Chapter 6

Woody Vegetation of the Upper Verde River: 1996-2007

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Introduction

Streamside vegetation is an integral component of a stable riparian ecosystem, providing benefits to both terrestrial and aquatic fauna (Brown and others 1977; National Research Council 2002) as well as Native Americans (Betancourt and Van Devender 1981). On the UVR, stable streambanks are a desirable management goal to attain channel stability for a variety of wildlife and fishery needs. Only recently have efforts begun to quantify streamside plant communities—owing to a paucity of adequate descriptions of riparian habitats and to address the managers need for qualitative and general descriptions (McLaughlin 2004). Vegetation environments are a focal point for land managers regulating land uses, such as livestock grazing, that could potentially impact aquatic communities. Managers rely on descriptions of the plant communities associated with streamside environments for qualitative and general descriptions (Brown and others 1979; Laurenzi and others 1983; McLaughlin 2004).

Previous vegetation studies on the Verde River (Brock 1987; Szaro 1989, 1990; Black and others 2005, Stromberg 2008) have provided some insight into riparian habitats, but the vegetation descriptions were unusable to managers interested in sensitive aquatic species management or their work was limited to flow-vegetation studies of the middle or lower Verde River (Beauchamp and Stromberg 2008). Shaw (2006) examined historic plant communities of the watershed and noted limited evidence of riparian communities. Szaro and Patton (1986) and Szaro (1989, 1990) provided generalized vegetation type descriptions that included the Verde River. Most vegetation descriptions for the UVR come from generalized species accounts and vegetation mapping using aerial photographs (Black and others 2005, Stromberg (2008).

The objective of this chapter is to provide a quantitative description of woody streamside vegetation along the UVR from 1996 to 2007. A need to understand the complexity of existing riparian vegetation, amidst the various changes in land uses and climate, is paramount for land managers (Pase and Layser 1977). The UVR possessed aquatic habitat highly suitable for native fishes decades ago. Today, riparian and aquatic habitats are much different raising questions about relationships between terrestrial and aquatic components that should benefit TES fishes. This description of the riparian vegetation will further the understanding of its role in management of TES species and other associated wildlife and plants in the ecosystem. All woody plants occurring within the streamside areas sampled are included in the analysis to reflect existing habitat conditions that vary from aquic to mesic, depending on their state.

Study Area

The UVR study area is defined as that portion bounded by the eastern edge of the Prescott National Forest near Tapco to Sullivan Dam on the west (see Chapter 1; figs. 1.1, 1.2, 1.3 and 6.1). The area lies within the transition zone between the Basin and Range and Colorado Plateau provinces. As such, the landscape displays lithologies common to both provinces, interspersed throughout the riparian corridor and uplands. Granitic materials are most common to the south, while limestone, sandstone, and basalt rock types are most common north of the river (Krieger 1965). For details, see Chapter 2.

The Verde River watershed covers 17,151 km^2 (6,622 mi^2) or about 6% of the State of Arizona. It is divided into three subwatersheds or HUCs—Upper, Middle, and Lower Verde River (Figure 6.2). The study area lies within the UVR subwatershed, which encompasses about 6,477.6 km^2 (2,501 mi^2) (Black and others 2005). The length of the Verde River is about 368.5 km (229 mi), of which the study reach approximates 56.3 km (35 mi). The elevation at the headwaters is about 1,311 m (4,300 ft) and about 1,067 m (3,500 ft) near the USDI Geological Survey Clarkdale stream gauge on the east end, averaging about 0.4% gradient. In the UVR corridor, landscapes vary from long, steep and narrow canyons to short and open valley forms. Likewise, floodplain widths range from 20 to 200 m (65.6 to 656.2 ft). The valley floor receives less rainfall than the average 508 mm (20 in)

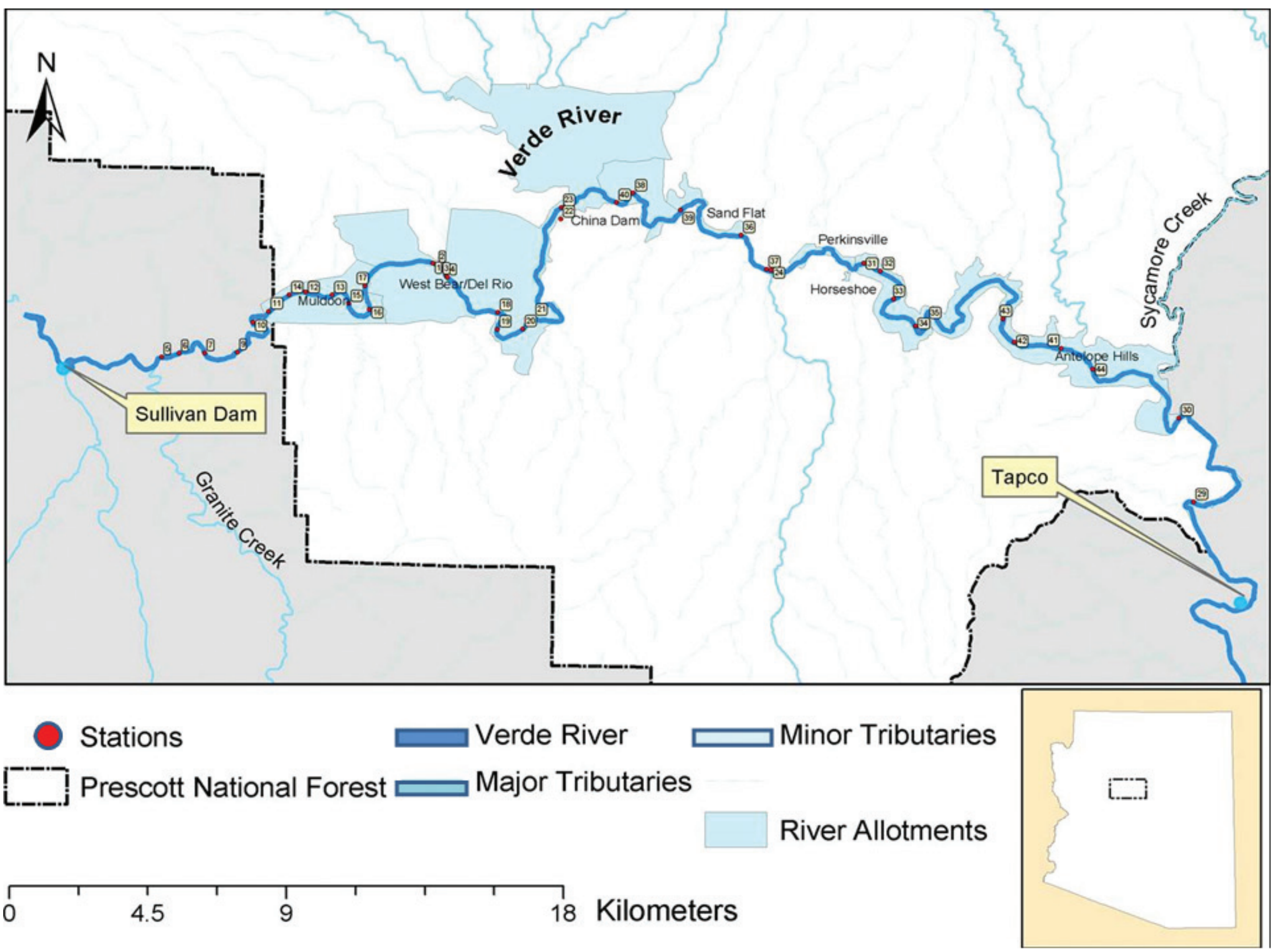

Figure 6.1—Location of UVR vegetation monitoring stations, Prescott National Forest, Arizona.

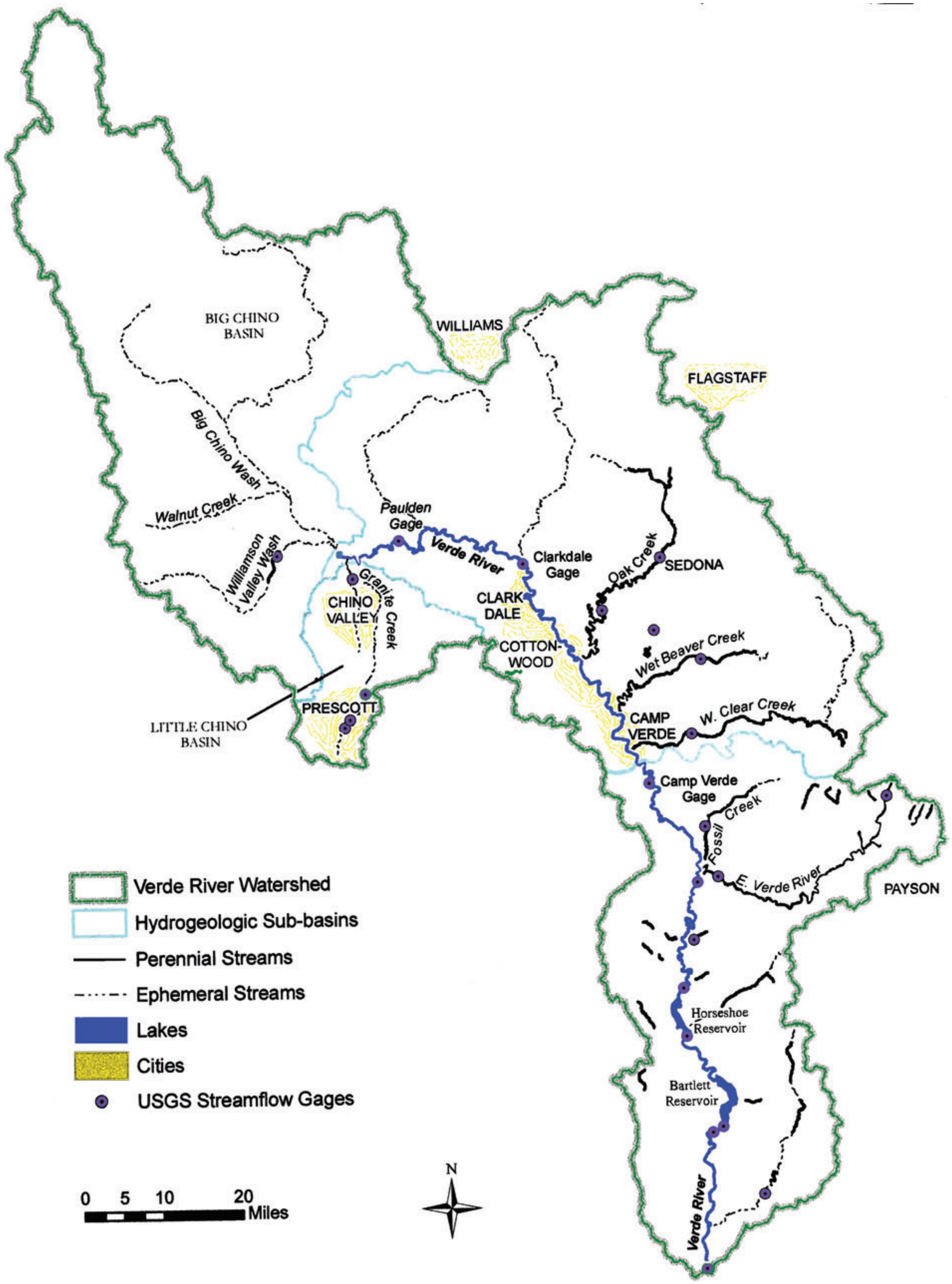

Figure 6.2—Verde River watershed showing HUCs 1506021, 15060202, and 15060203; basins; flow gauge locations; and proximity of major population centers.

for the watershed. In contrast, maximum summer temperatures can be greater within the narrow canyon landscapes than in the uplands.

Flows on the UVR have been highly variable for the period of record (see Chapter 3). Ely and others (1993) and Ely (1997) examined the paleofloods for the last 5,000 years and reported a high frequency in "extreme floods" correlated to periods of relatively cool, wet climate. Ely and others (1993) further noted unusually high frequency and magnitude of floods on the Verde River for the last 200 to 400 years. The largest recent flood was in 1993 and caused widespread channel scour and removal of woody vegetation. However, floods from the late 1800s and early 1900s were orders of magnitude larger. Peak flows at the Paulden Gauge and Clarkdale Gauge in 1993 approximated 657.0 and 1506.5 $m^3 sec^{-1}$ (23,200 and 53,200 $ft^3 sec^{-1}$), respectively. Typically, (median) base flows are around 0.7 and 2.3 $m^3 sec^{-1}$ (24 and 80 $ft^3 sec^{-1}$), respectively. Drought has also influenced the hydrology of the UVR (Ely and others 1993) to produce intermittent flow conditions (Wagner 1954). A survey of the UVR by Wagner (1954) recorded flows within the upper 38.6 km (24 mi) downstream from Sullivan Dam as "little perceptible flow." He further noted that flow was dependent on spring runoff and, when exhausted "the river ceases to flow, with any volume, until the arrival of summer rains."

Grazing by livestock occurred from the late 1890s until 1998. Today, principal herbivores are elk and beaver. Elk are a recent introduction to the UVR, moving in from adjacent mountains. Beaver have been historically common (Whittlesey 1997) and largely limited to dens within streambanks where large boulders afford protection from floods. Since 1993, more beaver dams have been evident, primarily within the floodplain in the extreme headwater reaches where flows and stream gradients are lower. A complete treatise on historical aspects and the setting of UVR is provided in Chapter 2.

Methodology

Site Selection

Streamside vegetation was sampled at 56 locations along the UVR (fig. 6.1). One-hundred sites were initially identified on aerial photographs in 1996. They were then stratified based on presence of pool, glide-run or riffle habitat, and 44 sites were randomly selected. In 1996, five additional sites were randomly established within a wetland meadow subject to high risk from erosion and inundation. Two additional sites were randomly established on private land in 2000, and five additional sites were methodically selected in 2006 on riffle habitats. Sites were selected and established to provide long-term monitoring points for both vegetation and channel conditions. Reaches immediately adjacent to side drainages and those near major changes in channel gradient were avoided.

Sampling

Time of Sampling—Five stations within a wetland meadow were sampled in 1996. Twenty-four of the stations were sampled in 1997, and 16 more were sampled in 1998. Eighteen of those stations, along with two new stations, were sampled in 2000, and all but two of the stations were sampled again in 2001. Finally, five additional stations were sampled from 2006 to 2007. Some sites were sampled across several years while others were only sampled once, depending on

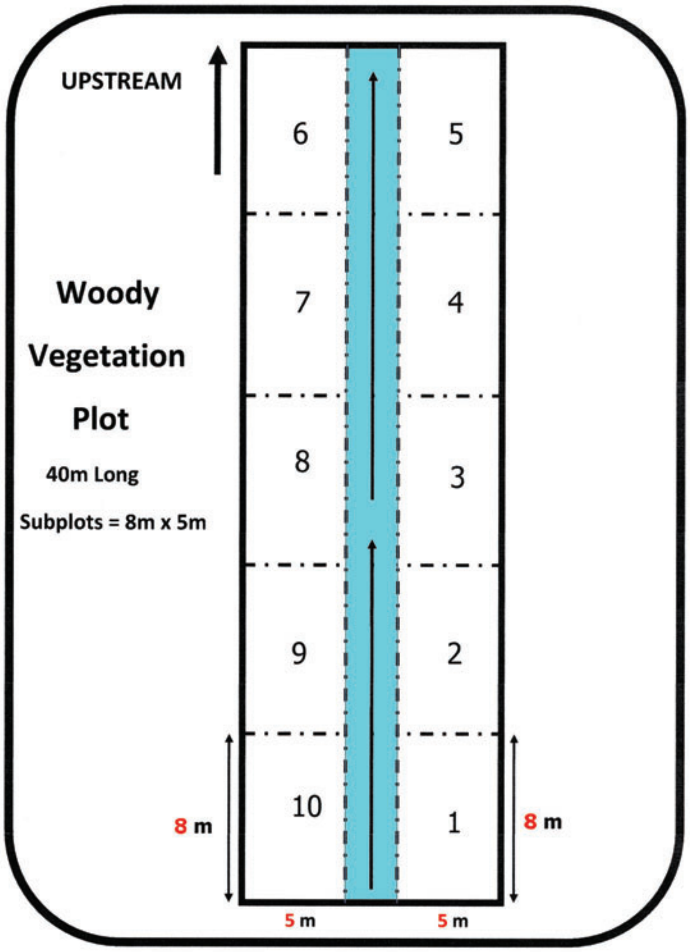

Figure 6.3—The sampling layout for woody vegetation consisted of a 40 m (131.2 ft) long plot, subdivided into 10-40 m^2 (430.6 ft^2) macro plots 5 x 8 m (16.4 x 26.25 ft).

the site's stability. For example, the wetland site was sampled once because subsequent floods eroded and inundated the sample locations.

General Sampling Methods—This study design allowed analysis of eight years of vegetation data for species composition and dominance. Vegetation was sampled during summers (June through August) of respective years. At each site, measurements of streamside herbaceous and woody vegetation were made within 40-m (131-ft) sampling transects (fig. 6.3). Transects were established along stream reaches with relatively uniform channel characteristics and vegetation. For all sampling work, the convention of denoting right and left streambanks facing upstream was used.

Woody Vegetation Sampling—Plant density estimates were determined using a technique designed to place emphasis on vegetation along the water's edge and on the streambanks immediately adjacent to the channel. Woody plant density was estimated using a modified Daubenmire (1959) approach tested on Southwestern riparian habitats (Medina 1986). Transects followed the edge of the streambank and thus were not straight lines, as illustrated in fig. 6.3. Woody vegetation was sampled in 5 x 8 m (16.4 x 26.2 ft) plots (10 total) along the same 40-m (131-ft) sampling reaches (i.e., stations). The term station was used to identify permanent sampling locations. Plot numbers 1 through 5 were located on the right streambank, while plots 6 through 10 were located on the left streambank (fig. 6.3). All tree and shrub species were counted and assigned to height and diameter size classes (table 6.1).

Table 6.1—Diameter and height classes for woody plants in the UVR survey.

Diameter class size	Height class	Size (trees)	Size (shrubs)
dm		*m*	
0-0.5	0	<1	<1 *dm*
0.5-0.9	0.5	1-1.9	1-1.9 *dm*
1-1.9	1	2-4.9	2-4.9 *dm*
2-2.9	2	5-9.9	5-9.9 *dm*
3-3.9	3	10-19.9	1-1.9 *m*
4-4.9	4	20-20.9	>2 m
5-5.9			
6-6.9			
7-7.9			
8-8.9			
9-9.9			
10>10			

Data Analysis

For the classification, data were used from the taxa that were identified as dominant species based on their average importance value (Curtis and Macintosh 1951). Relative importance values were derived for each relevé by dividing by the number of sampling events. A "relevé" consists of the entire collection of vegetation data for a given sampling station. Importance values (IV = relative dominance/constancy + relative density + relative frequency) were determined for the 22 major species (Braun-Blanquet 1932). For the classification, data from nine major tree species were used, both native and nonnative, and were limited to mature individuals.

For each vegetation type, Euclidean distance matrices were calculated as per Romesburg (1984) using IV values. Cluster analyses were performed using SAS Institute Incorporated (2002) procedures and Ward's Minimum Variance Method (Ward 1963) to produce dendrograms to estimate the dissimilarity between sites using measures of correlation. Vegetation groups were defined based on concurrence of the semi-partial-R^2, R^2, root-mean-square standard deviations, and examination of relevés for distinctness in taxa (Romesburg 1984). Community type names were assigned to each cluster group based on the relative species dominance (Shimwell 1971) indicated by the IV matrix. Estimates of frequency and density/cover were calculated for each community. Shrub species were incorporated into the final cluster groupings to identify important co-dominant strata using dominance data. Community descriptions are discussed in relative order of overall dominance in the study area.

Results

Flora

The woody vegetation of streamside habitats of the UVR consists of 62 species (tables 6.2A through 6.2C). Nomenclature follows the USDA Plant Database (http://plants.usda.gov). The UVR flora represents 12 years of plant collections on permanent stations. Plant identification of questionable taxa was performed by the

Table 6.2A—Woody taxa (ACGR/FAPA) found on riparian study plots (Stations) of the UVR 1996 to 2007. Abbreviations in this table are: **Life Form**: T = Tree, S = Shrub, SS = Sub-Shrub; **Native Status**: N = Native, I = Invasive; **Wetland Status**: U = Upland, F = Facultative, FW = Facultative Wetland, FU = Facultative Upland, O = Obligate Wetland, and NI = Native Invasive.

Taxa code	Genus	Species	Life form	Native status	Wetland indicator status	Common name
ACGR	*Acacia*	*greggii*	T/S	N	U	catclaw acacia
ACNE2	*Acer*	*negundo*	T	N	FW	boxelder
ALOB2	*Alnus*	*oblongifolia*	T	I	FU	Arizona alder
ALWR	*Aloysia*	*wrightii*	T	N	FW	Wright's beebrush
AMFR	*Amorpha*	*fruticosa*	S	N	FW	desert false indigo
ARLU	*Artemisia*	*ludoviciana*	SS	N	U	white sagebrush
ATCA2	*Atriplex*	*canescens*	S	N	U	fourwing saltbush
BAEM	*Baccharis*	*emoryi*	S	N	FW	Emory's baccharis
BAPT	*Baccharis*	*pteronioides*	S	N	U	yerba de pasmo
BASA2	*Baccharis*	*sarothroides*	S	N	F	desertbroom
BASA4	*Baccharis*	*salicifolia*	S	N	FW	seepwillow
BASE	*Baccharis*	*sergiloides*	S	N	F	desert baccharis
BRCA3	*Brickellia*	*californica*	S/SS	N	FU	CA brickellbush
CEPA	*Ceanothus*	*palmeri*	S	N	U	Palmer ceanothus
CELAR	*Celtis*	*laevigata*	T/S	N	FU	netleaf hackberry
CHLI2	*Chilopsis*	*linearis*	T/S	N	U	desert willow
ELAN	*Elaeagnus*	*angustifolia*	T/S	I	FW	Russian olive
EPVI	*Ephedra*	*viridis*	SS	N	U	Mormon tea
ERWR	*Eriogonum*	*wrightii*	S/SS	N	NI	bastardsage
FAPA	*Fallugia*	*paradoxa*	S	N	FU	Apache plume

Table 6.2B—Woody taxa (FOSP2/POHI8) found on riparian study plots (Stations) of the UVR 1996 to 2007. Abbreviations in this table are: **Life Form**: T = Tree, S = Shrub, SS = Sub-Shrub; **Native Status**: N = Native, I = Invasive; **Wetland Status**: U = Upland, F = Facultative, FW= Facultative Wetland, FU= Facultative Upland, O = Obligate Wetland, and NI = Native Invasive.

Taxa code	Genus	Species	Life form	Native status	Wetland indicator status	Common name
FOSP2	*Fouquieria*	*splendens*	S	N	U	ocotillo
FOPU2	*Forestiera*	*pubescens*	S	N	FU	stretchberry
FRVE2	*Fraxinus*	*velutina*	T	N	F	velvet ash
GAWR3	*Garrya*	*wrightii*	S	N	U	Wright's silktassel
GLSP	*Glossepetalon*	*spinescens*	SS/S	N	U	spiny greasebush
GUSA2	*Gutierrezia*	*sarothrae*	S/SS	N	U	broom snakeweed
JUMA	*Juglans*	*major*	T	N	FW	Arizona walnut
JUMO	*Juniperus*	*monosperma*	T	N	U	oneseed juniper
JUOS	*Juniperus*	*osteosperma*	T	N	U	Utah juniper
LYPA	*Lycium*	*pallidum*	S	N	U	pale desert thorn
MAFR3	*Mahonia*	*fremontii*	S	N	U	Fremont's mahonia
MAHA4	*Mahonia*	*haematocarpa*	S	N	U	red barberry
MIAC3	*Mimosa*	*aculeaticarpa*	T/S	N	U	catclaw mimosa
NOMI	*Nolina*	*microcarpa*	S/SS	N	U	sacahuista
PAQU2	*Parthenocissus*	*quinquefolia*	V	N	NI	Virginia creeper
PHAN3	*Phaseolus*	*angustissimus*	V	N	NI	slimleaf bean
PHAU7	*Phragmites*	*australis*	SS/S	N	FW	common reed
PLWR2	*Platanus*	*wrightii*	T	N	FW	Arizona sycamore
POFR2	*Populus*	*fremontii*	T	N	FW	Fremont cottonwood
POHI8	*Populus*	*hinckleyana*	T	N	FW	Hinckley poplar

Table 6.2C—Woody taxa found on riparian study plots (Stations) of the UVR 1996 to 2007. Abbreviations in this table are: **Life Form**: T = Tree, S = Shrub, SS = Sub-Shrub; **Native Status**: N = Native, I = Invasive; **Wetland Status**: U = Upland; F = Facultative, FW = Facultative Wetland, FU = Facultative Upland, O = Obligate Wetland, and NI = Native Invasive.

Taxa code	Genus	Species	Life form	Native status	Wetland indicator status	Common name
POGL9	*Potentilla*	*glandulosa*	SS	N	O	gland cinquefoil
PRVE	*Prosopis*	*velutina*	T/S	N	U	velvet mesquite
QUEM	*Quercus*	*emoryi*	T/S	N	U	Emory oak
QUGA	*Quercus*	*gambelii*	T/S	N	U	gambel oak
QUTU2	*Quercus*	*turbinella*	T/S	N	U	sonoran scrub oak
RHTR	*Rhus*	*trilobata*	S	N	U	skunkbush sumac
RHCA3	*Rhamnus*	*cathartica*	T/S	I	NI(FU)	common buckthorn
RIAU	*Ribes*	*aureum*	S	N	FW	golden currant
RICE	*Ribes*	*cereum*	S	N	U	wax currant
RONE	*Robinia*	*neomexicana*	T/S	N	U	New Mexican locust
SABO	*Salix*	*bonplandiana*	T	N	FW	Bonpland willow
SAEX	*Salix*	*exigua*	T/S	N	O	coyote willow
SAGO	*Salix*	*goodingii*	T	N	O	Gooding willow
SALA3	*Salix*	*laevigata*	S	N	O	red willow
SALA6	*Salix*	*lasiolepis*	T/S	N	FW	arroyo willow
SASA4	*Sapindus*	*saponaria*	T/S	N	U	wingleaf soapberry
TACH2	*Tamarix*	*chinensis*	T/S	I	NI	fivestamen tamarisk
TARA	*Tamarix*	*ramosissima*	T/S	I	NI	tamarisk, saltcedar
TORA2	*Toxicodendron*	*radicans*	S/SS	N	FW	poison ivy
ULPU	*Ulmus*	*pumila*	T/S	I	F	Siberian elm
VIAR2	*Vitus*	*arizonicus*	V	N	F	canyon grape
ZIOB	*Ziziphus*	*obtusifolia*	T/S	N	NI	lotebush

Rocky Mountain National Herbarium at the University of Wyoming in Laramie. The flora contains many obligate, facultative, and upland species. Obligate, facultative, and upland species are identified as per the "Wetland Indicator Status" descriptions in the USDA Plant Database (USDA Natural Resources Conservation Service 2008). Presence of facultative and upland species is a common occurrence, as many obligate species are recent (post-1993) to developing riparian-wetland habitats. In addition, the present erosional state of the channel is such that terraces are actively eroding with the active channel abutting upland terraces, thereby creating frequent streambank-terrace disturbances. Six nonnative species were found, of which saltcedar (*Tamarix ramosissima*) was the most frequent and abundant, existing as multiple single stems to very large dense colonies (fig. 6.4) approximating 25 to 5,000 stems ha^{-1}. Siberian elm (*Ulmus pumila*) commonly occurs as large mature trees (DBH = 0.2 to 0.8 m [7.9 to 31.5 in]) throughout the study area, while Russian olive (*Elaeagnus angustifolia*) occurs as young trees (DBH = 0.05 to 0.2 m, [2.0 to 7.9 in]) primarily in the upper reaches and camping areas. A species of interest is Hinckley's poplar (*Populus × hinckleyana Correll [pro sp.] [angustifolia × fremontii]*), which is proposed as a distinct species (Integrated Taxonomic Iinformation System 2010). It is most similar to Fremont cottonwood (*P. fremontii*) and relatively more abundant. However, no distinction was made between the two species during the early study periods. Hence, all references to Fremont cottonwood are equally applicable to Hinckley's poplar.

Cluster analysis resulted in the definition of 12 community types at $R^2 = 0.796$ (fig. 6.5). Approximately 80% of the variation is accounted for at this level. Plant communities were determined by using the statistical indicators and from examination of species data by groups, which revealed distinct types. Descriptions of the community types can be found in the following sections. Estimates of the community's species frequency and density are listed in the respective tables of each

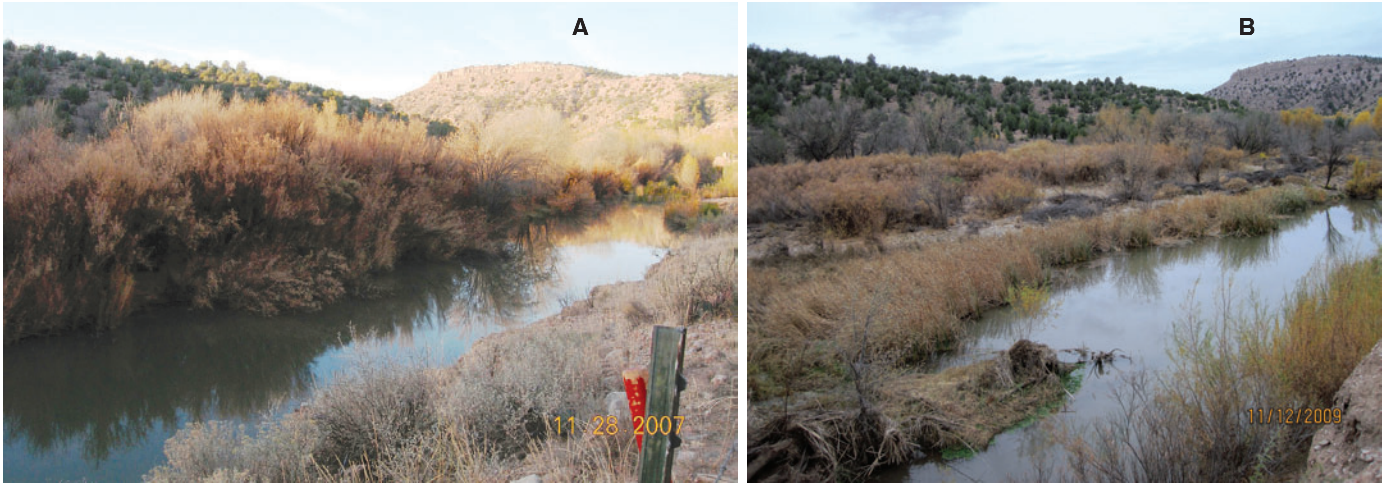

Figure 6.4—A large tamarisk stand occupies the entire streambank for about 350 m (1,148 ft) on the UVR (photo A taken in Oct 2007). These stands are relatively new with the oldest dating back to mid-1950s and pre-date most riparian trees and shrubs. B shows the site after the tamarisk stand was removed in 2007. (Photos by Alvin L. Medina.)

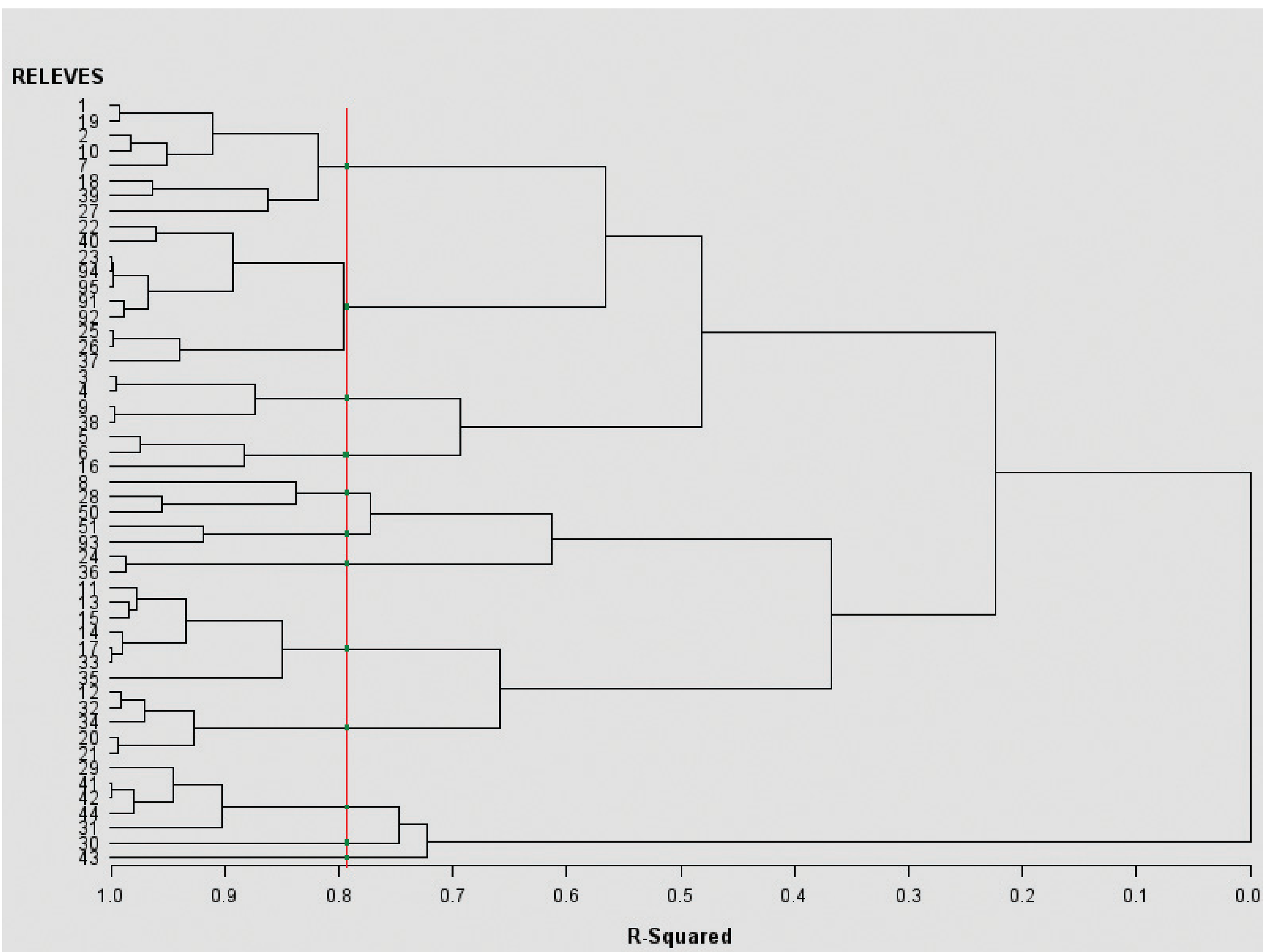

Figure 6.5—This dendrogram identifies 12 plant communities at an $R^2 = 0.796$ on the X-axis (red line). The nodes of the unions of relevés are noted with a green square. Communities may be unions of several relevés or only one when the relevé is unique. Relevés, identified as Station numbers, are listed on the Y-axis.

community. Parentheses indicate the number of stations comprising the community. Most stands of obligate species are dated to the 1993 flood.

*Gooding Willow (*Salix goodingii*) Series*

***Salix goodingii/Salix laevigata* (SAGO/SALA3) Community (N = 2)**—This community is characterized by the relative dominance of Gooding's willow in the overstory and red willow in the understory (fig. 6.6, table 6.3). Velvet ash (*Fraxinus velutina*) and boxelder (*Acer negundo*) are common mid-story species. This community is similar to the SAGO/FRVE2 community except that it is common on open, wet sites. Mature Fremont cottonwood (*Populus fremontii*) and saltcedar (*Tamarix ramosissima*) are generally absent. Depending on channel changes affecting water status, these two communities could become increasingly distinct or

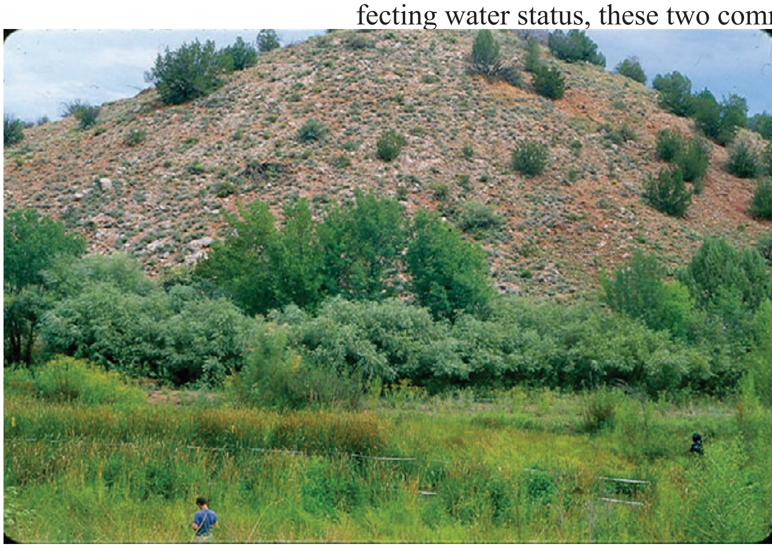

Figure 6.6—UVR representative *Salix goodingii/Salix laevigata* (SAGO/SALA3) community. (Photo by Alvin L. Medina.)

Table 6.3—Dominant woody taxa of the Salix goodingii/Salix laevigata (SAGO/SALA3) community.

Taxa	Total frequency	Mature mean density	Young mean density
	%	*Number ha^{-1}*	*Number ha^{-1}*
ACNE2	100	5	8
FRVE2	100	5	21
POFR2	50		3
SAGO	100	6	112
SALA3	100	16	188
TARA	100		127

Table 6.4—Comparison of species attributes for UVR communities.

Community	Species richness	Nonnative species	Obligate species
		Number	*Number*
ALOB/FRVE2	14	0	1
FRVE	37	3	3
FRVE/JUOS	33	2	3
FRVE/JUOS/CELAR	31	3	3
SAGO/ACNE2	11	2	2
SAGO/FRVE2	6	1	2
SAGO/FRVE2/JUOS	28	3	3
SAGO/SALA3	6	1	2
SAGO/SALA3/POFR2	31	4	3
SAGO/SASA4	16	1	2
POFR/SAGO	26	2	3
POFR/SALA3	21	2	3

similar (wet or dry). This community and the SAGO/FRVE2 community exhibited the lowest species richness (table 6.4).

***Salix goodingii/Salix laevigata/Populus fremontii* (SAGO/SALA3/POFR2) Community (N = 7)**—This community is characterized by the dominance of Gooding's willow in the overstory and red willow in the mid-story (fig. 6.7, table 6.5). Fremont cottonwood (*Populus fremontii*) is an important co-dominant on some sites with Gooding's willow. Velvet ash (*Fraxinus velutina*) is infrequent but may attain prevalence on some sites as young trees. Seepwillow (*Baccharis salicifolia*) is common in association with cattails (*Typha* spp.) and coyote willow (*Salix exigua*). It is common for some sites to have one streambank dominated by obligate species, while the opposite bank may be an actively eroding terrace or an

Figure 6.7—UVR representative *Salix goodingii/Salix laevigata/Populus fremontii* (SAGO/SALA3/POFR) community. (Photo by Alvin L. Medina.)

Table 6.5—Dominant woody taxa of the *Salix goodingii/Salix laevigata/Populus fremontii* (SAGO/SALA3/POFR2) community.

Taxa	Total frequency	Mature mean density	Young mean density
	%	*Number ha^{-1}*	*Number ha^{-1}*
ACGR	29		32
AMFR	86		14
ATCA2	14		3
BASA2	14		182
BASA4	100		211
BEFR	14		25
CELA	14		8
CHLI2	43	4	53
COLY2	14		3
ELPU	14		3
FOPU2	29		6
FOSP	14		20
FRVE2	100	7	19
GAWR3	14		28
JUMA	14		10
JUOS	29	4	5
MIBI3	29		3
POFR2	100	5	23
PRVE	14		49
RHTR	14		9
RONE	29		13
SABO	86	3	35
SAEX	57		189
SAGO	100	13	76
SALA3	100	13	68
SALA6	29		21
TACH2	100		37
TARA	100	3	24
ULPU	14	5	3
VIAR2	14		3

eroded terrace transitioning into an aquic streambank. This relevé is diverse—represented by 31 woody species (table 6.4).

***Salix goodingii/Acer negundo* (SAGO/ACNE2) Community (N = 2)**—This community is characterized by the relative dominance of Gooding's willow in the overstory with boxelder and velvet ash (*Fraxinus velutina*) in the mid-story (fig. 6.8, table 6.6). Velvet ash occurs in some stands and may be rare in others. Boxelder is a common mid-story co-dominant of Southwestern rivers and streams (Boles and Dick-Peddie 1983; Medina 1986; Skartvedt 2000). This community is similar to other Gooding's willow associations found on the Verde River, e.g., SAGO/FRVE2, SAGO/SALA3, except that here it is common on open, drier sites. Mature trees of other riparian obligate species are generally lacking. Various upland species, such as golden currant (*Ribes aureum)*, may dominate one streambank, while the opposite bank (or the active channel) is inhabited by common riparian shrubs, such as coyote willow (*Salix exigua*) or seepwillow (*Baccharis salicifolia*). This community has the lowest total stem density of young plants in

Figure 6.8—UVR representative *Salix goodingii/Acer negundo* (SAGO/ACNE2) community. (Photo by Alvin L. Medina.)

Table 6.6—Dominant woody taxa of the *Salix goodingii/Acer negundo* (SAGO/ACNE2) community.

Taxa	Total frequency	Mature mean density	Young mean density
	%	*Number ha^{-1}*	*Number ha^{-1}*
ACNE2	100	5	19
BASA4	100		79
FOPU2	50		29
FRVE2	100	3	19
JUMA	100		3
POFR2	100		18
RIAU	50		197
SAEX	50		223
SAGO	100	5	93
TACH2	100		31
TARA	100		3

an otherwise shrubby, mixed understory. Relatively, species richness is moderately low (table 6.4).

Salix Goodingii/Fraxinus velutina **(SAGO/FRVE2) Community (N = 3)—** This community is characterized by the relative dominance of Gooding's willow and velvet ash in the overstory (fig. 6.9, table 6.7). Fremont cottonwood (*Populus fremontii*) and red willow (*Salix laevigata)* are co-dominants on wetter sites, whereas boxelder (*Acer negundo*) and saltcedar (*Tamarix ramosissima*) are co-dominant on drier sites. It is different from the SAGO/FRVE/JUOS type because boxelder is

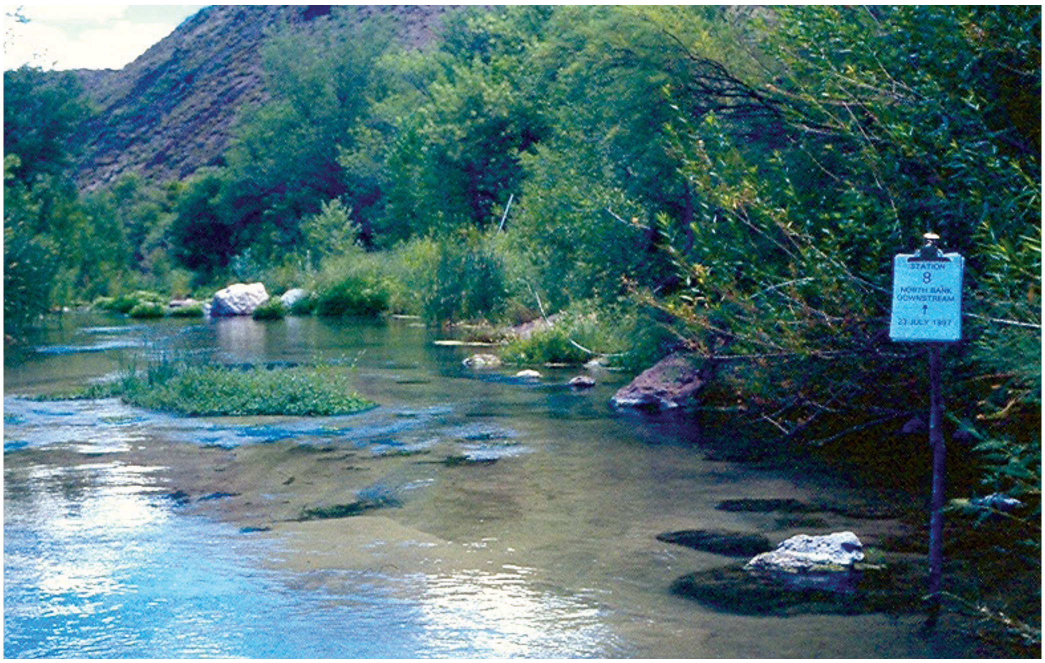

Figure 6.9—UVR representative *Salix Goodingii/ Fraxinus velutina* (SAGO/FRVE2) community. (Photo by Alvin L. Medina.)

Table 6.7—Dominant woody taxa of the *Salix Goodingii/Fraxinus velutina* (SAGO-FRVE2) community.

Taxa	Total frequency	Mature mean density	Young mean density
	%	*Number ha^{-1}*	*Number ha^{-1}*
ACNE2	67	8	13
FRVE2	100	6	37
POFR2	100	3	48
SAGO	100	5	28
SALA3	33	13	71
TARA	100	3	59

present, this type occupies generally wetter sites, and the vegetation is limited to six principal woody species. Species richness was relatively low (table 6.4).

Salix goodingii/Fraxinus velutina/Juniperus osteosperma **(SAGO/FRVE2/ JUOS) Community (N = 8)—**This community is the most common and characterized by the relative dominance of Gooding's willow and velvet ash in the overstory and Utah juniper in the mid-story (fig. 6.10, table 6.8). It is represented by at least 28 woody species, mostly upland species. Occasional mature cottonwoods dot the landscape. Young stands of Gooding's willow are generally absent, with mature stands dating to their establishment in 1993. Like many other communities, its habitat is characterized by an aquic streamside habitat occurring opposite a mesic terrace. Utah juniper is common on the floodplain and adjacent terraces. Recent flood disturbances have eroded channels onto the floodplain and against terraces, forming complex streamside habitats. Many obligate and facultative species quickly colonize newly formed habitats. Established upland and facultative species remain interspersed, thereby forming non-classical riparian habitat conditions. Levees are commonly found on drier sites. (Levees are microhabitats produced by the erosion of channel materials on both sides of impediments to flow, for example

Figure 6.10—UVR representative *Salix goodingii/Fraxinus velutina/Juniperus osteosperma* (SAGO/FRVE2/JUOS) community. (Photo by Alvin L. Medina.)

Table 6.8—Dominant woody taxa of the *Salix goodingii/Fraxinus velutina/Juniperus osteosperma* (SAGO/FRVE2/JUOS) community.

Taxa	Total frequency	Mature mean density	Young mean density
	%	*Number ha^{-1}*	*Number ha^{-1}*
ACGR	13		41
ALWR	13		30
AMFR	63		19
BASA4	88		194
BEFR	38		13
CELAR	13		3
CHLI2	25	3	16
FOPU2	25		92
FOSP	13		10
FRVE2	88	5	25
GAWR3	13		16
JUOS	25	4	6
MAHA4	13		5
PAQU2	13		45
POFR2	100	3	16
PRVE	13		3
QUGA	13	8	0
RONE	13		16
SABO	75		17
SAEX	88		151
SAGO	100	10	63
SALA3	50	3	16
TACH2	75		176
TARA	100	35	92
ULPU	13	3	4
VIAR2	13		6
ZIOB	13		3

trees and cattails.) Eroded materials deposit linearly behind the impediment. A variety of woody species quickly colonized these microhabitats. Minor floods may continue to erode and enhance the levee. Levees are common throughout the active floodplain, and depending on the age of the levee, observed streamflow may be within 1 to 2 m (3.3 to 6.6 ft) or more distant (4 to 12 m [13.1 to 39.4 ft]), hence the wet and dry site conditions. Total woody plant density is relatively high. Saltcedar (*Tamarix ramosissima*) is common on these sites. Species richness is moderately high (table 6.4).

***Salix goodingii/Sapindus saponaria* (SAGO/SASA4) Community (N = 1)—** An uncommon plant group on the Verde River makes up this community. It is characterized by the relative dominance of Gooding's willow in the overstory and soapberry in the understory (fig. 6.11, table 6.9). Soapberry occurs in limited quantities in other communities. Medina (1986) found similar stands in southwestern New Mexico but with much higher stand density (338 trees ha^{-1} or 137 trees ac^{-1}). Soapberry typically occurs away from the water's edge on mesic terrace sites but in close proximity to other obligate riparian trees. The diverse taxa found on this site are indicative of a site whose streambanks are distinct. One streambank might be populated by obligate riparian species, while the opposite bank might be a mesic terrace occupied by a variety of upland species. These microhabitat types are common on the Verde River, owing to active terrace erosion and channel downcutting. The absence of other mature trees suggests that the community is transitional.

Figure 6.11—UVR representative *Salix goodingii/Sapindus saponaria* (SAGO/SASA4) community. (Photo by Alvin L. Medina.)

Table 6.9—Dominant woody taxa of the Salix goodingii/Sapindus saponaria (SAGO/SASA4) community.

Taxa	Total frequency	Mature mean density	Young mean density
	%	*Number ha^{-1}*	*Number ha^{-1}*
ACGR	100		15
ACNE2	100		3
AMFR	100		47
BASA4	100		358
BEFR	100		94
CELAR	100		8
FRVE2	100		677
JUOS	100		3
PLWR2	0		20
POFR2	100		26
PRVE	100		23
SAEX	100		23
SAGO	100	8	21
SASA4	100	13	10
TACH2	0		3
ZIOB	0		6

This community has a moderately high total stem density of young plants. Species richness is relatively moderate (table 6.4).

*Fremont Cottonwood (*Populus fremontii*) Series*

***Populus fremontii/Salix goodingii* (POFR/SAGO) Community (N = 5)—** The co-dominance of Fremont cottonwood and Gooding's willow in the overstory characterizes this community (fig. 6.12, table 6.10). Velvet ash (*Fraxinus velutina*) is an important mid-story species with a frequency of 40% in the mature class and 100% in the young class. Seepwillow (*Baccharis salicifolia*) is dominant in the understory with high frequency and density. In general, this community is represented by 24 woody species and has a variety of both upland and riparian shrub species. This community has the highest total stem density of young plants and

Figure 6.12—UVR representative *Populus fremontii/Salix goodingii* (POFR/SAGO) community. (Photo by Alvin L. Medina.)

Table 6.10—Dominant woody taxa found on the *Populus fremontii/Salix goodingii* (POFR/SAGO) community.

Taxa	Total frequency	Mature mean density	Young mean density
	%	*Number ha^{-1}*	*Number ha^{-1}*
ACGR	60		5
AMFR	0		18
BASA4	100		273
BASE	20		26
BEFR	20		38
CELAR	40	35	15
CHLI2	40		45
FOPU2	40		17
FRVE2	100	12	16
GAWR3	20		3
JUOS	40	3	12
LERE	20		10
PLWR2	80		4
POFR2	100	13	109
PRVE	60		7
QUTU2	20		28
RONE	20		13
SABO	20		5
SAEX	20		520
SAGO	100	10	118
SALA6	20		13
TACH2	20		43
TARA	60		17

relatively high species richness (Table 6.4). Cattails (*Typha* spp.) may also be a co-dominant with coyote willow (*Salix exigua*) on some sites.

***Populus fremontii/Salix laevigata* (POFR/SALA3) Community (N = 3)**—This community is uniquely characterized by the dominance of Fremont cottonwood in the overstory and red willow in the mid-story (fig. 6.13, table 6.11). The shrub understory is comprised of dense stands of coyote willow (*Salix exigua*) interspersed with seepwillow (*Baccharis salicifolia*). The community is represented by 21 woody species and has relatively high species richness (table 6.4). Some sites are occupied by dense stands of cattails, usually occurring on opposite streambanks. The sites are generally aquic, but some sites may have streambanks along actively eroding terraces, hence, the occasional presence of upland species. In other cases, facultative species may extend into the eroded floodplain where desert willow (*Chilopsis linearis*) or saltcedar (*Tamarix ramosissima*) are present in mesic sites.

Figure 6.13—UVR representative *Populus fremontii/Salix laevigata* (POFR/SALA3) community. (Photo by Alvin L. Medina.)

Table 6.11—Dominant woody taxa found on the *Populus fremontii/Salix laevigata* (POFR/SALA3) community.

Taxa	Total frequency	Mature mean density	Young mean density
	%	*Number ha^{-1}*	*Number ha^{-1}*
AMFR	67		15
BASA4	100		720
CELA	33		28
CELAR	33		17
CHLI2	33		56
COLY2	33		6
FOPU2	33		46
FOSP	33		6
FRVE2	67		3
JUMA	33	4	4
JUOS	33	3	3
LYPA	67		24
POFR2	33	5	4
POHI8	67		3
SABO	33		96
SAEX	67		687
SAGO	100		3
SALA3	100	7	36
TACH2	67		72
TARA	33		35

Saltcedar is largely limited to occasional young stands adjacent to the water's edge and in association with coyote willow.

*Velvet Ash (*Fraxinus velutina*) Series*

***Fraxinus velutina* (FRVE) Community (N = 4)**—The FRVE community is common and characterized by the dominance of velvet ash (fig. 6.14, table 6.12). The community is very diverse with at least 36 woody species (table 6.4). Obligate species, e.g., Fremont cottonwood (*Populus fremontii*), are uncommon. The community is mostly mesic and typified by streamside conditions that include actively eroding terraces and floodplain, recent levee formations, and very old alluvial terraces with many boulders adjoining the water's edge. Total woody plant density is relatively moderate. Many species are represented in the young size classes, but their density is relatively low. Many obligate species, e.g., Gooding's willow, fail to establish because of erosion from floods. This community has elements that resemble other communities, e.g., SAGO/SASA4, FRVE/JUOS, but the presence

Table 6.12—Dominant woody taxa found on the *Fraxinus velutina* (FRVE) community.

Taxa	Total frequency	Mature mean density	Young mean density
	%	*Number ha^{-1}*	*Number ha^{-1}*
AMFR	75		41
BASA4	100		133
BEFR	50		19
BRCA3	50		104
CELAR	100	3	27
CEPA	25	3	3
CHLI2	50	4	110
ELAN	25	4	8
EPVI	25		63
ERWR	25		8
FAPA	25		10
FOPU2	75		15
FRVE2	100	8	19
GAWR3	25		5
GUSA	50		14
JUMA	100		7
JUMO	25		3
JUOS	50	3	6
MAHA4	50		3
POFR2	100	3	8
POHI8	25		4
PRVE	25		5
QUEM	25	8	9
QUTU2	50	10	58
RHCA	25		14
RHTR	50		8
SABO	50		33
SAEX	75		36
SAGO	100		9
SALA3	50		10
SASA4	50		66
TACH2	100	8	34
TARA	100	4	100
VIAR2	25		10
ZIOB	25		3

Figure 6.14—UVR representative *Fraxinus velutina* (FRVE) community. (Photo by Alvin L. Medina.)

of some species such as Emory oak (*Quercus emoryii*) or turbinella oak (*Q. turbinella*) is distinctive in some cases. In other cases, Arizona walnut (*Juglans major*) or netleaf hackberry (*Celtis laevigata)* are distinctive indicators.

Fraxinus velutina/Juniperus osteosperma **(FRVE/JUOS) Community (N = 5)—**The FRVE/JUOS community is characterized by the dominance of velvet ash and Utah juniper as dominant overstory species (fig. 6.15, table 6.13). The community is different from the FRVE community in that oak species are absent. Gooding's willow (*Salix goodingii*) is locally important on some sites but does not impart overall relative importance. Occasional mature Fremont cottonwood trees (*Populus fremontii*) are found in association with coyote willow (*Salix exigua*) or cattails (*Typha* spp.) on aquic sites. This community is mesic with more than 33

Figure 6.15—UVR representative *Fraxinus velutina/Juniperus osteosperma* (FRVE/JUOS) community. (Photo by Alvin L. Medina.)

Table 6.13—Dominant woody taxa found on the *Fraxinus velutina/Juniperus osteosperma* (FRVE/JUOS) community.

Taxa	Total frequency	Mature mean density	Young mean density
	%	*Number ha^{-1}*	*Number ha^{-1}*
ACGR	80	3	9
ALWR	20		5
AMFR	40		9
ARLU	20		8
ATCA2	40		60
BAPT	20		3
BASA2	20		69
BASA4	100		119
BEFR	40		28
CELAR	40	3	9
FOPU2	100		97
FRVE2	40	5	16
GAWR3	20		20
GUSA	40		8
JUMO	20	3	0
JUOS	20	9	12
LYPA	60		30
MAHA4	20		4
NOMI	20		10
PAQU2	100		51
POFR2	80	8	29
PRVE	20	11	29
RIAU	20		150
RICE	20		100
RONE	20		24
SABO	40		5
SAEX	100		55
SAGO	100	8	34
SALA3	20	6	31
TACH2	60		5
TARA	100		7
ZIOB	100		28

woody species and 23 facultative or upland types, and it ranks second in species richness (table 6.4). In addition, the presence of many upland and facultative species is indicative of a highly disturbed community. Streamside habitats are mostly along eroded terraces, with sloughed or sloughing streambanks. Obligate woody species occur on opposite banks. Some sites are typified by the presence of multiple levees where saltcedar (*Tamarix ramosissima*) or other facultative species establish. This community type is different from the FRVE/JUOS/CELAR type because of the presence of Wright's beebrush (*Aloysia wrightii*), white sagebrush (*Artemisia ludoviciana*), fourwing saltbush (*Atriplex canescens*), yerba de pasmo (*Baccharis pteronioides*), one-seeded juniper (*Juniperus monosperma*), sacahuista (*Nolina microcarpa*), Virginia creeper (*Parthenocissus quinquefolia*), golden currant (*Ribes aureum*), and wax currant (*Ribes cereum*).

Fraxinus velutina/Juniperus osteosperma/Celtis laevigata **(FRVE/JUOS/CELAR) Community (N = 10)**—This community is characterized by the dominance of velvet ash in the overstory of aquic sites (fig. 6.16, table 6.14). Utah juniper and netleaf hackberry are co-dominants on mesic sites. The community is diverse (table 6.4), being represented by 31 woody species. Obligate species are present at low densities, but are infrequent in the community and lack constancy. Most obligate species occur as young stems. This community is different from the FRVE/JUOS community because of the presence of eight distinct species—boxelder (*Acer negundo*), Emory's baccharis (*Baccharis emoryi*), desert willow

Figure 6.16—UVR representative *Fraxinus velutina/Juniperus osteosperma/Celtis laevigata* (FRVE/JUOS/CELAR) community. (Photo by Alvin L. Medina.)

Table 6.14—Dominant woody taxa found on the *Fraxinus velutina-Juniperus osteosperma/Celtis laevigata* (FRVE/JUOS/CELAR) community.

Taxa	Total frequency	Mature mean density	Young mean density
	%	*Number ha^{-1}*	*Number ha^{-1}*
ACGR	20		8
ACNE2	10		3
AMFR	20		10
BAEM	20		5
BASA2	10		3
BASA4	100		60
BEFR	20		57
CELAR	40	15	72
CHLI2	30		29
COLY2	10		5
FOPU2	30		57
FRVE2	90	9	36
GAWR3	20		40
JUOS	30	6	11
LYPA	20		6
MAHA4	10		5
POFR2	30		3
PRVE	40		12
RHTR	10		3
RONE	10		25
SABO	40	3	4
SAEX	20		125
SAGO	90	4	44
SALA3	20		17
SASA4	10		4
TACH2	20		44
TARA	70	8	35
ULPU	10		10
ZIOB	20		18

(*Chilopsis linearis*), skunkbush (*Rhus trilobata)*, soapberry (*Sapindus saponaria*), southern cattail (*Typha domingensis*), Siberian elm (*Ulmus pumila*), and saltcedar (*Tamarix ramosissima*) (present in large tree form).

***Alnus oblongifolia/Fraxinus velutina* (ALOB/FRVE2) Community (N = 1)—** This community is uniquely characterized by the dominance of Arizona alder in the overstory and velvet ash in the mid-story (fig. 6.17, table 6.15). It is comparatively poor in species richness (table 6.4). The community is relatively mesic, as exhibited by the prevalence of facultative and upland woody species. Obligate species are limited to narrow bands around the water's edge. Despite an abundance of young Gooding's willow (*Salix goodingii*), streambank scour limits seedling establishment and development into saplings. Arizona alder, although present in other communities, occurs with limited density of young stems. Alder is largely limited in distribution to sections at or immediately below Sycamore Creek. This community occurs at an elevation of 1,070 m (3,512 ft) but is common at higher elevations up on the creek. Alder and other obligate species fail to establish mature stands because of flooding scour of streambanks and also likely it is at the lower limits of its range. This community is similar to the alder type described by Szaro (1989, 1990).

Figure 6.17—UVR representative *Alnus oblongifolia/Fraxinus velutina* (ALOB/FRVE2) community. (Photo by Alvin L. Medina.)

Table 6.15—Dominant woody taxa found on the *Alnus oblongifolia/Fraxinus velutina* (ALOB/FRVE2) community.

Taxa	Total frequency	Mature mean density	Young mean density
	%	*Number ha^{-1}*	*Number ha^{-1}*
ALOB2	100	3	18
BASA4	100		50
BEFR	100		30
CELAR	100		55
FRVE2	100	3	49
JUOS	100		9
PAQU2	100		8
PLWR2	100	3	3
POFR2	100		5
PRVE	100		36
RHCA	100		67
SABO	100		3
SAGO	100		131
VIAR2	100		5

Species Richness, Nonnative Species, and Obligate Species

Species richness in the woody vegetation communities was greatest in FVRE (37) and lowest in SAGO/FRVE2 and the SAGO/SALA3 communities (6) (table 6.4). Nonnative species ranged from 0 to 4 across the range of communities with SAGO/SALA3/POFR2 containing the most nonnative species. Obligate woody species ranged from 1 to 3 across the communities.

Tree and Shrub Density

Mean tree and shrub density was highly variable (tables 6.16 and 6.17) across species. Seepwillow and Gooding's willow exhibited the highest relative frequency, constancy, and density of all shrubs and trees, respectively. Other tree species of importance were Arizona walnut (*Juglans major*), saltcedar (*Tamarix ramosissima*), velvet ash (*Fraxinus velutina*), and boxelder (*Acer negundo*). Important shrub species were all facultative and included New Mexican locust (*Robinia neomexicana*), catclaw acacia (*Acacia greggii*), desert false indigo (*Amorpha fruticosa*), and coyote willow (*Salix exigua*). Facultative species of both trees and shrubs were generally more dominant than obligate. This may be a result of the young age of stands with obligate species.

Table 6.16—Descriptive statistics for major tree species of the UVR, 1997 to 2007. Species order is ranked from largest to smallest sum of percent relative frequency, constancy, and density. Relative frequency refers to the occurrence of the species within relevés. Relative constancy refers to the occurrence of the species across all relevés.

Taxa code	Relative frequency	Relative constancy	Relative density	Mean stem density	Stem density range
	%	*%*	*%*	*Number ha^{-1} and (SD)*	*Number ha^{-1}*
SAGO	8.6	1.6	12.6	178 (313.1)	25-5000
JUMA	4.1	2.0	2.7	41 (27.8)	25-125
TARA	3.7	1.5	3.0	226 (379)	25-5000
FRVE2	3.9	3.4	0.8	111 (340.3)	25-6250
ACNE2	3.8	2.2	1.9	93 (135.1)	25-625
ULPU	2.7	1.5	1.5	45 (51)	25-175
PLWR2	2.2	1.0	1.5	58 (42.8)	25-175
SASA4	2.1	1.3	1.0	77 (80.7)	25-300
ELAN	1.7	1.1	0.7	54 (71.4)	25-200
JUMO	1.7	1.1	0.7	25 (0.0)	1-25
ZIOB	1.6	0.9	0.9	95 (144)	25-625
ALOB2	1.6	0.9	0.7	75 (86.6)	25-175
JUOS	0.7	0.0	2.5	49 (55.9)	25-500
PRVE	1.2	0.3	1.6	133 (182.3)	25-1000
POFR2	1.2	1.8	0.0	154 (405.5)	13-6250
CHLI2	1.3	1.1	0.3	257 (481.8)	25-3250
SALA3	0.4	0.0	1.3	181 (277.1)	25-2500
CELAR	0.7	0.2	0.8	140 (191.9)	25-1375
SABO	0.0	0.0	0.3	147 (229.1)	25-1800

Table 6.17—Descriptive statistics for major shrub species of the UVR, 1997 to 2007. Species order is ranked from largest to smallest sum of percent relative frequency, constancy, and density. Relative frequency refers to the occurrence of the species within relevés. Relative constancy refers to the occurrence of the species across all relevés.

Taxa code	Relative frequency	Relative constancy	Relative density	Mean stem density	Stem density range
	%	*%*	*%*	*Number ha^{-1} and (SD)*	*Number ha^{-1}*
BASA4	10.5	1.5	9.9	541 (1179.5)	25-25250
RONE	2.0	0.2	2.0	119 (96)	25-375
ACGR	1.3	0.0	2.5	112 (149.5)	25-1000
AMFR	0.3	1.1	2.4	206 (254.7)	25-1250
NOMI	1.6	0.3	1.4	59 (22.9)	25-75
MAHA4	1.4	0.2	1.3	42 (17.7)	25-75
SAEX	1.2	0.0	1.7	802 (1447.1)	25-10000
PAQU2	1.1	0.2	1.0	113 (92.2)	25-325
RHCA	1.0	0.2	0.9	417 (612.8)	25-2000
BASA2	0.9	0.3	0.6	489 (514.1)	25-1500
ALWR	0.8	0.2	0.6	163 (165.2)	50-400
FAPA	0.2	0.3	1.1	50 (35.4)	25-100
FOPU2	0.8	0.1	0.7	339 (728.5)	25-6250
GAWR3	0.7	0.1	0.7	135 (127.3)	25-500
SALA6	0.7	0.1	0.7	175 (141.4)	25-400
BRCA3	0.6	0.1	0.7	350 (363)	25-1000
QUTU2	0.7	0.1	0.6	114 (80.2)	25-250
RHTR	0.6	0.1	0.7	95 (95.9)	25-250
RIAU	0.7	0.3	0.4	888 (1548.8)	75-6250
BEFR	0.1	0.4	0.8	228 (251.8)	25-1125
VIAR2	0.6	0.0	0.7	41 (23.1)	25-75
ATCA2	0.5	0.0	0.6	251 (369.7)	25-1500
FOSP	0.1	0.2	0.7	83 (40.9)	25-125
LYPA	0.3	0.0	0.7	109 (69.8)	25-250

Discussion

The classification and description plant associations does not imply that communities types are discrete units. By virtue of the relative association of species within relevés, and their physical attributes, the proposed community types are reasonably predictable communities of the UVR as of current time. The riparian habitats are undergoing considerable change (see Chapter 2) and are apt to change relative to invasive species, erosional processes, and land uses. As such, species belonging to one community can be members of other communities (Begon and others 2006). However, abstract classification of plant communities remains useful for understanding the inherent variability and environmental complexity of plant-water relationships. In addition, some form of "discrete" units remains essential for land use planning and day-to-day decisions on land uses. In other cases, plant community attributes are used in monitoring and assessment of habitats.

The plant associations described for the UVR contain species that are common to other streams of the Sub-Mogollon region of the Southwest. Boles and Dick-Peddie (1983), Medina (1986), Skartvedt (2000), and Danzer and others (2001) all noted common obligate and facultative species, such as Fremont cottonwood, Gooding's willow, and various other species of willows. However, one difference is the relatively high frequency and abundance of upland woody species found in close association with obligate species on the Verde River. The presence of many facultative and upland species is attributed to the general absence of obligate

Figure 6.18—This large Fremont cottonwood is a rare find on the UVR. They are normally found on point bars, high on a terrace, within a wide valley, and protected from flood flows. Their girths approximate 1.5 to 2 m (5 to 6.5 ft) DBH. (Photo by Alvin L. Medina.)

species until recent time (circa 1980). Large cottonwood stands or willow thickets were absent until post-1993. Essentially, nearly all woody obligate (e.g., cottonwood) and facultative (boxelder) species established within the floodplain can be dated to 1993. Mature stands of velvet ash, Arizona walnut, and netleaf hackberry are common along the historical high water mark (3-8 m [9.8-26.3 ft] above present water levels) in and amongst talus boulders. Brock (1987) characterized the riparian vegetation as a shrub community dominated by seepwillow with interspersed species of velvet ash, Arizona walnut, Gooding's willow, Utah juniper, velvet mesquite, and desert willow. Oral accounts from the Perkins family, original settlers on the UVR, state that some cottonwoods were present in the Perkinsville area circa 1890 (Whiffen and Kayser 1966). However, photographs from 1920s show a limited number of mature trees (see Chapter 2). Large mature cottonwood trees such as those shown in fig. 6.18, are very rare, likely constituting less than 0.01% of all trees counted and observed along the UVR. In addition, historical land surveys (Fuller 2003) and channel change studies and aerial photography (Medina and others 1997) reveal that the general form of the flood channels has not changed substantially since at least since 1937, and probably not since the floods of the early 1900s.

Webb and others (1991, 2007) demonstrated that many Southwestern riparian habitats, including the Verde River, were historically devoid of typical gallery forests. They attributed floods as a principal agent in limiting the expansion of woody vegetation in Southwest rivers (Turner 1974; Turner and Karpiscak 1980; Webb and Baker 1987; Turner and others 2003). Evidence from climate and hydrologic reconstruction studies are strongly linked with photographic evidence to conclude that woody vegetation is a recent (Twentieth Century) phenomenon of Southwest riparian ecosystems. Similarly, vegetation data from this study and photographic data (see Chapter 2) do not support the popular belief that gallery forests were prevalent in the Twentieth Century on the UVR. Cottonwoods and similar woody species were likely present in open valleys but in very limited numbers and widely scattered stands. Arizona ash was more likely the dominant tree, as mature trees remain in greater abundance on terraces.

Some communities have similar attributes to others of the region. Medina (1986) found similar soapberry stands in southwestern New Mexico but with much higher stand density (338 trees ha^{-1} or 137 trees ac^{-1}) and prevalence. In this study, soapberry was limited to one stand. It is unlikely that soapberry was prevalent on the Upper and Middle Verde River, as its habitat is generally lacking and absent from plant surveys (Brock 1987; Whittlesey and others 1997; Schmidt and others 2005; Shaw 2006). The species is a Madro-tertiary (tropical) remnant with a preference for relatively moist sites and calcareous-clayey soils (Read 1974). Its occurrence on terraces is likely an artifact of recent hydrologic disturbances, as soapberry is commonly associated with various upland species (Hastings and Turner 1965; Szaro 1989) common to the UVR.

In general, several communities are similar to those described by Szaro (1989) regarding dominant woody species. Exceptions are noted for instances where upland species, e.g., Utah juniper (*Juniperus osterosperma*), are co-dominant in the mid- and understory. Szaro (1989, 1990) emphasized tree dominance, whereas this study considered all woody species in a structural context. Hence, small statured plants can be co-dominants as mid-story components. A major difference between this study and Szaro (1989, 1990) is red willow (*Salix laevigata*). Red willow is abundant on the UVR, whereas *S. irrorata* and *S. bondplandiana* are noted important species in Szaro (1989). It is possible that Szaro (1989, 1990) treated red willow as a *S. bonplandiana* synonym.

Many upland species, e.g., Apache plume (*Fallugia paradoxa*) and bricklebush (*Brickelia* spp.), were found in association with typical riparian obligate species. This is likely due to the recent expansion of obligate species upon former mesic habitats as a net result of flood disturbances and concomitant channel changes, e.g., incision and paleoterrace erosion. Browning (1989) described arroyo habitats in southern New Mexico where Apache plume (*Fallugia paradoxa*), bricklebush (*Brickelia* spp.), and sumacs (*Rhus* spp.) were dominant components. Hence, the common presence of upland species in mixtures with obligate riparian species suggests that a mesic environment likely predominated prior to the recent expansion of gallery species post-1993.

Management Implications

This analysis presents a current view of the dynamic woody flora of the UVR. It provides a reference for future Prescott National Forest management actions relative to exotic species invasions, floods, grazing, fire, or other disturbances. This effort provides the Prescott National Forest with a basis for conducting future surveys to determine status and trends of UVR woody flora. It also provides a basis for future research studies on the woody plants found in the riparian zone of the UVR. Management decisions regarding current and future use of the Prescott National Forest uplands can be made relative to the woody flora of the river, but the present data cannot be used for cause-and-effect determinations of the impacts of land uses. The UVR riparian ecosystem is dynamic, and natural processes of flood and drought can easily override human interventions. The largest human-related impact on the UVR plant communities could come from de-watering the river for human water consumption. Of special significance is use of the vegetation databases and analyses for management of TES species, e.g., native fishes, which has a long and contentious history in the UVR region (see Chapter 2). For decades, the fishery management model for UVR has been one that emulates the "trout model"—deep and cold water habitats with abundant overstory—versus the "warmwater model" with shallow, open canopy and chaotic flood disturbances (see Chapter 2).

The abundance of woody plants in the UVR is a recent occurrence and has initiated hydrological processes that lead to channel degradation (Richter and others 1996). These processes further complicate understanding the relationships between TES species and riparian vegetation. Certain aquatic habitats have changed considerably from shallow (riffles) and clear water to deep pools and glides and turbid gray-green water (see Chapters 2 and 8). These processes in combination with sediment and bedload deprivation from Sullivan Dam have induced long-term, irreversible changes to the UVR ecosystem.

With an eye to future management of woody plants and their debris in the UVR, a precautionary note is offered with respect to producing hyperabundance of woody material. Figure 6.19 shows downfall of large amounts of Fremont and Hinckley cottonwoods, a Gooding's willow, and coyote willow, following a moderate flood in spring 2005. The trees were not completely uprooted, and they continued to grow both laterally and vertically. Thousands of new sprouts emerged amongst the debris, further entangling the woody debris. Riparian soils were very shallow (<40 cm or 16 in) and woody plants had difficulty anchoring through the bedrock and armored bed. This site is in the narrowest canyon region below Perkinsville and

Figure 6.19—Heavy cottonwood downfall along the channel below Perkinsville following a 2005 spring flood in a canyon reach of the UVR. The trees are dated to 1993, when most riparian woody plants were established. The coyote willows in this reach were planted by the Y-D Ranch after the flood. (Photo by Alvin L. Medina.)

above the Camp Verde Valley. Should this debris amass during a larger flood, it could cause a debris jam that could send torrent flows downstream to Camp Verde. Dense tree growth of this magnitude was not witnessed along the UVR channel in the past century.

Finally, the removal of saltcedar, Siberian elm, and Russian olive in the upper 20 km (12.5 mi) of the headwaters (from 2008 to 2010) is apt to change the composition of woody communities. Niche voids will likely be colonized with a myriad other woody and herbaceous species. It is expected that additional channel erosion and levee building will occur as floods seek freeboard about the floodplain. The processes are certain to further change the terrestrial and aquatic habitats, and possibly limiting their availability for TES species. Herein lies an opportunity to manage aquatic habitats by managing riparian vegetation through silviculture or grazing.

Summary and Conclusions

This chapter contains a quantitative description of the woody vegetation of the UVR based on 56 permanently monumented sampling sites. At present, the UVR contains a large diversity of woody species (62) and plant associations. The plant associations found in the UVR contain species that are common to other streams of the Sub-Mogollon region of the Southwest. However, one notable difference is the relatively high frequency and abundance of upland woody species found in close association with obligate species on the Verde River. The presence of many facultative and upland species is attributable to the lack of conditions suitable for obligate species until recent time (circa 1980). Large cottonwood stands or willow thickets were absent until post-1993. Essentially, nearly all woody obligate (e.g., cottonwood) and facultative (e.g., boxelder) species established within the floodplain can be dated to 1993. Mature stands of velvet ash, Arizona walnut, and netleaf hackberry are common along the historical high water mark, in and amongst talus boulders. Brock (1987) characterized the riparian vegetation as a shrub community dominated by seepwillow, with interspersed species of velvet ash, Arizona walnut, Gooding's willow, Utah juniper, velvet mesquite, and desert willow. Species richness varies from low to very high and coincidentally with streambank disturbance. Generally, the greater the disturbance from erosional forces, either induced or natural, the higher the richness.

Webb and others (1991, 2007) demonstrated that, historically, many Southwest riparian habitats, including the Verde River, were largely devoid of typical gallery forests. The authors attributed floods as a principal agent in limiting the expansion of woody vegetation in Southwest rivers (Turner 1974; Turner and Karpiscak 1980; Webb and Baker 1987; Turner and others 2003). The same disturbances caused by major floods also created niches where riparian vegetation such as cottonwoods and willows establish. Evidence from climate and hydrologic reconstruction studies are strongly linked with photographic evidence to conclude that woody vegetation is a recent (Twentieth Century) phenomenon in the UVR. Similarly, vegetation data from this study coupled with photographic data and detailed observations of riparian soils and terraces (see Chapter 2) do not support the popular belief that gallery forests were prevalent in the Twentieth Century on the UVR. Cottonwoods and similar woody species were present in open valleys like Perkinsville but in very limited numbers. Arizona ash was more likely the dominant tree, as mature trees remain in greater abundance on terraces.