish washed down from tanks within the Bellota Ranch in the early 1990's, and still exist along the stream (Rosen, pers. comm., 2002).

Bear Canyon, Santa Catalina Mountains (2000). Downstream of the forest boundary, the bed is bouldery. Sycamores and hackberry are more frequent than cottonwoods or Goodding willows, but a closed-canopy forest is absent. Most large trees are located near channel margins or adjacent to mid-channel boulders. New roads and homes are under construction outside the channel, on the terrace where mesquite and hackberry grow. Acquisitions of land could reduce habitat loss and fragmentation. Grazing is minimal, recreational use is primarily hiking.

This watershed is dammed at Rose Canyon and Sycamore Reservoir. Effects of the lakes on water supply and flooding are not well known. Rose Canyon Lake has recently been drained (2001-2002). Elimination of sunfish in this watershed will have benefits for native fish such as Gila club (Rosen, 2000).No recent pygmy owl or leopard frog occurrences are known.

Canyon del Salto, Tucson (2000). The watershed has few developments in the National Forest, however a few residential developments have occurred downstream. Isolated young cottonwood trees were showing signs of water stress in late August 2000. In the National Forest, riparian includes young ash and willow. The condition is stable (USFS, nd.). A livestock enclosure was constructed in the late 1980s by the Forest Service. No recent pygmy owl, leopard frog or fish occurrences are known.

Finger Rock Wash (2000). This wash is one of the few which retains a distributary flow pattern at its confluence with the Rillito Valley. The upper watershed is located within the National Forest. The lower watershed is urbanizing. Bottomland vegetation is generally intact, although exotic species are increasing. Roadway construction has locally impaired hydrology. Residential development is fragmenting the watershed. Vegetation in the watercourse is primarily desert scrub. No recent pygmy owl, leopard frog or fish occurrences are known.

Molino Canyon, Santa Catalina Mountains (2000). The upper watershed in the National Forest is relatively undeveloped, except for the Catalina Highway and the Molino campground. Downstream of the forest boundary there are a few houses. Vegetation includes a few isolated ash trees, but no forest structure. Bumelia is present. No recent pygmy owl or fish occurrences are known. Lowland leopard frogs were known at this site, but disappeared, possibly due to drought.

Pima Canyon (1986-2002). This stream is heavily modified by flood control features and urban development, except near the National Forest boundary. There are many paved road crossings. Vegetation is xeroriparian desert scrub downstream of the National Forest. No recent pygmy owl, leopard frog or fish occurrences are known.

Rillito Creek, Tucson (1986-2001). The bottomland vegetation, bank stability and hydrology of this watercourse have been substantially altered by agriculture, gravel mining, groundwater pumping and urban development. Cottonwoods occur in many locations along the channel. Tamarisk, Goodding willow and ash are rare. Cottonwoods generally occur as isolated individuals located on channel bars and near storm sewer outfalls. There is a particularly large, healthy cottonwood located just upstream of the Interstate Highway 10 bridge, which seems to have survived the recent frontage road construction. There are several stands near Swan and Craycroft that probably rely upon a shallow aquifer. Their establishment pre-dates the 1993 flood. No recent pygmy owl, leopard frog or fish occurrences are known

Sabino Canyon (2000). Scattered mesquite, cottonwoods and sycamores grow along a bouldery stream channel. Most of the channel length is little modified by channelization or encroachment, however roads associated with single-lot development are beginning to fragment and diminish bottomland vegetation. Base flows of lower Sabino Canyon have been depleted by groundwater pumping. The lowermost reach is stabilized with soil cement, but elsewhere the channel banks lack significant modification.. Bullfrogs, crayfish and Gila chub exist in the National Forest. Leopard frogs have been sighted recently in the Forest (H. Blasius, pers. comm., 2000), but there is no known breeding population within the watercourse. No recent pygmy owl occurrences are known.

Leopard frogs may not be able to exist at this site, where they were once abundant, until the crayfish are controlled. It is believed that the crayfish are also threatening a damselfly that is endemic at Sabino Canyon. This stream might be a suitable for reintroduction of Gila topminnows.(Rosen, 2000).

Santa Cruz River (1999-2002). The bottomland vegetation, bank stability and hydrology of this watercourse have been substantially altered by agriculture, gravel mining, bank protection and channel straightening, groundwater pumping, off-road vehicles, overgrazing, and urban encroachments into the floodplain.

The West Branch of the Santa Cruz River preserves much of the vegetation and floodplain geometry of the historic river prior to incision, however it is very drought-stressed due to the lowering of the water table and cessation of irrigated agriculture in the vicinity.

Below the Roger Road Wastewater Treatment Facility, effluent discharges, a new flood control levee, and gravel mining alter hydrology and water quality. The effluent-dominated reach has several stands dominated by Goodding willow and tamarisk. Cottonwoods are present near the ADOT gravel pit, near Roger Road outfall. These stands are generally supported by surface flows. When the location of the flows shift, the stands can die, so the more mature trees are often found near locations where the channel stability is higher. The effluent-dominated reach has a high rate of ground water pumping (PAG 2000). The water table is generally greater than 50 feet. Bullfrogs and mosquito fish are known to occur here.

Soldier Canyon. An important tributary of Agua Caliente Wash, due to its size and origin at higher elevations in the National Forest. Largely undeveloped, except for a few residences in the lower reach. Mesquite dominated xeroriparian vegetation. No recent pygmy owl, leopard frog or fish occurrences are known.

Tanque Verde Creek, Tucson (1986-2001). The bottomland vegetation, bank stability and hydrology of this watercourse have been substantially altered by agriculture, groundwater pumping and urban development. A mesquite bosque is stressed, due to a decline in groundwater pumping in the reach below Wentworth Road (Stromberg et al., 1991). Upstream, groundwater levels have remained relatively shallow. Vegetation densities are higher upstream of Agua Caliente Wash than downstream. One of the best stands of cottonwoods is near the Tanque Verde Guest Ranch. These cottonwoods showed yellowing leaves in August 2000. Near here, spring flows have been diverted to serve a lake. Compared to Sabino and Bear Canyon, downstream of the National Forest, Tanque Verde below the Forest is much more heavily used for human residences, recreation and transportation needs.

Fires in the mid-1990s have eliminated many stands of mesquite and the old cottonwoods near the Pantano confluence. Horse grazing has destroyed understory structure in many areas. Off-road vehicular use degrades it elsewhere, where the mesquites have not yet been. Elderberry is a component of the mesquite woodlands, as is soapberry and hackberry. Cottonwood recruitment occurred in the 1980s and early 1990s in portions of the channel, particularly the soil-cemented reach between Tanque Verde Road bridge and the Sabino Canyon confluence, and the reach upstream of Wentworth Road. Channelization for urban development has reduced the floodplain, particularly downstream of Sabino Canyon Road. Upstream of Tanque Verde Road, informal levees of earth and dumped concrete are common. Acquisition of land or easements, reduction of vehicular use, removal of levees, and reductions in diversions or outright augmentation of natural water supply would be needed to reduce further losses.

In the National Forest, cottonwoods and Goodding willow are largely absent. Ash and sycamore are more common along with oak. Riparian conditions are up (USFS, 1999).

Fish are known to occur, and include the Gila topminnow as well as non-native species (Tom Skinner, pers. comm.). No recent pygmy owl occurrences are known. Leopard frogs have been sighted by the author in one privately-owned location, although no breeding population is known to occur along the stream. Lowland leopard frogs formerly abounded along this stream.

Ventana Canyon (1990-2000). In general, vegetation volume predicted by NDVI values is higher than most other Catalina foothills washes. A small, dense forest of Goodding willow trees is present at Sunrise Road. A few young cottonwoods and tamarisk are also present, as is a mesquite bosque. The channel bed is bouldery and the sediments are partially cemented by natural deposition. The floodplain and riparian corridor is encroached by urban development and roadway construction. Elsewhere, vegetation is xeroriparian, including acacia, mesquite blue palo verde. No recent pygmy owl, leopard frog or fish occurrences are known.

Yuma Mine Wash, Silvercroft Wash and other washes of the Tucson piedmont (1986-2002). Bottomland vegetation is increasingly altered by urbanization effects, including roadway construction and non-native species. The Silvercroft Wash system, particularly on the State land adjacent to Tumamoc Hill, has the highest vegetation volume, possibly due to increased urban runoff. Bank stability is generally good because of the nature of the material into which the watercourses are incised. Increasingly, the distributary flow zones where the washes join the Santa Cruz Valley are channelized. Vegetation is Sonoran desert scrub. Common trees include mesquite, catclaw acacia and ironwood. There are known pygmy owl occurrences at the north end of the Tucson Mountains. There are no leopard frog or fish occurrences.

Tortolita Piedmont Subarea

Alamo Canyon (D. Hall, pers. comm., 2000). Willow and cottonwood trees are dominant. Ash is absent or rare, as are sycamore and walnut. Mesquite is common. Intermittent section is short and centered around 3,400 ft elevation. Leopard Frogs were last seen in 1993 and are presumed to be extinct from this canyon after many subsequent surveys have failed to find them here. No recent pygmy owl or fish occurrences are known.

Big Wash, Oro Valley. This stream possesses a broad, braided valley floor, except where encroachments associated with the Rancho Vistoso development have occurred. This watershed is subject to a great deal of future development. Vegetation is xeroriparian. No recent pygmy owl, fish or leopard frog occurrences are known.

Cañada del Oro. Downstream of Catalina State Park, much of the formerly braided channel has been encroached, leveed, and channelized. Upstream of Catalina State Park, the channel form is affected by small-scale levees and encroachments associated with single-lot development. Vegetation is xeroriparian, and locally includes ironwood trees in the vicinity of Overton and La Canada roads. Individual walnut and hackberry trees are present in the Catalina reach (Tom Helfrich, pers. comm, 2002.). Xeroriparian vegetation downstream of La Canada Boulevard is less dense than upstream. No recent pygmy owl, fish or leopard frog occurrences are known.

Cargodera Canyon, Santa Catalina Mountains (D. Hall, pers. comm., 2000). Ephemeral outside of the National Forest. The lower reaches of the stream are mesquite dominated with desert willow. Lowland leopard frogs disappeared after a 1989 drought (Rosen, 2000). No recent pygmy owl or fish occurrences are known.

Cottonwood and Derrio Washes, Tortolita Mountains (1986-2002). The upper watershed

is largely undeveloped, and used for grazing. The valleys are deeply embedded into Pleistocene deposits. The channel form is largely braided and unaltered except by the Central Arizona Project Canal, which impedes flow. Vegetation is low density scrub. Recent pygmy owl occurrences are known. No leopard frog or fish occurrences are known.

Honey Bee Canyon, Tortolita Piedmont (1986). Goodding willow is the dominant broadleaf tree. A mesquite bosque and a breached dam are present at the lower end. Cattle were excluded in the 1990s, and levels of pedestrian-based recreation are increasing. The adjacent uplands are developed or will be developed for urban residential uses. No recent pygmy owl, fish or leopard frog occurrences are known.

Montrose Canyon. Ash, willow, and cottonwood dominate. Walnut and sycamore are rare. Hackberry and mesquite are common. This is the least disturbed riparian area on the west side of the Santa Catalina Mountains. Leopard frogs are common throughout, as are all obligate riparian herpetofauna (D. Hall, pers. comm., 2000). The lowland leopard frog population appears to be in the throes of a major, new disease epidemic (Rosen, 2000) No introduced fish species. Cattle have been excluded from the area for at least the past 20 years.

Romero Canyon (Rosen, 2000). This canyon is often visited by hikers. Lowland leopard frogs were present in this canyon around 1980, but were gone by 1986 or 1987, while green sunfish were abundant. Removal of green sunfish is needed. Lowland leopard frogs from adjoining Montrose Canyon may occur. This site might be considered as a native fish site (longfin dace, Gila chubs, Gila topminnows).

Prospect, Canada Agua, and Hardy Wash (1986-2000). The upper part of these watercourses have tributary flow. Channels are narrow and incised into Pleistocene alluvial deposits. Many of the watercourses have altered banks due to roadway construction and urban floodplain encroachment. The lower reaches typically exhibit distributary flow; increasingly, the hydrology of these areas is greatly altered by flood control structures and urbanization. Vegetation is similar to adjacent desert scrub, but denser. The Hardy Wash has generally higher vegetation volumes, but there are small areas of denser vegetation on upper reaches of Prospect and Canada Agua Washes. Recent pygmy owl occurrences are known. No leopard frog or fish occurrences are known.

Santa Cruz River (1999-2002). The bottomland vegetation, bank stability and hydrology of this watercourse have been substantially altered by agriculture, gravel mining, bank protection, levees, channel straightening, off-road vehicles, overgrazing, effluent discharges and urban encroachments into the floodplain. Many paved roads provide access.

The effluent-dominated reach has several dense stands dominated by Goodding willow and tamarisk. Cottonwoods are present near Avra Valley Road. These stands are supported by surface flows, not the groundwater table. When the location of the flows shift, the stands can die, so the more mature trees are often found near locations where the channel stability is higher. The water table is generally greater than 200 feet deep.

Bullfrogs and mosquito fish are known to occur here. There are no known pygmy owl observations.

Sutherland Wash. A wash with areas of distributary flow, dense mesquite bosque and grassland outside the National Forest (Fuller, 1988). Low density residential development is beginning to fragment bottomland vegetation. An area known as The Cottonwoods (area just west of Baby Jesus ridge) has a large and healthy gallery forest of cottonwood and hackberry. Below here are isolated patches of willow and cottonwood, as well as at least one seep with some sycamore trees (just above confluence of Cargodera stream). This wash may function as a corridor for dispersion between canyons for Sonoran Mud Turtles, Canyon Tree Frogs, and Lowland Leopard Frogs (D.Hall, pers. comm., 2000). No recent pygmy owl or fish occurrences are known.

Wild Burro, Ruelas and Cochie systems, outside Tortolita Mountain Park (1986-2000). Flow conditions along these watercourses are different from those to the south, due to the prevalence of distributary flow and sheet flow conditions, lower degree urbanization, and presence of the Central Arizona Project canal. The CAP berm impedes and channelizes flows in the lowermost piedmont. The piedmont is characterized by low relief, and very recent alluvial deposition. Most of the piedmont below the CAP canal is mapped as an alluvial fan flood hazard zone. Vegetation is low density xeroriparian. Recent pygmy owl occurrences are known. No leopard frog or fish occurrences are known.

Altar Valley Subarea

Altar Wash below Buenos Aires NWR. The bottomland vegetation, bank stability and hydrology of this watercourse have been substantially altered by historic incision, vegetation clearing for pasture, overgrazing, and roadway construction. According to NRCS (1992), sheet and all erosion account for a majority of the total erosion within the watershed. Stream channel erosion is most pronounced in the reach between Highway 86 and Highway 286. The uplands are being managed for livestock grazing and perpetuation of fire. Vegetation is denser on upper reaches. There are remnant sacaton bottomlands but they have been incised and mixed with Johnson grass. There are no recent pygmy owl, leopard frog or fish occurrences.

Arivaca Creek (2000). The hydrology of this watercourse have been substantially altered by upstream impoundments. Bank stability is good, in part due to lack of large flows. Roadway access and ranchette development is fragmenting bottomland vegetation. A variety of plant communities including sacaton, mesquite bosque, and stand of ash, cottonwood and Goodding willow forest. Elderberries are present in small numbers. Closed canopy; good regeneration (AGFD, 2000). Riparian condition is down (USFS, 1999). Recent pygmy owl occurrences are known. Mosquitofish, sunfish, bass, and crayfish are known (Rosen, 2000). Originally, the site supported a very large population of Chiricahua leopard frogs, and may also have had lowland leopard frogs, at least at times. It also had a Mexican garter snake population, probably a very large one. Now, bullfrogs are extremely abundant at the site, leopard frogs and Mexican garter snakes are extinct (Rosen, 2000). Recent pygmy owl observations are known (HDMS, 2001).

Brown Canyon (1997-1999) (Brian Powell, pers, comm.). Bottomland vegetation, bank stability and hydrology are intact. The lower canyon (from where Brown Canyon enters into the Altar Wash) has dense thickets of velvet mesquite trees (*Prosopis velutina*), netleaf hackberry (*Celtis reticulata*) and spinescent shrubs such as desert hackberry (*Celtis pallida*),

mimosa (*Mimosa spp.*), and acacia (*Acacia spp.*). The riparian area in this zone contained dense thickets of shrubs including gray thorn (*Ziziphus obtusifolia*), desert olive (*Forestiera shrevei*), wolfberry (Lycium spp.), and seep willow (*Baccharis salicifolia*) Sycamore (Platanus wrightii)enters the picture about 1.5 km downshtream from the Harm house. Sycamore are found along the entire stream, but only in a few places do they form dense stands. For the most part they are mature trees with huge crowns. There are only two or three areas that have any recruitment (from perhaps 5-10 years ago); young, even-aged (linear) stands of trees, many of which are dying. The xeroriparian stands are, in some places in the lower canyon, completely impenetrable. In a few, isolated areas, there are willows (desert or Gooddings?) The upper canyon is Madrean Evergreen Woodland dominated by three species of oak: Arizona white (Quercus arizonica), Mexican blue (Q. oblongifolia), and Emory (Q.emoryi) as well as Arizona walnut (Juglans major) and sycamore. There seems to be a moderate amount of recruitment of walnut trees. Also note that Jaguar Canyon, which flows into Brown above the lodge, also has some sycamore trees. There is no longer cattle grazing in the formal anywhere in the canyon, but there are feral cattle, and the refuge has given up trying to catch these animals.

Cedar Canyon. Bottomland vegetation, bank stability and hydrology are intact. This is an undeveloped tributary of Papalote Wash vegetation. Riparian include young ash and willow, with mature ash, willow-cottonwood mesquite, juniper and hackberry. Trend of riparian condition is down (USFS, 1999). There are no recent fish, frog or pygmy owl occurrences.

Los Encinos Canyon. Bottomland vegetation, bank stability and hydrology are intact. The watershed is undeveloped. Vegetation includes riparian oaks and sycamore trees (Dennis Suhre, pers. comm.) There are no recent fish or pygmy owl occurrences.

Fraguita Wash, near Arivaca (2001). Bottomland vegetation, bank stability and hydrology are intact This gravel-bed stream has one of the largest riparian decidous forests in Pima County, dominated by ash trees in the reach downstream of the National Forest. However, the canopy is not closed and there is relatively little recruitment of ash. There are a number of young hackberry. Seepwillow is abundant, along with annuals and lovegrass. Deergrass is not common. Flow is interrupted intermittently and in places, bedrock constrains the movement of the channel. This channel, along with Yellow Jacket Wash, received a large flood in the summer of 1992 (Francine Pierce, per. comm.). There is a rough road along the terrace, but otherwise few developments of any sort. There are some small mineral prospects on adjacent hillsides. There are no recent fish or pygmy owl occurrences.

Mendoza Canyon, Coyote Mountains. Bottomland vegetation, bank stability and hydrology are intact. The wash has dense thickets of mesquite. The watershed is undeveloped. Recent pygmy owl occurrences are known, but no frogs or fish.

Oro Blanco and Tonkin Wash Confluence (2000). A floodplain of annuals and isolated hackberries, where many of the mesquites were removed at some time in the past (Nathan Sayre, pers. comm.). Bank stability and hydrology are intact. Along Oro Blanco Wash, there are old ash trees with young ash, hackberry and mesquite. Interestingly, hackberry occurs high above the stream bed on rocky north-facing slopes, a pattern which is not

uncommon in the Arivaca area. The site is grazed, but there is evidence of recruitment. Yew-leafed willow and yellow-billed cuckoo is present. The rancher recently closed the road along the creek bottom (S. Chilton, pers. comm.). There are no recent fish or pygmy owl occurrences.

Peñitas Wash and Champurrado Wash. Bottomland vegetation is intact, but there is evidence of bank instability on some tributaries. Mesquite woodland and xeroriparian vegetation is among the densest of the east-side tributaries of Altar Wash. Lowland leopard frogs were found as recently as the early 1980's and might still occur. Recent fish and pygmy owl occurrences are not known.

Proctor and Batamote Washes. These tributaries of Sopori Wash have denser xeroriparian vegetation than most of the others of the southeastern flank of the Sierrita Mountains. Bottomland vegetation includes small patches of mesquite bosque, which are desiccating due to streambed incision. The watersheds are undeveloped and are used for grazing. There are no recent fish, leopard frog or pygmy owl occurrences.

San Luis, Fresnal, Canoa, Wilbur Canyon, SE margin of Altar Valley. These washes are embedded in a landscape with high biodiversity. These are among some of the few drainages in this area that support significant riparian resources. A major effort is underway at BANWR to re-establish and preserve the Chiricahua and lowland leopard frog (see Rosen 2000), with efforts centered at Cumero Mountain and San Luis Wash for bullfrog control. Alamito Tank, Las Encinas Tank, and Unnamed Upper San Luis Canyon Tank, around the east and north flank of Cumero Mountain, are of particular conservation interest. There are no recent fish observations, but pygmy owl occurrences are known.

Thomas Canyon (1997-1999). Bottomland vegetation, bank stability and hydrology are intact. The watershed is undeveloped. This stream has a few sycamore trees down in the lower part of the canyon (Brian Powell, pers. communication). Downstream of Reservation boundary, for approximately one mile, there are pockets of sycamore with good regeneration (AGFD, 2000) There is no evidence of exotics (AGFD, 2000).

Upper Santa Cruz Subarea

Fagan, Franco Wash, Flato Wash and Other Tributaries of Lee Moore Wash, Santa Rita Piedmont. The bottomland vegetation, bank stability and hydrology of these watercourses have been altered by severe local grazing, roadway construction, aggregate mining and stock tank development, but the floodplains have not yet incised. Future urban floodplain encroachments and roadway developments will probably cause channel entrenchment. If this occurs, the discharge of vast quantities of sediment will further de-stabilize downstream reaches of Lee Moore Wash and the Santa Cruz River near Martinez Hill.

Vegetation includes tobosa grasslands, desert scrub and mesquite thickets. The densest vegetation is found on lower Fagan Wash below Cuprite Wash, upstream of Lee Moore Wash. No recent pygmy owl, leopard frog or fish occurrences are known.

Madera Canyon. The bottomland vegetation, bank stability and hydrology of this watercourse is largely unaltered. Bottomland vegetation includes ash and cottonwood just

below the National Forest, and becomes xeroriparian scrub downstream. Recreational use levels within the National Forest is high. No recent pygmy owl or fish occurrences are known. Chiricahua leopard frog occurs nearby.

Lee Moore Wash. Bottomland vegetation, bank stability and hydrology of this watercourse have been severely altered by agriculture, roadway and groundwater depletion. There is very little vegetation. No recent pygmy owl, leopard frog or fish occurrences are known.

Santa Cruz River (1986-2002). Bottomland vegetation is greatly altered by agriculture, urbanization, and groundwater pumping. Bank stability is poor, and hydrology is altered by flood control efforts and groundwater pumping. Effluent discharges at Canoa Ranch also change hydrology and water quality. Some cottonwood saplings and obligate riparian vegetation is found in the effluent-dominated reach, but in general the channel is sparsely vegetation, with burrobrush and tumbleweed as the dominant species throughout the subregion.

Sopori Wash (2000). The bottomland vegetation of this watercourse, which is largely mesquite forest, has been cleared in places for pasture or other forms of agriculture. There is evidence of bank instability. Potential for future development is high due to proximity of the Arivaca Road. Goodding willow, ash, and hackberry occur in association with Elias Spring #1. The majority of the cottonwood groves are in Santa Cruz County in association with the Batamote Wash confluence and Elias Spring #2. No recent pygmy owl or fish occurrences are known.

Papalote Wash and tributaries (2002). The bottomland vegetation, bank stability and hydrology of this watercourse is largely unaltered in the upper reaches. The proximity to paved roads is lower than along Sopori Wash. Like Arivaca Creek and upper Cienega Creek, Papalote Wash possesses an extensive, unincised sacaton grassland. Smaller areas of mesquite-hackberry exist outside the National Forest boundaries. Single-lot rural development is beginning to fragment bottomland vegetation. No recent pygmy owl, leopard frog or fish occurrences are known. Exotic fish are known in at least one permanent tank.

Sycamore Wash, Santa Ritas (2001). Bottomland vegetation and hydrology are intact. This stream shows evidence of increased channel instability. Channel bank widening from recent flows is removing adjoining mesquite and hackberry trees. Isolated mature ash, walnut and cottonwood trees amidst burrobrush and Bebbia with little evidence of tree recruitment in the lower reaches below and just above the National Forest boundary. There are intermittent flows in the bedrock reaches near the National Forest boundary. An inactive limestone quarry is located in the bed of the channel. No recent pygmy owl, leopard frog or fish occurrences are known.

Shamrod Spring, Santa Ritas (2000). Ash with oak, Carex ultra and Rhus choriophylla. At times, water from one spring is diverted. Direct livestock use is minimal due to the steep, rocky slopes. No recent pygmy owl, leopard frog or fish occurrences are known.

Avra Subarea

Black Wash. Black Wash has one of the largest mesquite bosques in Pima County. Bottomland vegetation is increasingly fragmented by residential construction, and wood cutting. Bank stability is relatively good, but likely to change greatly as the result of development occurring in the watershed, which is diverting and channeling flow and increasing the percentage of impervious cover. Roadways are also changing the hydrology. No recent pygmy owl, fish or leopard frog occurrences are known.

Blanco Wash (1990-2001). The bottomland vegetation, bank stability and hydrology of this watercourse have been substantially altered by agriculture. No recent pygmy owl, leopard frog or fish occurrences are known.

Brawley Wash/Los Robles. The bottomland vegetation, bank stability and hydrology of this watercourse have been substantially altered by agriculture. Brawley Wash is mapped as having an extensive mesquite bosque, but much of it is rather low density and short canopy structure. No recent pygmy owl, leopard frog or fish occurrences are known.

Cocio Wash (1999-2001). Hydrology of this watershed has been severely disrupted by mining. This watercourse used to have perennial pools with leopard frogs and native fish, as recently as the 1980's. The perennial portion is now ephemeral. Tamarisk dominates some of the riparian area. Recreational and mining use is increasing. This wash still has some of the densest vegetation in the area.

Aguirre Subarea

Aguirre Wash System, Aguirre Valley. Bottomland vegetation is largely intact; however, agriculture and livestock grazing have modified the vegetation in places. Floodplain conditions are complex and relatively intact; evidently this area has not become entrenched as have so many other axial valley floor drainages. Aerial photographs and a brief field visit suggests the possibility that there are stabilized dunes in the valley floor. Aguirre Wash is mapped as having an extensive mesquite bosque, but there is no information about its ecological condition. No recent pygmy owl, fish or leopard frog occurrences are known.

Western Pima County

Cuerda de Leña Wash, near Why. Watershed hydrology is intact. This watercourse has some of the densest riparian vegetation outside protected areas within western Pima County. The structural diversity offered by tall palo verde trees, draped with vines and surrounded by desert shrubs, at times rivals a mesquite bosque. Grazing and a growing amount of recreational vehicle traffic is affecting bank stability and bottomland vegetation. The floodplain is broad, complex and slightly entrenched.

Sikort Chuapo, Rio Cornez: Bottomland vegetation and hydrology are intact, and bank stability is generally good. This riparian system lies at the bottom of the broad valley that extends from Why north beyond the community of Ajo. Sikort Chuapo, a wash originating on the Tohono O'Odham Nation, flows into Rio Cornez, and has higher vegetation densities

than the reach of Rio Cornez upstream of their mutual confluence. There is a traditional picnic ground along Rio Cornez near the Ajo Airport, and several roads and wells in the vicinity.

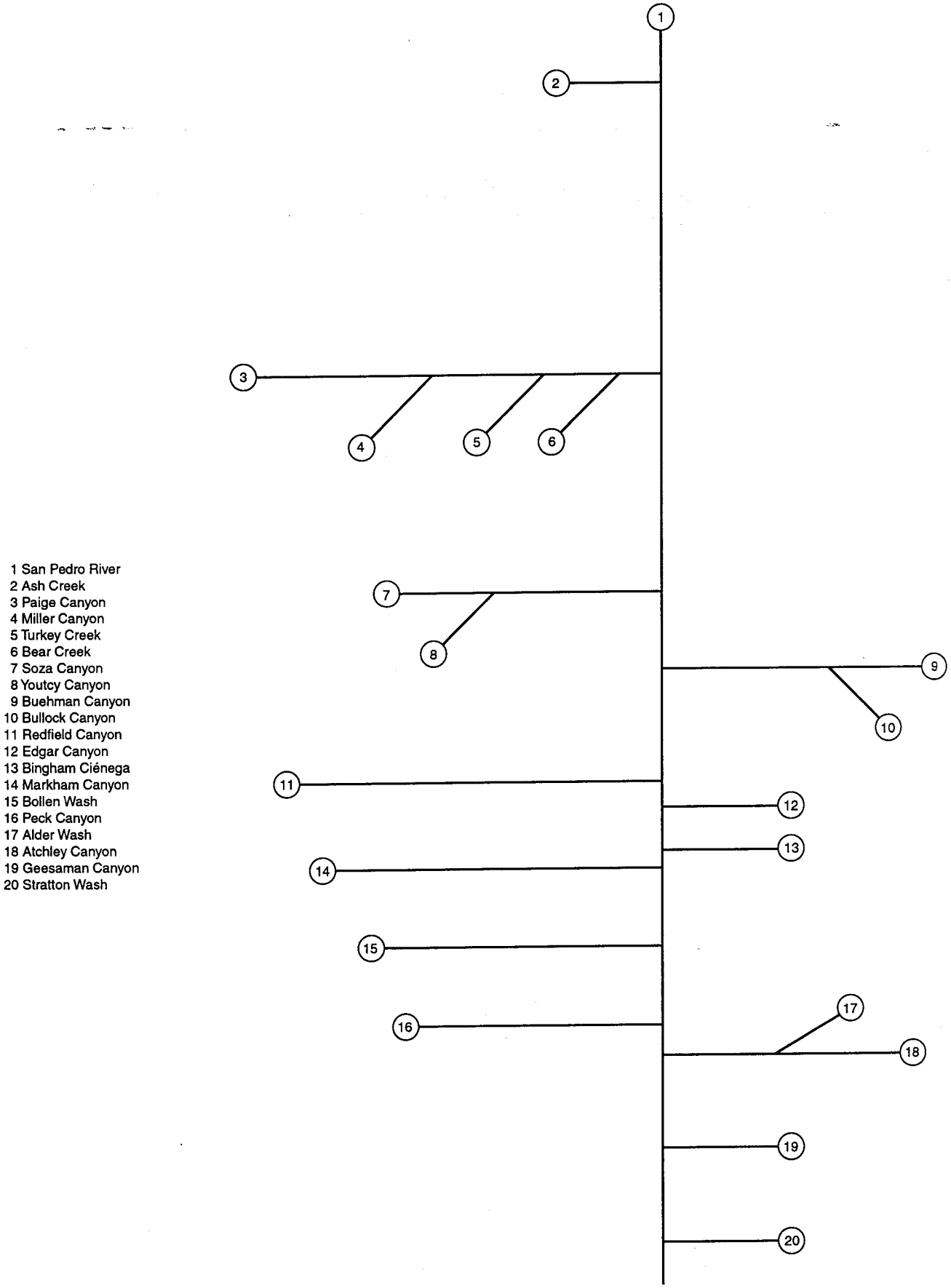

Figure B1 San Pedro River Basin Topology (Pima County portion)

1 Redrock Canyon Wash
2 Barrel Canyon Wash
3 Agua Verde Creek
4 Chimenea Canyon Wash
5 Agua Caliente Wash
6 Sabino Creek
7 Ventana Canyon Wash
8 Sycamore Canyon Wash
9 Nogales Wash
10 Harshaw Creek
11 Temporal Gulch
12 Alum Canyon Wash
13 Ash Canyon Wash
14 Fresno Canyon Wash
15 Bond Canyon Wash
16 Alamo Canyon Wash
17 Papalote Wash
18 Sardina Canyon Wash
19 Batamote Wash
20 Proctor Wash
21 Gardner Canyon Wash
22 Springwater Canyon Wash
23 Empire Gulch
24 Apache Canyon Wash
25 Wakefield Canyon Wash
26 Mescal Arroyo
27 Davidson Canyon Wash
28 Posta Quemada Canyon
29 Rincon Creek
30 Tanque Verde Creek
31 Finger Rock Canyon
32 Pima Wash
33 Sutherland Wash
34 Big Wash
35 Mowry Wash
36 Adams Canyon Wash
37 Parker Canyon Wash
38 Bodie Canyon Wash
39 Los Negros Wash
40 Providencia Canyon Wash
41 Portrero Creek
42 Sonoita Creek
43 Agua Fria Canyon Wash
44 Peck Canyon Wash
45 Josephine Canyon Wash
46 Cottonwood Canyon Wash
47 Montosa Canyon Wash
48 Sopori Wash
49 Madera Canyon Wash
50 Esperanza Wash
51 Sawmill Canyon Wash
52 Sycamore Canyon Wash
53 Franco Wash
54 New West Branch
55 Rodeo Wash
56 Julian Wash
57 Old West Branch
58 Cienega Creek
59 Cañada del Oro
60 Santa Cruz River

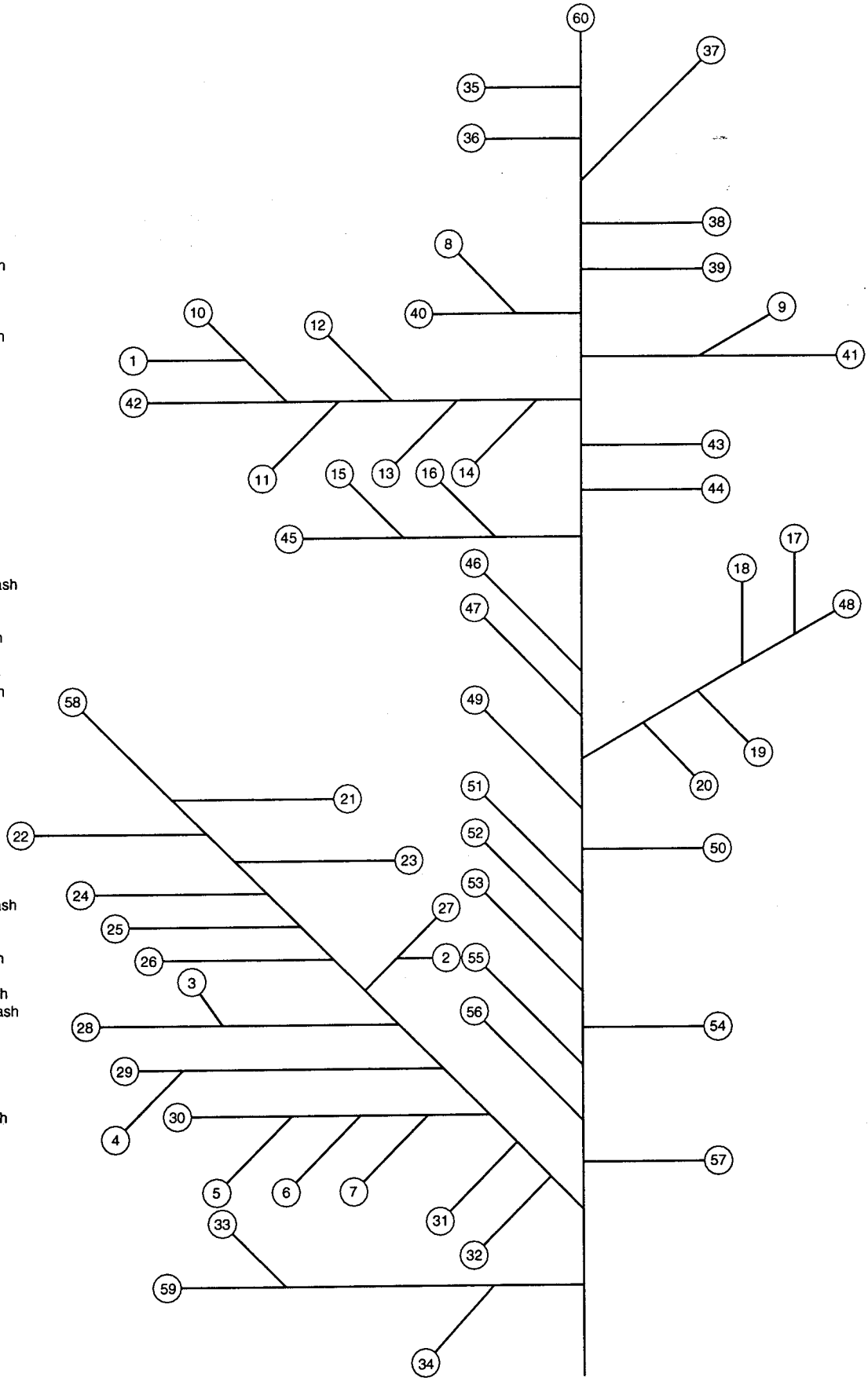

Figure B2 Santa Cruz River Basin Topology.

1 Arroyo del Compartido
2 Lopez Wash
3 Bailey Wash
4 Los Encinos Wash
5 Las Moras Wash
6 Santa Margarita Wash
7 Arivaca Wash
8 Oro Blanco Wash
9 Yellow Jacket Wash
10 Fraguita Wash
11 San Luis Wash
12 Las Guijas Wash
13 Thomas Canyon
14 Arroyo Seco
15 Bolas Blancas Wash
16 Peñitas Wash
17 Champurrado Wash
18 San Miguel Wash
19 San Juan Wash
20 Cerro Prieto Wash
21 Sabino Wash
22 Fresno Wash
23 Alambre Wash
24 Fresnal Canyon
25 Mendoza Wash
26 Black Wash
27 Blanco Wash
28 Cocio Wash
29 Los Robles Wash

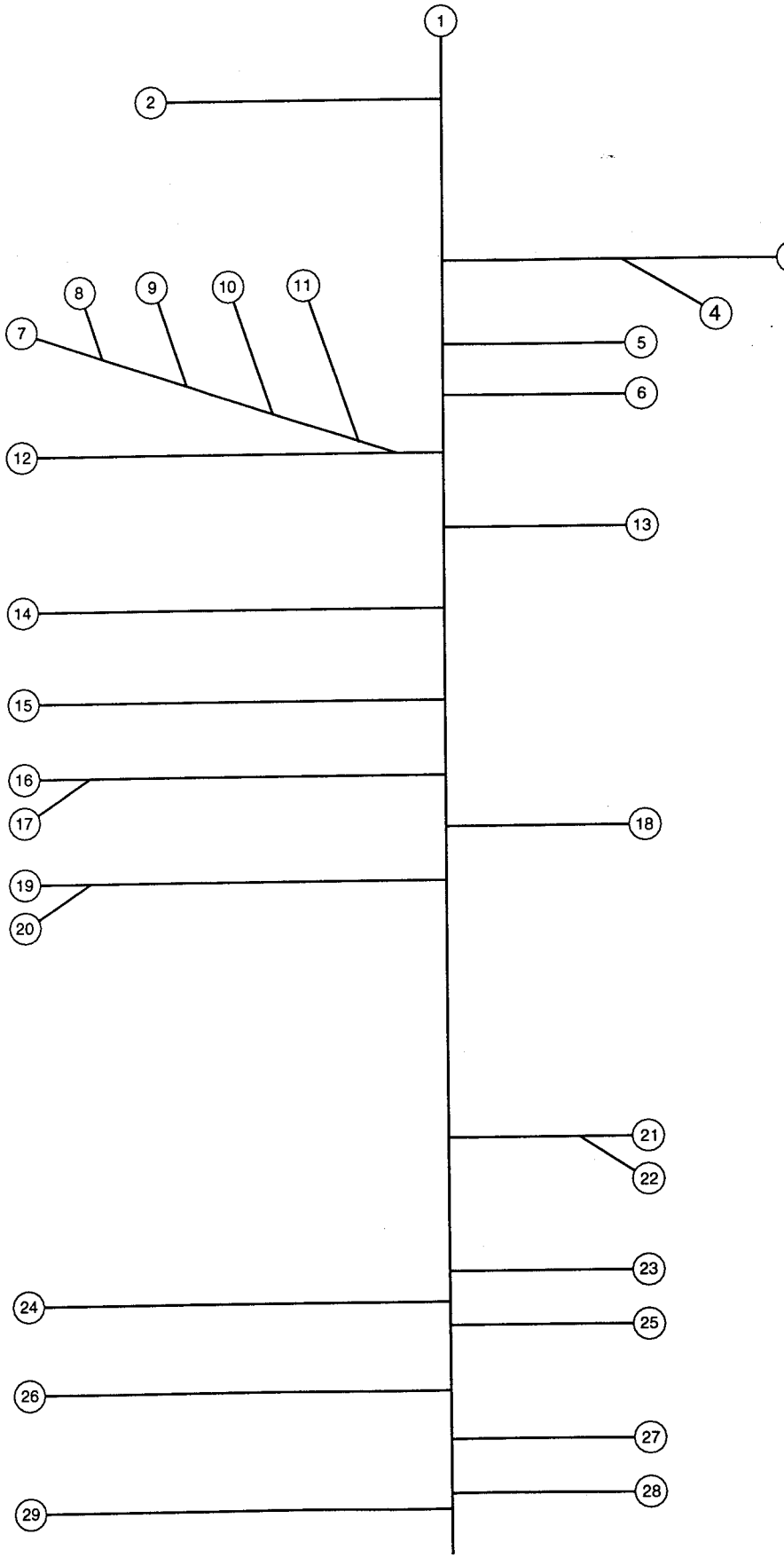

Figure B3 Los Robles Basin Topology

Appendix C

Some Common Names of Native Plants and Animals of Hydromesoriparian Areas in Pima County, Arizona

Scientific Name	Common Name
Baccharis glutinosa	Seepwillow
Cephalanthus occidentalis	Common Button Bush
Distichlis spicata	Desert Saltgrass
Fraxinus velutina	Velvet Ash
Hymenoclea monogyra	Burrobrush
Juglans major	Walnut
Muhlenbergia rigens	Deergrass
Platanus wrightii	Sycamore
Populus fremontii	Cottonwood, Fremont cottonwood
Prosopis velutina	Velvet Mesquite
Salix exigua	Coyote Willow
Salix gooddingii	Goodding Willow
Salix taxifolia	Yew-leafed Willow
Sambucus mexicana	Elderberry, Mexican Elder
Sapindus drummondii	Western Soapberry