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SOUTHERN ARIZONA RIPARIAN HABITAT: SPATIAL DISTRIBUTION AND ANALYSIS

by

John R. Lacey, Phil R. Ogden, and Kennith E. Foster

A Report of Work Performed Jointly Under
NASA Grant No. NGL 03-002-313 and the
School of Renewable Natural Resources
College of Agriculture, University of Arizona

In Cooperation with
the Natural Resources Committee
Arizona State Senate

SCHOOL OF RENEWABLE NATURAL RESOURCES
AND
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University of Arizona
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John R. Lacey
Research Associate
School of Renewable Natural Resources
College of Agriculture
The University of Arizona

Phil R. Ogden
Professor
School of Renewable Natural Resources
College of Agriculture
University of Arizona

Kennith E. Foster
Assistant Director
Office of Arid Lands Studies
University of Arizona

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FOREWORD

This Bulletin is published in furtherance of the purposes of NASA grant NGL 03-002-313 entitled "Application of Remote Sensing to State and Local Government." The purpose of the grant is to assist, with the use of NASA high-altitude photography and satellite imagery, state and local agencies whose responsibility lies in planning, zoning, and environmental monitoring and/or assessment.

This report is the eighth in a series of publications designed to present information bearing on remote sensing application in Arizona. This study details the interdisciplinary efforts of the 1974 Natural Resources Committee, Arizona State Senate, the School of Renewable Natural Resources, University of Arizona, and the NASA grant to utilize remote sensing techniques to inventory and assess management needs of Southern Arizona's unique riparian habitat.

Arizona recognizes the need for statewide land-use planning, and the foundation for such planning has been laid by the state Environmental Planning Commission. During 1975 legislation was introduced calling for delineation of areas of environmental concern.

The authors feel that within Arizona's riparian habitat there are such areas, and that this study may provide basic data for state land-use planning which will include the recognition and resulting policy decisions needed to manage this unique vegetation resource.

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INTRODUCTION

Southwestern United States riparian habitats provide a main source of water to man and other animals, forage for livestock, habitat for wildlife, wood products for man, and soil and water for farming; and because of this diversity, conflicts of interests frequently occur among users of the limited riparian lands.

The Arizona State Senate Committee on Natural Resources and Environment introduced in 1974 Senate Bill 1049 providing for the protection by the State Land Commissioner of water courses and riparian environment on state-trust lands. Although not yet passed by the Arizona legislature, such a bill could have far-reaching consequences on the future management of vegetation communities adjacent to major drainages in the State. Proper adjudication of uses regulated by such a bill immediately requires that an inventory of riparian vegetation be made to provide data on the kinds and locations of riparian habitat to be regulated.

Objectives

The objectives of this study were sevenfold, but basically centered around the demonstration of remote sensing as an inventory tool and completion of a comprehensive literature review documenting the multiple uses of riparian vegetation.

Specific study objectives included:

1. Map riparian vegetation along the following stream channels:
    a. Gila River (Solomon, Arizona to New Mexico border)
    b. San Simon Creek (Solomon, Arizona to New Mexico border)
    c. San Pedro River (within Cochise County)
    d. Pantano Wash (Sonoita, Arizona to Tucson, Arizona);
2. Determine the feasibility of automated mapping using LANDSAT-1 computer compatible tapes;
3. Locate and summarize existing maps delineating riparian vegetation;
4. Summarize published data relevant to Southern Arizona's riparian products and uses;
5. Document recent riparian vegetation changes along a selected portion of the San Pedro River;
6. Summarize published literature documenting historical changes in composition and distribution of riparian vegetation; and
7. Summarize sources of available photography pertinent to Southern Arizona.

Riparian Habitat Definition

Riparian vegetation was well defined by Lowe (1964), "A riparian association of any kind is one which occurs in or adjacent to drainageways and/or their floodplains and which is further characterized by species and/or life forms different from that of the immediately surrounding nonriparian climax." Campbell and Green (1968) recognized an obligatory relationship between the riparian plant and its site and delineated a facultative relationship where "woody plants can complete their life cycle on relatively xeric or mesic sites, but which respond to more mesic conditions with greater growth and density." They explained that pseudoriparian species remain geographically confined "and neither migrate upstream nor downstream beyond major vegetation types of adjacent slopes." Campbell and Green's (1968) original usage of pseudoriparian terminology has been recently enlarged by Brown and Lowe (In Review) to include extensions of higher elevation, more mesic climax associations fingering downward in drainageways. An extension of oak woodlands into Southwestern Arizona's plains and desert grasslands is an example of their pseudoriparian vegetation. This report makes no attempt to separate pseudoriparian from riparian vegetation.

Phreatophytes were defined by Meinzer (1923) as plants that obtain their water from the zone of saturation, whether directly or through the capillary fringe; thus are usually found growing along streambanks or on floodplains and playas (Pacific Southwest Interagency Committee, 1958). Some studies (Robinson, 1958, 1961 and 1967; Muckel, 1966; and Blaney, 1958) have distinguished phreatophytes from riparian vegetation, and as late as 1972 Horton made the distinction that riparian plants depend largely on flowing water rather than groundwater. A more recent report (Ffolliott and Thorud, 1974) recognized the problem of separating phreatophytes from riparian vegetation to be academic, and pointed out that there "is no clean division between shallow alluvial deposits in mountain streams for storage of groundwater and the deeper deposits in typical phreatophyte zones." Phreatophytes growing in channels and floodplains are considered as riparian vegetation in this Bulletin.

Communities within the riparian association can either be temporary and unstable or as permanent as the landscape drainage patterns which form its physical habitat. A dynamic vegetation is to be expected because the stream itself is dynamic, with aggradation and degradation proceeding simultaneously along various parts of the channel (Hastings, 1963).

MAPPING OF RIPARIAN VEGETATION

Methods and Procedures

Riparian vegetation in four drainage basins (Fig. 1) was mapped using high and medium altitude aerial photography as the primary data base. Photographic specifications are given below in Table 1.

Table 1. Drainages, photographic data sources and specifications for photography used in vegetation mapping.

DRAINAGE	FLIGHT	DATE	SOURCE	SCALE	FILM
Gila River (Solomon, Arizona to New Mexico border)	73-056	6 April 1973	NASA	1:31,680	Color IR
San Simon Creek (Solomon, Arizona to New Mexico border)	2 through 18	16 Oct. 1972 to 14 April 1973	BLM	1:25,000	BW
San Pedro River (Cochise County)	73-152 72-129	7 Sept. 1973 1 Aug. 1972	NASA NASA	1:125,000 1:125,000	Color IR Color IR
Pantano Wash-Cienega Creek (Sonoita, Arizona to Tucson, Arizona)	72-129	1 Aug. 1972	NASA	1:125,000	Color IR

The procedure used for mapping riparian communities was similar to that outlined by Horton, Robinson and McDonald (1964). Color infrared transparencies were examined individually and riparian communities were delineated on mylar overlays of the individual frames utilizing a binocular microscope and light table. Mylar overlays were also prepared for black and white photos. Delineations were made at the community level (in some cases into associations) using Brown and Lowe's (1974a) digitized classification system based on the natural criteria of moisture, temperature, and vegetation structure and composition. Delineated community boundaries were refined by observations from the ground and low level aircraft flights.

After final corrections were made on the vegetation maps, they were overlain on U.S. Geological Survey Topographic Maps and a dot grid was used to determine the area within sections occupied by each community. Riparian associations were difficult to delineate and tally on the 1:125,000-scale photography; thus, tabulated acreages should be interpreted in view of this limitation.

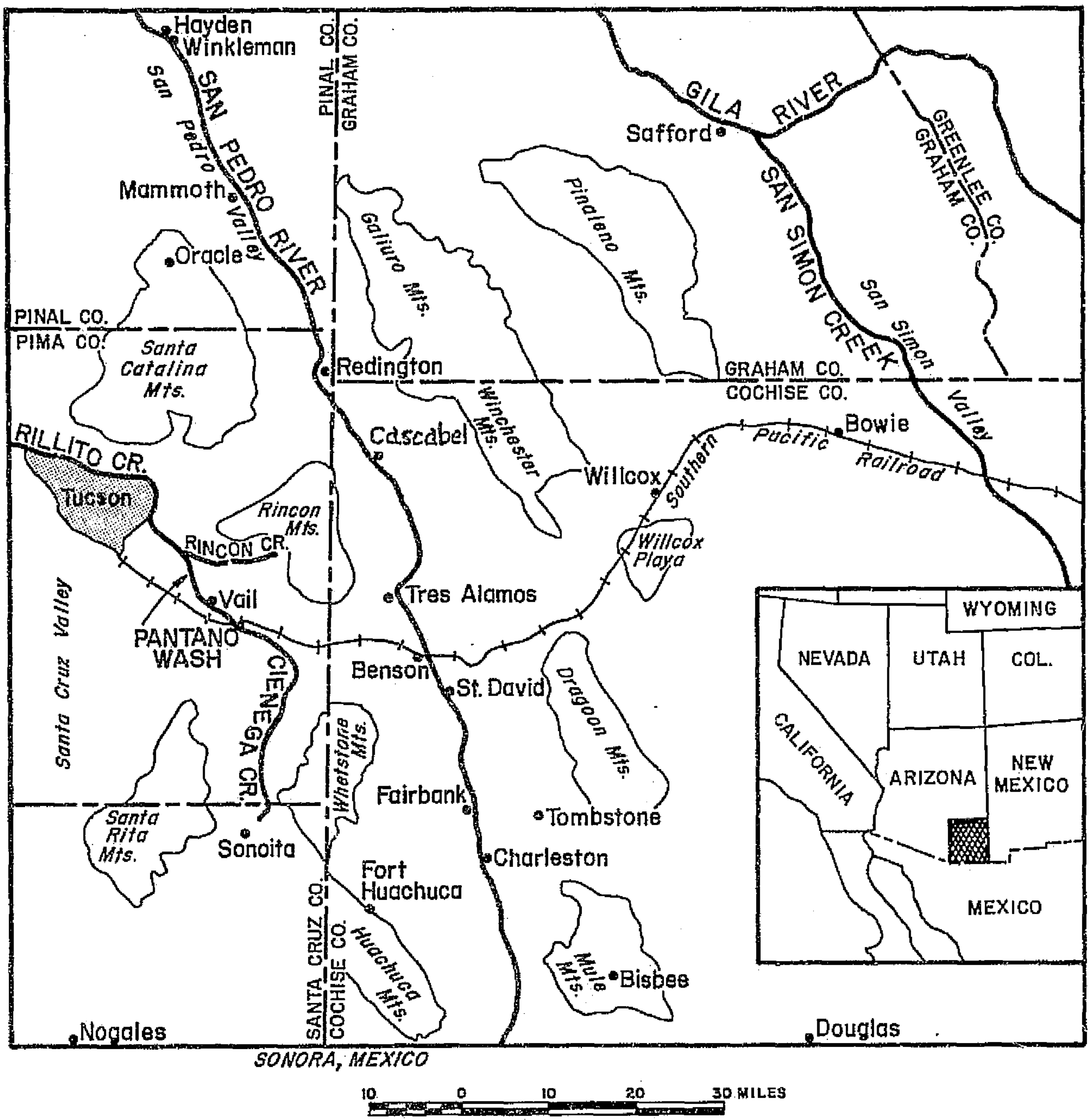

Figure 1. Riparian vegetation along the Gila River, San Simon Creek, San Pedro River and Pantano Wash-Cienega Creek was mapped using photo-interpretation techniques.

Riparian vegetation maps were developed at the contact scale of the photography available for the area. Thus the San Pedro and Pantano-Cienega drainages were developed at a scale of 1:125,000 and maps for the San Simon and upper Gila Rivers were drawn at respective scales of 1:25,000 and 1:31,680. All maps are reproduced for this publication, however, at a scale of 1:125,000 (1/2 inch = 1 mile).

Riparian vegetation on a test site along the lower Gila River near Dome, Arizona was automatically mapped using LANDSAT-1 satellite data in a digital format. This is a technique whereby reflected radiation sensed by the orbiting satellite is recorded on magnetic tape for computer analysis instead of being converted into a photographic product. The study area consisted of a 30-mile reach of the lower Gila River floodplain east of Yuma, Arizona, much of which has been converted to irrigated agricultural lands as part of the Wellton-Mohawk Irrigation District.

Historical changes in riparian vegetation were documented by a literature review. Actual changes during a 36-year period, along a 22-mile stretch of the San Pedro River were determined using a vegetation map derived from 1936 Soil Conservation Service black and white aerial photographs (scale 1:31,680), then compared to a vegetation map of the same area derived from 1973 NASA high-altitude photography (scale 1:125,000).

Riparian Community Descriptions

Based on the present investigation, and Brown and Lowe's (1974a) publication, the riparian vegetation was classified into nine plant communities (Table 2). Where associations within communities could be reliably delineated these were mapped, but all summary tables providing acreage of types by section are at the community level. Appendices B and C provide an alphabetical listing of common plant names equated to scientific names and an alphabetical listing of scientific names equated to common names, respectively. The authority for scientific names utilized in this Bulletin is Arizona Flora (Kearney and Peebles, 1969).

Cottonwood-Willow Community

This community was restricted to the more mesic sites and occurred primarily as a gallery forest along the channels or as small isolated stands in old channel bends (Fig. 2). Cottonwoods and willows produce short-lived

Table 5. Acres of riparian communities along the San Simon Creek from Solomon, Arizona to the New Mexico border, tabulated by geographic location and cover class.

	Township, Range and Section													
Community	T7S, R26E		T7S, R27E			T8S, R27E								
% Cover	24	25	30	31	32	5	4	9	10	15	22	23	26	35
Mesquite														
<25			84	38	26	44	8	56	2	50				6
26-50	12	13	66	27										
51-75	17	11												
>75														
Tamarisk														
<25				9	28					27				
26-50			18	1		48	50	75	36	6	83	2	61	62
51-75					5	10	11			1			4	11
>75														
Sacaton Grass														
<25														
26-50														
51-75														
>75														
Mixed Grass-Scrub														
<25														
26-50														
51-75														
>75														
Saltbush														
<25					117	162		49		26	20			12
26-50														
51-75														
>75														
Total	29	24	168	75	176	264	69	180	38	110	103	2	65	91

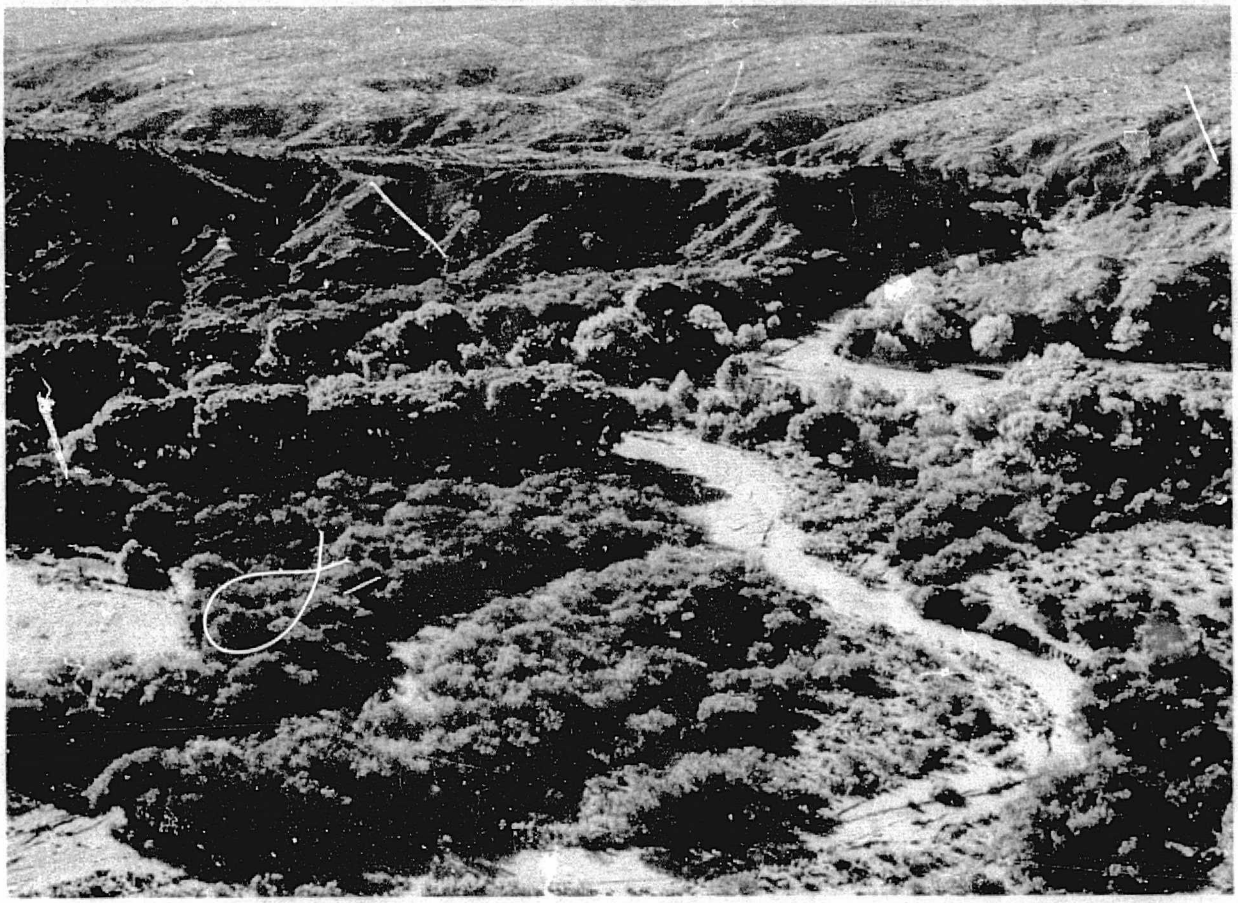

Figure 2. Cottonwood-Willow Communities form ribbon-like strands along the San Pedro River where soil moisture conditions are favorable.

seed only for short periods during spring, thus moisture during this time of year is essential for establishment (Horton, Mounts, and Kraft, 1960; Zimmerman, 1969; and Turner, 1974). Other riparian species were inadvertently lumped into the Cottonwood-Willow Community when maps were derived from the 1:125,000-scale photographs. For example, at this scale 1/8 square inch represents about 40 acres, an area much larger than the area covered by many of the existing stands.

Mesquite Bosque Community

Mesquite establishment is intolerant of a shallow groundwater table, and some channel cutting to lower the water table is beneficial (Hastings, 1963; Zimmerman, 1969; and Gavin, 1973). Thus, Mesquite Bosque Communities (Fig. 3) primarily occur on floodplains elevated above the current channel level. Because seed remain viable for long periods of time, mesquite can become established when environmental conditions become favorable (Gary, 1965). Although its roots are capable of growing to depths of 175 ft. (Phillips, 1963); Zimmerman's (1969) observations along the San Pedro River revealed that the bulk of the roots occurred within 25 ft. of the surface and coincided with groundwater depths of 45 ft. or less. Bosques are quickly replaced by open stands of shrubs in areas away from the river where the water table is deeper.

All riparian associations which had a dominant aspect of mesquite were classed as Mesquite Bosque Communities. Because of their importance, stands of large, dense mesquite were mapped as a separate association.

Tamarisk Community

Young Tamarisk (also called saltcedar) Communities were found primarily in the lowest bottomlands, on soils subject to varying periods of surface moisture (Fig. 4), or in areas of shallow groundwater. Older communities occurred above the lowest bottomlands, often in striated patterns which represent once-dependable streamflows (Fig. 5). First-year seedlings may produce seed, and saltcedar is a prolific seed producer (Horton et al., 1960; Zimmerman, 1969; and Turner, 1974). Although saltcedar usually germinates in saturated soil, seeds can germinate while floating on water (Horton et al., 1960). Because seed production occurs from March through October, seedlings are established during periods of spring and summer flow (Zimmerman, 1969; and Turner, 1974).

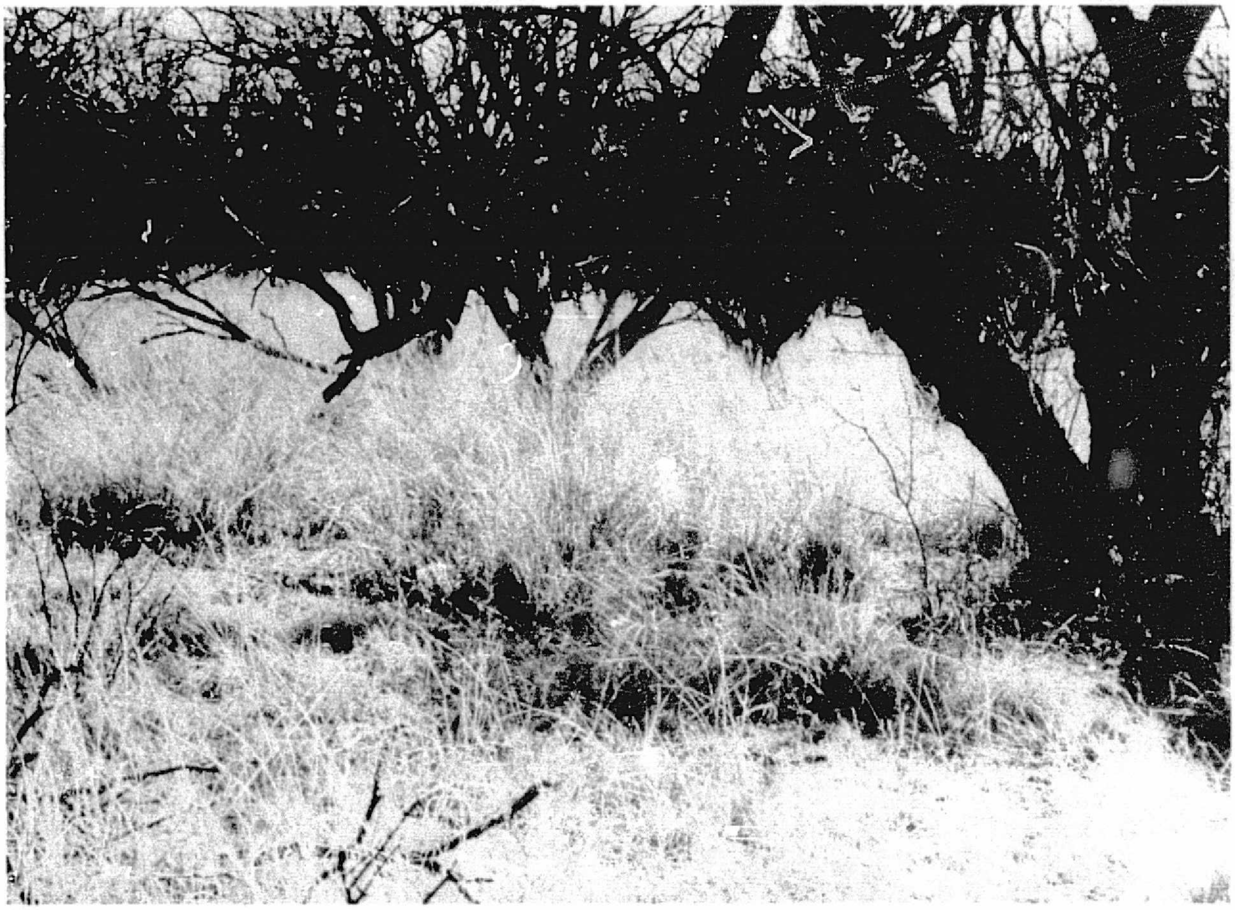

Figure 3. Mesquite Bosque Community along Upper Cienega Creek, Arizona.

Figure 4. Tamarisk along channel which receives periodic flow of water.

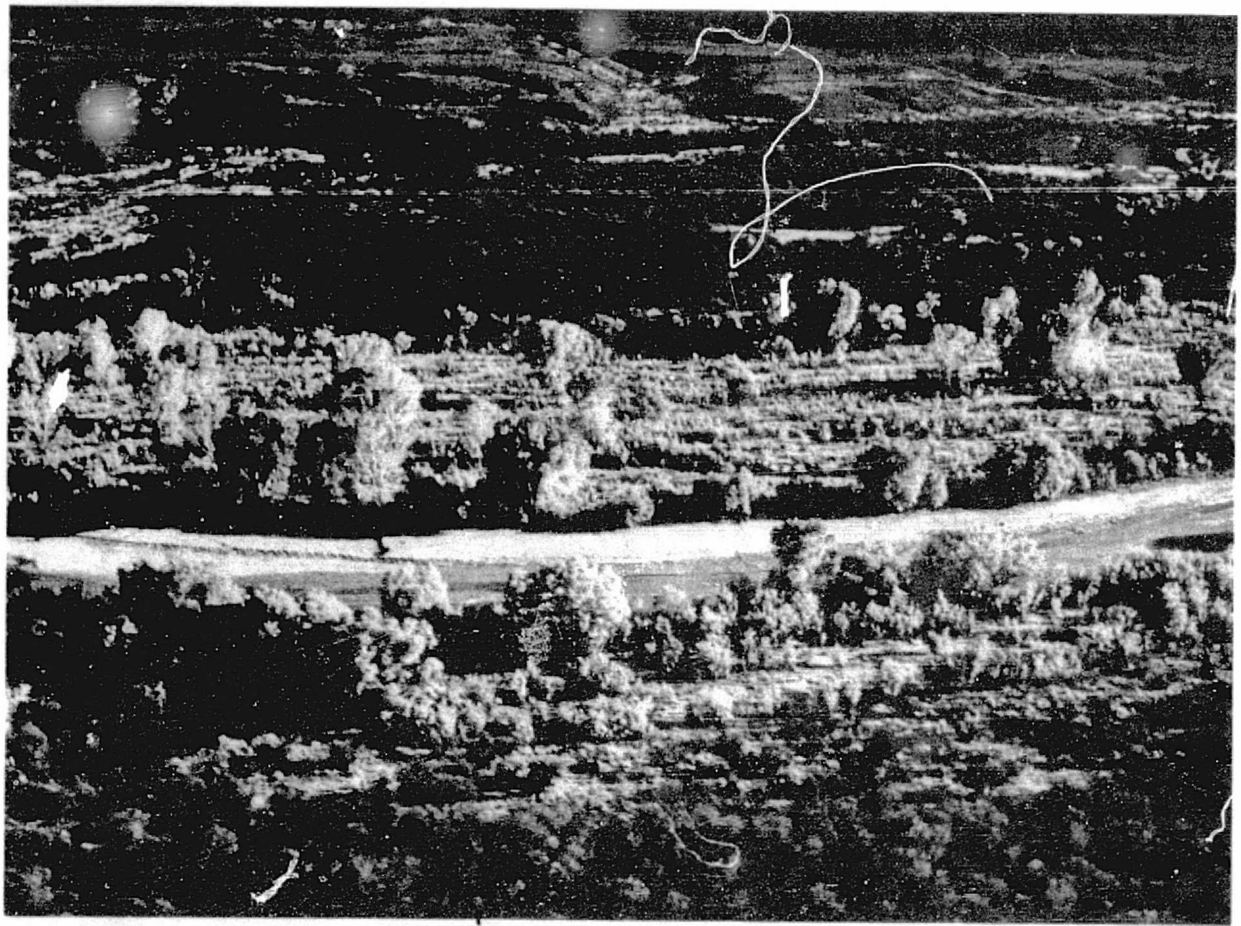

Figure 5. Striated vegetative pattern is the result of tamarisk establishment and coincides with former dependable San Pedro River flows.

Seep Willow-Broom, Mixed Scrub and Burrobrush Communities

The Riparian Scrub Biome includes species commonly occurring along stream channels: seep willow, desert broom, burrobrush (Fig. 6), saltcedar and desert willow. Communities were specified by the dominant species present. If, however, several of the previously listed species made up the community, the area was classified as a Mixed Scrub Community.

Germination conditions are favorable for burrobrush, desert broom, and desert willow on wide sandy channels that are disturbed by summer floods. These species may be intolerant of prolonged saturation of the superficial layers of the alluvium (Zimmerman, 1969). Seep willow, however, requires a sustained flow for germination and seedling establishment (Zimmerman, 1969; and Turner, 1974). Because of its shallow roots, it is restricted to shallow groundwater sites (Gary, 1965) and when mesquite and seep willow occur together, mesquite eventually dominates because it adapts to aggradation by sprouting, and seep willow is adversely affected by the loss of shallow water (Turner, 1974).

Sacaton Grass Community

This community is found primarily on floodplains characterized by a shallow groundwater table (Fig. 7). Successional stages along the San Pedro River ranged from recently-formed floodplains, with high water tables, where sacaton was replacing riparian scrub species, to older floodplains where channel cutting had lowered the water table and the less-vigorous sacaton was being replaced by mesquite.

Mixed Grass-Scrub Community

The Mixed Grass-Scrub Community was found in the San Simon Valley. A mixture of grasses and shrubs, native and introduced, dominate the site. Soil moisture and nutrient conditions are favorable, and productivity is high. Grass species include Johnson grass, tobosa, sacaton, vine mesquite and jungle rice. Shrubs are mesquite and tamarisk.

Saltbush Community

This community occurred on terraces along the upper Gila and San Simon Valleys (Fig. 8) and was often interspersed with mesquite associations.

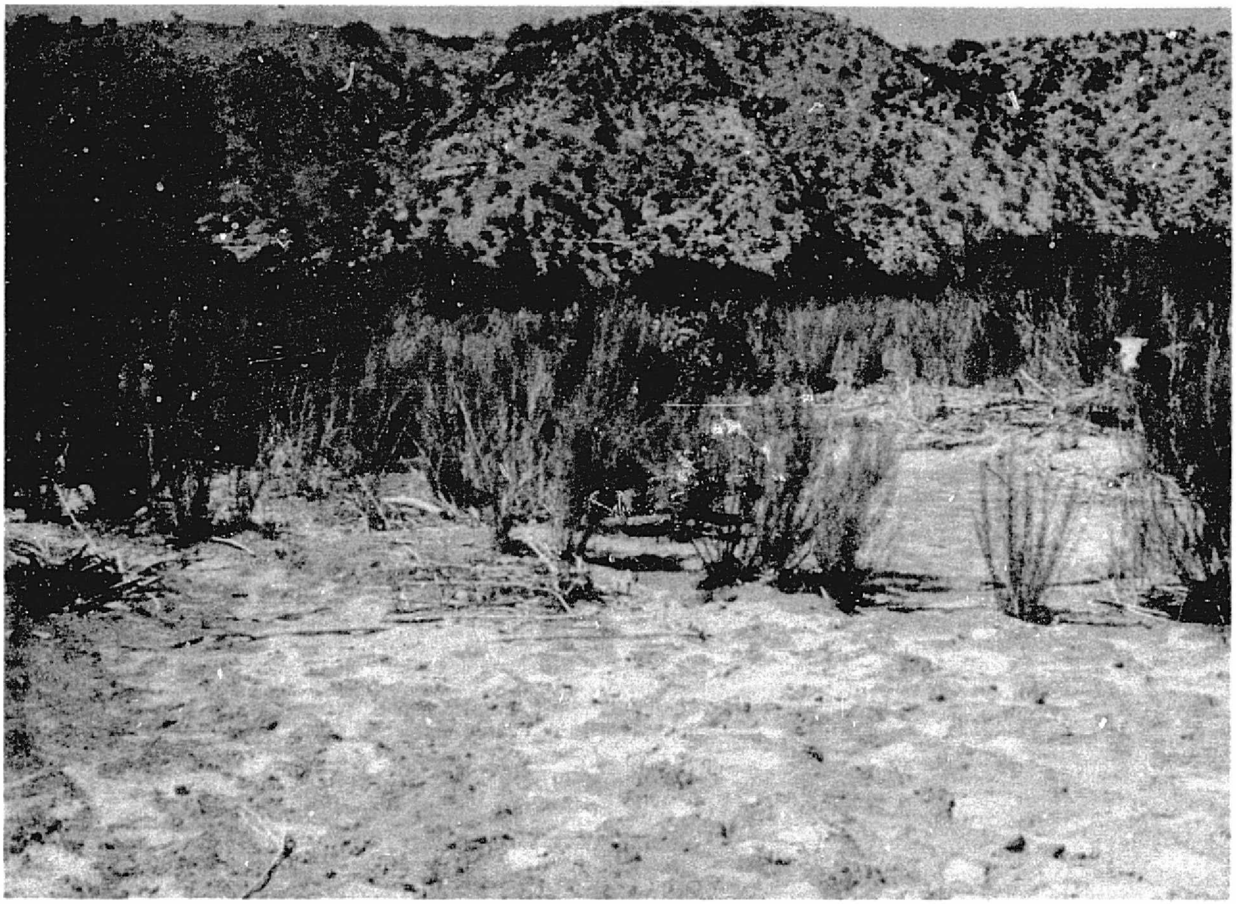

Figure 6. Burrobrush Community along Upper Gila River.

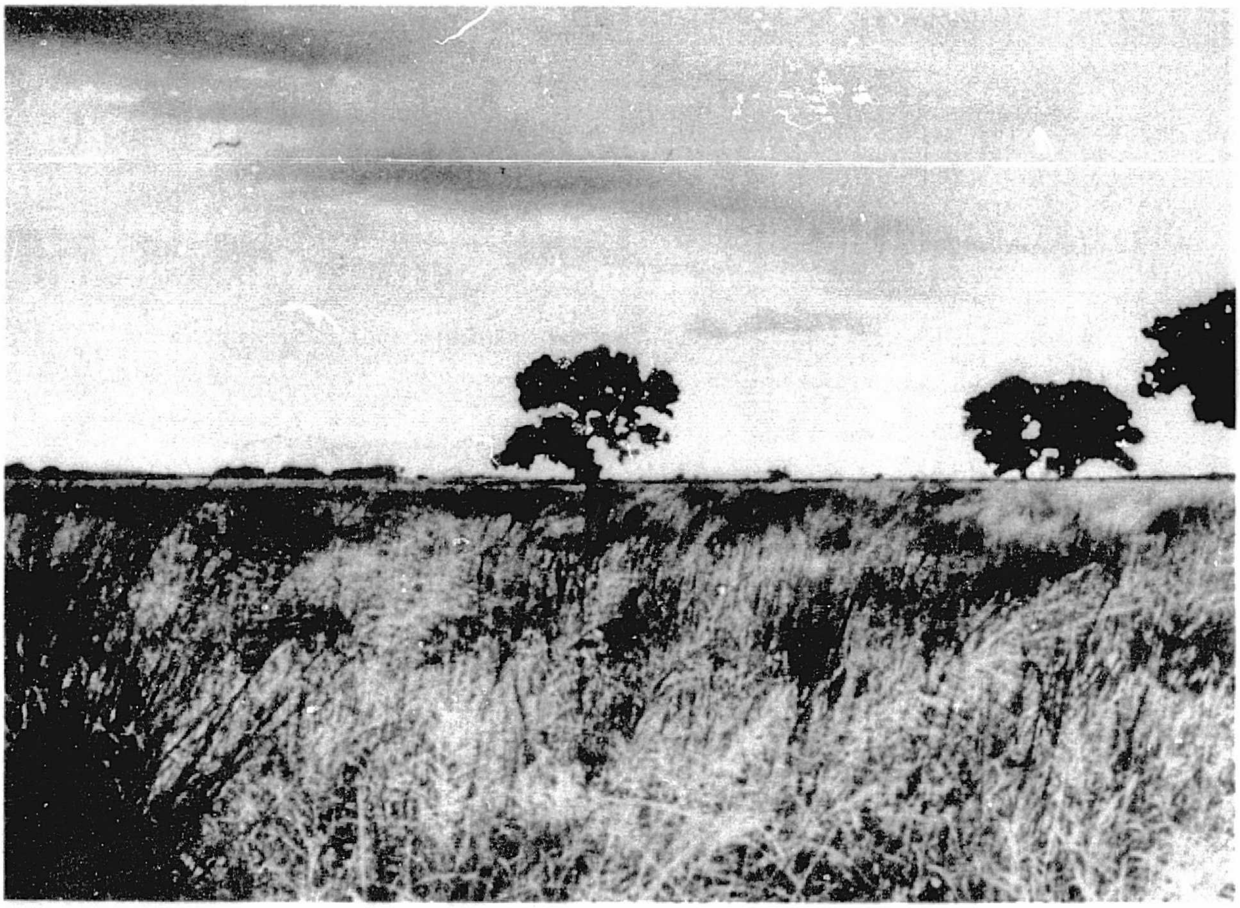

Figure 7. Sacaton Grass Community along San Pedro River.

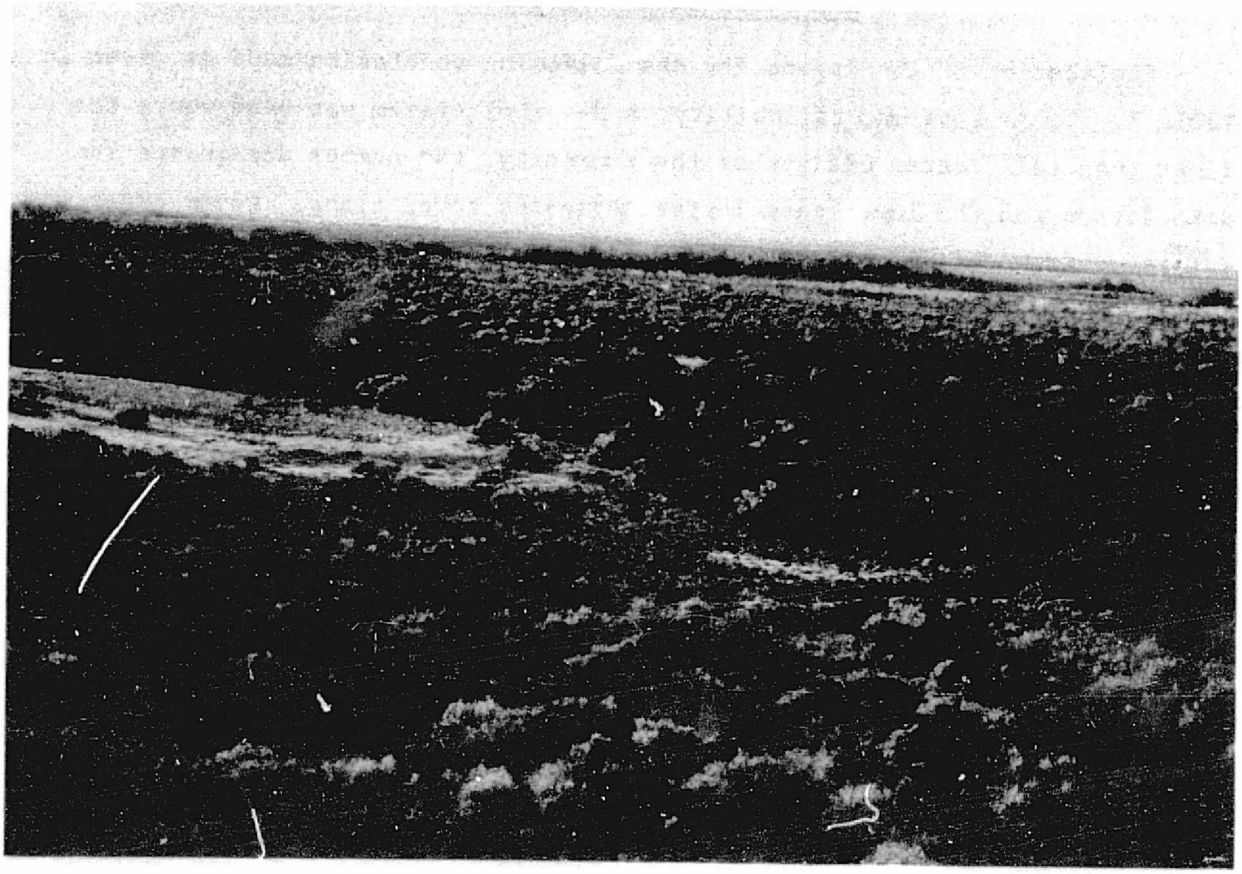

Figure 8. Saltbush Community along San Simon drainage.

Saltbush along the lower Gila River became interspersed with creosote bush and seepweed when soil conditions became drier and lighter, or more saline, respectively (Haase, 1972).

San Pedro River Vegetation

Explanation of the legend for the following vegetation maps is given in Table 3. To improve map readability, a 3-symbol system was used where the first (capital) letter designates the community, the number designates the association and the lower case letter indicates cover class. Cover class was estimated from aerial photographs and randomly checked in the field. The letters a, b, c, and d, denote cover classes of <25, 26-50, 51-75, and >75%, respectively.

Riparian communities along the main channel of the San Pedro River (within Cochise County) were mapped to the association level at a scale of 1:125,000 (Figs. 9a-9f) and are tabulated by acreages, geographic location and cover class (Table 4). The maps and tabular data are arranged to cover the river from north at the Pima County line south to the International Boundary.

Near 60 percent of the 18,700 riparian acres along the San Pedro River in Cochise County are dominated by mesquite (Table 4). Several successional stages of the mesquite community are delineated on Figs. 9a-9f. True mesquite bosque was designated as a separate association (B_6) because of its biological uniqueness. Many associations designated (B_1) have the potential to develop into bosques, if not cleared and the water table is not depleted. Bosques primarily occurred downstream from Charleston. Data in Table 4 shows that about 3600 acres are covered by mesquite with greater than 75 percent cover.

Sacaton communities dominate 2800 acres, mostly on floodplains south of Highway 90 to the International Boundary. Saltcedar primarily occurred north of Fairbanks; however, small stands do exist as far upstream as Palominas. On high-altitude (1:125,000) photography, small stands of saltcedar could not be accurately delineated and were often lumped into mixed riparian scrub communities; however, 870 acres of saltcedar were delineated. Many young saltcedar stands presently growing in the channel will mature; thus saltcedar acreage will increase in proportion to other riparian communities.

Table 3. Legend for communities and associations shown on maps and correlation with Brown and Lowe's (1974a) 5- and 6-digit classification for vegetation in the Southwest.

Map Symbol	Communities and/or Associations	Brown and Lowe Classification
A_0	Cottonwood-Willow Communities	322.32
A_1	<u>Populus fremonti-Salix</u> Mixed Broadleaf Assoc.	322.321
A_2	<u>Populus fremonti-Sporobolus</u> Associations	322.32-*
B_0	Mesquite Bosque Communities	333.11
B_1	<u>Prosopis juliflora</u> Associations	333.111
B_2	<u>Prosopis juliflora</u> Mixed Narrowleaf (e.g., <u>Tamarix pentandra</u>, <u>Chilopsis linearis</u>, <u>Celtis reticulata</u>) Associations	333.112
B_3	<u>Prosopis juliflora-Sporobolus</u> Associations	333.11-
B_4	<u>Prosopis juliflora-Atriplex</u> Associations	333.11-
B_5	<u>Prosopis juliflora-Baccharis</u> Associations	333.11-
B_6	<u>Prosopis juliflora</u> True Bosque Associations	333.11-
C_0	Tamarisk disclimax Communities	333.12
C_1	<u>Tamarix pentandra</u> Associations	333.121
C_2	<u>Tamarix-Prosopis</u> Associations	333.12-
C_3	<u>Tamarix-Salsola-Sorghum</u> Associations	333.12-
D_0	Channel with scattered Mixed Scrub Communities	342.43
D_1	Seep Willow-Broom Communities	342.42
D_2	Mixed Scrub (seep willow, burrobrush, and tamarisk) Communities	342.43
D_3	Burrobrush Communities	342.4-
E_0	Sacaton Grass Communities	352.23
E_1	<u>Sporobolus-Prosopis</u> Associations	352.23-
E_2	<u>Sporobolus-Populus</u> Associations	352.23-
E_3	<u>Sporobolus</u>-Scrub Associations	352.23-
F_0	Mixed Grass-Scrub Communities	352.35
G_0	Saltbush Communities	363.17

*Associations with dash in 6th digit position were not numbered by Brown and Lowe (1974a).

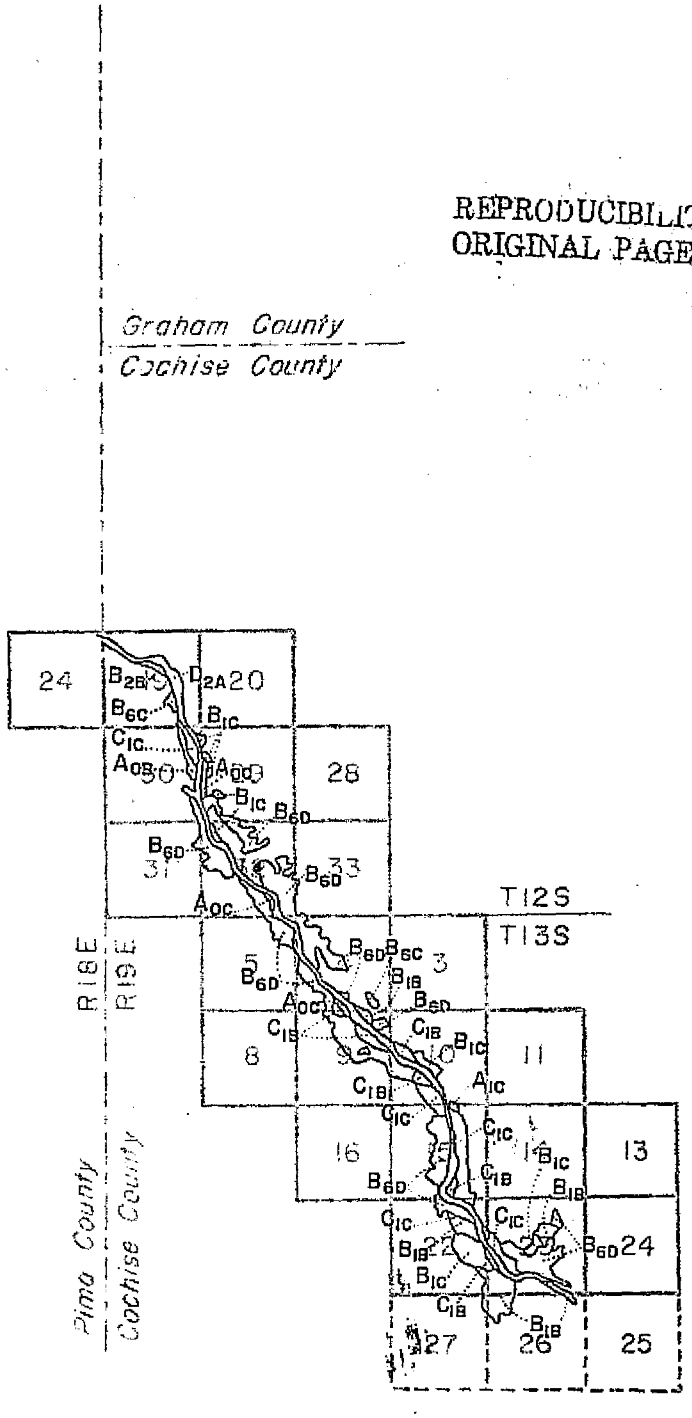

Figure 9a. Riparian vegetation map of Section A of the San Pedro River south from the Pima County line. See Table 3 for legend. Scale - 1:125,000.

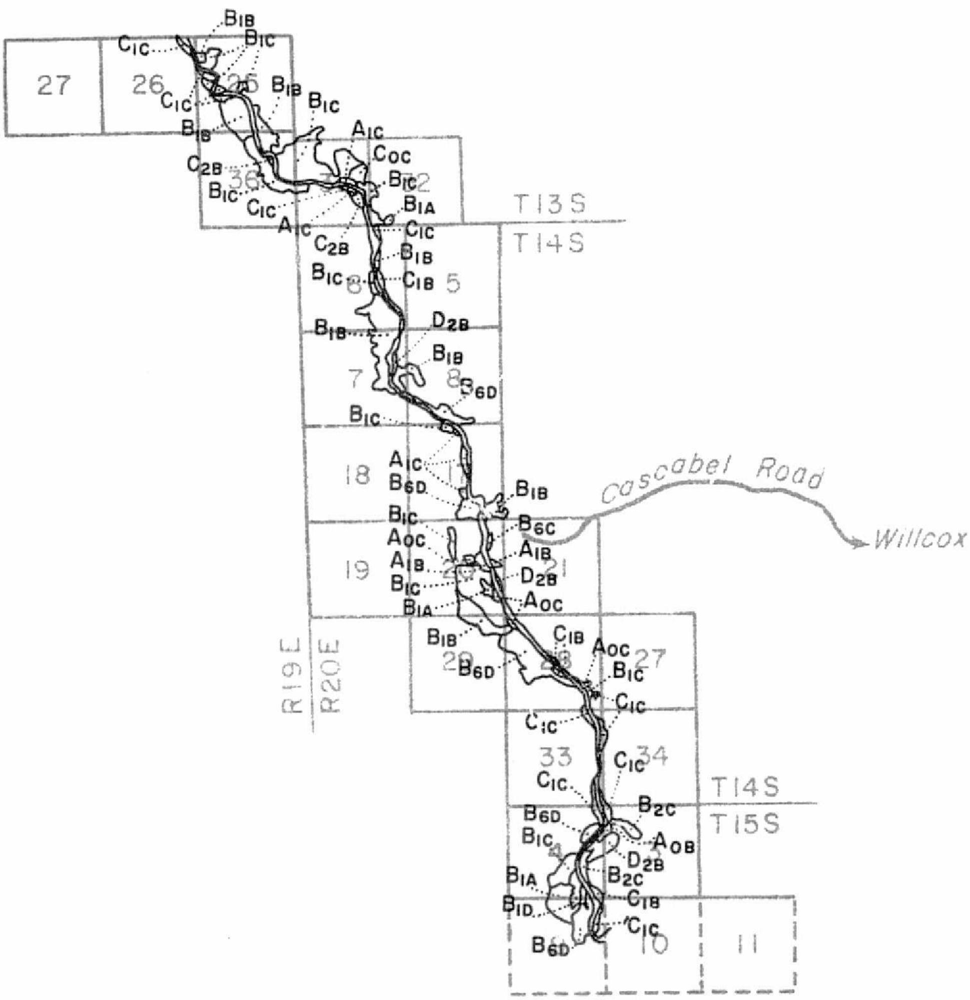

Figure 9b. Riparian vegetation map of Section B of the San Pedro River. See Table 3 for legend. Scale - 1:125,000.

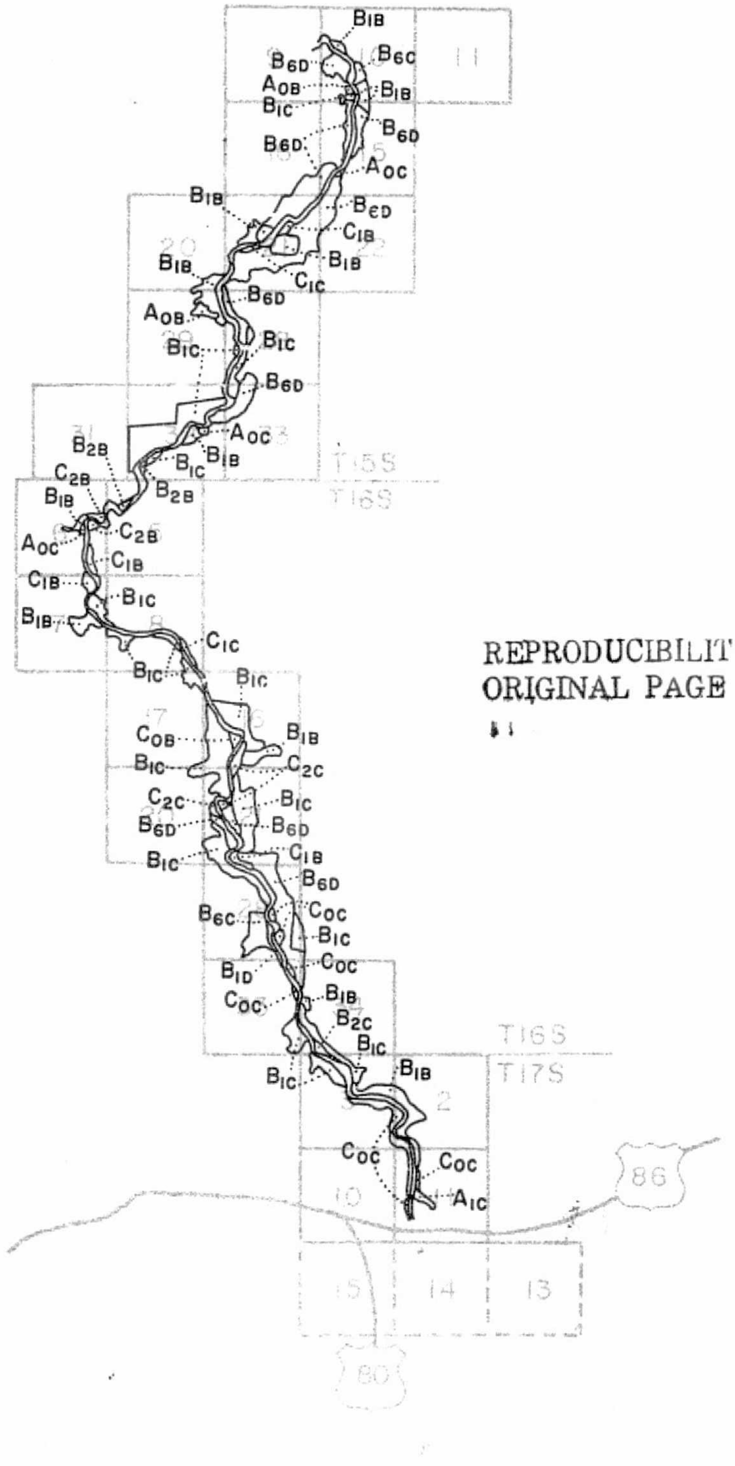

Figure 9c. Riparian vegetation map of Section C of the San Pedro River. See Table 3 for legend. Scale - 1:125,000.

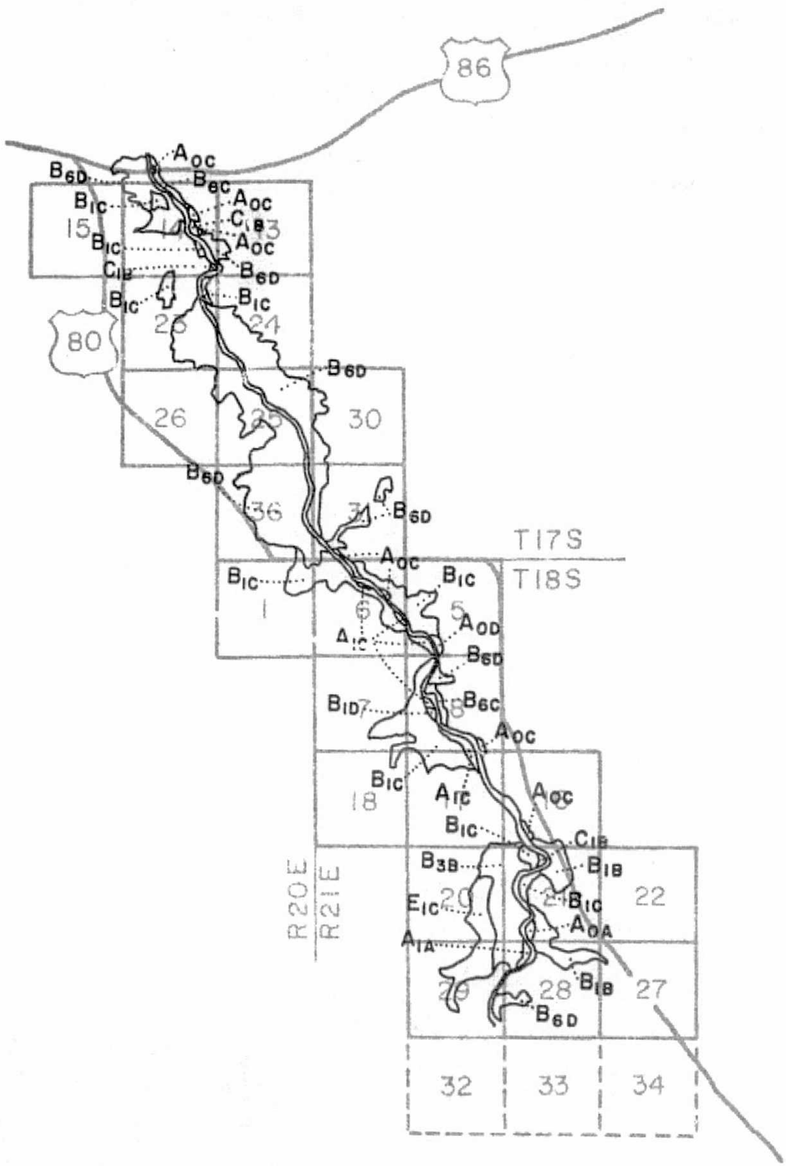

Figure 9d. Riparian vegetation map of Section D of the San Pedro River. See Table 3 for legend. Scale - 1:125,000.

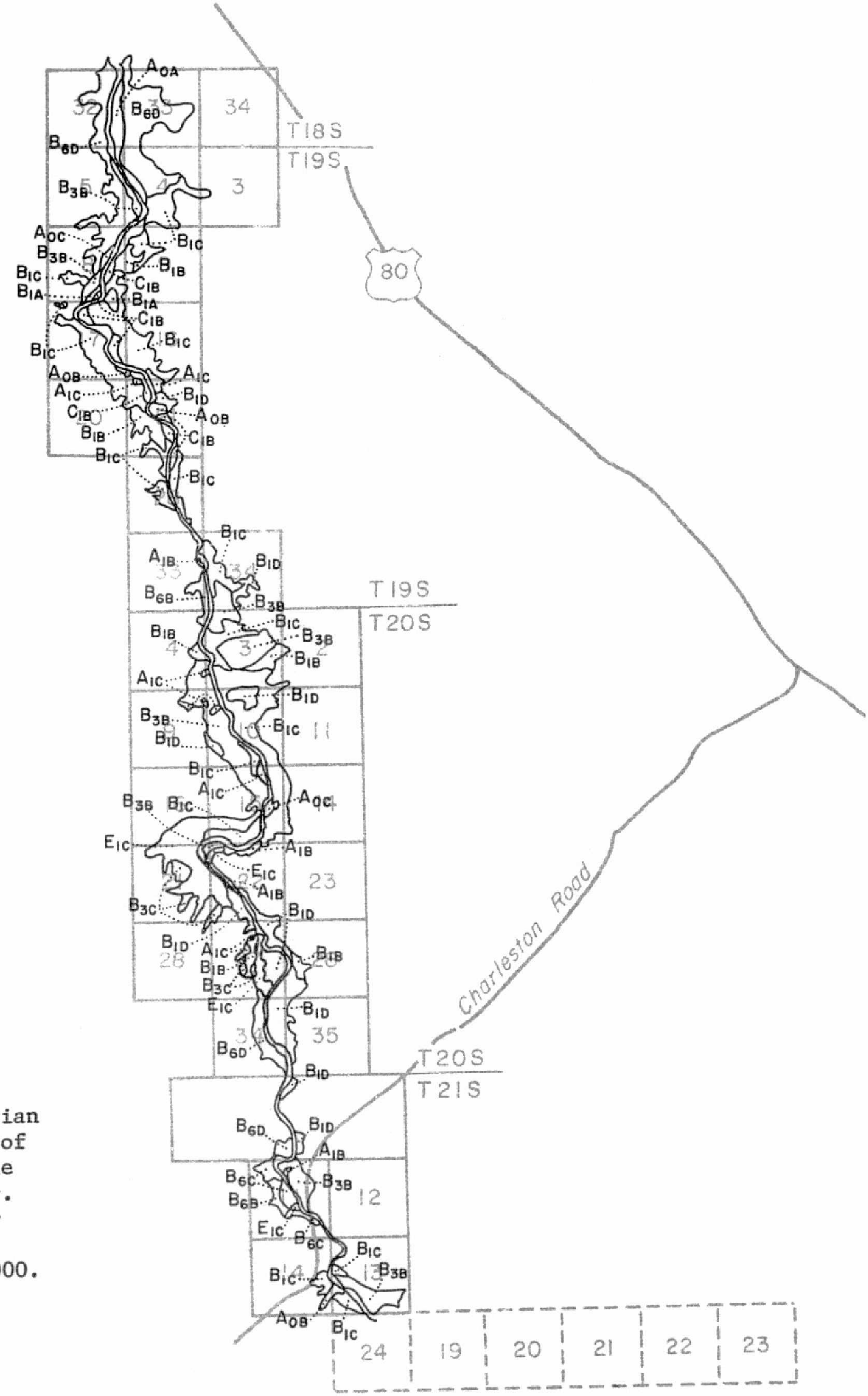

Figure 9e. Riparian vegetation map of Section E of the San Pedro River. See Table 3 for legend. Scale - 1:125,000.

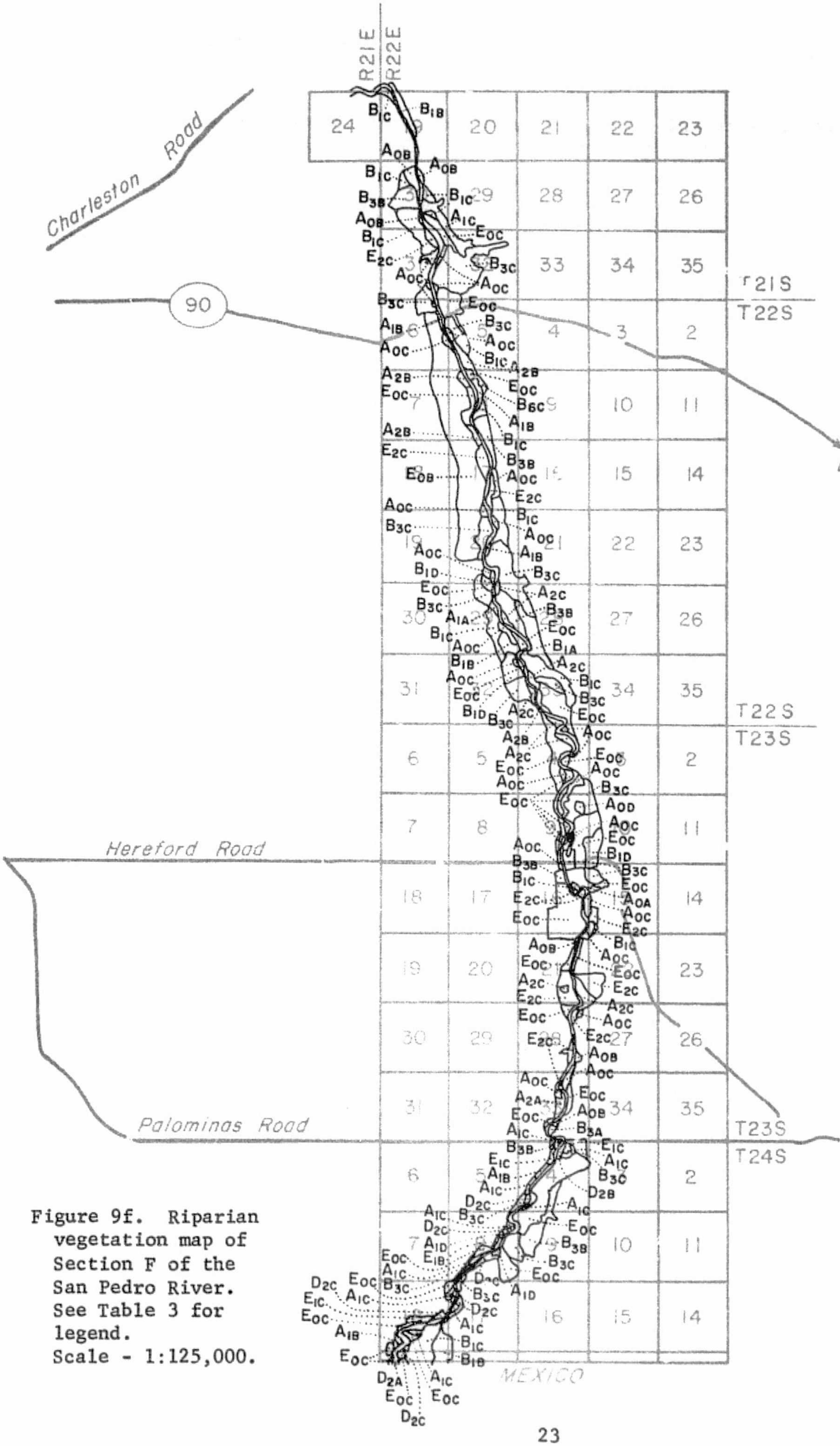

Figure 9f. Riparian vegetation map of Section F of the San Pedro River. See Table 3 for legend. Scale - 1:125,000.

Table 4. Acres of riparian communities along the San Pedro River within Cochise County tabulated by geographic location and cover class.

Community	Township, Range and Section												
	T12S, R19E					T13S, R19E							
% Cover	32	31	30	29	19	36	27	26	25	23	22	15	10
Cottonwood-Willow													
<25													
26-50			16										
51-75				8									
>75													
Mesquite													
<25													
26-50					16	24	16	32	71	71	24		
51-75				24		103			32	8	55		16
>75	205	8	16	24						111	32	71	24
Tamarisk													
<25													
26-50						8					8	16	24
51-75			24	8				8	32	32		87	40
>75													
Mixed Scrub													
<25	47		24	8	63	8		8	24	32	24	47	32
26-50													
51-75													
>75													
Sacaton Grass													
<25													
26-50													
51-75													
>75													
Total	252	8	80	64	87	143	16	48	159	254	143	221	136

Table 4. Continued

Community % Cover	Township, Range and Section									
	T13S, R19E			T13S, R20E			T14S, R20E			
	9	5	4	32	31	30	33	29	28	21
Cottonwood-Willow										
<25										
26-50										
51-75			8						8	
>75										
Mesquite										
<25										
26-50	8		8					32		
51-75			8	8	111	8		8		
>75	111	24	87					8	79	
Tamarisk										
<25										
26-50	16		16		8				8	
51-75					32		47		16	
>75										
Mixed Scrub										
<25	32	24	40		32		24		47	8
26-50										
51-75										
>75										
Sacaton Grass										
<25										
26-50										
51-75										
>75										
Total	167	48	167	8	183	8	71	48	158	8

Table 4. Continued

Community % Cover	Township, Range and Section T14S, R20E 20	 17	 8	 7	 6	 T15S, R20E 33	 32	 29	 28	 22	 21	 20
Cottonwood-Willow												
<25												
26-50								16				
51-75	16	24										
>75												
Mesquite												
<25	8											
26-50	24	32	16	87	40		24	16			32	24
51-75	95	8			16	8	166		24			
>75		24	32			40			47	16	229	
Tamarisk												
<25												
26-50					24						8	
51-75					8						16	
>75												
Mixed Scrub												
<25	32	32	16	40	32	8	40	8	16		40	
26-50				8								
51-75												
>75												
Sacaton Grass												
<25												
26-50												
51-75												
>75												
Total	175	120	64	135	120	56	230	40	87	16	325	24

Table 4. Continued

Community	Township, Range and Section												
	T15S, R20E						T16S, R20E						
% Cover	16	15	10	9	4	3	34	33	28	27	21	17	16
Cottonwood-Willow													
<25													
26-50			8		8								
51-75													
>75													
Mesquite													
<25				40	16								
26-50			24				8						40
51-75			16		55	24	32	24	95	8	142	8	126
>75	24	103	40	24	32		8		87		63		
Tamarisk													
<25													
26-50				8	8						8		8
51-75				8	16			16	16		16		8
>75													
Mixed Scrub													
<25		24	32	24	32		8	16	32		16		32
26-50					24	8							
51-75													
>75													
Sacaton Grass													
<25													
26-50													
51-75													
>75													
Total	24	127	120	104	191	32	56	56	230	8	245	8	214

Table 4. Continued

	Township, Range and Section											
Community	T16S, R20E				T17S, R20E							
% Cover	8	7	6	5	36	26	25	24	23	14	13	11
Cottonwood-Willow												
<25												
26-50												
51-75										8		8
>75												
Mesquite												
<25												
26-50		24										
51-75	32	16							8	8		
>75					111	8	158	55	47	47	8	16
Tamarisk												
<25												
26-50		16	24									
51-75	8											55
>75												
Mixed Scrub												
<25	24	32	40	40			8		8	24		16
26-50												
51-75												
>75												
Sacaton Grass												
<25												
26-50												
51-75												
>75												
Total	64	88	64	40	111	8	166	55	63	87	8	95

Table 4. Continued

Community % Cover	Township, Range and Section T17S, R20E 10	 3	 2	 T17S, R21E 31	 30	 T18S, R20E 1	 T18S, R21E 33	 32
Cottonwood-Willow								
<25							24	40
26-50								
51-75								
>75								
Mesquite								
<25								
26-50		16	32					
51-75		32				55		
>75	8			40	24		261	119
Tamarisk								
<25								
26-50								
51-75		8	32					
>75								
Mixed Scrub								
<25		24	24	8				40
26-50								
51-75								
>75								
Sacaton Grass								
<25								
26-50								
51-75								
>75								
Total	8	80	88	48	24	55	285	199

Table 4. Continued

Community % Cover	Township, Range and Section											
	T18S, R21E											
	28	27	29	21	20	18	17	16	8	7	6	5
Cottonwood-Willow												
<25	8			8								
26-50												
51-75							8	8	24		8	8
>75												8
Mesquite												
<25												
26-50	79		16	190	87			8				
51-75				40		8	63		166	55	150	63
>75	16	8	16						32			
Tamarisk												
<25												
26-50												
51-75												
>75												
Mixed Scrub												
<25	8		24	40			24	24	24		24	16
26-50												
51-75												
>75												
Sacaton Grass												
<25												
26-50												
51-75			103		79							
>75												
Total	111	8	159	278	166	8	95	40	246	55	182	95

Table 4. Continued

Community % Cover	Township, Range and Section													
	T19S, R21E											T20S, R21E		
	34	33	28	21	20	17	16	9	8	5	4	35	34	27
Cottonwood-Willow														
<25										16	32			
26-50				8		8								
51-75				8			8		16					16
>75														
Mesquite														
<25									8					
26-50	47	16		63				40	47	8	24			32
51-75	79		79	71	24	253	134	55	71		126			8
>75	32			24					71	87	190	25	166	126
Tamarisk														
<25														
26-50				40		40	8	16	24					
51-75														
>75														
Mixed Scrub														
<25	32	16	40	40		40	24		47	8	32	8	16	32
26-50														
51-75														
>75														
Sacaton Grass														
<25														
26-50														
51-75														55
>75														
Total	190	32	119	254	24	341	174	111	284	119	404	33	182	269

Table 4. Continued

Community % Cover	Township, Range and Section															
	T20S, R21E											T21S, R21E				
	26	22	21	16	15	14	10	9	4	3	2	24	14	13	11	2
Cottonwood-Willow																
<25																
26-50		8											8	16	8	
51-75					24			8	8							
>75																
Mesquite																
<25																
26-50	32			8	63		158	32	63	237	8			95	103	
51-75		24	55		158	24	158			174			32	40	71	
>75	55	47					40			8						63
Tamarisk																
<25																
26-50																
51-75																
>75																
Mixed Scrub																
<25	16	32	8		55		32		8	32		8		40	40	24
26-50																
51-75																
>75																
Sacaton Grass																
<25																
26-50																
51-75		40	134	111	55										8	
>75																
Total	103	151	197	119	355	24	388	40	79	451	8	8	40	191	230	87

Table 4. Continued

Community % Cover	T21S, R22E				T22S, R22E										
	32	31	30	19	33	32	29	28	21	20	17	8	7	6	5
Cottonwood-Willow															
<25							8								
26-50			32		8							47		8	32
51-75	16	32	40		24		32			16	24			16	
>75															
Mesquite															
<25								63							
26-50			63	32			71	8			16	32			
51-75	150	111	79	16	166	16	79	47	16	190	24	16		24	55
>75					8	32	8			8					
Tamarisk															
<25															
26-50															
51-75															
>75															
Mixed Scrub															
<25		40	32	32	24		16	16		24	32	24		24	16
26-50															
51-75															
>75															
Sacaton Grass															
<25															
26-50										142	213	142	95	95	
51-75	16	55	24		119			16			63	47		24	40
>75															
Total	182	238	270	80	349	48	214	150	16	380	372	308	95	191	143

Table 4. Continued

Community % Cover	Township, Range and Section																	Total
	T23S, R22E										T24S, R22E							
	33	28	22	21	16	15	10	9	4	3	20	19	18	17	9	8	4	
Cottonwood-Willow																		
<25	16					8												160
26-50		8											16			16	16	287
51-75	24	8	8	24	8	16		32	40					16		24	8	632
>75								8								16		32
																		1,111
Mesquite																		
<25	8																	143
26-50					16						8		24	16	71	24	24	2,602
51-75					8	40	24	55	24	8		32	71	16	16	8	8	4,859
>75							63											3,596
																		11,200
Tamarisk																		
<25																		0
26-50																		336
51-75																		533
>75																		0
																		869
Mixed Scrub																		
<25	16	32		32	32			24	47			8	32	16	16	32	40	2,713
26-50																		40
51-75												8		8		16	8	40
>75																		0
																		2,793
Sacaton Grass																		
<25																		0
26-50																		687
51-75	40	32	47	111	221	24	40	119	119			16	32	8	47	55	182	2,082
>75																		0
																		2,769
Total	104	80	55	167	285	88	127	238	230	8	8	64	175	80	150	191	286	18,742

San Simon Creek Vegetation

Riparian communities along the main channel of the San Simon Creek from Solomon, Arizona to the New Mexico border are tabulated by acreage, geographic location, and cover class in Table 5. Vegetation was mapped at a scale of 1:25,000 and reduced to 1:125,000 for publication purposes (Fig. 10a - 10d).

Shrubby form mesquite dominated nearly 45 percent of the riparian vegetation along the main San Simon channel. No bosques were mapped along the main channel. Saltcedar dominated about a fifth of the total riparian vegetation and occurred primarily on recently formed floodplains in the exposed northern and central reaches of the channel. Diversity of riparian vegetation is relatively low. Upstream reaches of the channel were mapped as mesquite. The Sacaton Grass Community was delineated in the San Simon Cienega, and the Mixed grass-Scrub Community dominates about 2,000 acres behind the San Simon fan drop structure. About 1,000 acres of Saltbush Community were mapped as riparian vegetation. However, many acres of saltbush occurring near the main channel were not designated as riparian because they were severely eroded and surface flow water does not contribute greatly to soil moisture recharge.

Pantano Wash-Cienega Creek Vegetation

Riparian communities along the main channel of Pantano Wash and Cienega Creek were mapped at a scale of 1:125,000 (Figs. 11a - 11d). Communities are tabulated by acreage, geographic location and cover class in Table 6.

Mesquite was shrub-like along Pantano Wash, but formed bosques along upper Cienega Creek where groundwater conditions became more favorable. Most of the base channel and recently exposed floodplains occurring along Pantano Wash and lower Cienega Creek were mapped as Mixed Scrub Communities. Small saltcedar stands which could not be reliably delineated on the 1:125,000 scale photography were also lumped into the Mixed Scrub Community. Old terraces and floodplains along lower Pantano Wash (Tucson area) are dominated by creosote bush and were not mapped as riparian vegetation.

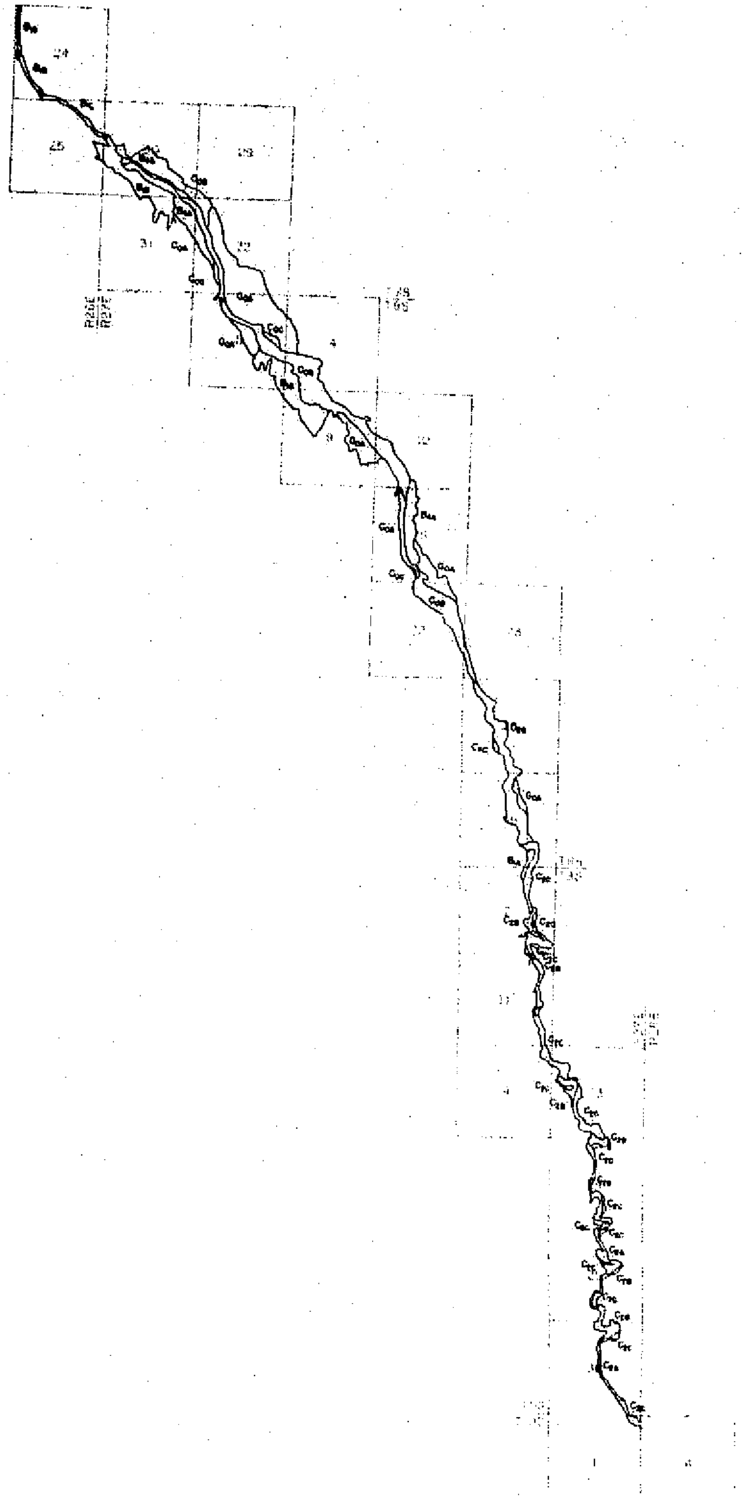

Figure 10a. Riparian vegetation map of Section A of San Simon Creek from north at its junction with the Gila River south and east for about 16 miles. See Table 3 for legend. Scale - 1:125,000.

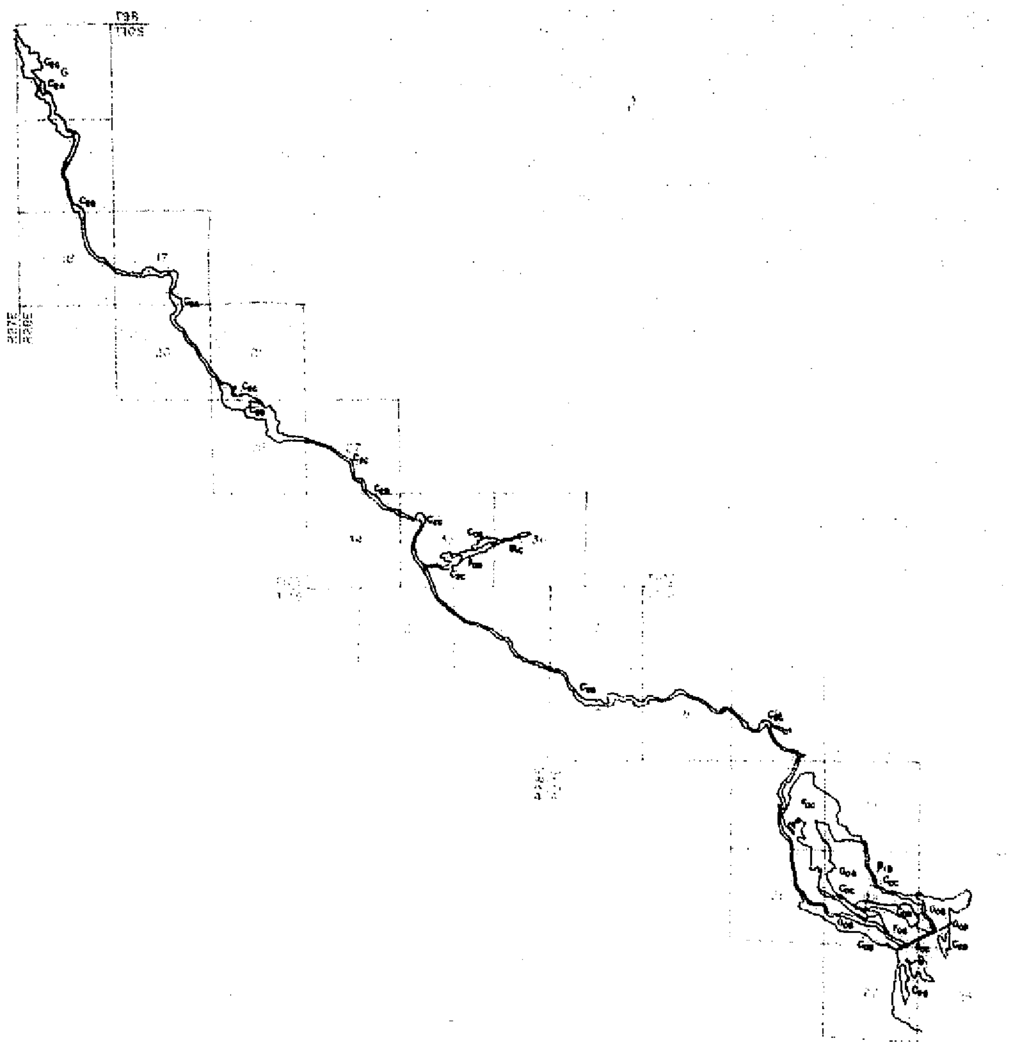

Figure 10b. Riparian vegetation map of Section B of San Simon Creek. See Table 3 for legend. Scale - 1:125,000.

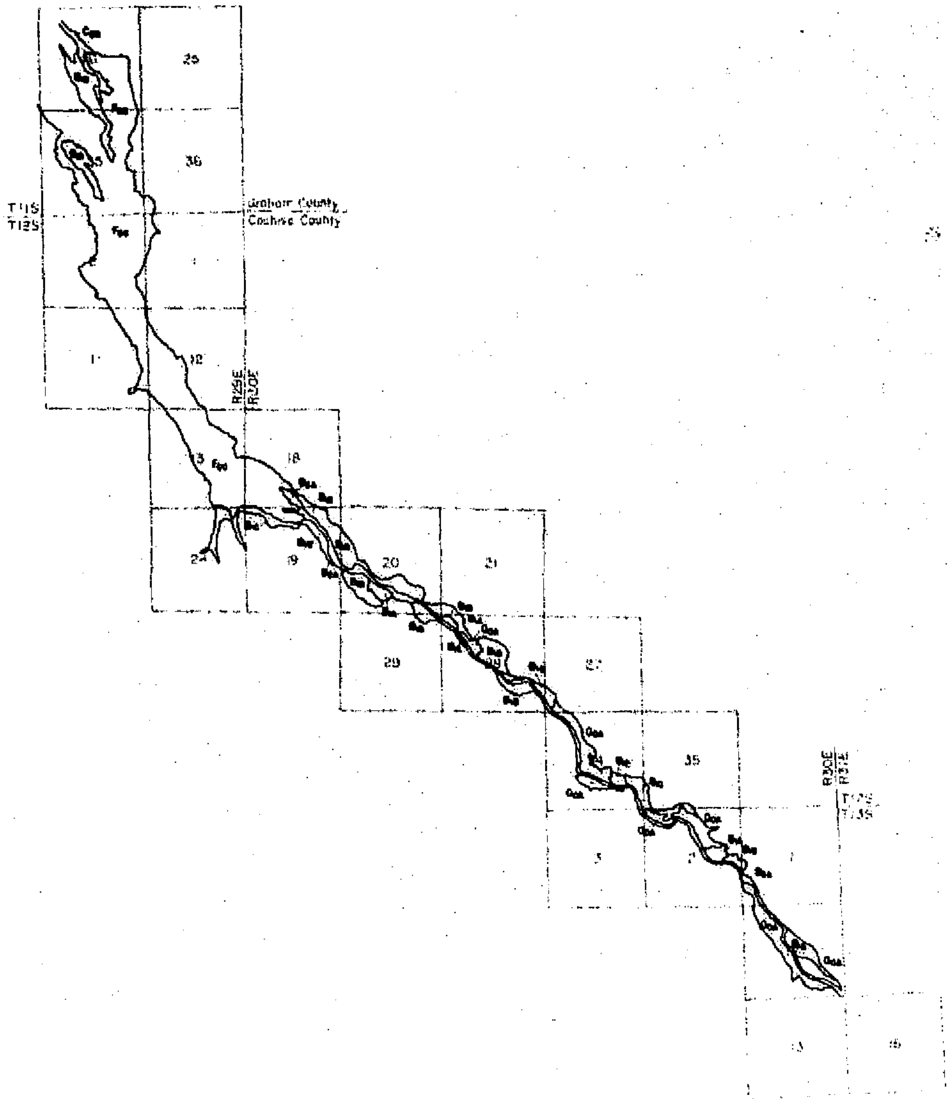

Figure 10c. Riparian vegetation map of Section C of San Simon Creek. See Table 3 for legend. Scale - 1:125,000.

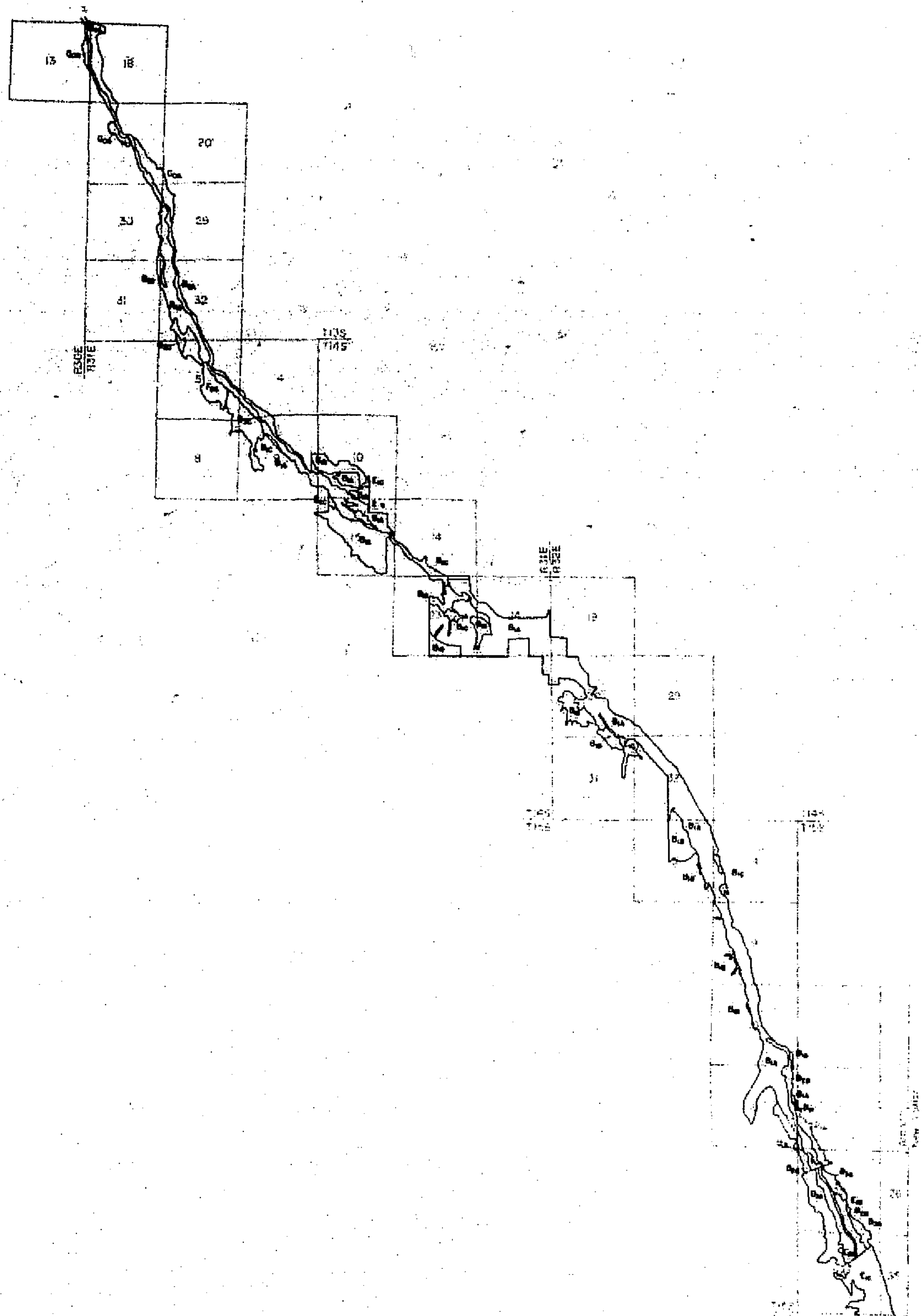

Figure 10d. Riparian vegetation map of Section D of San Simon Creek. See Table 3 for legend. Scale - 1:125,000.

Table 5. Acres of riparian communities along the San Simon Creek from Solomon, Arizona to the New Mexico border, tabulated by geographic location and cover class.

	Township, Range and Section													
Community	T7S, R26E		T7S, R27E			T8S, R27E								
% Cover	24	25	30	31	32	5	4	9	10	15	22	23	26	35
Mesquite														
<25			84	38	26	44	8	56	2	50				6
26-50	12	13	66	27										
51-75	17	11												
>75														
Tamarisk														
<25				9	28					27				
26-50			18	1		48	50	75	36	6	83	2	61	62
51-75					5	10	11			1			4	11
>75														
Sacaton Grass														
<25														
26-50														
51-75														
>75														
Mixed Grass-Scrub														
<25														
26-50														
51-75														
>75														
Saltbush														
<25					117	162		49		26	20			12
26-50														
51-75														
>75														
Total	29	24	168	75	176	264	69	180	38	110	103	2	65	91

Table 5. Continued

Community % Cover	Township, Range and Section													
	T9S, R27E							T10S, R27E	T10S, R28E					
	2	11	14	13	24	25	36	1	6	7	18	17	20	21
Mesquite														
<25	4													
26-50														
51-75														
>75														
Tamarisk														
<25					4	29	13		4			17	18	6
26-50	29	21		15	23	10	13			25	12	17		
51-75	30	16	8	44	18	8	10	4	57	8				25
>75														
Sacaton Grass														
<25														
26-50														
51-75														
>75														
Mixed Grass-Scrub														
<25														
26-50														
51-75														
>75														
Saltbush														
<25														
26-50														
51-75														
>75														
Total	63	37	8	59	45	47	36	4	61	33	12	34	18	31

Table 5. Continued

Community % Cover	Township, Range and Section													
	T10S, R28E					T11S, R28E		T11S, R29E						
	28	27	34	35	36	2	1	6	7	8	9	16	15	21	22
Mesquite															
<25															
26-50															4
51-75					7										
>75															
Tamarisk															
<25															
26-50	49	6	7	7		4	21	1	32	20					45
51-75	9	13		38	3					2	24	20	2	8	55
>75															
Sacaton Grass															
<25															
26-50															
51-75															
>75															
Mixed Grass-Scrub															
<25															
26-50				14	1										
51-75												127	52	23	74
>75															
Saltbush															
<25												5	30		146
26-50														18	55
51-75															
>75															
Total	58	19	7	59	11	4	21	1	32	22	24	152	84	49	379

Table 5. Continued

Community	Township, Range and Section																
	T11S, R29E						T12S, R29E						T12S, R30E				
% Cover	23	27	26	25	35	36	2	1	11	12	13	24	18	19	20	21	29
Mesquite																	
<25													13	14	42	1	
26-50			61		59								11	34	119	16	2
51-75											4	23	8	14			
>75																	
Tamarisk																	
<25																	
26-50	8	22	51														
51-75	8																
>75																	
Sacaton Grass																	
<25																	
26-50																	
51-75																	
>75																	
Mixed Grass-Scrub																	
<25																	
26-50																	
51-75	22	85	330	4	319	23	224	47	38	191	198	2	127	14			
>75																	
Saltbush																	
<25	3																
26-50	83																
51-75																	
>75																	
Total	124	107	442	4	378	23	224	47	38	191	202	25	159	76	161	17	2

Table 5. Continued

Community	Township, Range and Section																	
	T12S, R30E				T13S, R30E				T13S, R31E						T14S, R31E			
% Cover	28	27	34	35	2	1	12	13	18	19	20	30	29	32	5	4	9	10
Mesquite																		
<25	27	5	25		41	11	54		83	35		4	67	115	45	28	56	65
26-50	80	11	11		6	4								6				70
51-75	2		11	19	11									1	17	26	71	1
>75																		
Tamarisk																		
<25																		
26-50																		
51-75																		
>75																		
Sacaton Grass																		
<25																		
26-50																		
51-75																		30
>75																		
Mixed Grass-Scrub																		
<25																		
26-50																		
51-75															81			
>75																		
Saltbush																		
<25	11	7	61		48	9	83	2	6	49	8	1	30	15				
26-50																		
51-75																		
>75																		
Total	120	23	108	19	106	24	137	2	89	84	8	5	97	137	143	54	127	166

Table 5. Continued

Community % Cover	Township, Range and Section															
	T14S, R31E				T14S, R32E					T15S, R31E						
	15	14	23	24	19	30	29	32	31	5	4	9	16	15	21	22
Mesquite																
<25	64	3	21	197	58	167	18	141		54	82	89	101	4	103	40
26-50	16		73	25		59		8	10	66	1	5	8	5	14	56
51-75	176	30	27								13					
>75																
Tamarisk																
<25																
26-50																
50-75																
>75																
Sacaton Grass																
<25																
26-50																
51-75						7		20								
>75																
Mixed Grass-Scrub																
<25																
26-50																
51-75									9							
>75																
Saltbush																
<25																
26-50																
51-75																
>75																
Total	256	33	121	222	58	233	18	169	19	120	96	94	109	9	117	96

Table 5. Continued

Community % Cover	Township, Range and Section T15S, R31E 27	26	34	35		Total
Mesquite						
<25	132	1	39	1		2,364
26-50	30		4			992
51-75						489
>75						0
						3,845
Tamarisk						
<25						155
26-50						880
51-75						452
>75						0
						1,487
Sacaton Grass						
<25						0
26-50	61		34			95
51-75			78	100		235
>75						0
						330
Mixed Grass-Scrub						
<25						0
26-50						96
51-75						1,909
>75						0
						2,005
Saltbush						
<25						900
26-50						156
51-75						0
>75						0
						1,056
Total	223	1	155	101		8,723

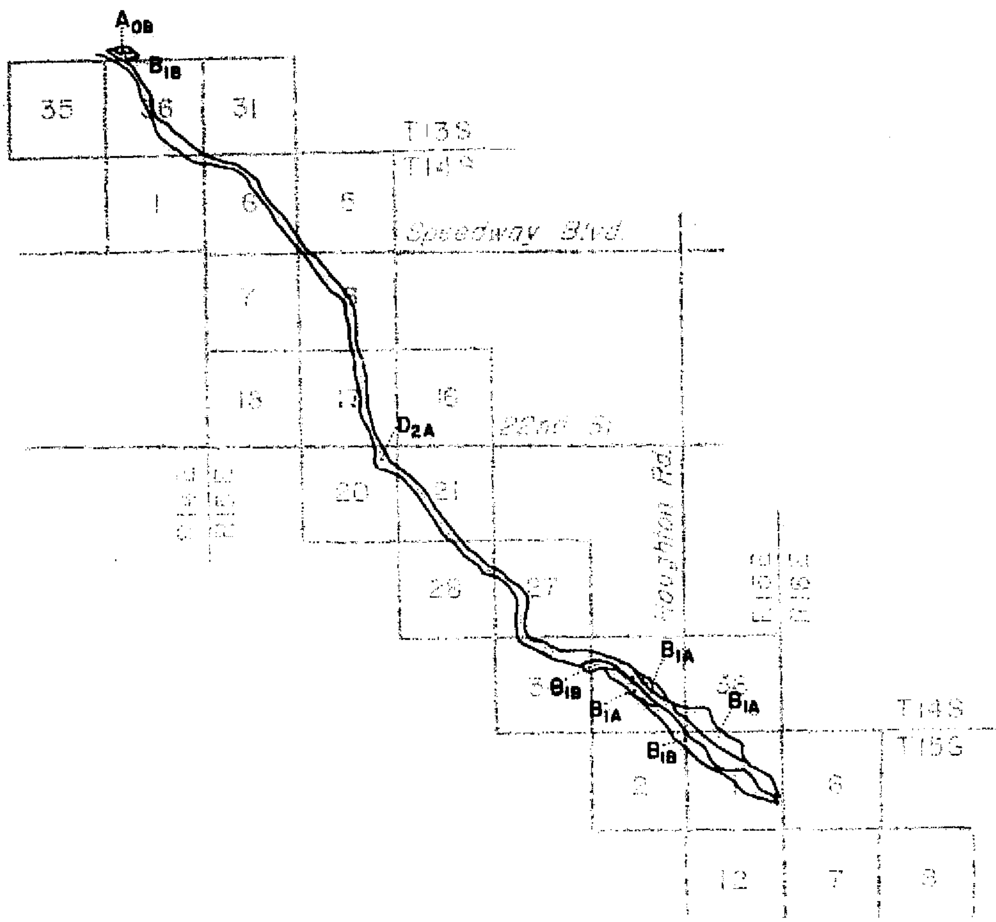

Figure 11a. Riparian vegetation map of Section A along Pantano Wash from north at Rillito River south and east to about Houghton Road. See Table 3 for legend. Scale - 1:125,000.

Figure 11b. Riparian vegetation map of Section B of Pantano Wash and Cienega Creek. See Table 3 for legend. Scale - 1:125,000.

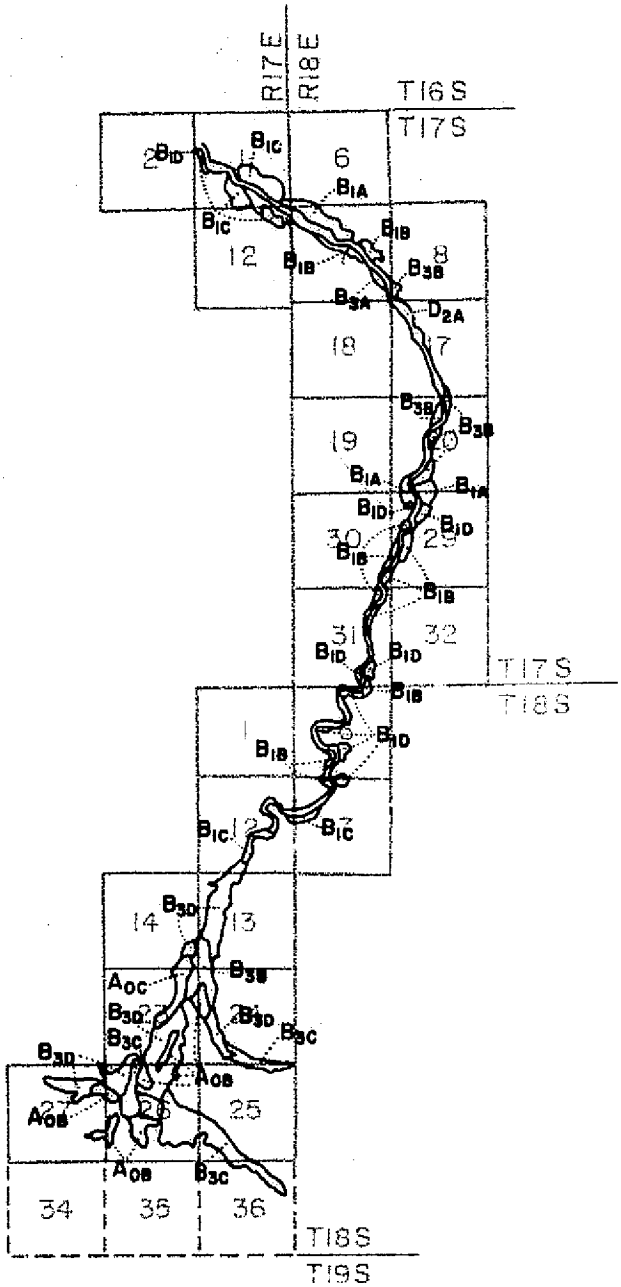

Figure 11c. Riparian vegetation map of Section C of Cienega Creek. See Table 3 for legend. Scale - 1:125,000.

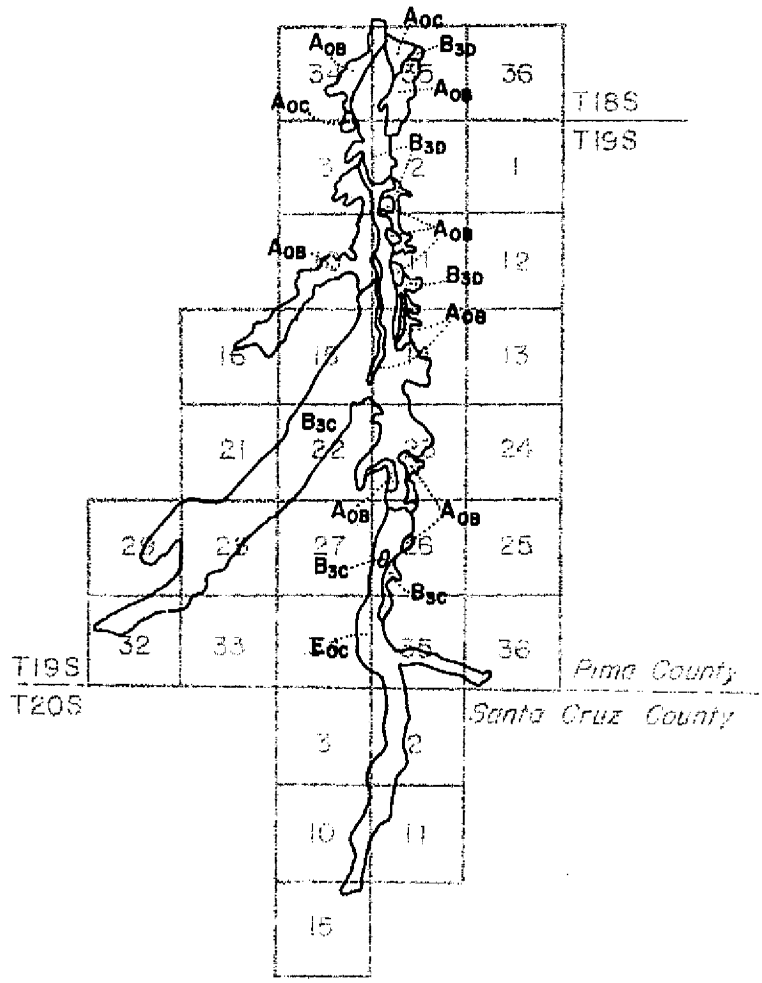

Figure 11d. Riparian vegetation map of Section D of Cienega Creek. See Table 3 for legend. Scale - 1:125,000

Table 6. Acres of riparian communities along the Pantano Wash and Cienega Creek from Tucson, Arizona to Sonoita, Arizona, tabulated by geographic location and cover class.

	Township, Range and Section														
Community	T13S, R14E		T14S, R15E											T15S, R15E	
% Cover	36	25	6	5	8	17	20	21	28	27	34	35	36	1	2
Cottonwood-Willow															
<25															
26-50		8													
51-75															
>75															
Mesquite															
<25												55	24	40	
26-50											8	32		71	16
51-75															
>75															
Mixed Scrub															
<25	63		71		71	71	32	55	40	47	71	63	8	79	
26-50															
51-75															
>75															
Burrobrush															
<25															
26-50															
51-75															
>75															
Sacaton Grass															
<25															
26-50															
51-75															
>75															
Total	63	8	71		71	71	32	55	40	47	79	150	32	190	16

Table 6. Continued

Community % Cover	Township, Range and Section																		
	T15S, R16E										T16S, R16E								
	6	7	8	17	18	19	20	29	32	33	4	9	10	15	14	22	23	24	25
Cottonwood-Willow																			
<25																			
26-50																			
51-75																			
>75																			
Mesquite																			
<25																			
26-50	8	134	47									47	8	40	16	24	8		
51-75				24											8				
>75															8		24	55	16
Mixed Scrub																			
<25															8		16	40	
26-50																			
51-75																			
>75																			
Burrobrush																			
<25	24	55			87	63	32	103	63	8	79	47	32	32	24				
26-50																			
51-75																			
>75																			
Sacaton Grass																			
<25																			
26-50																			
51-75																			
>75																			
Total	32	189	47	24	87	63	32	103	63	8	79	94	40	72	64	24	48	95	16

Table 6. Continued

Community % Cover	Township, Range and Section T16S, R17E 19	30	29	28	33	34	35	T17S, R17E 1	2	12	T17S, R18E 6	7	8	17	20	29	30	31
Cottonwood-Willow																		
<25																		
26-50																		
51-75																		
>75																		
Mesquite																		
<25											16	55			16	32		
26-50						24		24		8		32	8		40	16	8	16
51-75		24	16	16	32			95		16								
>75		16	16			47	119	24	32							16		16
Mixed Scrub																		
<25		47	40	24	47	40	47	47	24	8		63	8	55	32	24	8	40
26-50																		
51-75																		
>75																		
Burrobrush																		
<25																		
26-50																		
51-75																		
>75																		
Sacaton Grass																		
<25																		
26-50																		
51-75						8	24											
>75																		
Total	0	87	72	40	79	119	190	190	56	32	16	150	16	55	88	88	16	72

Table 6. Continued

Community % Cover	Township, Range and Section																				
	T18S, R17E											T18S, R18E		T19S, R17E							
	12	13	14	23	24	25	26	27	36	35	34	6	7	2	3	10	11	14	15	16	21
Cottonwood-Willow																					
<25																					
26-50				16	24		71	16		95	87			16	63	166	40	32	32	55	
51-75			16	40						47					8						
>75																					
Mesquite																					
<25																					
26-50		24		16	24							16	8								
51-75	24			8	32	71	134		24				8	16	16	16	95	174	253		95
>75	16	103	8	103			63	47		71	55	16	8	87	63		71	32			
Mixed Scrub																					
<25	32											47	24								
26-50																					
51-75																					
>75																					
Burrobrush																					
<25																					
26-50																					
51-75																					
>75																					
Sacaton Grass																					
<25																					
26-50																					
51-75																					
>75																					
Total	72	127	24	183	80	71	268	63	24	213	142	79	48	119	150	182	206	238	285	55	95

Table 6. Continued

Community % Cover	Township, Range and Section													Total
	T19S, R17E										T20S, R17E			
	22	23	26	28	29	32	33	34	35	36	2	10	11	
Cottonwood-Willow														
<25														0
26-50		63	8											792
51-75														111
>75														0
														903
Mesquite														
<25														238
26-50														723
51-75	292	190	40	356	87	95	8		16					2,281
>75														1,132
														4,374
Mixed Scrub														
<25														1,392
26-50														0
51-75														0
>75														0
														1,392
Burrobrush														
<25														649
26-50														0
51-75														0
>75														0
														649
Sacaton Grass														
<25														0
26-50														0
51-75			126					32	166	24	158	40	63	641
>75														0
														641
Total	292	253	174	356	87	95	8	32	182	24	158	40	63	7,959

Gila River Vegetation

Riparian communities along the upper Gila River were mapped at a scale of 1:31,680 and reduced to 1:125,000 for publication (Figs. 12a - 12d). Data are tabulated by acreage, geographic location and cover class in Table 7.

Mesquite dominated nearly 45 percent of the riparian vegetation. Mature stands were small in area, and were designated on the maps as mesquite associations with greater than 75 percent cover. The Cottonwood-Willow Communities generally occur as small-isolated stands, with the largest areas occurring near Duncan, Arizona; however, young seedlings are absent in the understory and saltcedar is becoming established on these sites. Riparian communities dominating the current channel were mostly classified as channel with Mixed Scrub because of low vegetal cover. The channel was often dominated by Burrobrush. However, where vegetal cover was greater than along the current channel, Mixed Scrub Communities were designated. These communities occurred on recent floodplains where saltcedar was prevalent. Former "floodplain" farmland destroyed in the 1972 flooding was invaded by saltcedar, Russian thistle and Johnson grass. These areas have the potential to be reconverted to crop production and were not mapped as natural riparian vegetation.

Automated Computer Mapping

Vegetation along a 30-mile stretch of the Gila River (Fig. 13) was computer mapped in two sections, a lower and upper reach using NASA computer compatible tapes for computer processing. Because the site, in an arid portion of the Sonoran Desert, receives an annual average rainfall of approximately four inches, the riparian vegetation in the area relies on agricultural tailwater runoff for its predominant water supply. Dissected block mountains, intermontane plains and bajadas, and alluvial surfaces are found in the area. The intermontane plains are dominated by creosote bush and white bursage; the bajada areas are characterized by paloverde.

The site was chosen because of vegetative control established through recent detailed riparian mapping produced from U.S. Corps of Engineers' color infrared photography (Haase, 1972).

Digital data analysis was conducted in three major steps: a) LANDSAT-1 image (Scene 1320-17390, 8 June 1973), scale 1:1,000,000, containing the study area was overlain on an X-Y grid to determine corner coordinate (scanline) numbers which allowed computer processing of the small study area; b) a digital

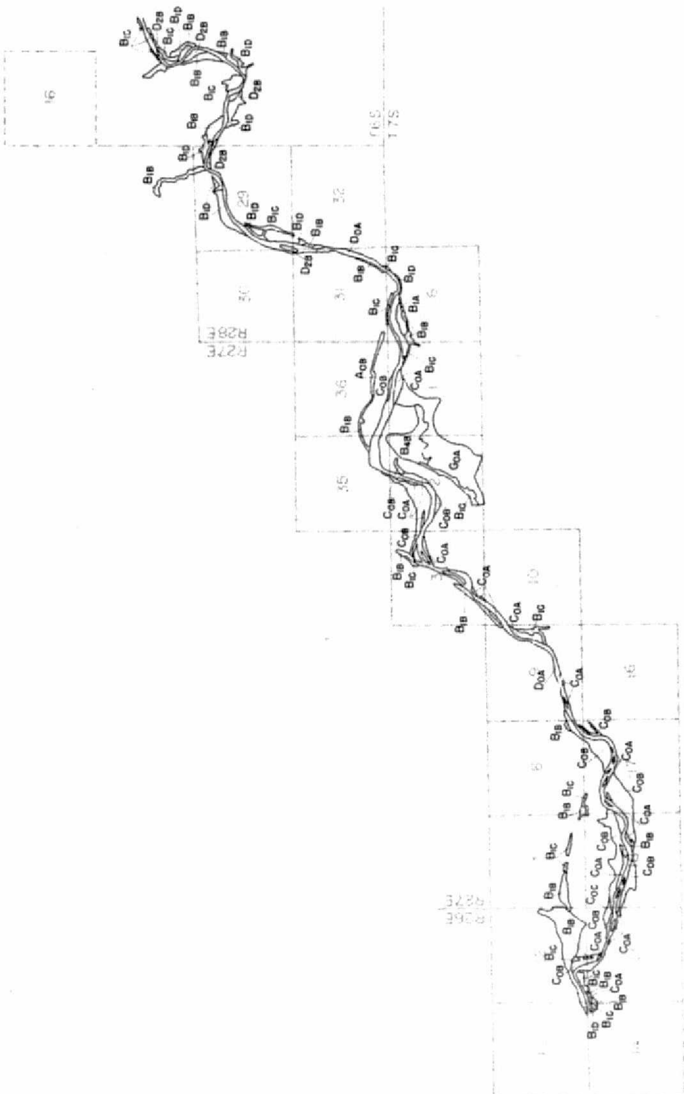

Figure 12a. Riparian vegetation of Section A of the upper Gila River from Solomon, Arizona eastward for approximately 12 miles. See Table 3 for legend. Scale - 1:125,000.

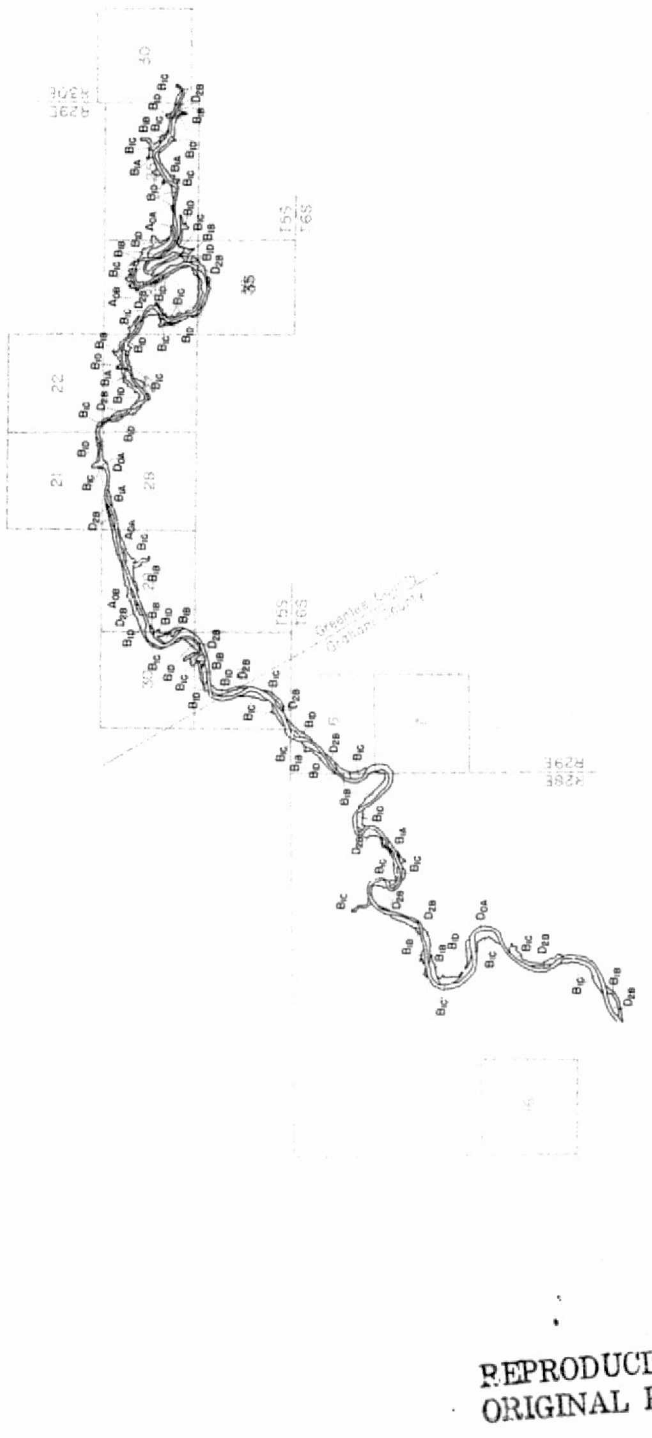

Figure 12b. Riparian vegetation of Section B of the upper Gila River. See Table 3 for legend. Scale - 1:125,000.

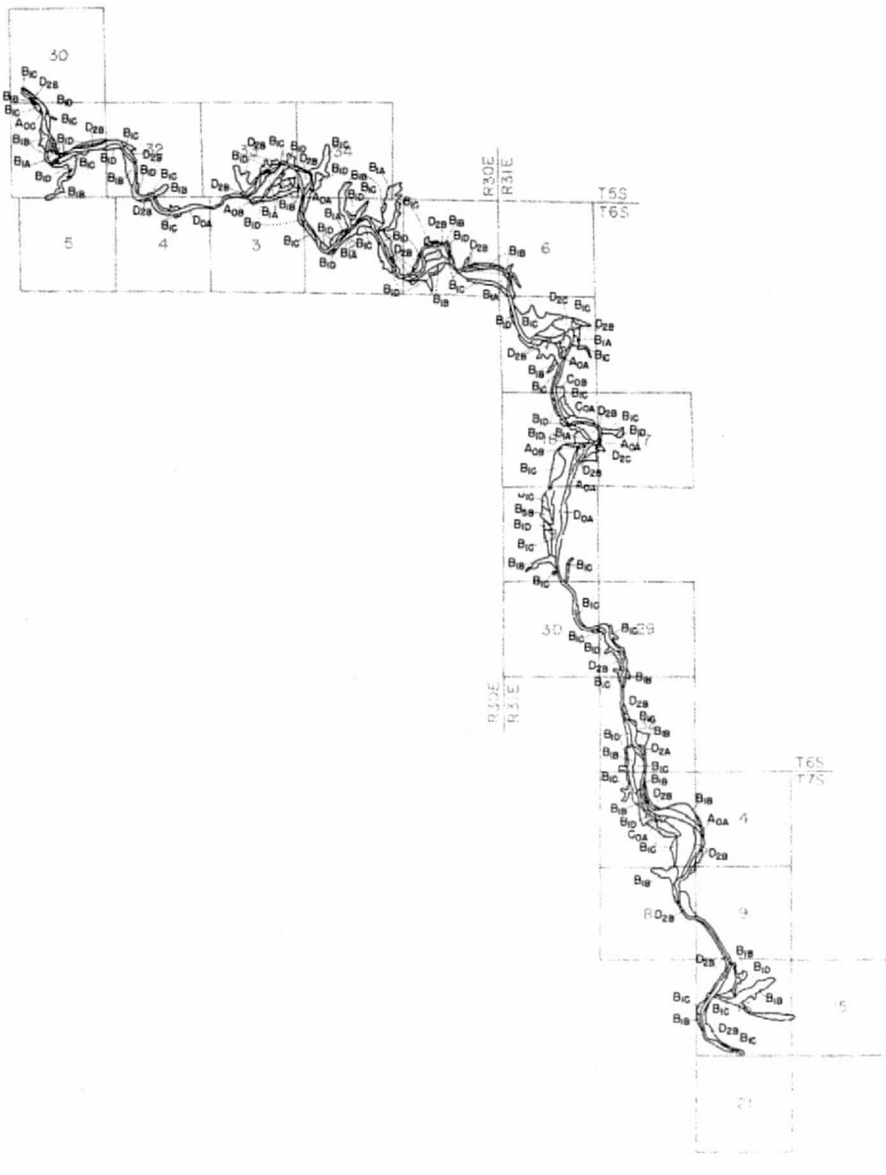

Figure 12c. Riparian vegetation of Section C of the upper Gila River. See Table 3 for legend. Scale - 1:125,000.

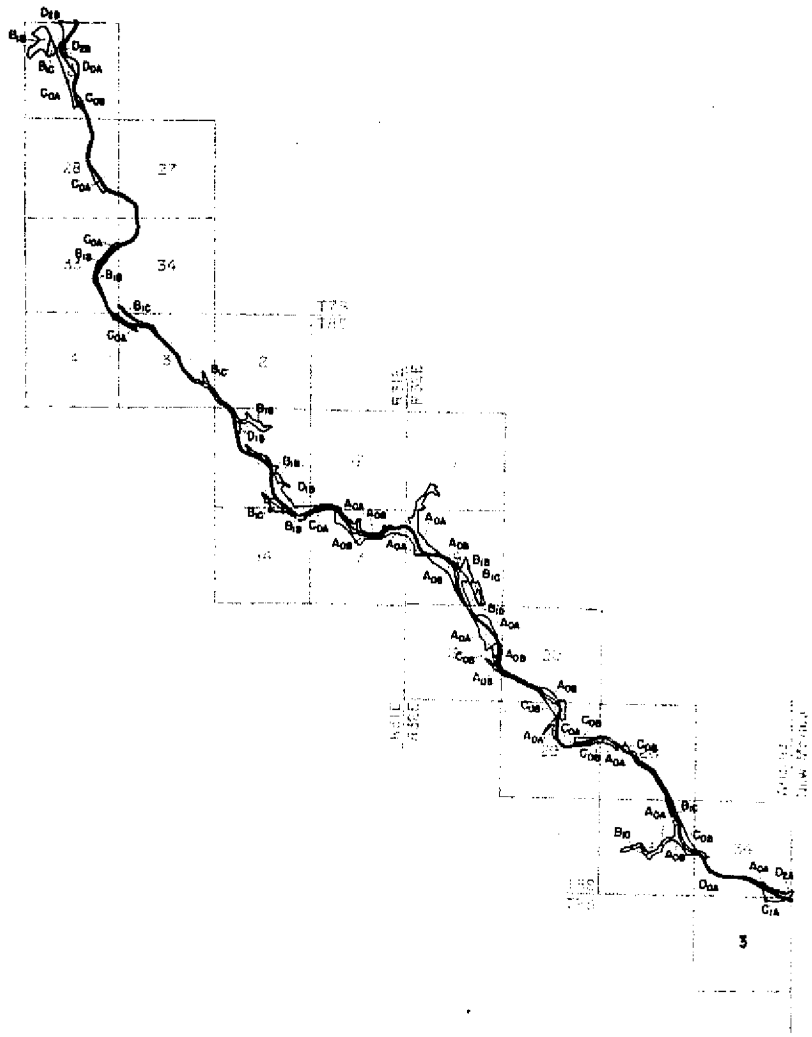

Figure 12d. Riparian vegetation of Section D of the upper Gila River. See Table 3 for legend. Scale - 1:125,000.

Table 7. Acres of riparian communities along the upper Gila River from Solomon, Arizona to the New Mexico border, tabulated by geographic location and cover class.

Community % Cover	Township, Range and Section																	
	T5S, R30E							T5S, R29E									T6S,R29E	
	35	34	33	32	31	30	35	25	26	27	28	29	22	21	30	31	6	7
Cottonwood-Willow																		
<25								1	4			1						
26-50									4			1						
51-75																		
>75																		
Mesquite																		
<25	4	3	20		9			12		6	3							
26-50		6	19	16	20			10	34	3		4			9	6	7	
51-75		22	10	4	13	3		12	35	10		13	3		7	20	1	
>75		7	29	4	23		6	22	32	23	1	25		4	19	13	12	
Tamarisk																		
<25																		
26-50																		
51-75																		
>75																		
Channel with Mixed Scrub																		
<25		9	10	15	30	6	6	25	39	23	12	20	1	10	22	39	13	4
26-50																		
51-75																		
>75																		
Seepwillow-Broom																		
<25																		
26-50																		
51-75																		
>75																		
Mixed Scrub																		
<25																		
26-50		10	4	4	7	4	3	1	4	4	3	3			3	12	4	
51-75																		
>75																		
Saltbush																		
<25																		
26-50																		
51-75																		
>75																		
Total	4	57	92	43	102	13	15	83	152	69	19	67	4	14	60	90	37	4

Table 7. Continued

Community % Cover	T6S, R28E				T6S, R27E		T7S, R28E	T7S, R27E									T7S, R26E	
	*	29	32	31	36	35	6	1	2	3	10	9	8	17	18	7	13	12
Cottonwood-Willow																		
<25																		
26-50				3	12													
51-75																		
>75																		
Mesquite																		
<25	3						13											
26-50	97	3	3	4	10	3	12	27	52	16	3		3		1	15		77
51-75	112	10		3			1	1	17	3		10	3			4		10
>75	45	41	1				1											
Tamarisk																		
<25								12	12	15	3	20		9	17		6	
26-50					3	4			57	6		4	10	80	88		9	9
51-75															1		7	
>75																		
Channel with Mixed Scrub																		
<25	190	30	4	25	20	25	12	12	25	30	7	29	6	29	22		16	12
26-50																		
51-75																		
>75																		
Seepwillow-Broom																		
<25																		
26-50																		
51-75																		
>75																		
Mixed Scrub																		
<25																		
26-50	74	9	1															
51-75																		
>75																		
Saltbush																		
<25								58	133									
26-50																		
51-75																		
>75																		
Total	521	93	9	35	45	32	39	110	296	70	13	63	22	118	129	19	38	108

*Unsurveyed

Table 7. Continued

Community % Cover	T7S, R26E		T6S, R31E								T6S, R30E					T7S, R31E					
	14	11	32	29	30	19	18	17	7	6	1	2	3	4	5	34	33	28	27	21	16
Cottonwood-Willow																					
<25							9		4			4	3								
26-50							1						3								
51-75																					
>75																					
Mesquite																					
<25							9		3	7	29	41	7								
26-50	1	4	23			34			6	6	17		4	3	3		13			22	53
51-75	1		12	4	7	25	25	6	86	1	26	33	1	7						6	10
>75	1		13	9		3	13	3	1		16	39	13								3
Tamarisk																					
<25							9										3	6		25	
26-50							9													1	
51-75																					
>75																					
Channel with Mixed Scrub																					
<25		4	19	16	17	25	25	3	36	6	25	28	16	23		9	10	12	3	20	23
26-50																					
51-75																					
>75																					
Seepwillow-Broom																					
<25																					
26-50																					
51-75																					
>75																					
Mixed Scrub																					
<25			4																		
26-50			3	3			26		25	1	25	6	3	1						15	38
51-75							6		20												
>75																					
Saltbush																					
<25																					
26-50																					
51-75																					
>75																					
Total	3	8	74	32	24	87	132	12	181	21	138	151	50	34	3	9	26	18	3	89	127

Table 7. Continued

Community % Cover	T7S, R31E				T8S, R32E								T8S, R31E							T9S, R32E	Total
	9	8	5	4	34	33	28	29	20	19	18	7	12	13	14	11	2	3	4	3	
Cottonwood-Willow																					
<25				1	7	12	4	6		25	30	10	1	19							141
26-50						12		7	13	7	35			26							124
51-75																					0
>75																					0
																					265
Mesquite																					
<25																					169
26-50		19	22								12				9	23					734
51-75			54			3					6				6	3	3	9			661
>75			6			7					4										439
																					2003
Tamarisk																					
<25			1					1						3	1			3	1	4	151
26-50					4	10	7	16		4											321
51-75																					8
>75																					0
																					480
Channel with Mixed Scrub																					
<25	7	13	28	4	16	10	13	9	7	12	13			12	4	16	3	19	1		1285
26-50																					0
51-75																					0
>75																					0
																					1285
Seepwillow-Broom																					
<25																					0
26-50															12	19					31
51-75																					0
>75																					0
																					31
Mixed Scrub																					
<25					6																10
26-50	6	23	20	15																	360
51-75																					26
>75																					0
																					396
Saltbush																					
<25																					191
26-50																					0
51-75																					0
>75																					0
																					191
Total	13	55	131	20	33	54	24	39	20	48	100	10	1	60	32	61	6	31	2	4	4651

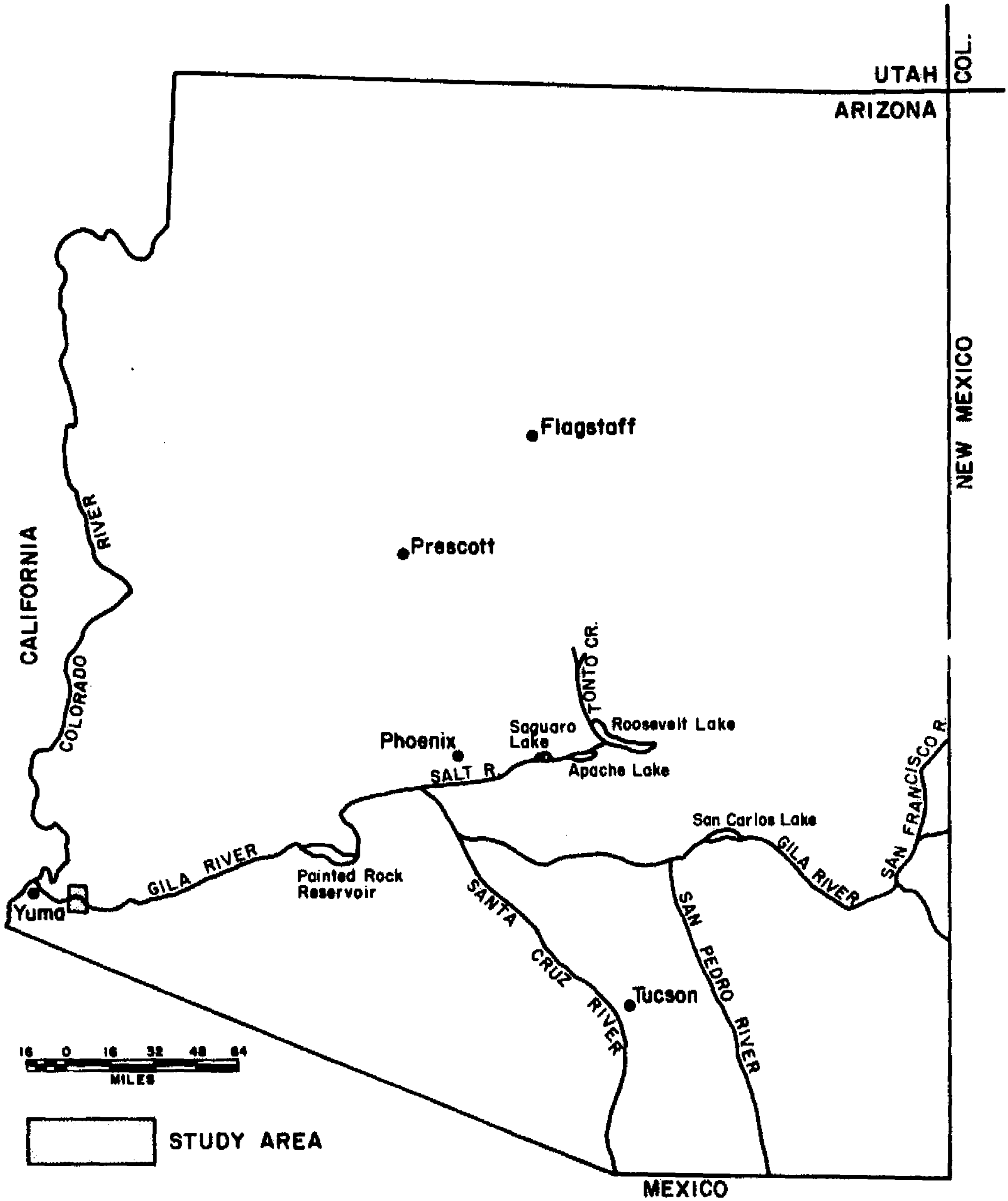

Figure 13. Study area for automated computer mapping on the lower Gila River.

grey shade rendition of each of the four LANDSAT-1 MSS bands was produced for the study area. The computer program, called PICTOUT, classifies the 256 grey shades detected by LANDSAT-1 into a range of values. The four-channel printout is used to provide training field coordinates for CALSCAN, the University of Arizona version of the Purdue Laboratory for Application of Remote Sensing (LARS) statistical pattern recognition program; and c) training sets were chosen, inserted into CALSCAN, and the program performed four major user functions: statistics generation (STAT), class separation (SELECT), image classification (CLASSIFY) and map display (DISPLAY).

STAT performs statistical analysis on the specified training fields. The following data are generated using the relative radiance (brightness) values recorded pixel by pixel for a homogeneous vegetation community: mean, standard deviation, covariance matrix, correlation matrix, histogram, and spectrogram.

The mean refers to the average relative radiance for each of the four spectral bands within each training field.

The standard deviation for the mean for all training fields and classes is calculated, as is the covariance and correlations matrices between the four LANDSAT channels for each training field.

The histogram is a plot of relative radiance versus the number of pixels with a given relative radiance for all training fields of a given vegetation type.

The spectogram is a plot of channel number versus mean reflective radiance $\pm$ one standard deviation for each vegetative type.

SELECT analyzes the output from STAT to determine which combination of LANDSAT spectral bands offers the best separability (correct classification potential) for all vegetative classes. CLASSIFY takes the training field output from STAT and classifies each pixel corresponding to one of the training classes supplied by the user. DISPLAY then processes the map produced by CLASSIFY and prints out the results in the form of a digital grey shade product at an approximate scale of 1:24,000.

The natural vegetation of the study area had previously been separated into six communities and two cover categories of less-than and greater-than 50 percent (Haase, 1972). For the computer analysis only four communities were classified: 1) creosote bush-mesquite, 2) tamarisk-arrowweed, 3) seepweed-pickleweed and 4) mesquite. No attempt was made to identify cover differences. The cattail community which represented only 23 of 2681 total acres mapped was not considered a mapping unit, and saltbush did not occur in the lower 15-mile stretch. One additional natural class, bare rock, and four agricultural-use classes were added to the four natural communities to complete the nine-category classification scheme.

Training sets within each of the four communities were defined on Haase's vegetation map (Fig. 14) of the study site (1:24,000) and on 9- x 9-inch NASA high-altitude color infrared transparencies (1:120,000, Flight 73-016, 9 February 1972). The location of each training set was then located on the PICTOUT grey shades so the coordinates of the training fields could be accurately determined for CALSCAN processing. Because the riparian communities varied in size and tended to integrate into adjacent communities, the training sets varied in size and thus in number of pixels.

Figure 15 is the computer map of the lower 15-mile stretch and encompasses the training field areas used in the computer classification. Each riparian community, agricultural class, and bare rock is shown by a unique computer symbol which denotes the classification given to each pixel (i.e., creosote bush-mesquite .; tamarisk-arrowweed -; seepweed-pickleweed +; and mesquite /). The mapped floodplain averages 1,350 to 2,800 ft in width and is delineated from the adjacent alluvial surfaces, intermontane bajadas, and dissected block mountains by the - symbol also corresponding to the seepweed-arrowweed community. Riparian communities tended to intergrade and there was also a tendency for the creosote bush-mesquite community to occur on the nonriparian bajadas which accounts for some intermixing of computer symbols. Low-level flights over the study area confirmed the continuum distribution of some riparian species; but community boundaries could generally be delineated. Riparian vegetation can be readily distinguished from agricultural areas. The abrupt transition between cultivated fields and natural plant communities facilitates this separation.

Two additional training sets were established in the upper reach before training sets derived in the lower reach were used by the computer to generate a map of the upper 15-mile reach. A Saltbush Community which did not occur in the lower stretch, and a natural area (bajada) were added to facilitate the computer classification.

A classification summary by training class for the lower reach and a summary which combines the lower and upper reach is shown in Table 8. The percentage correct refers to the actual percentage of each training field subsequently classified into a given class by CALSCAN. An overall performance

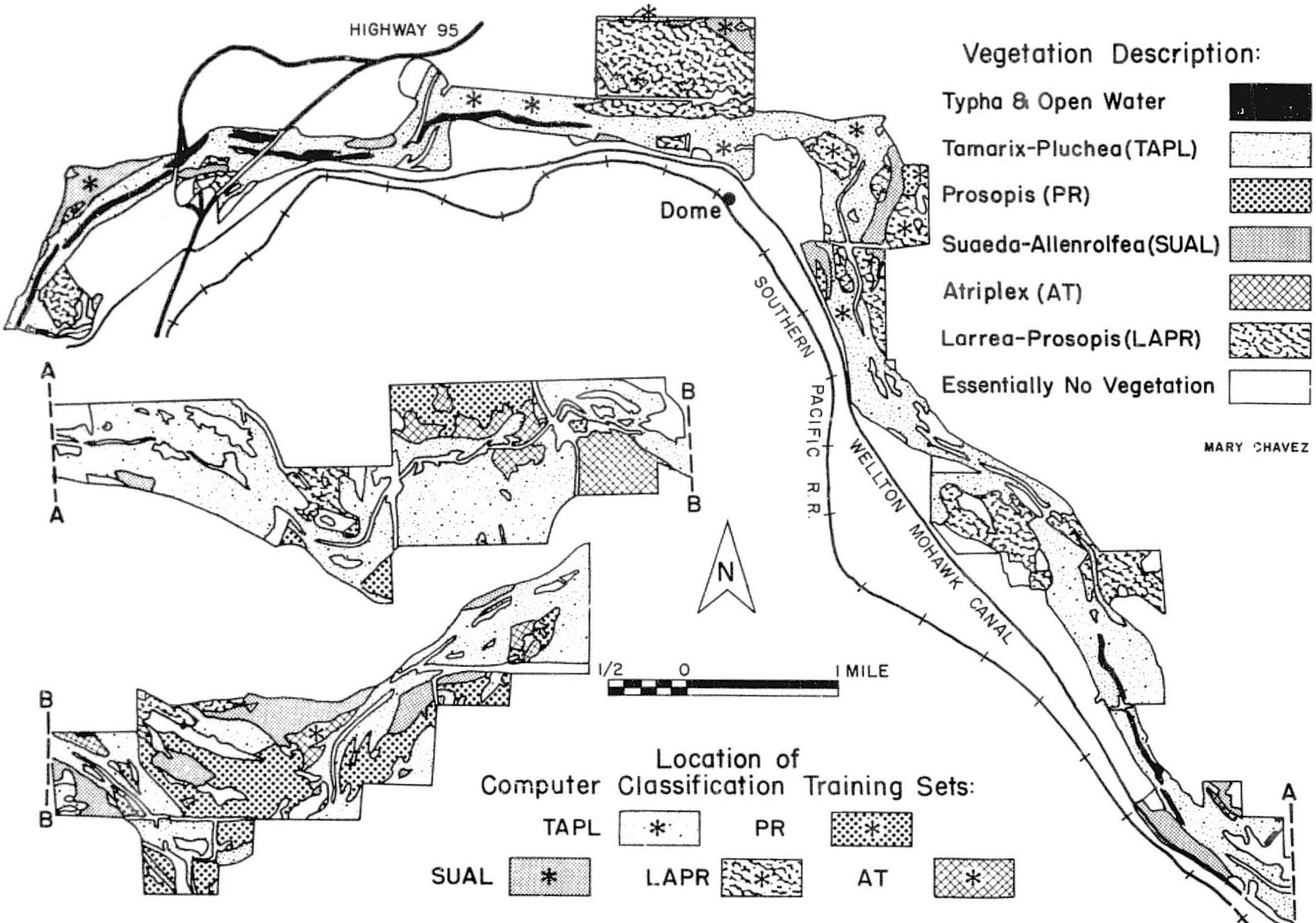

Figure 14. Floodplain vegetation along the Lower Gila River was mapped by Haase (1972) and his map was used as a vegetative control in the present study.

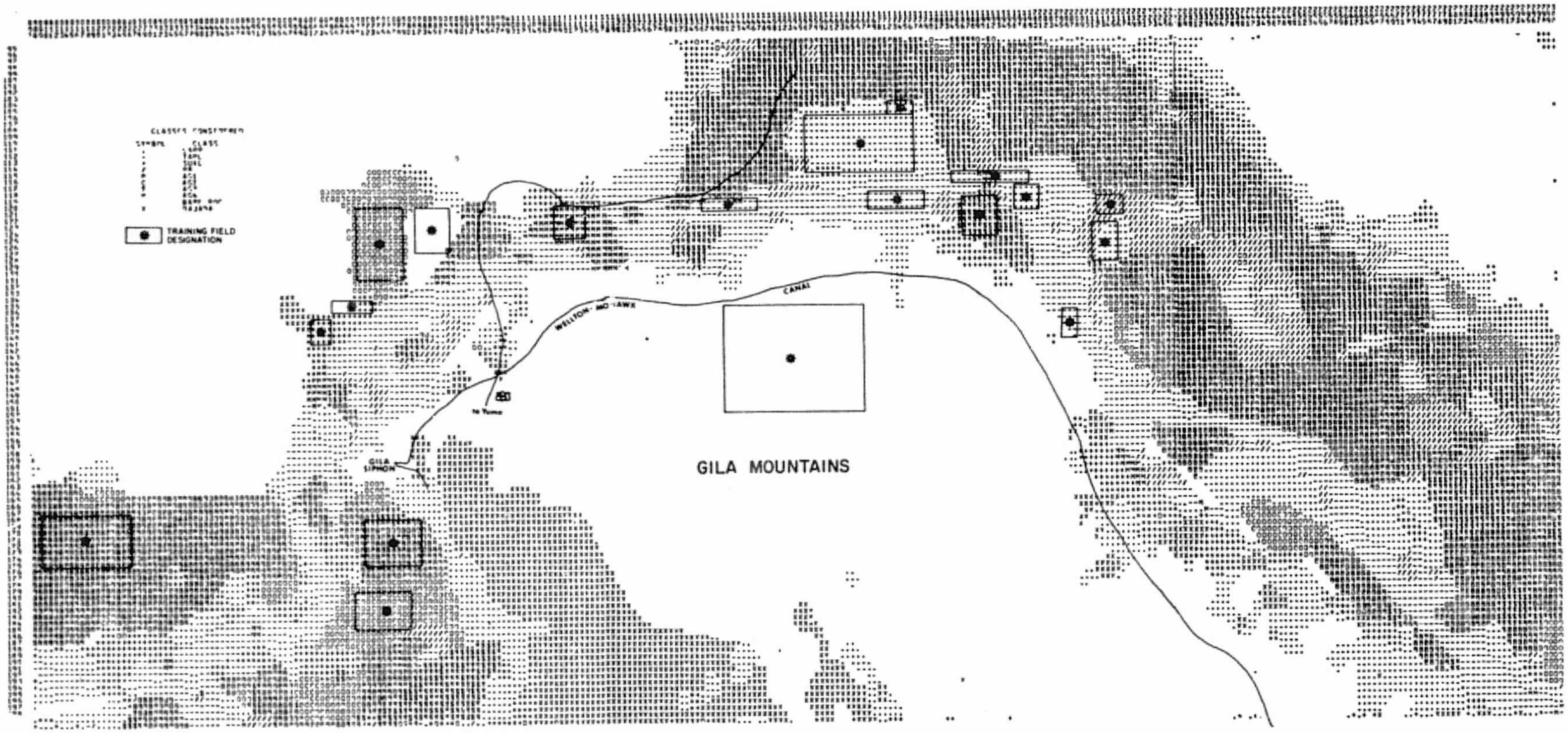

Figure 15. Computer generated vegetation map for lower reach of the Gila River.

Table 8. Classification summary by training classes for lower reach, and combined for lower and upper reaches of Gila River study area.

Class	Number of Samples Within Training Fields		Percentage Correct	
	Lower	Lower and Upper	Lower	Lower and Upper
creosote-mesquite	239	239	92.9	33.9
saltcedar-arrowweed	100	100	89.0	89.0
seepweek-pickleweed	50	50	90.0	84.0
mesquite	15	15	100.0	100.0
agriculture 1	213	213	97.7	97.7
agriculture 2	165	165	98.2	99.4
agriculture 3	42	42	100.0	100.0
agriculture 4	30	30	100.0	100.0
bare rock	508	508	99.8	99.8
bajada		105		100.0
saltbush		64		39.1

of 96.9 percent was generated using a CALSCAN option, which reclassifies pixels on the basis of nine surrounding points, to produce a more homogeneous classification. Overall performance can be defined as the sum of the products of columns two and three above, divided by the sum of column two. The miscellaneous agricultural classifications were used to aid the separation of riparian communities from nonriparian vegetation.

An overall performance of 85.3 percent was generated for the upper reach using the CALSCAN reclassify option. Data in Table 8 can be used to explain the drop in overall performance from 96.9 percent to 85.3 percent between the lower and upper 15-mile reaches. The creosote-mesquite training field declined 59 percent to a low of 33.9 percent correctly classified. This decline is attributed to the introduction of saltbush as a new vegetation community in the upper reach with spectral characteristics similar to the creosote-mesquite community. Eighty-one pixels (33.9 percent) in a training field of 239 pixels were correctly identified as creosote-mesquite, with 42.7 percent or 102 pixels being classified as saltbush and 23.4 percent or 56 pixels falling into the other classification (Table 8).

Areal extent of each riparian community occurring in the upper reach was tabulated (Table 9) for: 1) Haase's map (Fig. 14), 2) the CALSCAN map (Fig. 15) and 3) the visibly-recognizable floodplain on the CALSCAN map. Total

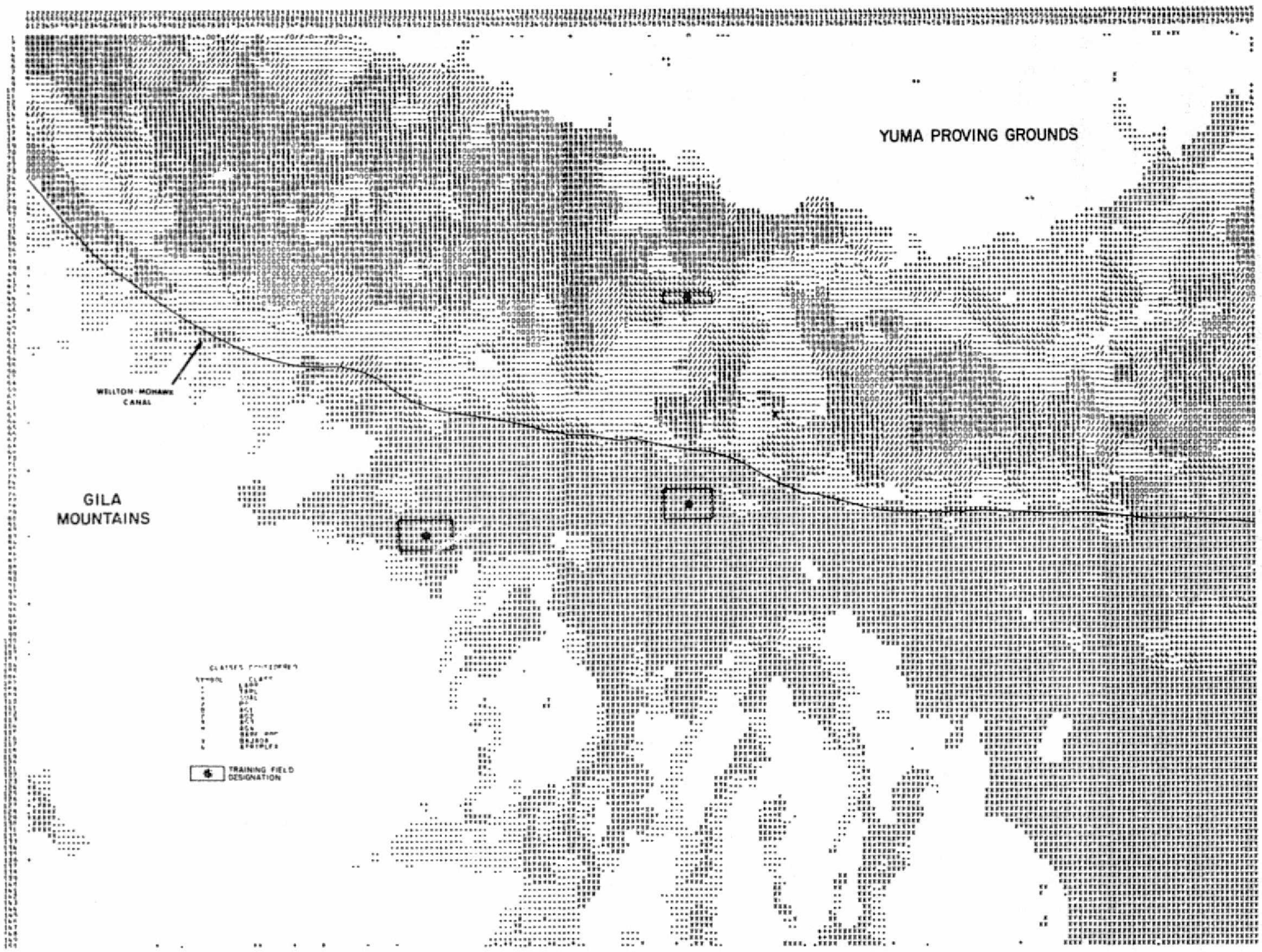

Figure 16. Computer generated vegetation map for upper reach of the Gila River.

floodplain acreage that was outlined (by human eye and pencil) on the computer map compared well with Haase's estimate of total floodplain acreage, 3,682 versus 3,838 acres, respectively (Table 9). However, large discrepancies

Table 9. Areal extent of vegetation communities along upper reach of the Gila River as shown by three methods.

Community	Haase's Map	Computer Classified Map	Floodplain Only
creosote-mesquite	267	4824	1623
saltcedar-arrowweed	2386	1835	1679
seepweed-pickleweed	284	1875	190
mesquite	590	1092	183
saltbush	311	1722	7
Total	3838	11348	3682

occur when acreage estimates from the computer map are matched with respective communities on Haase's map (Table 9). The creosote bush-mesquite community was the most difficult for the computer to delineate. Apparently the spectral response of the riparian and nonriparian communities on the study area is not consistently distinguishable. Similar phenology and lifeform between riparian and nonriparian species, and failure to use cover differences as criteria in establishing training sets may explain why spectral responses appeared inseparable.

Much of the discrepancy in vegetation estimates may be due to geology, land forms and surficial deposits. The University of Arizona, Office of Arid Lands Studies (1970) described the Lower Gila watershed as consisting of dissected block mountains (Mesozoic granite, gneiss, and other metamorphics) dominated by tertiary volcanics and sediments, Pleistocene lavas, fans, river terrace deposits and playa sediments. Their sediment samples from the aggradating ephemeral river channel also reflect tremendous variability. Quartz, feldspar, mica, heavy minerals and minor amounts of volcanic fragments made up the sand fraction of the samples.

This initial investigation suggests that all site characteristics should be evaluated before training sets derived in one area are used in another area. The possibility of using "standardized training sets" to computer map riparian communities appears unlikely because reparian species are often similar in lifeform, phenology, and are difficult to delineate. In addition, delineations between riparian and nonriparian communities often lack reliability. Therefore, further research is needed before automated computers can be used to map riparian communities.

EXISTING VEGETATION MAPS

Vegetation maps of Arizona are characterized by their variability in accuracy and scale of the map, identification and classification of plant communities, agency responsible for the map, and thus, in their inherent value for displaying riparian information.

Kuchler (1967) believes optimum scale varies with the purpose of the map and the skill of the author in organizing the map content. Because of the continuum nature of riparian vegetation and the occurrence of mosaics within a vegetation type, it is often physically impossible or impractical to delineate riparian communities on small-scale vegetation maps. Thus, large-scale maps of small areas are often necessary to display riparian information. However, some of the small-scale vegetation maps of Arizona merit discussion.

The Department of Range Ecology, University of Arizona, cooperating with the U.S. Forest Service and the U.S. Soil Conservation Service mapped the natural vegetation of Arizona into 10 cover types at a scale of 1:2,217,600 (Nichol, 1952). This published map shows the mesquite-saltbush type occupying large areas along the San Pedro, Santa Cruz and Gila River bottomlands.

Nine principal vegetation types in Cochise County were distinguished and mapped in the early 1940's (Darrow, 1944). Darrow's published map (scale 1:443,500) delineates some riparian communities and describes the occurrence of sacaton, tobosa and mesquite along bottomlands; respective acreages of each are summarized.

Mesquite bosque is the potential natural vegetation of the Phoenix area when lifeforms and taxa are used to separate units of vegetation (Kuchler, 1964). Kuchler's small-scale map (1:3,168,000) includes the San Simon and San Pedro drainages in the creosote bush-tarbush types.

Robinson (1965) diagrammed saltcedar occurrence along streams, reservoirs, lakes and playas on a small-scale (1:7,500,000) map of the western United States. He tabulated more than 900,000 acres of saltcedar in the western states, with 118,000 acres in Arizona. It is of interest that he shows saltcedar occurring in much of the bottomland along the San Pedro, San Simon and Gila Rivers.

The most complete estimate of areal extent of phreatophytes and hydrophytes in Arizona appears in Robinson's (unpublished) report. Phreatophyte growth in Arizona was reported along the main stem and minor tributaries of the Colorado River and in the Gila-Salt River basin (Table 10). Mesquite and paloverde covered 43 percent, saltcedar 38 percent, and arrowweed and baccharis 12 percent of the 280,000-acre area. Although his assembled data are probably the best statewide estimate, the primary weakness is related to the number of data sources and an inadequate standardization of vegetation recognition and mapping techniques.

A vegetative study covering 90,328,000 acres in the Lower Colorado Region classified riparian vegetation into a single riparian type without any separation of species (Lower Colorado Region State-Federal Interagency Group for the Pacific Southwest Interagency Committee, 1971). This Interagency Group tabulated vegetation occurring in blocks larger than 1,000 acres and the total estimate of 106,000 acres is lower than that of Robinson. The Salt, San Francisco and Gila Rivers as well as Tonto Creek are centers of riparian vegetation on the Interagency Group map (1:3,168,000).

Thirteen natural vegetative communities are delineated on Brown's (1973) vegetation map of Arizona; however, riparian communities were omitted. The Arizona Resource Information System published the map at a scale of 1:500,000.

Riparian communities were also omitted from a vegetative cover map prepared for four counties in Southeastern Arizona (Coronado Resource Conservation and Development Council, 1973). Their report includes a map (scale 1:1,000,000) delineating five major vegetation types: coniferous forest, wood-grassland, chaparral, desert grassland and desert shrub.

The Arizona State Land Department personnel surveyed private, Bureau of Land Management and state lands for potential rural land use, development, and protection needs (Sayers, 1974). Natural vegetation was mapped as described by Kuchler (1964) and acreages of the respective vegetation types are tabulated by county. Some estimates of riparian communities are higher than estimates appearing in other studies. For example, Sayers (1974) reports mesquite bosques cover 780,509 acres of state, private, and Bureau of Land Management land in Cochise County. The interpretation of mesquite bosque used differs from the definition

Table 10. Location and acreage of phreatophytes and hydrophytes in Arizona (from unpublished report by T.W. Robinson).

Area	Saltcedar and Saltbush	Mesquite and Paloverde	Willow and Cottonwood	Arrowweed and Baccharis	Phreato-phytic grasses and Tules	Unknown	Total
COLORADO RIVER DRAINAGE							
Main stem-Davis Dam to International Boundary	38,000	33,500	100	31,100	8,300		111,000
Little Colorado River Basin	10,000	5,000				5,000	20,000
Virgin River and Kanab Creek Basins	1,000					1,000	2,000
Bill Williams River Basin at Alamo	200						200
Big Sandy Wash below Cane Springs	3,000	1,500	—	1,000	—	500	6,000
Colorado River-main stem Total	52,200	40,000	100	32,100	8,300	6,500	139,200
GILA RIVER BASIN							
Duncan Valley		1,800					1,800
Cactus Flat-Artesia area		300					300
Safford Valley	3,200	600	500	1,100		1,200	6,600
San Carlos Indian Reservation area	5,600	3,400	200				9,200
San Carlos River Valley, San Carlos to San Carlos Reservoir	1,400		1,000				2,400
Coolidge Dam to San Pedro River	100	1,000					1,100
San Pedro River Valley	2,500	20,300	800				23,600
Confluence San Pedro to Buttes Dam site	1,400	1,600		100			3,100
Sacaton to confluence with Salt River	6,000	5,000					11,000

Table 10. Continued

Area	Saltcedar and Saltbush	Mesquite and Paloverde	Willow and Cottonwood	Arrowweed and Baccharis	Phreato-phytic grasses and Tules	Unknown	Total
Confluence with Salt River to Gillispie Dam	8,000	2,000				100	10,100
Gillispie Dam to Painted Rock Dam	5,600	5,000					10,600
Painted Rock Dam to Texas Hill	5,000	1,000					6,000
Texas Hill to Dome	6,000	800					6,800
Hassayampa and Agua Fria River Valleys	2,000	2,000				1,000	5,000
Palomas Plain	1,500	1,200	200	200			3,100
Gila River Basin Total	48,300	46,000	2,700	1,400		2,300	100,700
SALT RIVER BASIN							
Verde River, Bartlett Dam to confluence with Salt River		18,000					18,000
Confluence with Verde River to Tempe	1,000	5,000				2,000	8,000
Salt River Basin Total	1,000	23,000				2,000	26,000
MINOR DRAINAGE BASINS							
Picacho Reservoir	1,000	400					1,400
Udall Reservoir-Carrizo Creek	200						200
Santa Rosa Wash-Pinal County		1,700		600	300		2,600
Douglas Basin		4,500					4,500
Willcox Basin		5,000					5,000
Minor Drainage Areas Total	1,200	11,600		600	300		13,700
State Total	102,700	120,600	2,800	34,100	8,600	10,800	279,600

used by other agencies. On a statewide basis, Sayers (1974) estimated 1,407,584 acres of mesquite bosques occur, and an additional 46,697 acres of mesquite-cottonwood vegetation type occur on private, state, and Bureau of Land Management land.

Vegetation maps for the Phoenix-Tucson corridor are available in the U.S. Geological Survey Resource and Land Information (RALI) series at the 1:250,000 scale (Turner, 1974). Riparian vegetation growing along perennial and ephemeral streams, and where groundwater levels are high were not separated by taxa or cover class, but were lumped into the "Deciduous Riparian Forest" category.

Cottonwood occurrence and density in Arizona were graphically displayed by summarizing input from 11 government agencies (Barger and Ffolliott, 1971). Major concentrations of cottonwood occurred in the Verde, Little Colorado and Gila River drainages.

Vegetation maps dated 1914, 1937, 1944 and 1964, and studies by the U.S. Geological Survey along a 15-mile stretch of the Upper Gila River provide a quantitative record of changes during a 50-year period (Turner, 1974). Probably the most marked vegetation change has been saltcedar replacing such native species as seepwillow and cottonwood. Maps (scale 1:28,160) of the riparian communities for each of the mapping dates appear with Turner's publications.

Distribution of valley floor vegetation in the 30-mile Tres Alamos-Redington reach of the San Pedro Valley was mainly affected by drainage area, geology, and flow region (Zimmerman, 1969). He mapped the distribution of 11 riparian species in the 750-square-mile study area at a scale of 1,250,000. Saltcedar was the primary species growing within the entrenched channel, and covered 450 acres of bottomland.

Phreatophyte density on the Gila River and its tributaries above Safford Valley was mapped in 1963 by the Bureau of Reclamation (George, 1964). A summary of findings is given below:

Area	Average Height (ft.)	Average Density (%)	Acres
San Pedro	13	64	23,614 (mainly mesquite)
Upper Gila River	50	65	1,532 (mainly cottonwood)
San Francisco	50	65	152 (mainly cottonwood)

These data were included in Robinson's (unpublished) report. Only areas with more than 25% crown density were mapped on aerial photographs (scale 1:7,920).

The Bureau's study was updated in 1969 to show agricultural conversions; however, maps were never constructed and the photographs are filed at the U.S. Bureau of Reclamation Office in Phoenix (Mel Persons, Personal Communication, 1974).

Arizona Game and Fish Department personnel surveyed 26 million acres in Southern Arizona and found only 70,000 acres of suitable white-wing dove habitat (Wigal, 1973). Suitable habitat was defined as thicket-forming vegetation with 25% or greater crown coverage and with trees averaging at least 10 ft. in height. The habitat maps have not been published and are maintained in the Arizona Game and Fish Department files.

Vegetation along the Lower Gila River floodplain has been mapped (University of Arizona, Office of Arid Lands Studies, 1970; Haase, 1972). The authors used field studies and a literature review to develop a classification scheme of seven communities:

1) Cattail-Marsh
2) Salt Cedar-Arrowweed
3) Big Saltbush
4) Mesquite
5) Mixed Saltbush
6) Seepweek-Pickleweed
7) Creosote bush-Mesquite

The distribution of the communities is shown in Fig. 14 and served as the basis of comparison for the previously described computer mapping. Haase lumped the Big Saltbush and Mixed Saltbush Communities into one community and thus recognized six vegetative communities for mapping. His map shows the floodplain vegetation between Gila Siphon and Texas Hill, at a scale of 1:24,000, and is available for use in the Map Library, Main Library, University of Arizona.

Floodplain vegetation on the Gila River was mapped for 36 river miles from Gillespie Dam to the confluence of the Salt and Gila Rivers using NASA high-altitude color and color infrared transparencies (Haase, 1973). Land use in the study area and four floodplain communities (mesquite, saltbush, salt cedar and cattail) were mapped at a scale of 1:84,480. Maps and tabular data appear in Haase's report submitted to the U.S. Army Corps of Engineers.

Saltcedar and arrowweed dominated over 100,000 acres along the Lower Colorado River when it was mapped by the Bureau of Reclamation (Pacific Southwest Interagency Committee, 1958). Scientists from Arizona State University are presently studying and remapping this area. Vegetation and soil maps from Davis

Dam to the Mexican Border have been constructed at a scale of 1:24,000 (Nancy Stamp, Department of Zoology, Arizona State University, personal communication, 1974). Vegetation is classified into nine communities and cover is separated into five classes.

The U.S. Geological Survey is currently mapping vegetation along 993 miles of riparian channels (Beaver, Tonto, San Francisco, etc., drainages) in North-central Arizona (Tom Anderson, U.S. Geological Survey, personal communication, 1974). Riparian vegetation is being delineated into seven classes on aerial photographs (scale 1:13,000). The purpose of this study is to estimate evapotranspiration from the riparian zones and plans to publish the maps do not exist at this time.

HISTORICAL PERSPECTIVE AND RECENT CHANGES OF RIPARIAN HABITATS

Recent major changes in Arizona's riparian environment have been documented (Miller, 1961). Minckley (1965) reported that squawfish (<u>Ptychocheilus lucius</u> Girard), a large native minnow sometimes weighing 100 lbs. and reaching a length of six ft. was an important constituent in Indian fishing operations along the Lower Gila River. As late as 1911, farmers in the Yuma area were taking this fish from irrigation canals to be used as fertilizer on farmland (Minckley, 1965). In 1849, mountain lions were reported in dense cottonwood and willow growth along the lower Gila River (Davis, 1973).

In the middle 1800's, parts of the San Pedro River were marked by channelization and "other parts flowed slowly through grassy marshes, flush with its banks, often flooding extensively behind beaver dams" (Davis, 1973). The exact role of beavers has not been documented; however, Davis felt the pools created by their dams were partly responsible for the marshy conditions. Beaver were apparently numerous because James O. Pattie and his trapping company took over 200 beaver from the San Pedro River during March, 1826 (Hastings, 1959; Davis, 1973; and Gavin, 1973). As late as 1859, grizzly bears were still abundant in riparian woodland along the San Pedro (Davis, 1973) and during Tombstone's glory days, the large humpback sucker (<u>Xyrauchen texanus</u> Abbott) was caught in the San Pedro and sold commercially in Tombstone (Minckley, 1965).

A gradual shift from more mesic to a more xeric condition along the San Pedro River can also be inferred from Hasting's (1959) review of the malaria problem. According to military records, 215 men were stationed at Camp Grant (junction of Aravaipa and San Pedro) during 1827, and each averaged about nine hospitalizations (over 1700 cases) for malaria.

Historical accounts of the San Simon Valley attest to lush grasses, abundant wildlife, numerous springs and cienegas lined with willows, and a nearly marshy condition during the 1880's (Jordan and Maynard, 1970; and Davis, 1973). Hastings (1959) reported that the "San Simon Creek seems to have been more intermittent than the Santa Cruz and the San Pedro" but he also felt it flowed through an unchanneled, almost imperceptible bed. He feels that the San Simon Cienega, located in the upper reaches of San Simon Creek, is fairly representative of former marshy areas, and its existence is attributed to a dam constructed below the Cienega which checked the headward channeling of the Creek.

Vegetation changes in the southwestern grasslands and possible causes for it were discussed by Humphrey (1958), Hastings (1963), Hastings and Turner (1965), Buffington and Herbel (1965) and York and Dick-Peddie (1969). Generally, the last 100 years have seen: 1) the steady decline in abundance of grass; 2) a marked increase in shrubs on the desert plains and foothills; and 3) initiation of channel-cutting on all main rivers with subsequent head-cutting through many acres of grassland.

Although exact causes of the vegetation and landscape changes are not fully understood, three principal causes have been hypothesized: biological, climatic and geologic (Hastings, 1963; and Hastings and Turner, 1965). Hastings (1959) reported that geological and climatic explanations are advocated by individuals who are primarily dissatisfied with the overgrazing hypothesis. He cites studies by Bryan (1925) which indicated there have been several erosion cycles in the Southwest, with the next most recent one occurring about 600 years ago. However, Morrison (1972) interpreted geologic and archeologic data differently and believes the larger streams in Southeastern Arizona were stable in their main tributaries for some four millenia, broken only by several brief and minor erosional episodes. From Bryan's theory, one can argue that if channel cutting occurred in pre-Columbian times, factors other than livestock grazing must be responsible. Hastings and Turner (1965) have introduced another salient point, the initiation of channel cutting and the introduction of large-scale livestock grazing do not necessarily correlate. Large-scale cattle raising began in Sonora around 1680, yet no significant vegetation changes or arroyo cutting were observed until about 1880. They also report a substantial development of ranching in parts of Southeastern Arizona during the 1820's and 1830's, yet no erosional problems developed until around 1880.

Proponents of the biological explanation believe that overgrazing disrupted a delicate ecosystem by causing vegetative deterioration which altered the hydrologic cycle (Antevs, 1952). Infiltration was reduced, runoff increased, and higher flood crests with greater erosive powers resulted (Phillips, Marshall, and Monson, 1964). Although Phillips et al. (1964) do not present data to document their explanation, Dobson (1973) presented data which suggests grazing caused vegetative changes on a previously ungrazed riparian site. Livestock grazing removed Phalaris arundinacea, a rhizomatous pioneer species, and made the site more susceptible to erosion. After four years of grazing, 43 new species, mostly ephemeral weeds, had invaded and Dobson felt vegetative complexity and diversity had increased.

Hastings (1959) reports an interesting relationship between dates of channel cutting and growth of the livestock industry in three Arizona counties (Cochise, Pima and Graham). His literature review found no evidence of an anomaly in the hydrologic cycle during 1883 when cattle numbered 68,000. However, when cattle numbered 156,000 in 1886, unwarranted flooding occurred and extensive channel cutting was observed in 1890 when cattle numbers reached 253,000.

Duce (1918) was unable to find old terraces and thus assumed arroyos were noncyclic and that arroyos developed in Southern Colorado contemporaneously with ranching. He wrote that cattle increased the rates of runoff and erosion by destroying vegetation, compacting the soil, and forming channels for the passage of water. Therefore, the balanced forces of erosion were disturbed and canyon bottoms were no longer planes of equilibrium. Cottam and Stewart (1940) similarly felt they had adequate data to link excessive livestock grazing and vegetative destruction with subsequent channel cutting and meadow desiccation in Southwestern Utah.

Recently there has been general agreement that overgrazing and climate were both important and contributing factors to channel cutting and vegetational changes in the Southwest (Hastings, 1959; Leopold, 1951; Antevs, 1952; Hastings and Turner, 1965; and Morrison, 1972). Hastings (1959) summarizes the "trigger-pull" theory which states that long-term erosional trends were in existence by 1880, and the "coming of the cattle merely served as the trigger-pull that set off an already loaded weapon." Nevertheless, periods of channel cutting, with subsequent periods of lateral cutting re-creating conditions of equilibrium, have always been a part of the normal history of desert streamways (Shreve and Wiggins, 1964).

When discussion centers on riparian environment, however, evidence suggests the biological factor, with man acting as a controlling factor, was most directly responsible for recent vegetative changes. Native vegetation was partially cleared by miners, farmers and ranchers for a variety of uses (Horton, 1972; Haase, 1972; and Shreve and Wiggins, 1964) (Fig. 17). Man's manipulative powers were increased by the Reclamation Act of 1902 which led to dams, artificial drainages, and exposed large areas of bare, moist soil (Haase, 1972). Groundwater levels were raised in some instances when drainage systems were inadequate for the irrigation water; but usually groundwater levels were lowered as a result of large-scale pumping to supply agricultural and urban demands.

Hoover Dam on the Lower Colorado River illustrates how the construction of a dam can alter riparian environment and affect bird populations (Phillips et al. 1964). Prior to construction, cottonwoods and willows grew along the banks and periodic flooding created large backwater areas and silt flats which made excellent habitat for many species of birds. After construction, the river no longer overflowed, and much bird habitat was lost because lagoons and silt flats were no longer created below the dam, and a large clear lake of open water was formed above the dam.

Man also introduced saltcedar as an ornamental early in the nineteenth century and it was established in Arizona in the early twentieth century (Horton, 1966). Seed dispersal was aided by early settlers who originally appreciated the plant's potential for shade and windbreaks.

Judd et al. (1971) could not correlate any insect infestation or disease with the lethal decline of mesquite on the Casa Grande National Monument, but felt the mesquite trees may have been weakened by a mistletoe infestation. However, their summary of water table data indicates water availability was probably the critical factor:

1902 - First well dug on area; water standing at 10-16 ft.

1918 - New well dry; water level 42 ft. 6 in.

1931 - Well drilled on area; water level 42 ft. 6 in., 186 ft. 5 in. of pipe in hole

1949 - Depth to water in well, 102 ft.

1952 - Depth to water in well, 180 ft.

Judd et al. (1971) reviewed earlier studies which indicate mesquite tends to develop strong taproots on deep soils with adequate moisture, but on upland slopes where moisture penetration is limited by shallow soils, it tends to develop

Figure 17. Overall ranch operation may be enhanced by clearing native vegetation and managing bottomland site for irrigated pasture.

extensive lateral roots. They speculated that the mesquite trees were able to modify its roots and survive the 32-ft. water table drop that occurred between 1902 and 1931, but were unable to adapt to the subsequent drop to 180 ft.

A mesquite bosque, located in the Santa Cruz Valley near Tucson, is described in Arnold's (1940) summary of early literature. In 1902, "the bottomlands on either side of the river are covered, miles in extent, with a thick growth of giant mesquite trees. This magnificent grove is included in the Papago Indian Reservation, which is the only reason for the trees surviving as long as they have, since elsewhere every mesquite large enough to be used as firewood has been ruthlessly cut down." In 1911, the mesquite trees were described as wonders of their kind, with trunks over four feet in diameter. "The large bases branched a few feet from the ground into several limbs 15 or 18 inches in diameter." By 1917, a policy of deforestation had reduced the heavier timber to four-fifths of its former abundance, and the cutting was removing 2,500 cords per annum. Arnold's (1940) assessment indicated some areas had good second growth stands, and every mesquite limb large enough to be used as fuel had been removed from other areas.

In an unpublished report, T.W. Robinson estimated there were 118,000 acres of saltcedar in Arizona, and a University of Arizona, Office of Arid Lands Studies report (1970) considers this "retrogressive succession." Saltcedar is an introduced species that has replaced native riparian plants because of its competitive ability, relative to the native species, and was favored by man's riparian manipulations (Harris, 1966). Haase (1972) uses the term "monoclimax" to describe pure stands of saltcedar and suspected their lack of diversity would make them susceptible to ecological catastrophe. Horton and Campbell (1974) wrote that dense stands of saltcedar were susceptible to fire during periods of drought and to a sharp lowering of the water table.

Farming practices have adversely affected riparian environments by changing water table levels or salinity, influencing erosional hazard, or converting many acres of riparian vegetation into farmland (Marks, 1950; Haase, 1972; Hastings, 1959; and Horton and Campbell, 1974).

The impact of farming practices on riparian communities is illustrated by the ditch dug near Solomonsville in the late 1800's to control floodwater (Bryan, 1925; Hastings, 1959; and Miller, 1961). By 1925 the initial channel (4 ft. deep and 20 ft. wide) averaged 20 ft. in depth, 700 ft. in width, and extended over 60 miles (Bryan, 1925). Farming practices were also implicated with channel cutting along the Santa Cruz. Hastings (1959) cites late 1880 issues of the

Arizona Daily Star, "On August 5, 1890, the Santa Cruz began cutting its present channel along a ditch dug by Sam Hughes to irrigate some holdings of his lying in the present riverbed north of Speedway."

Mesquite was probably the predominant Lower Gila Valley community prior to settlement (Marks, 1950). White farmers started farming in the area around 1860, were irrigating by 1875, and by 1930 there were 11,000 acres under irrigation in the Wellton-Mohawk area (University of Arizona, Office of Arid Lands Studies, 1970). In 1970, riparian vegetation was mapped from Gila Siphon to Texas Hill, a 58-mile stretch of the Lower Gila River (Haase, 1972). Floodplain width varied between one and five miles, but was four to five miles wide along most of the stretch. Assuming the floodplain averages three miles in width along the 58-mile study area, 111,360 acres of floodplain were examined by Haase; however, his map delineates only 16,363 acres of riparian vegetation. Therefore, if one can assume that the floodplain was covered by riparian vegetation in 1860, about 85 percent of the total riparian communities have been converted to agricultural lands.

Saltcedar communities accounted for more than one-half of the remaining riparian vegetation (Haase, 1972) and when the total acreage of this exotic is subtracted from the riparian total, only 5,285 acres of native riparian communities remain. This represents about 5% of the theoretical 1860 riparian base.

For state-wide comparisons, the rate and extent of riparian community replacement by croplands is probably exaggerated in the Lower Gila area, and Nichol's (1952) assessment merits consideration. He described mesquite bottoms as being productive agricultural soils if they were free of alkali and not subject to floods, but felt that except for the Yuma Valley, the areas used agriculturally in this type are very minute and are composed mainly of small individual farms which have been established on the inside bends along the rivers.

Irrigated acreage along the San Pedro River shows a gradual increase along the riparian environment until 1966 and then a decrease (Table 11) (Roeske and Werrell, 1973). The decline from 12,000 irrigated acres in 1969 to 9,700 acres in 1970 is of interest. It is not known whether this decrease reflects less intensive farming practices which allowed some irrigated land to return either to nonirrigated farmland or to native vegetation, or is the result of a possible sampling error.

Table 11. Irrigated acreage in the San Pedro River Valley increased from 1890 through 1966 and subsequently declined through 1970. Data adapted from Roeske and Werrell (1973).

Year	Irrigated Acreage
1890	2,700
1899	3,500
1913	5,800
1936	6,400
1941	6,900
1953	8,100
1962	11,100
1966	12,500
1969	12,000
1970	9,700

On the basis of Roeske and Werrell's (1973) report, 7,000 acres of land was converted to irrigated production in an 80-year period, or at a rate of 87 acres per year. However, this cannot be interpreted as the loss-rate of riparian environment along the San Pedro because not all land converted from riparian vegetation is placed under irrigation.

Riparian environment has declined much more rapidly than 87 acres per year in the 22-mile stretch from St. David to Cascabel Road. Changes during a 36-year period along a 22-mile stretch of the San Pedro River were documented by comparing 1936 U.S. Soil Conservation Service black and white aerial photographs (scale 1:31,680) to derive a map of vegetative conditions in 1936 to a recent vegetative map of the respective area derived from 1973 NASA high-altitude color infrared photography (scale 1:125,000). In 1936, mesquite was a dominating component in the riparian communities and no attempt was made to delineate other riparian communities. All inclusions were lumped into mesquite classes on the 1936 (SCS) aerial photographs. Along this stretch of the river, riparian communities have declined from 10,690 acres in 1936 (Fig. 18) to 5,500 acres in 1972 (Fig. 9), nearly a 50 percent reduction. This represents a loss of about 144 acres per year since 1936, or an annual decline of 1.4 percent of the 1936 riparian base. By 1965 man had also converted nearly half (3,900 acres) of the total mesquite forests on the pre-1880 floodplain between

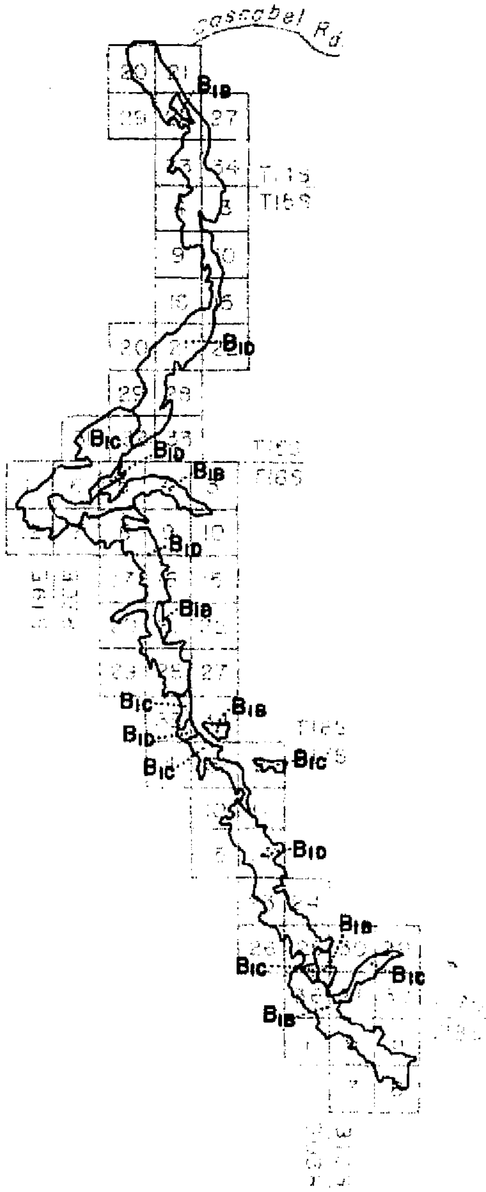

Figure 18. Mesquite dominated the riparian communities (10,690 acres) along the San Pedro River in 1936. Study reach includes 22 river miles, from St. David to Cascabel Road, mapped from 1936 SCS aerial photographs. See Table 3 for legend and Figure 9 for comparison of riparian communities in 1972.

Tres Alamos and Redington to agricultural production (Zimmerman, 1969). Because the former study reach included cultural activities in the Benson-Pomerene area, and the latter a more active farming area, these loss rates are possibly atypical of--and should not be assumed representative of the total river.

The U.S. Geological Survey mapped 9,303 acres of phreatophytes in the 46-mile reach of the Gila River from Thatcher to Calva in 1944 (Gatewood et al., 1950). When this area was examined on aerial photographs taken in 1958 by the Army Corps of Engineers, 15.9 percent or 1,482 acres had been cleared for farm use (Horton, 1962). Clearing practices continued and T.W. Robinson, in an unpublished report, reported only 6,600 acres of phreatophytes along this reach in 1967. This is a 30 percent reduction in 23 years.

A detailed historical study of vegetation along a five-mile reach of the Upper Gila showed dramatic increases in saltcedar distribution (Turner, 1974). Maps of the 2,360-acre study site confirms an increase in saltcedar from 146 acres in 1937 to 1,006 acres in 1964. Turner observed that the cyclic pattern of vegetative change had been interrupted by saltcedar dominating low areas and replacing the native riparian plants (cottonwood and seep willow). In his study area, total acres of riparian communities increased slightly at the expense of barren or cultivated and channel land.

Many studies report the general reduction of cottonwood and willow along various drainages (Haase, 1972; Phillips et al., 1964; Brown and Lowe, 1974b; and Turner, 1974); however, photographic evidence suggests there has been a post-1880 increase in cottonwoods along at least one stretch of the San Pedro River (Hastings and Turner, 1965). They believe the increased cottonwood establishment is related to arroyo cutting. This is possible because a sudden lowering of the water table would reduce competition by weakening existing vegetation, create a variety of microhabitats and eliminate marshy conditions.

Some inferences regarding future riparian succession can be drawn from earlier studies. For example, the dynamic conditions characterizing the riparian environment (Zimmerman, 1969; Hastings, 1963; and Campbell and Green, 1968) help explain patterns of riparian vegetation. Mesquite establishment would be unlikely in waterlogged and poorly aerated soils found on marshy bottoms dominated by phreatophytic grasses; therefore, some channel cutting made environmental conditions more conducive for mesquite establishment (Hastings, 1963). Thus, many of the mesquite bosques appear to have developed simultaneously with initial channel cutting and mature mesquite trees along the San Pedro

River (Gavin, 1973) and at Casa Grande National Monument (Judd et al., 1971) are from 95 to 137 years old.

Riparian succession along many southern Arizona floodplains now fits the "retrogressive succession" described along the Lower Gila River in the University of Arizona, Office of Arid Lands Studies, study (1970) and by Haase (1972). Thus, many riparian communities (cottonwood, willow, mesquite and arrowweed) may be irreversibly gone because of man's activities. Not only have large areas of mesquite bosques been converted to farmland, but additional acreages are threatened because of the recently revived interest in cutting mesquite for firewood. Saltcedar will continue to play a significant role in succession of riparian vegetation, but Haase (1972) is hesitant to make any exact predictions because of its recent introduction and man's environmental manipulations.

Riparian habitats on lands administered by the U.S. Forest Service and Bureau of Land Management will probably continue to receive more consideration in their multiple-use planning. An example is the current effort by the Bureau of Land Management to classify the Gila River from Old Clifton Bridge to Bonita Creek either as a wild and scenic river or a primitive area (Paul Yull, Wildlife Management Biologist, Bureau of Land Management, personal communication). If this trend continues, riparian communities on federal lands may be maintained. Horton (1972) wrote that vegetation along mountain streams has developed under near normal ecological processes and has not changed as distinctly as floodplain areas.

However, there is little reason for long-term optimism regarding the riparian environment in many parts of Arizona. There is no rationale to expect a reversal in the ever-increasing population and an ever-declining groundwater table. For example, although Roeske and Werrell (1973) did not detect any long-term net decline in groundwater level along most parts of the San Pedro River, the amount of groundwater withdrawal is in excess of recharge in the Sierra Vista-Fort Huachuca area. Water levels have declined about 30 feet in 25 years and a cone of depression has developed in this area. Roeske and Werrell (1973) believe this cone of depression will expand and deepen.

Dasmann (1959) defines a renewable natural resource as "a living or biotic resource that is capable of reproducing or replacing itself," and distinguishes from it the nonrenewable resources "consisting of nonliving materials which are not capable of reproducing themselves." Therefore, under these conditions, it may be justifiable to regard the native riparian environment as a nonrenewable resource in many areas.

PRODUCTS AND USES OF SOUTHERN ARIZONA RIPARIAN HABITATS

Benefits derived from riparian communities (Table 12) can either be tangible and measured in monetary terms or intangible and not easily quantified. Two kinds of demands have historically been placed on riparian communities: 1) consumptive demand for physiological and industrial uses and 2) recreational demand (Deevey, 1971). From these two contrasting demands, a conflict has tended to evolve with the biologist, ecologist and environmentalist on one side, and the engineer, economist and administrator on the other. Because the latter group has historically been able to discuss costs and benefits in monetary terms, they have consistently dominated the political scene that governs land-use policies (Deevey, 1971; and Jahn and Trefethen, 1972).

Table 12. Some potential goods and services supplied by riparian ecosystems.

- INTANGIBLE
  - Habitat
    - Wildlife
    - Endangered plant and animal species
  - Beauty
  - Healthful environment
  - Natural or seminatural ecosystems for scientific study
  - Germ plasm for domestication or breeding
- TANGIBLE
  - Forage for livestock and wildlife
  - Nectar for bees
  - Water
  - Recreation
    - Swimming
    - Hiking
    - Canoeing
    - Fishing and hunting
    - Biking
    - Photography
    - Bird watching
  - Minerals
  - Timber

Riparian Vegetation Water-Conservation Controversy

Water is a limiting factor in the arid Southwest and its interaction with riparian vegetation has major ramifications. From the time when Indians and Spanish-Mexican societies adapted their way of life to the water scarcity problems, man has become more manipulative, and now the environment is adapted to meet the needs of the dominant Anglo-American society (Kelso *et al.*, 1973).

Most early riparian vegetation research was conducted by the U.S. Geological Survey and the U.S. Bureau of Reclamation and was aimed toward determining water losses by phreatophytes and controlling saltcedar (Horton and Campbell, 1974). Robinson (1958) determined that phreatophytes covered about 16 million acres in the 17 Western States and discharged 25 million acre-feet of water into the atmosphere annually. For example, annual evapotranspiration loss in the 17 Western States is equivalent to 75 percent of the storage capacity of Lake Mead (Robinson, 1958) and a square mile of cottonwood transpires enough water to supply the needs of a city with a population of 23,500 (Cole, 1968). Three-year-old saltcedar plants near Safford, Arizona (Gatewood *et al.*, 1950) were found to use 10.3 gallons of water per day over a 205-day growing season. In terms of animal needs, one three-year-old cottonwood or saltcedar requires a little more water than one cow or four sheep. Robinson (1961) summarized annual rate of water use by some phreatophytes for the 61-4 Pacific Southwest Interagency Committee (Table 13).

Blaney, Morin, and Criddle (1942) and Gatewood *et al.* (1950) agreed that transpiring plants use large amounts of water; however, many reports (Gatewood *et al.*, 1950; Turner and Skibitzke, 1952; Rowe, 1963; U.S. Senate, 1963; Bowie and Kam, 1968; and Culler *et al.*, 1970) do not agree on how much water could be saved by vegetation removal. Different methods of measuring evapotranspiration were partly responsible for the inconsistent estimates (Robinson, 1966; Muckel, 1966; Horton and Campbell, 1974) and the bias of measuring evapotranspiration from standard tanks, then converting vegetation to 100 percent volume density to compute water loss was discussed (Horton, 1963). But most of the discrepancy is due to variation in plant growth, climate, soil texture, soil fertility, soil salinity, soil alkalinity, and groundwater depth and quality (Fletcher and Elmendorf, 1955; and Robinson, 1966). This hypothesis was substantiated when the influence of topographic and climatic parameters on evaporation and saltcedar transpiration was investigated (Hughes, 1971). Therefore, total stream losses should be analyzed when water

Table 13. Water use data summarized and presented by T.W. Robinson (1961) at 61-4 Pacific Southwest Interagency Committee.

Plant	Annual rate (acre-feet per acre) including precipitation	Volume density (percent)	Depth to water (feet)	Locality and remarks
Alder	5.3	-	-	Santa Ana River drainage Basin, Calif.
Batamote	4.7	100	6	Safford Valley, Ariz.
Cottonwood	6.0	100	6	Safford Valley, Ariz.
Cottonwood	5.2	100	4	San Luis Rey River, Calif.
Cottonwood	7.6	100	3	San Luis Rey River, Calif.
Mesquite	3.3	100	10	Safford Valley, Ariz.
Saltcedar	7.2	100	7	Safford Valley, Ariz.
Saltcedar	6.0	-	-	Pecos River, N. Mex.
Willow	4.4 1/2/	-	2	Santa Ana, Calif.
Willow	2.5 1/	-	1.1	Isleta, N. Mex.
Saltgrass	0.8 to 4.0 1/	-	0.5 to 5.0	

1/ For plants grown in tanks.
2/ Tank isolated; not in natural environment.

losses are evaluated (Horton and Campbell, 1974). Ideally, this approach would the most applicable; however, riparian systems are complex. When transpiration losses along one portion of the stream are reduced, increasing evapotranspiration losses may occur from a higher groundwater level, and actual water savings are difficult to ascertain (Muckel, 1966). Gilluly (1971) voiced his concern that this water loss definitely threatens the economic feasibility of many water salvage programs.

Riparian research also focused on remedial programs and the economic ramifications involved in salvage or the conversion of consumptive waste water to consumptive use were soon recognized (Robinson, 1958). Consumptive use is water that is beneficially used in growing plants of economic value, and consumptive waste refers to water used by plants having little utility for man. Salvage is possible by 1) removal or destruction of the phreatophytes by mechanical or chemical means, 2) lowering the water table by diverting the stream flow, and 3) substituting plants of high economic value (Muckel, 1966).

The major controversy of water salvage programs focuses on the actual amount of water saved. Recent estimates of water that can be salvaged by removing floodplain vegetation varies from 1-1/2 acre-feet (Horton and

Campbell, 1974) to two acre-feet (Ffolliott and Thorud, 1974) per acre of vegetation removed. Thus, Ffolliott and Thorud (1974) calculated that it would be possible to increase annual water yield by 600,000 acre-feet if all 300,000 acres of Arizona's riparian vegetation were converted, but recognized that many constraints would prevent this.

Methods of controlling phreatophytes are summarized (Fletcher and Elmendorf, 1955; Timmons and Klingman, 1960; and Lowry, 1966) and have created a cost dilemma because of the relative levels of effectiveness. Although early studies (U.S. Bureau of Reclamation, 1964; U.S. Bureau of Reclamation, 1965; and Frost and Hamilton, 1960) estimate clearing costs of about $50 per acre; Gilluly (1971) estimates that costs may have escalated to $350 per acre.

Channelizing a 35-mile stretch of the Rio Grande River in New Mexico saved 200,000 acre-feet of water between 1951 and 1956 (Lowry, 1957). Muckel (1966) believed that lowering the water table by pumping, drainage, channelizing or other means of removing the water supply from the plant was the best method of salvage. However, opposition against channelization has grown recently and Jahn and Trefethen (1972) believe the method can seldom be economically justified even if it does entail major channel modification measures for flood control or for increasing agricultural production. They contend that channelization does not eliminate flooding, channelization only modifies flood patterns, and problems of downstream flooding and sedimentation (Wharton, 1971). Jahn and Trefethen (1972) feel that cost-benefit analyses should include 1) costs of increased sedimentation in lakes and reservoirs, 2) higher risk costs which occur when streamflow regulation stimulates land uses to encroach on floodplains, thus increasing the potential damage of future floods, and 3) loss of nutrients and sediments which would have been trapped by normal flooding processes and stored for future use.

Substituting plants of high economic value for plants having little utility for man converts water from nonbeneficial use to beneficial use, and if the beneficial plant has a lower water requirement than the original plant, the difference is conceivably available for off-site use (Muckel, 1966). However, in the Humboldt River Basin, irrigation was required to maintain tall wheatgrass and wild rye seeded on a former greasewood-rabbitbrush site (Eckert et al., 1973). Although the water table varied in depth from only six to nine feet, the seeded grasses could not use this water because their roots were restricted by physical characteristics of the soil.

Floodplain vegetation in Arizona is often cleared for agricultural purposes (Shreve and Wiggins, 1964; Haase, 1972; Gavin, 1973; Horton and Campbell, 1974; Brown and Lowe, In review). Land being used for agricultural production can be evaluated in monetary terms; however, no studies investigating the economics of floodplain farming in Arizona were found. Monetary benefits from these practices should be similar to the annual net return of $87.00 per acre obtained from a permanent irrigated pasture in Tucson (Taylor et al.,1972) or $136.00 net return over operating costs of long-staple cotton production on large Pinal and Pima County farms in 1966 (Kelso et al., 1973). Because of various environmental conditions which may cause the site to be of low agricultural potential (Fig. 19), flood prone, or reinvaded by riparian plants, many of these cleared floodplains are eventually allowed to return to a natural state. No acreage estimates of abandoned farmland occupying Arizona's floodplains were found; however, in 1973, 44,000 more acres of farmland were planted to corn, wheat and sorghum than were harvested (Arizona Crop and Livestock Reporting Service, 1974). What percent of this total represents abandoned cropland or was utilized for silage or hay, etc., is unknown; however, the decline of irrigated acreage in the San Pedro Valley from 12,500 acres in 1966 to 9,700 acres in 1970 (Roeske and Werrell, 1973) may imply that floodplain farming is a marginal operation in some areas.

The interactions of riparian vegetation and flooding are complex and the economic impact is not fully understood. Riparian vegetation has been reported to increase flooding by clogging channels, increasing sedimentation, and forcing water out onto adjacent lands (Anonymous, 1948; Cramer, 1961; and Robinson, 1957). Arnold (1972) explained how riparian vegetation, located north of the Black Canyon Highway Bridge over the Verde River, caused flooding in 1966 that damaged the highway approach to the bridge. He believes the riparian plants could have been controlled for a nominal fee in 1957, thus averting $46,000 in repairs for the approach.

The deleterious effect of riparian vegetation on flooding in some cases can be offset by its influence on sedimentation and deposition. Fletcher and Elmendorf (1955) and Robinson (1958) noted that dense stands of riparian vegetation reduce the velocity of floodwater and cause deposition of sediment. This was especially significant along the Pecos River above Lake McMillan where saltcedar acted as a desilting agent and prolonged the effective life of the reservoir (Robinson, 1958).

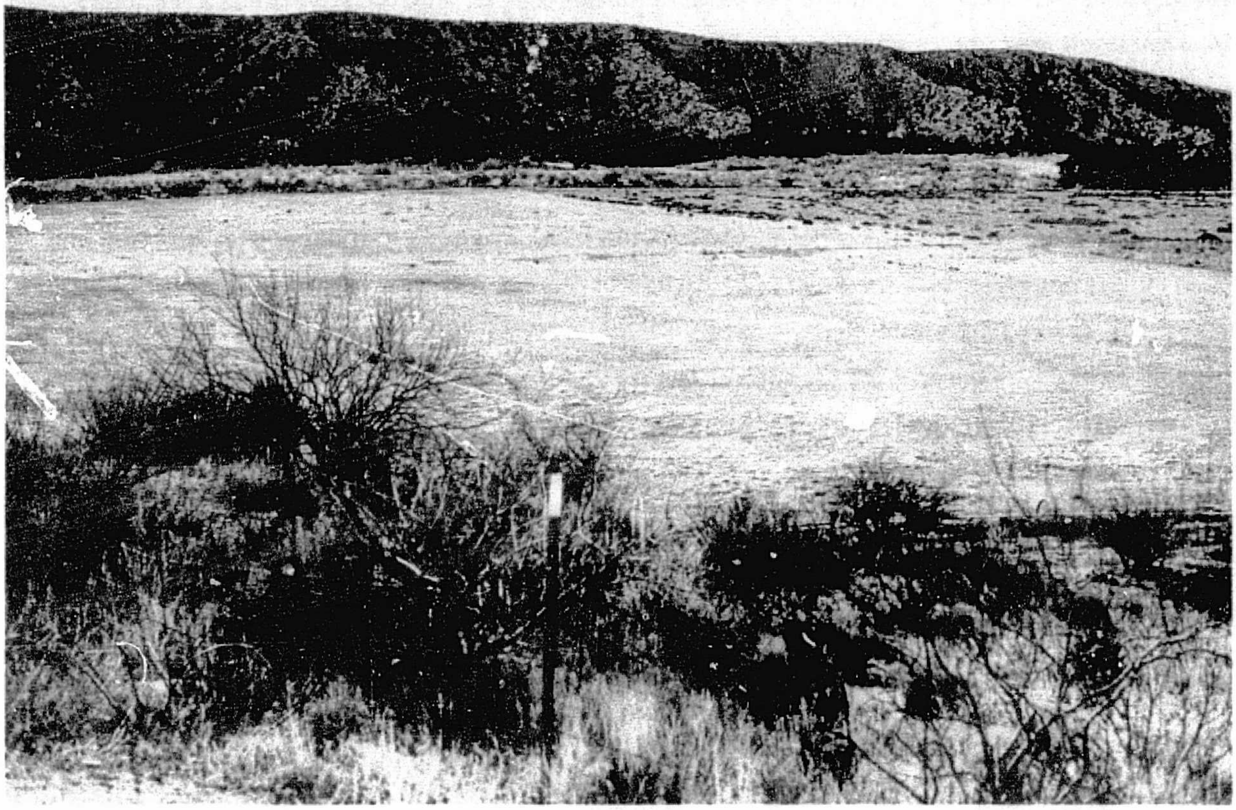

Figure 19. Productivity of this Cienega Creek floodplain is marginal when used as irrigated pasture. Because water supply is inadequate for irrigating the entire site, native vegetation is being allowed to reinvade portions of the cleared floodplain.

Benefits Associated with Riparian Vegetation

Riparian communities supply Arizona with a variety of goods and services (Table 12) which are difficult to categorize and discuss. Many reports have centered on one particular good or service (Olson, 1940; Barger and Ffolliott, 1971; Gavin, 1973; Arnold, 1940; and Gallizioli, 1965).

Other reports (Woods, 1966; Campbell, 1970; Horton, 1972; and Horton and Campbell, 1974) have discussed riparian benefits in the multiple-use concept. This approach merits consideration because Odum (1971) believes man requires four basic kinds of environments: 1) productive, 2) protective, 3) compromise between productive and protective, and 4) urban-industrial. He warns that compromise systems are neither suitable nor desirable for the whole landscape. He feels compartmentalization is important, and regards landscape planning and zoning as necessities. Odum (1971) praises "open space" legislation (recently enacted in California and New Jersey) which places unoccupied land into "protective" status. Odum's philosophy is needed for Southwestern riparian communities where Brown and Lowe (In review) specifically recommend setting aside several areas representative of the major natural types for investigation purposes. They feel that public values of many riparian environments have been compromised through degradation of flora and fauna, and they call for the elimination or better control of grazing and other disruptive influences.

Many values are difficult to restrict to a single community and some studies refer to the general value of the riparian habitat. Thompson (1968) and Brown and Lowe (In review) explain that due to their unique and favorable habitats, riparian vegetation support a fauna disproportionate to their limited acreage. Regardless of species, riparian vegetation is the most valuable wildlife habitat in Arizona (Jahn and Trefethen, 1972). The San Pedro, the Santa Cruz, and other drainages form continuous ribbons of riparian plants from Mexico into the United States (Horton and Campbell, 1974) and are especially important because they serve as routes for many migratory species of birds and reptiles.

The approach taken in this section of the Bulletin is to discuss: 1) general values of riparian habitats which are often overlooked, 2) the recreational value of the riparian habitat in Arizona, and 3) primary benefits (direct value for human use, value for wildlife, and vegetative products--forage for livestock, nectar for bees, and firewood for man) from five important riparian communities (riparian deciduous woodland, riparian forest, riparian grassland, riparian scrub and marshland) in Southern Arizona.

Frequently Overlooked Uses of Riparian Habitats

Many potential uses of riparian communities are often overlooked. The importance of small natural environments (outdoor laboratories) to public school systems has been recognized (Wharton, 1971). His partial economic evaluation of 2,300 acres of Alcovy River swamp in Georgia indicated a value worth $1.3 million annually to Georgia schools within a 50-mile radius (Wharton, 1971). His analysis utilized eight environmental study areas and assumed the acreage was properly used, land owners would cooperate, and interpretative assistance was available.

A similar educational program is feasible in Southern Arizona. Riparian communities are accessible; they offer a wide variety of habitats which contribute to a diverse flora and fauna; they are especially unique and differ from the more common nonriparian communities; and they appear adaptable to a management plan which would minimize damage from continual class use.

Utilization of desert plants either for industrial uses of medicinal purposes as another alternative of economically developing arid lands is possible (Krochmal, et al.,1954; Duisberg, 1963; and Cruse, 1973). These studies stress the importance of not overlooking the potential resource of native desert plants simply because irrigated farming and livestock production are currently being emphasized.

Mesquite, ironwood and catclaw are "artist's woods" because of their dark colored heartwood, attractive grain and high density (Cruse, 1973). These woods have a great use for small gift and souvenir items. Cruse also believes that knotty burls of catclaw and ironwood are excellent substitutes for expensive imported briar in smoking pipe bowls.

Krochmal et al., (1954) included several riparian plants in a list of useful native plants found in America's Southwestern deserts (Table 14). Although opportunities to exploit riparian plants for industrial uses may not present themselves for several decades, Cruse's (1973) plea to evaluate the cultivation of xerophytic plants on marginal land or adjacent to floodways is valid.

Riparian plants must be recognized as being part of a dynamic, functioning ecosystem (Jahn and Trefethen, 1972; LeCren, 1971; and Sanders, 1971), and as having a certain value in site maintenance or site improvement (Fig. 20). Although the role of an individual plant as a "site-improver" or "site-maintainer" has not been equated in monetary terms, all riparian plants have

Table 14. Native riparian plants have contributed many products to man's welfare. List adapted from Krochmal et al. (1954).

Product and Plant	Reported Use
Drugs	
Tobacco plant	Indians used one species for smoking during ceremonies, another species used to control aphids.
Arrowweed	Pima Indians made an infusion from the herbage to treat sore eyes.
Cottonwood and Aspen	Indians used the inner bark as an anti-scorbutic.
New Mexico Locust	Hopi Indians used this plant for treating rheumatism.
Willow	Dry salicin was derived from the bark and used as a tonic and antiperiodic. It also has febrifugal properties.
Foods, Flavorings and Seasonings	
Catclaw	Mush and cakes were made from the pods and seeds.
Pigweed	Leaves and stems were used as greens and seeds for meal.
Giantreed	Young shoots are edible.
Fourwing Saltbush	Its ashes were used as a substitute for baking powder.
Goosefoot	Seeds were used for mush and leaves were used for greens.
Pale Wolfberry	Ripe fruit is edible, either raw or cooked.
Mesquite	Pods were used to make pinole (a meal) and pinole was allowed to ferment into an alcoholic beverage.
Seepweed	Seeds were used to make pinole and herbage was used as greens.
Fibers	
Cottonwood	Fibrous material
Mesquite	Fibrous material
Willow	Fibrous material
Skunkbush Sumac	Fibrous material
Gums and Resins	
Baby Bonnets	Papago Indians used the lac, formed on the stems by insects, to seal jars of saguaro fruit.
Mesquite	Exudates were used as gum.
Oils	
Coyote melon	Oils were derived from this plant.

Table 14. Continued

Product and Plant	Reported Use
Pigments	
Alder	A pale, red dye was made from the bark.
Rabbitbrush	Yellow and green dyes, respectively, were derived from the flowers and inner bark.
Latex	
Milkweed	Products derived from the plant were used as a latex-type material.
Rubber Rabbitbrush	Products derived from the plant were used as a latex-type material.
Saponins	
Coyote melon	Saponins were derived from the plant.
Western Soapberry	Fruit was used to make soap for washing clothes.

Figure 20. Riparian vegetation has been largely removed from this bottomland site (San Simon Creek) and site deterioration is evident.

a certain value in preventing erosion (Fig. 21) (Robinson, 1967; and Garcia-Moya and McKell, 1970). One of the major functions of the ecosystem is trapping and using sediments (Wharton, 1971). Sediments are a source of valuable minerals. Lake McMillan on the Pecos River in New Mexico is one example where the effect of the riparian plants on sedimentation has been determined. Robinson (1967) reports a sixfold decrease in rate of sedimentation in the lake over the last 25 years, and attributes the decrease to saltcedar invasion of delta areas above the lake.

Uses of Riparian Habitats for Recreation

The use of Southern Arizona riparian communities for recreation is chaotic. Most riparian areas are privately owned (U.S.D.A. Soil Conservation Service, 1970), accessibility to riparian communities on public land is often restricted by land ownership pattern and lack of roads, and developed camp sites and other recreational facilities are scarce.

Activities include hunting, hiking, camping, picnicking, rock-hunting, sightseeing, birding, fishing, horseback riding and driving off-road vehicles (Fig. 22). It should be noted, however, that although dense monotypic saltcedar stands are valuable for dove nesting (Kufeld, 1966; and Gallizioli, 1965), other recreational use of this community may be limited (Haase, 1972).

Many of the recreational activities have intangible values and economists and land-use planners are attempting to find ways to quantify them. Born (1974) describes problems encountered in measuring natural beauty and discusses several new techniques being used to measure beauty. Morisawa (1972) developed a method for categorizing and inventorying watersheds on the basis of geologic, hydrologic, historical, aesthetic and recreational aspects.

Decisions in land-use planning and land management must include economic considerations. While the economic value of land for urban development or agricultural potential is determinable, monetary values are not easily associated with natural resources used for recreation. Martin _et al_. (1974) have completed economic analysis of Arizona's natural resources. They recognized the need to measure value added by a particular recreation opportunity. A user benefit method was employed to measure the net increase in the value of the resources when used for recreation. They estimated economic demand curves for the household by expressing demand for the "whole recreation experience." This includes planning, traveling to and from the site, memories, etc.

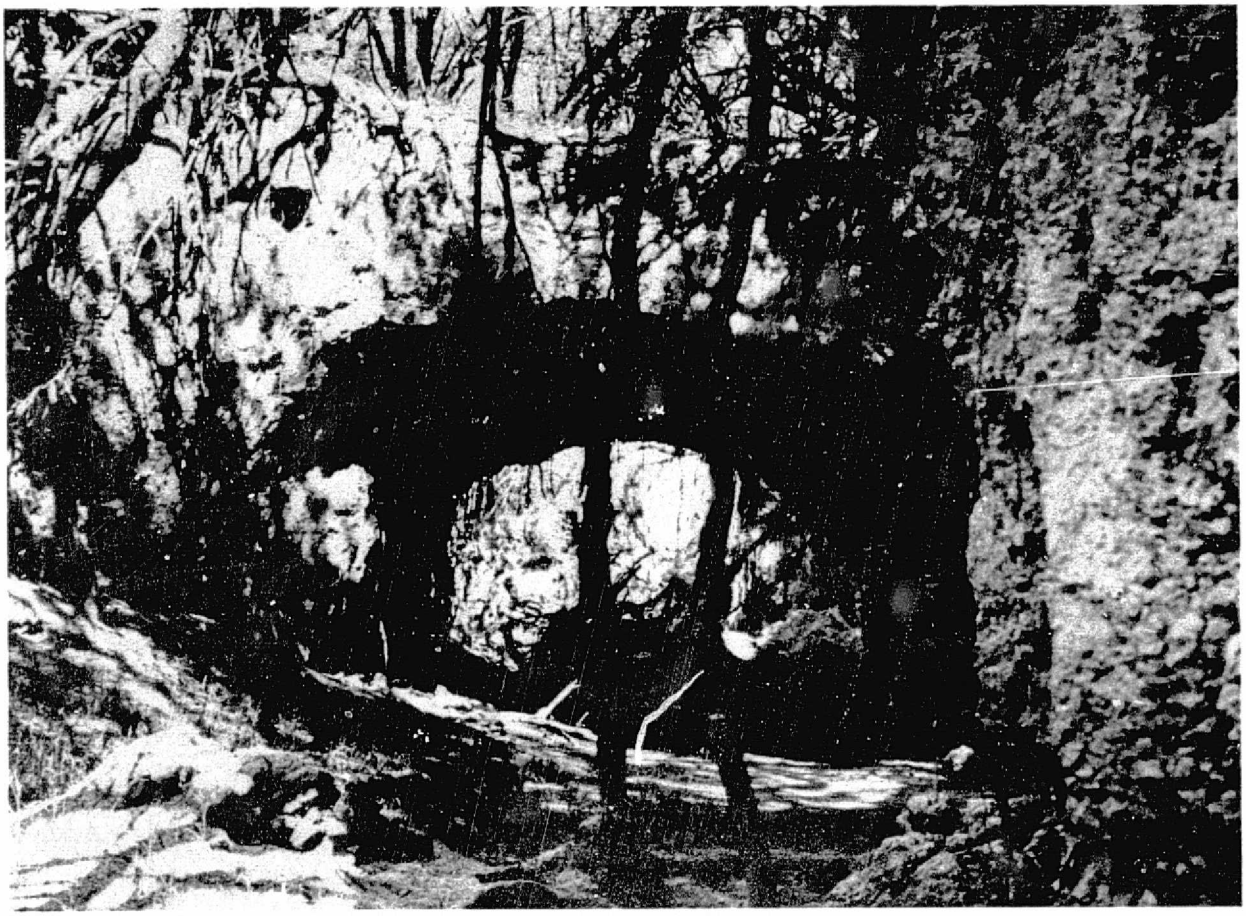

Figure 21. Mesquite has a certain value in retarding erosion along Cienega Creek.

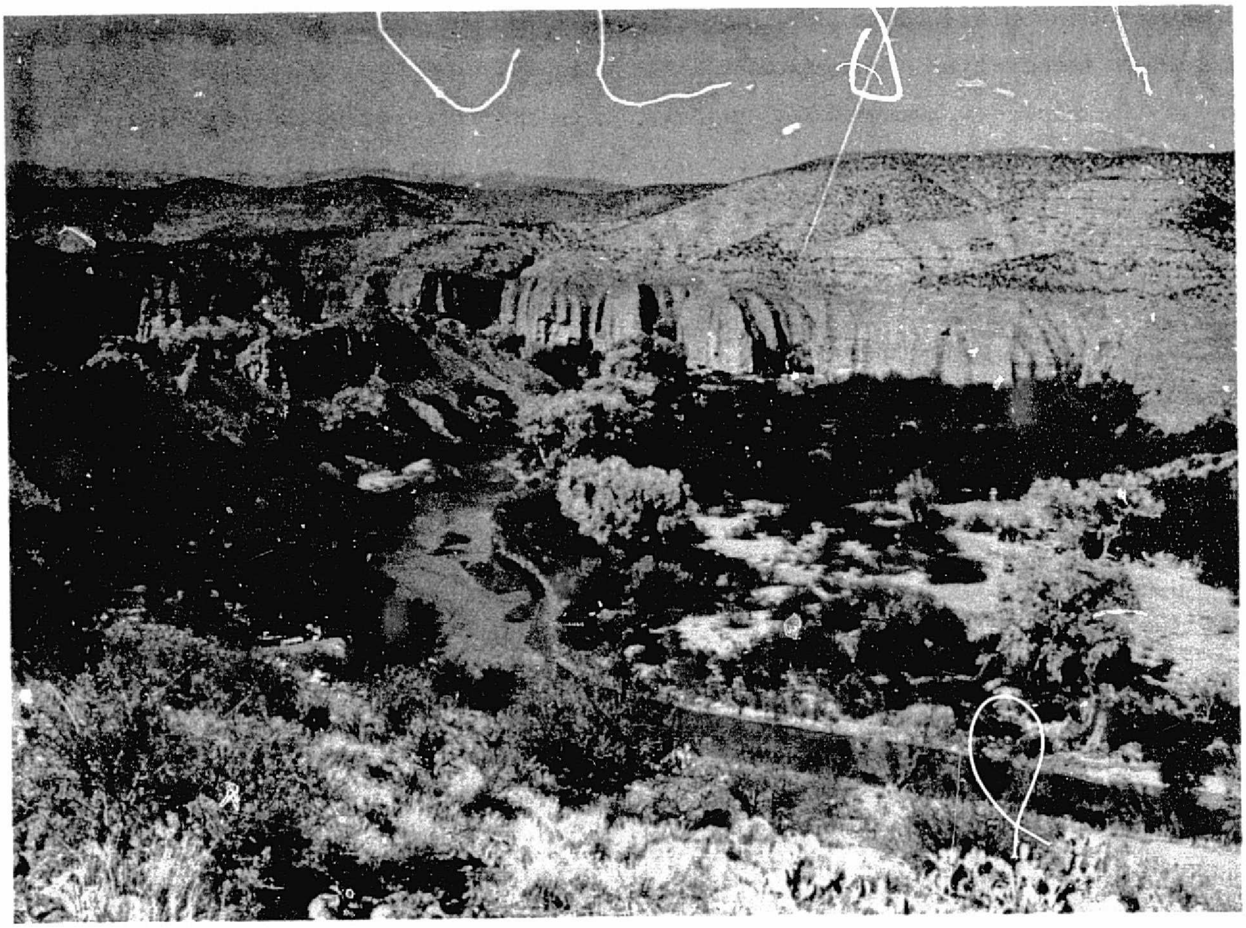

Figure 22. Recreational activities along the Upper Gila River include hunting, hiking, camping, picnicking, rock hunting, sightseeing, birding, fishing and horseback riding.

Demand curves for the recreation resource itself (i.e., deer hunting in a specific area) were then derived. Similar studies applying to riparian vegetation are lacking. In an arid or semiarid environment, life is attracted to unique and favorable habitats found only in riparian communities. For example, over 50 percent of the 197 known and hypothetical vertebrate species found in Chevelon Canyon are dependent, for at least part of their life cycle, on the riparian association (Aitchison and Theroux, 1974). The "multiplier effect" which the riparian communities contribute to the average value per square mile of outdoor recreation and wildlife habitat in Arizona must be considered in future planning.

Uses of Riparian Deciduous Woodland Communities

The riparian deciduous woodland community has historically supplied many products demanded by consumers and recreationalists. Mesquite dominates many of these communities and is one of the most important species. Indians, Mexicans and early settlers used its pods for food and drink; gum for candy, dye and hair tonic; bark for diapers, skirts, baskets, ropes and as a source of tannin; branches and roots for a variety of tools and weapons; logs and branches for fenceposts, corral poles, railroad ties, repairing wagon wheels, paving streets and in construction of dwellings; the wood was used in making cabinets, furniture and trinkets. Other common members of this community, canyon grape, gourds, netleaf hackberry and screwbean were also used for human consumption (Kearney and Peebles, 1969). Saltcedar has been used in basketry for charcoal, tannin and wattlework, and for making a crude beer (Standley, 1920-1926; and Bowser, 1957).

Nesting Areas: Riparian deciduous woodlands are important nesting areas for whitewing and mourning doves (Shaw, 1961; Gallizioli, 1965; Kufeld, 1966; Haase, 1972; Wigal, 1973; Brown and Lowe, In review; Horton and Campbell, 1974). Historically, mesquite bosques were important dove habitat, but because of their gradual replacement by saltcedar, doves have been forced to adapt to saltcedar for nesting (Gallizioli, 1965; and Wigal, 1973). In his literature review, Haase (1972) found that cultivated crops represent about 40 percent of the whitewings' diet, and crop depredation can be serious in localized areas that support large dove populations (Kufeld, 1966; and Horton and Campbell, 1974).

The riparian woodland community is diminishing in total area (Brown and Lowe (In review). Wigal (1973) found only 70,000 acres of suitable dove habitat in 26 million acres of Southern Arizona. His definition of suitable dove habitat included thicket-forming vegetation with trees averaging at least 10 feet in height and 25 percent or greater crown coverage. Bristow (1969) dramatized the problem of diminishing habitat when he wrote that nearly every river mile of riparian woodland habitat important to dove was either being cleared, authorized for clearing, or was under study for clearing by the U.S. Army Corps of Engineers of the U.S. Bureau of Reclamation.

Recent literature (Carothers and Johnson, 1971; Brown and Lowe, In review; and Horton and Campbell, 1974) all emphasize the importance of riparian vegetation as nongame bird habitat. Cottonwood communities in Verde Valley have the highest known concentration of birds in the United States (Carothers and Johnson, 1971) with the highest population of nesting birds occurring in the dense, undisturbed stands and the least number in the most heavily thinned stands.

Food and Cover: Mesquite is also important to wildlife for food and cover (Van Dersal, 1938; Martin, *et al*., 1951; and Langford, 1969). A list prepared by Martin *et al*. (1951) is especially useful because it estimates the percentage of mesquite in the diet of upland gamebirds, songbirds, fur and game animals, small mammals, and hoofed browsers.

Mesquite beans are relished by all classes of domestic livestock (Langford, 1969; Scifres and Hoffman, 1974; and Van Dersal, 1938). Pods are eaten whole, but they make better feed when ground into a meal. Digestibility and nutritive value of ground beans is comparable to that of alfalfa (Langford, 1969). Toxicity can occur, however, if large quantities of beans are consumed and become compacted in the digestive tract. Livestock also utilize mesquite for shade and for shelter from adverse weather conditions.

Saltcedar seedlings may have some value for livestock browsing (Campbell, 1966). He observed heavy browsing on young tamarisk on floodplains throughout the Southwest and recommended mowing at prescribed intervals to increase production. When the water table is less than four feet deep, mowing saltcedar-bermuda grass sites is recommended (Horton and Campbell, 1974). Grazing (Gary, 1960) and clipping (Campbell, 1966) studies indicate saltcedar is resistant to normal foliage removal.

Bee Production: Bees play an important role in Southwestern agricultural programs by pollinating melons, alfalfa seed, orchards and other specialty crops (Edwards, 1971). Specific data for Arizona is not available, but the

U.S. Department of Agriculture places the annual dollar value of bees at $4 to $6 billion (Dr. Standifer, USDA-ARS Entomologist, personal communication). In Arizona, 53,000 colonies produced $562,000 worth of honey and beeswax in 1971 (Table 15) (Foster, 1972). Current values would be higher because 60,000 colonies were reported in 1974 and the wholesale price of "grade A" honey is between 45¢ and 50¢ per pound (Dr. Standifer, January, 1975, personal communication).

Usefulness of riparian deciduous woodlands to the bee industry is twofold. Not only are mesquite and catclaw important sources of nectar and pollen (Kearney and Peebles, 1969) but a large number of colonies are maintained in the riparian vegetation (Fig. 23). The habitat factor is especially important near agricultural areas where farmers use pesticides and becomes more critical during periods of heavy insecticide use (Edwards, 1971). He cites a stretch of the Rio Grande River, New Mexico, where 4,000 colonies are moved to saltcedar stands for refuge during periods of insecticide use.

Table 15. Honey and beeswax production in Arizona (Foster, 1972).

HONEY AND BEESWAX: Number of colonies and production, Arizona, 1965-71

Year	Colonies of Bees 1/	Honey Yield per Colony	Honey Production	Value	Beeswax Production	Value
	1,000 Colonies	Lbs.	1,000 Lbs.	1,000 Dol.	1,000 Lbs.	1,000 Dol.
1965	96	70	6,720	867	94	40
1966	96	68	6,528	796	118	54
1967	88	41	3,608	400	76	37
1968	83	57	4,731	530	90	50
1969	75	42	3,150	384	82	48
1970	59	45	2,655	345	69	38
1971	53	56	2,968	543	36	19

1/ Number of colonies on hand at the beginning of the main honey flow.

Firewood Production: Managing riparian deciduous woodlands for wood also may be economically feasible (Fig. 24). Mesquite was economically important 30 years ago when fuelwood dealers in Phoenix, Tucson and surrounding communities annually purchased over 16,000 cords of firewood (Olson, 1940) and was still a valuable resource in 1971 when dealers purchased about 9,700 cords (George Campbell, unpublished report submitted to Arizona State Land Department). During this period, price increased from $10 to $55 per cord (Olson, 1940;

Figure 23. Riparian woodland habitat is important to the bee industry as a source of nectar and pollen and as a refuge from agricultural insecticides.

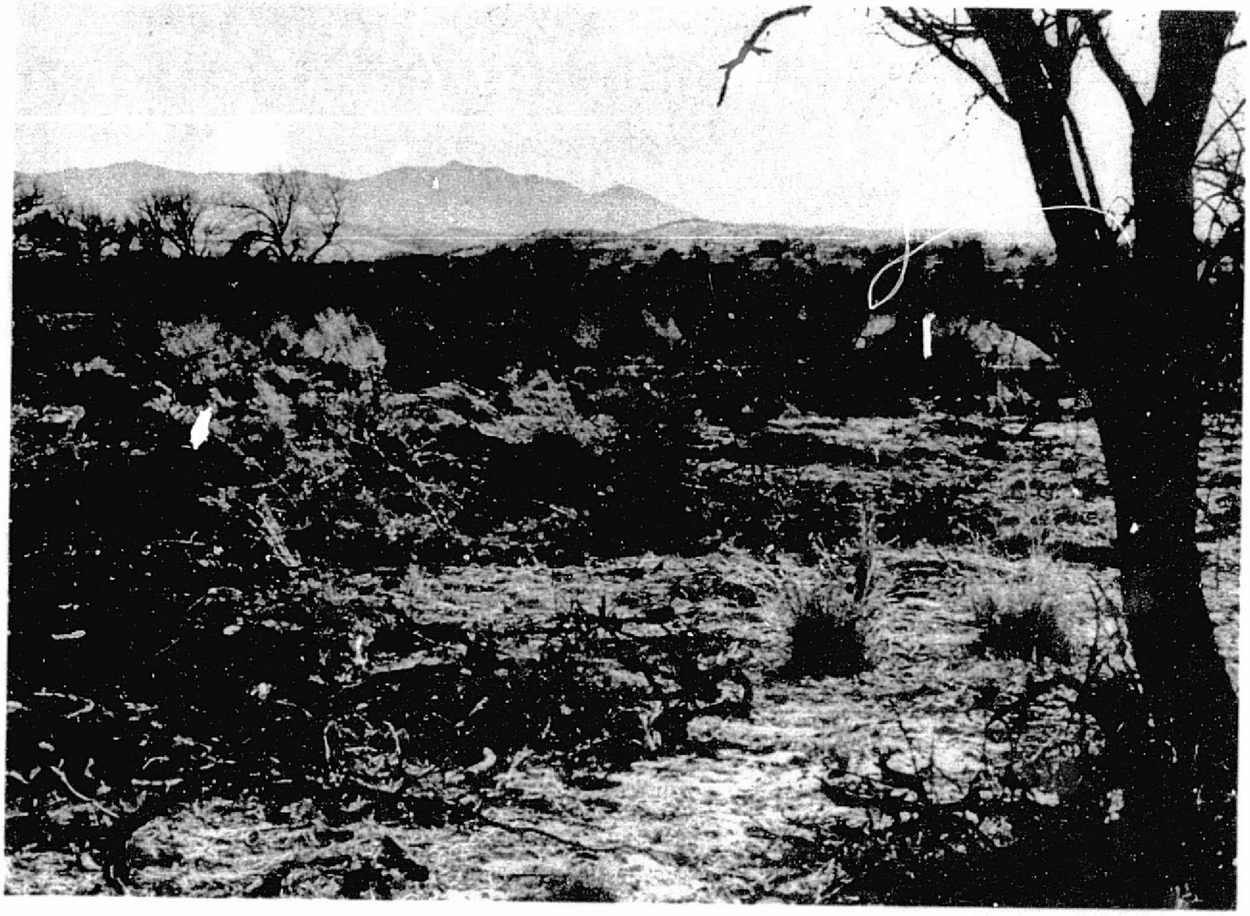

Figure 24. Mesquite-covered bottomlands contain a merchantable product, firewood, and can be managed as a renewable resource.

Campbell, unpublished report) and Saye :s (1974) expects demand for firewood to continue to increase because of recent energy crisis and resultant rise in fuel costs.

On dry upland sites, mesquite tend to develop into small, multi-stem shrubs. On lower floodplains, however, dense stands occur and when left uncut, develop a large, straight stem. Stem diameters may reach four feet, range from 25 to 36 inches in diameter at breast height, and often be 60 ft. tall (Olson, 1940).

Site index curves have not been established for mesquite in Southern Arizona; however, in some instances growth rings can be counted (Fig. 25). Olson (1940) reported a diameter growth of five inches in 15 years on Indian Reservations in Southern Arizona, and believed a diameter could reach 10 inches in 40 years (Table 16). Mean annual volume growth reached its maximum at 35 years and growth on an area basis varied from six to 14 cubic feet per acre per year. The more productive stands showed an average annual growth of 25 cubic feet per acre. Gavin (1973) predicts a slower growth rate and expects a diameter of 10 inches in 60 years (Fig. 26).

Table 16. Mesquite diameter growth is fairly rapid on floodplain sites. Data adapted from Olson, 1940.

Location (Indian Reservation)	Diameter Inches							
	5 yrs.	10 yrs.	15 yrs.	20 yrs.	25 yrs.	30 yrs.	35 yrs.	40 yrs.
Gila River	1.7	3.7	5.3	6.9	8.0	8.8	9.4	9.9
San Xavier	1.3	3.1	4.7	6.3	7.7	8.7	9.1	---
Papago	1.3	2.9	4.0	5.6	7.2	8.2	8.7	8.8
Camp McDowell	1.5	3.0	4.5	5.6	6.8	7.8	8.4	---

Cutting, hauling and selling mesquite firewood shows a small profit in Tucson where fireplace wood sells for about $55 per cord when based on Campbell's total costs of cutting and delivering firewood (Table 17) (George Campbell, unpublished report to Arizona State Land Department). Before this profit can be realized hard work is a prerequisite; specialized equipment is needed; trees must be of suitable size and form (open limb type of tree with trunks at least eight inches in diameter); trees should be spaced less than 125 feet apart and trees must be available for cutting at no cost or a nominal

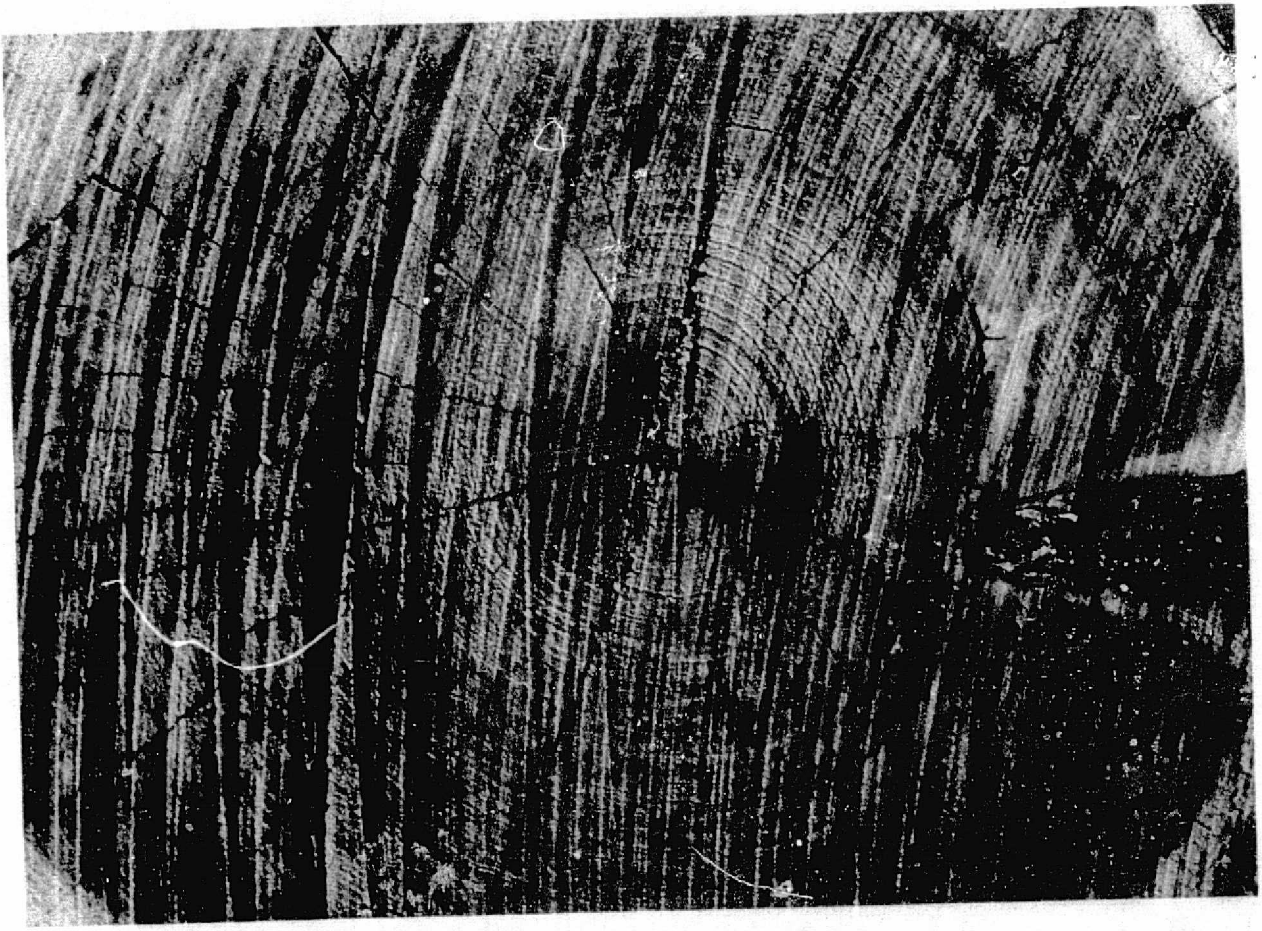

Figure 25. Mesquite growth rings can be counted; and reliable site index curves would facilitate management decisions in mesquite communities.

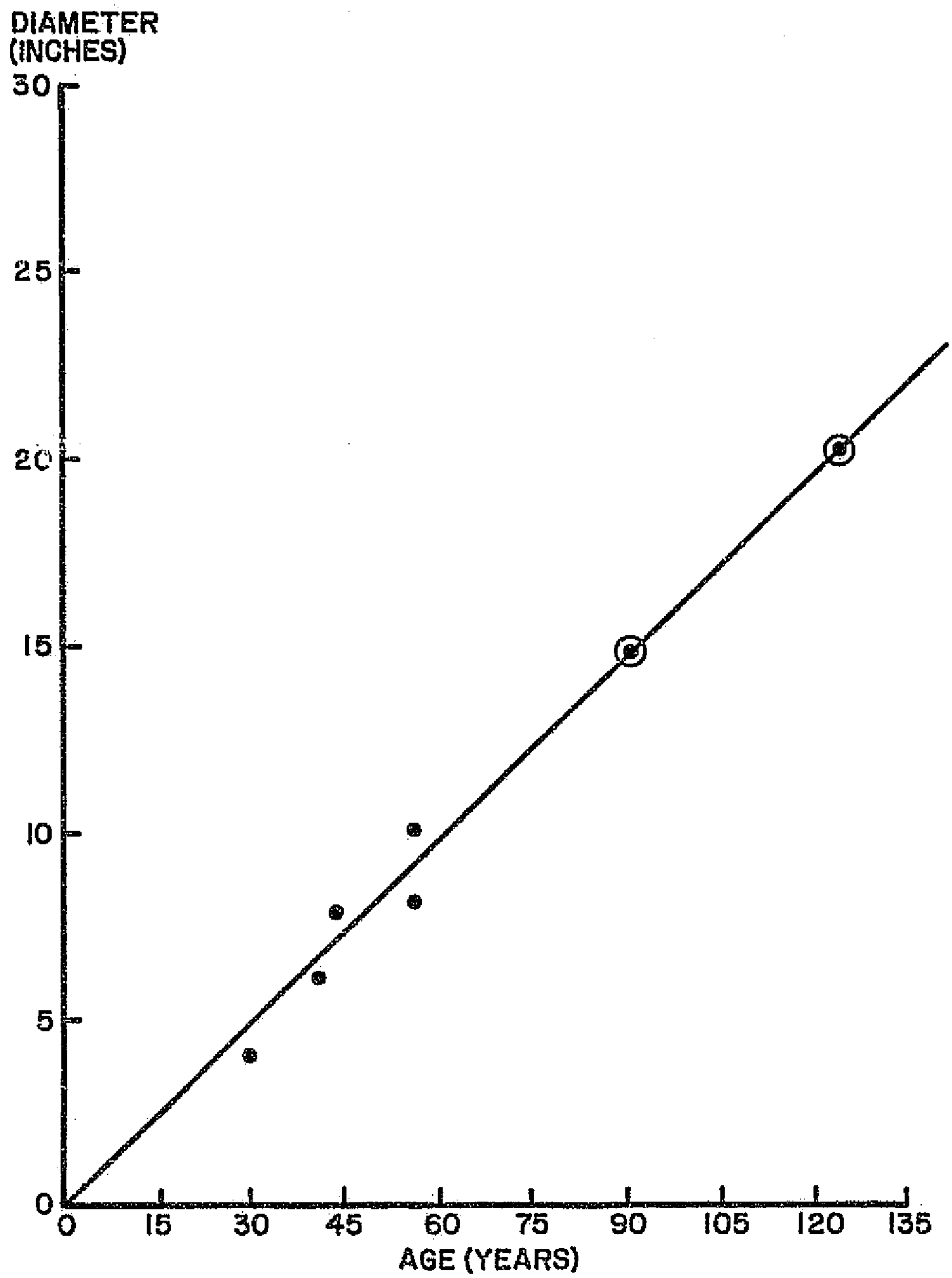

Figure 26. Gavin (1973) estimated mesquite to be 60 years old when he measured 10-inch stem diameters on a floodplain along the San Pedro River near Mammoth, Arizona.

Table 17. George Campbell's unpublished report to the Arizona State Land Department includes an estimate of 1974 costs and returns for a mesquite firewood operation.

Item	Two ft. wood	Four ft. wood
Transport personnel and equipment	$ 2.50	$ 2.50
Labor of cutting, loading and stockpiling	10.00	8.00
Saw expenses, including purchase	3.75	2.75
Haul from woods to stockpile	3.50	3.50
Camp supplies and miscellaneous	2.25	2.25
Overhead and supervision	2.75	2.75
Total Cost of Cutting & Stockpiling	$24.75	$21.75
Hauling from stockpile to woodlot (75 miles)	$ 5.00	$ 4.00
Unload at woodlot or restaurant	1.75	1.75
Load, deliver, unload and stock at customer's home	6.00	--
Total Cost of Delivering from Stockpile	$12.75	$ 5.75
Total Cost per Cord of Wood Delivered to Destination	$37.50	$27.50

cost not exceeding $1 or $2 per cord (George Campbell, unpublished report). These logging conditions exist on patented lands where farmers and ranchers are clearing floodplains for agricultural uses.

To obtain additional data on mesquite wood production, measurements of mesquite stand characteristics were made on three 1/4-care study plots. Plants larger than one-inch diameter were counted and identified by stapling a "numbered" three-by-five-inch card to each tree (Fig. 27). The number of stems on each plant was counted and a diameter tape used to find the diameter breast-high (DBH) of the average-sized stem for each plant. The average-sized stem was used as a basis to separate plants into stem diameter classes. An Abney level was used to find the average height of each stem diameter class. Basal area data were extrapolated from the DBH data (Gevorkiantz and Olsen, 1955) and multiplied by average height to determine average volume (ft.^{3}/stem) for each stem diameter class. This figure was multiplied by the number of stems in each stem diameter class to derive volume (ft.^{3}/acre) estimates. The total volume (ft.^{3}/acre) estimates were divided by 128 ft.^{3} to derive the solid cords, then this figure adjusted to cords of firewood by dividing by 0.8.

Timber measurements along the San Pedro suggest money equivalents for mesquite woodlands varies with stand characteristics. Mesquite growth was measured at three locations and volume ranged from 721 ft.^{3}/acre at the Charleston

Figure 27. Cards were used to number each tree for subsequent measurements of diameter, total height and number of stems.

plot (Fig. 28) to 223 ft.^{3}/acre on the Fairbanks plot where stem density approached 3,900 per acre. Because of the small diameter stems, this latter stand currently has little value for firewood (Fig. 29 and Table 18). Although old stumps were not visible, this was an immature stand, and probably represented secondary succession from earlier farming practices.

Stands at St. David and Charleston were many ages but most trees were less than eight inches in diameter and trees in the three, four and five-inch diameter classes represent about 45 percent of the total number of trees (Tables 19 and 20). Average mesquite density, on these two mature sites, is 276 trees and 675 stems per acre (about 60 percent of the stems were in the three- to five-inch diameter classes).

Trees on the Charleston study plot were estimated to be 70 years old because the old mining town was probably abandoned during the 1890's. These stands contain about seven cords of firewood per acre and at current prices ($55/cord) have a gross marketable value of $385 per acre. On the basis of a 70-year rotation harvest, the gross return would be $5.50/acre/year.

Growth data suggest that growth volume for mesquite is rapid the first 20 years, then gradually declines and a 35-year rotation is conceivable (Fig. 30). If the Charleston site could produce seven cords of firewood per acre on a 35-year rotation, the gross return would be $11.00/acre/year. These assumptions include an average annual growth of 20.6 ft.^{3}/acre/year, slightly less than what Olson (1940) observed on the good sites (25 ft.^{3}/acre/year).

The possibility of harvesting mesquite from State Trust Land for firewood has been proposed (Sayers, 1974). Campbell (unpublished report) believes that managing State land for mesquite firewood has little economic potential. He concluded: 1) mesquite firewood on State land has little interest for commercial buyers, 2) the cost of making sales and "policing" the cutting would be prohibitive and 3) State land leasees would object to the increased traffic on grazing lands.

Sayer's (1974) assessment, however, is more optimistic. His tabulated data of state, private and Bureau of Land Management land show 780,509 and 1,407,584 acres of mesquite bosques in Cochise County and statewide, respectively. However, his acreage figures appear high in comparison with earlier estimates (106,000 to 300,000 acres of riparian vegetation in the total State) by Robinson (unpublished report), Lower Colorado Region State-Federal Interagency Group for the Pacific Southwest Interagency Committee (1971) and Ffolliott and Thorud (1974). The potential of harvesting mesquite from State

Figure 28. Seventy-year-old mesquite community had 288 trees, 700 stems and seven cords of firewood per acre. Data based on 1/4-acre plot along the San Pedro River, Charleston, Arizona.

Figure 29. Immature mesquite community along the San Pedro River had 84 trees, 3904 stems, 2.1 cords of wood per acre and was designated unmerchantable for firewood. Data based on 1/4-acre plot near Fairbanks, Arizona.

Table 18. Mesquite parameters measured on the Fairbanks plot. Data based on measurements from one 1/4-acre plot.

Stem Diameter Class	DBH (inches)	Basal Area sq. ft.	Height (ft.)	x(.48)	Vol. ft.^{3}/stem	Trees 1/4-acre	# Stems 1/4-acre	# Stems acre	Vol. ft.^{3}/acre
0-1.0	.5	.0013	6	.0078	.0037	36	432	1728	6.393
1.1-2.0	1	.0055	8	.0440	.021	32	320	1280	26.88
2.1-3.0	2	.0218	9	.1962	.0941	8	112	448	42.156
3.1-4.0	3	.0491	14	.6874	.3299	8	112	448	147.795
4.1-5.0	4	.0873							
									223.224

$$\frac{223.224}{128} = 1.7439 \qquad \frac{1.7439375}{.8} = 2.179 \text{ cords of wood/acre.}$$

Table 19. Mesquite parameters measured on the St. David plot. Data based on measurements from one 1/4-acre plot.

Stem Diameter Class	DBH (inches)	Basal Area sq. ft.	Height (ft.)	x(.48)	Vol. ft.^{3}/stem	Trees 1/4-acre	# Stems 1/4-acre	# Stems acre	Vol. ft.^{3}/acre
1.1-2.0	1	.0055	8	.0440	.0211	12	17	68	1.434
2.1-3.0	2	.0218	10	.218	.1046	16	37	148	15.480
3.1-4.0	3	.0491	14	.6874	.3299	11	26	104	34.309
4.1-5.0	4	.0873	19	1.6587	.7961	10	34	136	108.269
5.1-6.0	5	.1364	22	3.000	1.44	9	29	116	167.04
6.1-7.0	6	.1963	23	4.5149	2.1671	3	7	28	60.678
7.1-8.0	7	.2673	23	6.1479	2.9507	2	2	8	23.607
8.1-9.0	8	.3491	25	8.727	4.188	2	8	32	134.016
9.1-	9	.4418	26	11.486	5.513	1	4	16	88.208
						67		656	633.041

$$\frac{633.041}{128} = 4.9456 \qquad \frac{4.9456}{.8} = 6.18 \text{ cords of wood/acre}$$

Table 20. Mesquite parameters measured on the Charleston plot. Data based on one 1/4-acre plot.

Stem Diameter Class	DBH (inches)	Basal Area sq. ft.	Height (ft.)	x(.48)	Vol. ft.^{3}/stem	Trees 1/4-acre	# Stems 1/4-acre	# Stems acre	Vol. ft.^{3}/acre
1.1-2.0	1	.0055	8	.0440	.0211	11	26	100	2.194
2.1-3.0	2	.0218	10	.218	.1046	8	20	80	8.368
3.1-4.0	3	.0491	14	.6874	.3299	12	41	164	54.103
4.1-5.0	4	.0873	19	1.6587	.7961	14	40	176	140.113
5.1-6.0	5	.1364	21	2.8644	1.3749	9	15	60	82.494
6.1-7.0	6	.1763	23	4.5149	2.1671	5	10	40	86.684
7.1-8.0	7	.2673	23	6.1479	2.9509	5	10	40	118.036
8.1-9.0	8	.3491	24	8.3784	4.0216	1	1	4	16.086
9.1-10.0	9	.4418	25	11.045	5.3016	3	4	16	84.825
10.1-11.0	10	.545	25	13.625	6.54	2	2	8	52.32
11.1-12.0	11	.660	25	16.5	7.92	1	1	4	31.68
12.1-13.0	12	.785				0			
13.1-	13	.722	25	23.5	11.064	1	1	4	44.256
						72		700	721.159

$$\frac{721.159}{128} = 5.634 \qquad \frac{5.634}{.8} = 7.04 \text{ cords of wood/acre}$$

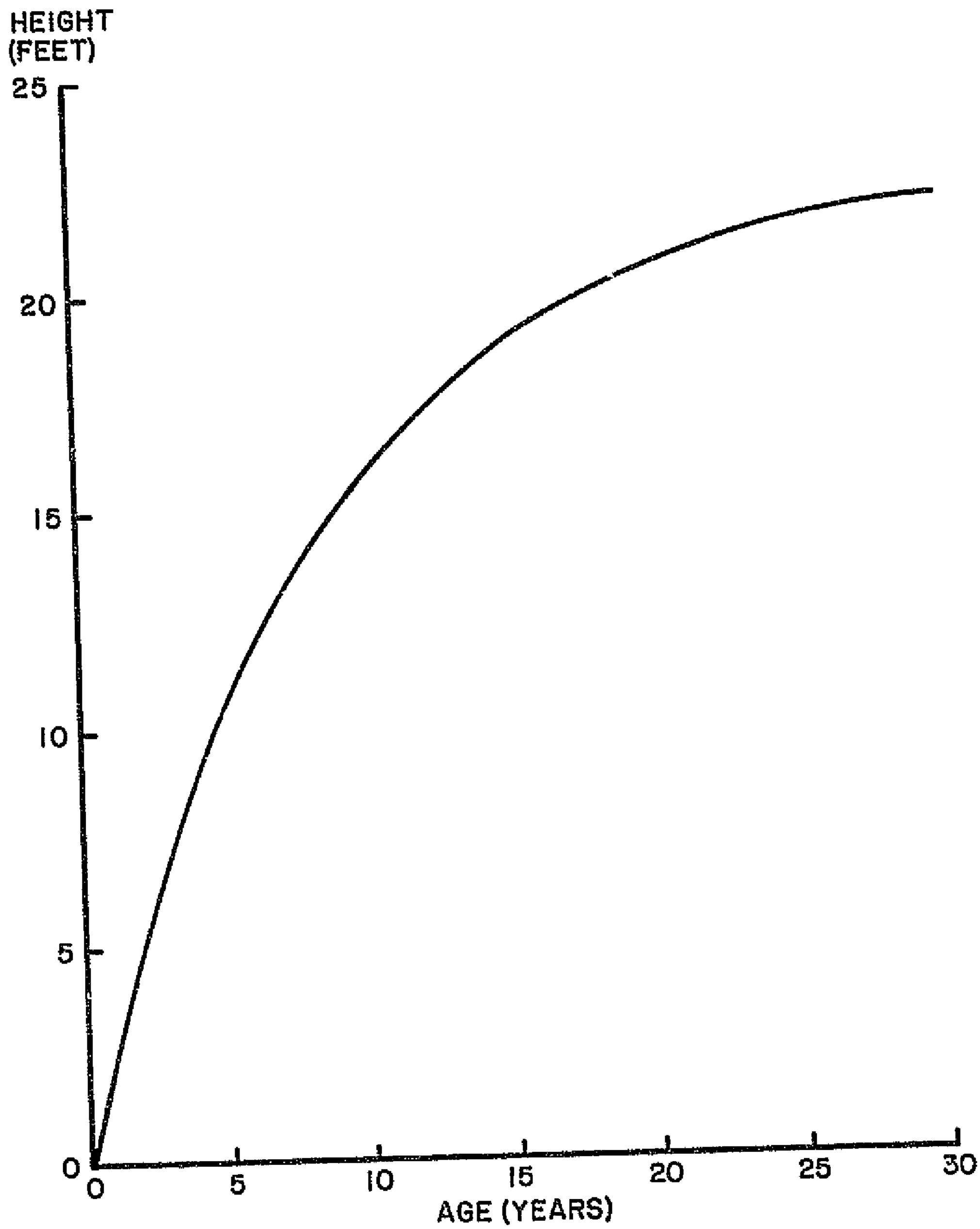

Figure 30. Mesquite grows rapidly on floodplain sites. Data adapted from Olson's (1940) study on Indian Reservations in Southern Arizona.

lands may also be limited because only about 10 percent (9,000 out of total of 103,000 acres) of the total riparian acreage occur on State Trust Land (USDA Soil Conservation Service, 1970).

The large discrepancy of riparian estimates emphasize the need for Arizona's riparian communities to be properly identified and classified. Although Sayers (1974) used Kuchler's (1964) system to identify and classify vegetation, Kuchler's original map designates only the Phoenix area as a potential "mesquite bosque" site. This is a much smaller area than that mapped by Sayers. Differences in definition of mesquite bosque are illustrated in Figs. 31 and 32. The Pettinger et al. (1970) definition, "mesquite bosque is a vegetational unit where tree-sized (20-30 feet) mesquite completely dominate the aspect giving a thicket appearance" is most easily interpreted and is compatible with Kuchler (1964) and Brown and Lowe (1974b) and should be used as a basic to identify and map mesquite bosques.

Mesquite bosque represent a "marketable" product and under suitable environmental conditions, a renewable resource. Olson (1940) wrote that sound forest management practices on mesquite woodlands would be economically feasible. He warned, however, that sound forest management and utilization practices were needed for a sustained yield of mesquite products. Monetary returns from mesquite harvest must also be in balance with other uses of a resource that includes many values for humans, wildlife and site maintenance. Some preliminary economic analyses of combined mesquite management for wood and grazing management for forage indicate higher economic returns than from either use alone. These data illustrate the need for critical evaluation of uses, singly and in combination.

Uses of Riparian Deciduous Gallery Forest Communities

Brown and Lowe (In review) separate the riparian deciduous gallery forest into two major communities: the mixed broadleaf, above 3,500 ft. and the cottonwood-willow, below 3,500 ft. Their importance of these communities to the Arizona grey squirrel (*Sciurus arizonica*), water shrew (*Sorex palustris*), otter (*Lutra canadensis*) and canyon tree frog (*Hyla arenicolor*) is reviewed. by Brown and Lowe (In review) and their value as bird habitat is documented (Carothers and Johnson, 1971). These communities are dwindling in area and Brown and Lowe (In review) believe that excessive cattle grazing has negatively influenced the understory and quality of remaining stands.

Figure 31. Sayers (1974) apparently included scattered mesquite stands on non-riparian sites into his "mesquite bosque" community. This photograph is interpreted to be similar to the one he presents in his publication.

Figure 32. Pettinger et al. (1970), Kuchler (1964) and the present study classify a vegetational unit where tree-sized (20-30 feet) mesquite dominate the aspect as a mesquite bosque.

In the riparian deciduous gallery forest, Indians used walnut, Texas mulberry and cottonwood for food. Cottonwood and willow were also used in making baskets and for a variety of medicinal purposes (Kearney and Peebles, 1969).

There is a possibility of utilizing timber from the riparian deciduous forest. Cottonwood is the most important species, but utilization prospects are limited because it occurs on less than 8,000 acres and these are being removed in various land-use programs (Barger and Ffolliott, 1971). They felt, however, that privately owned lands could be managed for cottonwood production on a sustained yield basis. This may be justified because, in some areas, cottonwood has been used for pulpwood, wood shavings, crating, boxes, pallets, veneer in plywood, fireplace wood, and it may be suited as a feed supplement for animals (Barger and Ffolliott, 1971). According to Horton and Campbell (1974) a small crafts industry in northern Mexico uses cottonwood for making small statues and bowls. Although Barger and Ffolliott (1971) conclude that present use in Arizona is restricted by the supply problem and lack of immediate market for the timber, they believe there is some economic potential for utilizing cottonwood in Arizona.

Uses of Riparian Grassland Communities

Sacaton, tobosa and other riparian grassland communities are economically important forage resources (Fig. 33). Tobosa and sacaton communities occur on heavy-textured soils of bottomlands and swales and are an important component of ranchers' total livestock operation. Sacaton also forms thick ground cover in openings and along edges of mesquite bosques.

Effective management and utilization of tobosa and sacaton grasslands depend on the availability of other forage species, season of use, and livestock distribution (Darrow, 1944). Livestock will utilize tobosa when it is green but will often avoid it if other feed is available or if it becomes coarse. Therefore, Darrow believed tobosa grasslands should be used during summer months to obtain even utilization (stubble height of three or four inches). However, he warned that these areas could be converted into barren adobe flats if vegetational cover was seriously depleted. Under these conditions, the heavy clay soils become impervious to water percolation and aeration. Sacaton can be an important source of green feed in the spring when many other grasses are dry.

Converting Arizona's floodplains that have shallow water tables (0-4 feet) to bermuda grass or saltgrass also has high economic potential, and there is some potential for floodplains with water table depths of four to eight feet to be converted to grass (Horton and Campbell, 1974). Riparian grassland communities

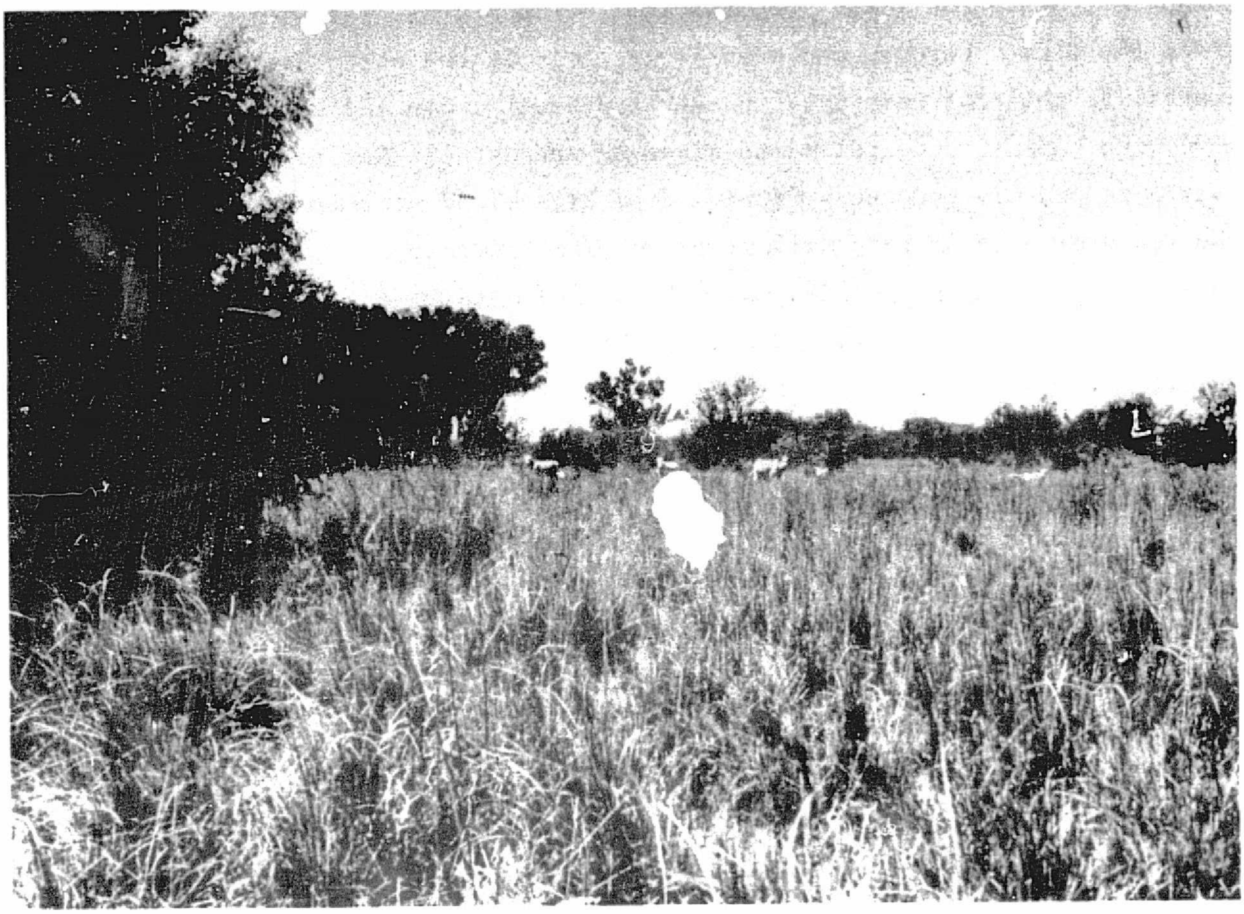

Figure 33. Sacaton bottomlands (San Pedro River) are an important grazing resource and contribute to the overall ranch operation.

provide for soil stability, furnish forage, utilize less water than woody plants and when they exist in combination with other riparian communities improve habitat for some wildlife species.

Bermuda grass is an important introduced species of the riparian grassland community. Kneebone (1966) reports that bermuda grass has been used medicinally since the first century, and even as recently as the early days of the United States its rhizomes were used to make a diuretic. In India, the rhizomes were used with tumeric and applied to bleeding wounds. In Mexico, an infusion of leaves reportedly reduces suffering from high blood pressure and experiments at The University of Arizona College of Pharmacy indicated injections of soaked bermuda lawn clippings would reduce blood pressure in dogs (Kneebone, 1966).

Bermuda grass is also economically important for pasturage, as a soil stabilizer and as a pest in alfalfa seed (Kneebone, 1966). He reports, "At present time, more than 6,000,000 pounds of bermuda grass seed are being sold in the United States annually, primarily from Yuma County, Arizona, and all grown as a specialty crop. This brings over a million dollars to the growers, much of it from land too salty to grow anything else or from land which bermuda grass was allowed to take over as a reclamation measure."

Uses of Riparian Scrub Communities

In Southern Arizona these communities lie in or near the level of the stream bed and are subject to irregular or at least intermittent streamflow, often in the form of flash floods. Substratum of these sites is a mixture of sand and coarse, partially worn gravel. Conditions are very unfavorable for tree establishment and the plants (Salix, Populus and Prosopis) which do occur usually show distortion and root exposure due to floods. Dominant plants are burrobrush, desert broom, desert willow and saltcedar, and these have little value for timber or livestock grazing.

Pods from catclaw and mesquite have been used for mush and cakes, and arrowweed used in constructing huts and for making arrows and baskets (Kearney and Peebles, 1969).

Uses of Marshland Communities

Brown and Lowe (In review) define marshland communities as "those communities, the principal constituents of which are not trees nor nonhalophytic grasses, and which normally or regularly have their base portions annually, periodically or continually submerged." These are Arizona's most hydric communities and include saltgrass, carrizo, bulrush, giant reed, and cattail.

Brown and Lowe (In review) believe marsh communities have been harmed more than any other community in Arizona by man's water manipulations. It is a rare community and Haase (1972) found only 250 acres on the 16,000-acre floodplain of the lower Gila River; yet, they are important to endangered, threatened, and peripheral wildlife species (University of Arizona, Office of Arid Lands Studies, 1970; Haase, 1972; Brown and Lowe, In review). Cattail marsh communities provide nesting sites for about 13 species out of the 150 species of birds observed along the Lower Gila River (University of Arizona, Office of Arid Lands Studies, 1970). Nesting species include the Yuma clapper rail (*Rallus longirestris* Boddaert), an endangered species (U.S. Bureau of Sport Fisheries and Wildlife, 1968). These communities are important habitat for other rare and vanishing wildlife species: black rail (*Laterallus jamaicensis*), bitterns (*Ixobrychus exilis*, and *Botaurus lentiginosus*) and Mexican duck (*Anas diazi*) (Brown and Lowe, In review).

In the marshland communities, "culms of reed were used to make arrows, prayer sticks, weaving rods, pipestems, mats, screens, nets and thatching," Kearney and Peebles (1969). Seeds and rootstocks of reed were used as food. Culms of giant reed were used for lattices, nets, screens, and in constructing huts. Various parts of cattail were used as food (Kearney and Peebles, 1969). They also report that the Hopi Indians ate the bases of one of the bulrushes.

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APPENDIX A: Sources of Available Aerial Photography

For current aerial photographic coverage over the United States, the United States Department of the Interior Geological Survey has compiled an index map including the following government agencies and commercial firms:

Federal Government Agencies

Agricultural Stabilization and
Conservation Service
Department of Agriculture
Western Laboratory
2505 Parley's Way
Salt Lake City, Utah 84109
(For North Dakota, Nebraska, Kansas, Arkansas, Louisiana, and other States to the west)

Agricultural Stabilization and
Conservation Service
Department of Agriculture
Eastern Laboratory
45 South French Broad Avenue
Asheville, North Carolina 28801
(For all other states)

Soil Conservation Service
Department of Agriculture
Federal Center Building
East-West Highway & Belcrest Road
Hyattsville, Maryland 20781

National Ocean Survey
Department of Commerce
Washington Science Center
Rockville, Maryland 20852

Bureau of Land Management
Department of Interior
Washington, D.C. 20240

Map Information Office
Geological Survey
Department of the Interior
Washington, D.C. 20244

Forest Service
Department of Agriculture
Washington, D.C. 20250

Tennessee Valley Authority
Maps and Surveys Branch
210 Haney Building
Chattanooga, Tennessee 37401

State Agencies

Arizona Highway Department
Administrative Services Division
206 South 17th Avenue
Phoenix, Arizona 85007

State of Arkansas Highway Department
Surveys, 9500 New Denton Highway
P.O. Box 2261, Little Rock, Arkansas

State of Nebraska
Department of Roads
14th & Burnham Streets
Lincoln, Nebraska 68502

State of Ohio
Department of Highways
Columbus, Ohio 43216

Oregon State Highway Division
Salem, Oregon 97310

Virginia Department of Highways
Location and Design Engineer
1401 East Broad Street
Richmond, Virginia 23219

State of Washington
Department of Natural Resources
600 North Capitol Way
Olympia, Washington 98501

Commercial Firms

Aerial Data Service
10338 East 21st Street
Tulsa, Oklahoma 74129

Air Photographics Inc.
P.O. Box 786
Purcellville, Virginia 23132

Ammann International Base Map &
Air Photo Library
223 Tenth Street
San Antonio, Texas 78215

Burlington Northern Inc.
650 Central Building
Seattle, Washington 98104

Cartwright Aerial Surveys Inc.
Executive Airport
6151 Freeport Boulevard
Sacramento, California 95822

Lockwood, Kessler & Bartlett, Inc.
One Aerial Way
Syosset, New York 11791

Mark Hurd Aerial Surveys, Inc.
345 Pennsylvania Avenue South
Minneapolis, Minnesota 55426

Merrick and Company
Consulting Engineers
2700 West Evans
Denver, Colorado 80219

Murray-McCormick
Aerial Surveys Inc.
6220 24th Street
Sacramento, California 95822

Photographic Interpretation Corporation
Box 868, Hanover, New Hampshire 03755

Quinn and Associates
460 Caredean Drive
Horsham, Pennsylvania 13044

Sanborn Map Company, Inc.
P.O. Box 61
629 Fifth Avenue
Pelham, New York 10803

H.G. Chickering, Jr.
Consulting Photogrammetrist, Inc.
P.O. Box 2767
1190 West 7th Avenue
Eugene, Oregon 97402

Fairchild Aeromaps Inc.
14437 North 73rd Street
Scottsdale, Arizona 85254

Grumman Ecosystems Corp.
Bethpage, New York 11714

Henderson Aerial Surveys Inc.
5125 West Broad Street
Columbus, Ohio 43228

L. Robert Kimball
615 West Highland Avenue
Ebensburg, Pennsylvania 15931

The Sidwell Company
Sidwell Park
28 West 240 North Avenue
West Chicago, Illinois 60185

Surdex Corporation
25 Mercury Boulevard
Chesterfield, Missouri 63017

Teledyne Geotronics
725 East Third Street
Long Beach, California 90812

United Aerial Mapping
5411 Jackwood Drive
San Antonio, Texas 78238

Walker and Associates Inc.
310 Prefontaine Building
Seattle, Washington 98104

Western Aerial Contractors, Inc.
Mahlon Sweet Airport
Route 1, Box
Eugene, Oregon 97401

Other Agencies

Southeast Michigan
Council of Governments
1249 Washington Boulevard
Detroit, Michigan 48226

The U.S.G.S. index map "Status of Aerial Photography in the U.S." shows where aerial coverage is available, and indicates the responsible agency and firm. The map is available through:

MAP INFORMATION OFFICE
U.S. Dept. of the Interior
Geological Survey
Washington, D.C. 20242

This office also maintains records of available maps, aerial mosaics, etc.

Index maps showing aerial coverage by a single government agency can be obtained upon request through the appropriate Regional Headquarters.

To procure aerial photographs the recommended procedure is to use the "Status Map" to determine who has the film, then contact the agency or firm to inquire about price and film characteristics.

Requests should state the purpose for which the photographs are desired, define the specific area of interest, and specify the size of photographs and type of coverage desired. Requests for reproduction of government photography of Arizona may be sent to the appropriate Regional Headquarters:

Pacific Region Engineer
U.S. Geological Survey
345 Middlefield Road
Menlo Park, Calif. 94025

U.S. Forest Service
Division of Engineering
Federal Office Building
Ogden, Utah 84401
Attn: Surveys and Maps Branch

Western Aerial Photography Laboratory
ASCS-USDA
2505 Parley's Way
Salt Lake City, Utah 84109

Inquiries regarding aerial photographic coverage during the 1930's and 1940's should be directed to:

National Archives & Records Service
Cartographic Branch, G.S.A. Room G-6
8th and PA. Ave. N.W.
Washington, D.C. 20408

The EROS Data Center is operated for the Earth Resources Observation Systems Program of the Department of the Interior by the Topographic Division of the Geological Survey to provide access to Earth Resources Technology Satellite (ERTS) imagery, USGS aerial photography, and NASA aircraft data. The EROS Data Center is located at:

10th & Dakota Avenue
Sioux Falls, South Dakota 57198

Their staff also maintains a catalog of all NASA imagery and photography and will respond to inquiries by telephone, letter, and personal visits.

The Department of the Interior has established and maintains a browse file at:

Water Resources Division
U.S. Geological Survey
Room 5107, Federal Building
230 North 1st Avenue
Phoenix, Arizona 85025
Phone: 602-216-3188

Other local sources of information regarding Arizona imagery and photography are:

Center of Remote Sensing
School of Renewable Natural Resources
University of Arizona
Tucson, Arizona 85721

and

Office of Arid Lands Studies
University of Arizona
Tucson, Arizona 85719
Attn: Mr. Robin Clark

These departments have assembled aerial photography and imagery germane to Arizona and they have facilities, equipment and personnel to assist in remote sensing investigations.

The Department of Commerce, National Oceanographic and Atmospheric Administration (NOAA) has Earth Resources Data Center at Suitland, MD. This Center will provide ERTS data to the general public and to users in the oceanographic, hydrologic and atmospheric sciences. Their costs are the same as those at the EROS Data Center; however, they do not maintain a browse file in Arizona. Direct all orders to:

National Climate Center
NOAA Environmental Data Service
Federal Building
Asheville, N.C. 28801

ERTS imagery dealing with agriculture is available through the Department of Agriculture. Costs are the same as from the EROS Data Center and orders should be directed to:

Agricultural Stabilization & Conservation Service
USDA
2505 Parley's Way
Salt Lake City, Utah 84109

A cooperative effort between NASA, U.S. Geological Survey, and the State of Arizona has resulted in a set of photographs covering the entire state. The ORTHOPHOTOQUADS are rectified, black and white photographs printed at scale of 1:24,000 (1 inch = 2,000 feet) to match the U.S.G.S. 7.5 minute topographic series. Due to processing difficulties, the orthophotoquads vary in quality. Therefore, instead of having high value for detailed interpretations, they primarily function as a relatively inexpensive and excellent photo base for the presentation of overlays. They are available through the Arizona Resources Information System:

3500 N. Central
Suite 118
Phoenix, Arizona 85012

APPENDIX B: Scientific Name Equivalents for Common Names of Plants Used in the Text and Captions

Common Name	Scientific Name
alder	*Alnus* sp.
alfalfa	*Medicago sativa*
alkali sacaton	*Sporobolus airoides* Torr.
arrowweed	*Pluchea sericea* (Nutt.) Coville.
aspen	*Populus tremuloides* Michx.
aster	*Aster* sp.
baby bonnets	*Coursetia microphylla* Gray.
baccharis	*Baccharis* sp.
batamote (seep willow)	*Baccharis glutinosa* Pers.
bermuda grass	*Cynodon dactylon* (L.) Pers.
big saltbush	*Atriplex lentiformis* (Torr.) Wats.
blue panic	*Panicum antidotale* Retz.
bulrush	*Scirpus* sp.
burrobrush	*Hymenoclea monogyra* Torr. & Gray.
canyon grape	*Vitis arizonica* Engelm.
cat claw	*Acacia greggii* Gray.
cattail	*Typha* sp.
corn	*Zea* sp.
cotton	*Gossypium* sp.
cottonwood	*Populus* sp.
coyote melon (gourd)	*Cucurbita palmata* Wats.
creosote bush	*Larrea tridentata* (DC.) Coville
desert broom	*Baccharis sarothroides* (*B. arizonica*)
desert saltbush	*Atriplex polycarpa* (Torr.) Wats.
desert tobacco (tobacco)	*Nicotiana trigonophylla* Dunal.
desert willow	*Chilopsis linearis* (Cav.) Sweet.
devil's-claw	*Proboscidea* sp.
elderberry	*Sambucus neomexicana* Wooton.
four-wing saltbush	*Atriplex canescens* (Pursh) Nutt.
Fremont cottonwood	*Populus fremontii* Wats.
giant reed	*Arundo donax* L.
goose foot	*Chenopodium* sp.

Common Name	Scientific Name
greasewood	Sarcobatus vermiculatus (Hook.) Torr.
hackberry (netleaf hackberry)	Celtis reticulata Torr.
iodine bush	Allenrolfea sp.
ironwood	Olneya tesota Gray.
Johnson grass	Sorghum halepense (L.) Pers.
jungle rice	Echinochloa colonum (L.) Link.
lycium	Lycium sp.
marsh fleabane	Pluchea sp.
mesquite	Prosopis juliflora (Swartz) DC.
monkey flower	Mimulus sp.
mulberry	Morus microphylla Buckl.
New Mexico locust	Robinia neomexicana Gray.
oak	Quercus spp.
pale wolfberry	Lycium pallidum Miers.
paloverde	Cercidium spp.
pickle weed	Allenrolfea occidentalis (Wats.) Kuntze.
pigweed	Amaranthus sp.
rabbitbrush	Chrysothamnus spp.
reed	Phragmites communis Trin.
reed canary grass	Phalaris arundinaceae L.
rubber rabbitbrush	Chrysothamnus nauseosus (Pall.) Britton.
Russian thistle	Salsola kali L.
sacaton	Sporobolus wrightii Monro.
sacred datura	Datura meteloides DC.
safflower	Carthamus sp.
saltbush	Atriplex sp.
saltcedar (tamarix or tamarisk)	Tamarix pentandra Pall.
saltgrass	Distichlis stricta (Torr.) Rydb. (D. dentata Rydb.)
screwbean	Prosopis pubescens Benth.
seepweed	Suaeda torreyana Wats.
skunkbush sumac	Rhus trilobata Nutt.
sorgho or sorghum	Sorghum sp.
tall wheatgrass	Agropyron elongatum Host.
thread-leaf groundsel	Senecio longilobus Benth.

Common Name	Scientific Name
tobosa	_Hilaria_ _mutica_ (Buckl.) Benth.
velvet ash	_Fraxinus_ _velutina_ Torr. (_F._ _standleyi_ Rehder.)
vine mesquite	_Panicum_ _obtusum_ H.B.K.
walnut	_Juglans_ _major_ (Torr.) Heller (_J._ _rupestris_ Engelm. var. _major_ Toot.)
western soapberry	_Sapindus_ _drummondi_
wheat	_Triticum_ sp.
white bursage	_Franseria_ _dumosa_ Gray.
wild rye	_Elymus_ sp.
willow	_Salix_ sp.
wire grass	_Juncus_ _balticus_ Willd.

APPENDIX C: Common Name Equivalents for Scientific Names of Plants Used in the Text and Captions

Scientific Name	Common Name
Acacia greggii Gray.	cat claw
Agropyron elongatum Host.	tall wheatgrass
Allenrolfea sp.	iodine bush
Allenrolfea occidentalis (Wats.) Kuntze.	pickleweed
Alnus sp.	alder
Amaranthus sp.	pigweed
Arundo donax L.	giant reed
Aster sp.	aster
Atriplex sp.	saltbush
Atriplex canescens (Pursh.) Nutt.	four-wing saltbush
Atriplex lentiformis (Torr.) Wats.	big saltbush
Atriplex polycarpa (Torr.) Wats.	desert saltbush
Baccharis sp.	baccharis
Baccharis glutinosa Pers.	batamote (seep willow)
Baccharis sarothroides (*B. arizonica*)	desert broom
Carthamus sp.	safflower
Celtis reticulata Torr.	netleaf hackberry
Cercidium spp.	paloverde
Chenopodium sp.	goose foot
Chilopsis linearis (Cav.) Sweet.	desert willow
Chrysothamnus spp.	rabbitbrush
Chrysothamnus nauseosus (Pall.) Britton.	rubber rabbitbrush
Coursetia microphylla Gray.	baby bonnets
Cucurbita palmata Wats.	coyote melon (gourd)
Cynodon dactylon (L.) Pers.	bermuda grass
Datura meteloides DC.	sacred datura
Distichlis stricta (Torr.) Rydb. (*D. dentata* Rydb.)	saltgrass
Echinochloa colonum (L.) Link.	jungle rice
Elymus sp.	wild rye
Franseria dumosa Gray.	white bursage

Scientific Name	Common Name
Fraxinus velutina Torr. (*F. standleyi* Rehder.)	velvet ash
Gossypium sp.	cotton
Hilaria mutica (Buckl.) Benth.	tobosa
Hymenoclea monogyra Torr. & Gray.	burrobrush
Juglans major (Torr.) Heller (*J. rupestris* Engelm. var. *major* Toot.)	walnut
Juncus balticus Willd.	wiregrass
Larrea tridentata (DC.) Coville	creosote bush
Lycium sp.	lycium
Lycium pallidum, Miers.	pale wolfberry
Medicago sativa	alfalfa
Mimulus sp.	monkey flower
Morus microphylla Buckl.	mulberry
Nicotiana trigonophylla Dunal.	desert tobacco
Olneya tesota Gray.	ironwood
Panicum antidotale Retz.	blue panic
Panicum obtusum H.B.K.	vine mesquite
Phalaris arundinaceae L.	reed canary grass
Phragmites communis Trin.	reed
Pluchea sp.	march fleabane
Pluchea sericea (Nutt.) Coville.	arrowweed
Populus sp.	cottonwood
Populus fremontii Wats.	Fremont cottonwood
Populus tremuloides Michx.	aspen
Proboscidea sp.	devil's-claw
Prosopis juliflora (Swartz) DC.	mesquite
Prosopis pubescens Benth.	screwbean
Quercus spp.	oak
Rhus trilobata Nutt.	skunkbush sumac
Robinia neomexicana Gray.	New Mexico locust
Salix sp.	willow
Salsola kali L.	Russian thistle
Sambucus neomexicana Wooton.	elderberry
Sapindus drummondi	western soapberry
Sarcobatus vermiculatus (Hook.) Torr.	greasewood
Scirpus sp.	bulrush

Scientific Name	Common Name
Senecio longilobus Benth.	thread-leaf groundsel
Sorghum sp.	sorgho or sorghum
Sorghum halepense (L.) Pers.	Johnson grass
Sporobolus airoides Torr.	alkali sacaton
Sporobolus wrightii Monro.	sacaton
Suaeda torreyana Wats.	seepweed
Tamarix pentandra Pall.	tamarisk (saltcedar)
Typha sp.	cattail
Triticum sp.	wheat
Vitis arizonica Engelm.	canyon grape
Zea sp.	corn