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Chapter 2

Historical and Pictorial Perspective of the Upper Verde River

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Introduction

The UVR corridor is a diverse riverine ecosystem in central Arizona (see Chapter 1). Since European settlement, it has witnessed many events such as droughts, floods, construction of Sullivan Dam, groundwater withdrawals, cattle grazing, mining, nonnative fish introductions, native fish extinctions, and urbanization that are not fully understood. Geologically, the UVR displays a wide array of formations of spectacular color and variety; the landscapes vary from open valleys to narrow and deep canyons. Several publications have described the Verde River (Wirt and Hjalmarson 2000; Blasch and others 2006), yet few provide pictorial descriptions of historical and existing conditions. Oral accounts offer different glimpses of purported historic conditions (Byrkit 1978). For the most part, descriptions of the Verde River are largely limited to the Middle Verde River and the Lower Verde River. The UVR is distinct from the former sections due to the smaller character of the landscapes, yet it is unique in many attributes.

In this chapter, repeat photography is used to display the vivid texture of the river vegetation, channel, and valley landscapes and to contrast the historic with current conditions. These contrasts are interpreted within the context of plant ecology and hydrogeomorphology to provide a comprehensive understanding of the changes that have occurred in the past century. In some cases, additional photographs provide a larger perspective of the area and its habitats. A principal objective is to provide a broad understanding of historic influences that is necessary to comprehend the physical and biological processes that govern present-day conditions on the UVR. Climate and land uses undoubtedly have affected the flow and sediment regimes, which, in turn, have influenced such factors as riparian vegetation and aquatic life. Paleo-reconstruction studies of historic environmental conditions are utilized to put forward alternative descriptions of the Verde River for the period of record (1890 to present). These paleoecological data are useful for discriminating between natural and cultural influences on observed environmental changes (Swetnam and others 1999). The most significant period regarding vegetation and hydrologic changes may be the last 400 to 500 years (the time of European influence in the area). The introduction of livestock circa 1890 is an important event that is often cited as crucially influential on present-day conditions. However, many past descriptions of the UVR that have been extrapolated from general sources do not recognize climatic conditions during this period. These changes in climate may have misunderstood and long-lasting consequences on the future evolution of riparian and aquatic habitats.

Credits

Several people and organizations contributed photographs to this effort. Mr. James Cowlin (Cowlin 2008) is a freelance photographer who captured many views of the UVR in 1979. Some photographs are courtesy of and used with permission from Sharlot Hall Museum, Prescott, Arizona. Many photographs are courtesy of Mr. Thomas Perkins, a descendant of the original settlers on the UVR. Mr. Perkins shared photographs that are now archived at Sharlot Hall Museum. Dr. and Mrs. George and Sharon Yard of the Y-D Ranch in Perkinsville provided photographs of their private lands and the Horseshoe Allotment. Mr. and Mrs. David and JoAnn Gipe of the Verde River Ranch provided historical photos of ranching activities. Some photographs of the 1920s were taken by Mr. Matt Cully while working for Southwestern Forest and Range Experiment Station on the Santa Rita Experimental Range in southern Arizona. A special thanks is extended to Mr. James Steed who assisted in the collection and archival of repeat photographs. Photographs are also provided from the author's private collections.

Methods

Layout

A spatial sequence is used to reference locations of historic photos, starting at the headwaters on the west of the UVR and proceeding easterly downstream. Photographs were selected that depict significant changes in the vegetation and channel conditions for the period of record. Repeat photographs were utilized to provide a temporal aspect and spatial contrast through the riverine corridor, as well as extended areas above the headwaters. Relative changes that are observed in the photographs are described and discussed in order to provide differing perspectives of riparian conditions using background studies of the hydrology and vegetation of the UVR.

The Verde River and its watershed have been studied extensively since the early Twentieth Century. More than 2000 science and popular articles have been written on diverse aspects of the river, including many on historical, ecological, and socio-economic issues. It was impractical to review all of the collective works, so only those with original context relevant to the objectives of this Report were selected. Considerable works on watershed management of all of the principal vegetation types of the Southwest, compiled by Dr. Malchus B. Baker, Jr. are available online (<http://ag.arizona.edu/OALS/watershed/>). In addition, selected scientific works on the UVR are available at the RMRS, Flagstaff, Arizona web site: <http://www.rmrs.nau.edu/lab/4302/4302VerdeRiverBibliography.htm>.

Terminology

The following definitions are provided to assist the reader. The UVR study area is defined as the section of river starting at the Prescott National Forest boundary to the east near Tapco, Arizona, to the headwaters at Sullivan Dam to the west (fig. 1.1). This designation is consistent with the Arizona Department of Water Resources watershed area, which drains to the Clarkdale USDI Geological Survey gauge (#0904000). The Middle Verde River study area is defined as the section of river starting at the Prescott National Forest boundary to the west near Tapco,

inclusive of the Verde Valley, to the eastern boundary of the Prescott National Forest. This Report deals only with the UVR, but references to or examples from the Middle Verde River (Camp Verde area) are utilized. The Lower Verde River extends from the Middle Verde River section south to the river's confluence with the Salt River.

The Verde River was historically referred to as "El Rio de Los Reyes" by Antonio de Espejo in 1583, "Sacramento River" and "El Rio Azul" in Seventeenth and Eighteenth Century Spanish maps, and "San Francisco River" and "Granite Creek" by Nineteenth Century Anglo-American pioneers (Byrkit 2001). In this chapter, the term "historical" refers to time of recorded history since Antonio de Espejo's travel in the Southwest. The word "paleo" refers to time before recorded history. The Pecos Classification refers to a period sequence used to describe paleo and historic settlements of Southwestern Native Americans (Morrow and Price 1997). The classification is as follows:

Paleo-Indian (unknown dates to 8500 before present [B.P.]

Basketmaker I (6700 B.P. to A.D. 1) (Archaic)

Basketmaker II (A.D. 1 to 500)

Basketmaker III (A.D. 500 to 700)

Pueblo I (A.D. 700 to 900)

Pueblo II (A.D. 900 to 1100)

Pueblo III (A.D. 1100 to 1300)

Pueblo IV (A.D. 1300 to 1600)

Pueblo V (A.D. 1600 to 2000)

Common geomorphic and hydrologic terms used in this Report can be found in the Glossary (Appendix 1). "Floodplain" refers to "the area along the river that has been subject to erosion and deposition by the Verde River in the past few thousand years" (Pearthree 1996). This geomorphic feature and the river itself are the foci of this report, but the surrounding landscape is considered in this and other chapters.

Study Area

The Verde River is centrally located within Arizona, flowing about 350 km (220 mi) southward to its confluence with the Salt River (fig. 1.1). The watershed area, elevations, and other features are discussed in Chapter 1. Landownership is mostly public lands, with private ownerships centered about the river and transportation corridors (fig. 1.5).

Major vegetation types of the Verde Valley range from mixed conifer on peaks of the Mogollon Rim to Sonoran Desert Scrub at the confluence with the Salt River. (see Chapter 1). Original riparian woody vegetation was largely coincident with valley form, with large cottonwoods scattered in the wide open valleys, and Arizona ash on terrace slopes of canyon bound reaches. Since 1993, an expansion of many obligate species has occurred owing to such factors as floods, land use changes, and general climate changes. Invasive plants such as saltcedar have been a developing component since about the 1950s (see Chapter 6).

Several scientists have recently provided characterizations of the geohydrology of the UVR (Wirt and Hjalmarsen 2000; Blasch and others 2006), owing to public demand for estimates of the water resources and locations. Perennial flow in the UVR watershed is limited from the confluence of Granite Creek easterly. The Del

Rio Springs in the Chino Valley supplied perennial flow above the Granite Creek confluence prior to the construction of Sullivan Dam in 1938. Principal intermittent and ephemeral streams above Sullivan Dam are Big Chino Wash, Little Chino Wash, Williamson Valley Wash, Walnut Creek, Granite Creek, Pine Creek, and Partridge Creek (Blasch and others 2006). Other major tributaries that contribute significant flow and bedload from the Rim to the north include Hells Canyon, Grindstone Wash, MC Canyon, Bear Canyon, Government Canyon, Railroad Wash, and Sycamore Creek. The southern tributaries from the south are Muldoon Canyon, Bull Basin, Wildcat Draw, Munds Draw, Orchard Draw, and SOB Canyon.

Paleo-Historic Description

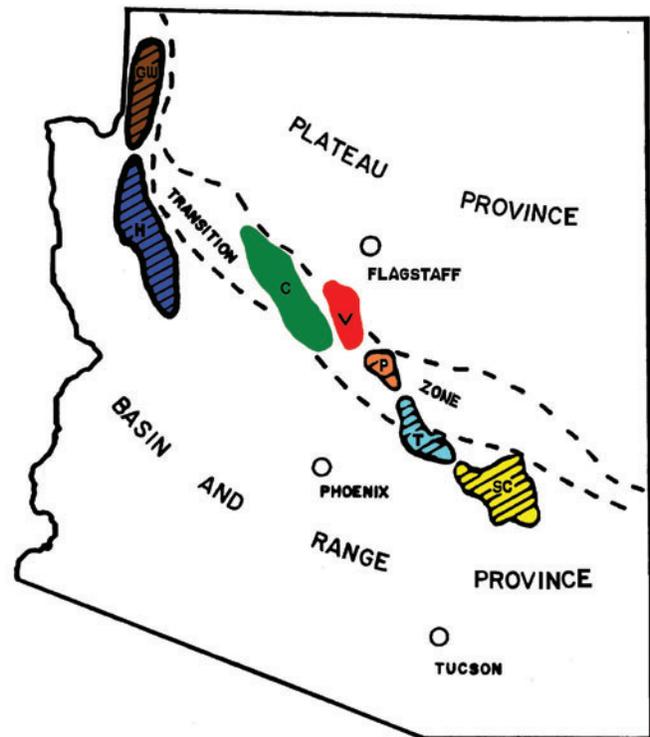
Many authors have provided insight into paleoecological conditions of local and regional riverine and upland environments of the UVR (Gladwin and Gladwin 1930; Fish 1967, 1974; Hevly 1974; Fish and Fish 1977; Hevly and others 1979; Smith and Stockton 1981; Ely and Baker 1985; Hevly 1985; Anderson 1993; Pearthree 1993, 1996; Ely and others 1993; Ely 1997; House and Hirschboeck 1997; Allen and others 1998; Swetnam and Betancourt 1998; Blasch and others 2006). This analysis mainly addresses scholarly works that pertain to the river within the context of human influences and land uses, vegetation changes, and hydrology and geomorphology, but it also includes relevant works of upland influences. There are many descriptions of the Verde River with often conflicting accounts of historic and current conditions. The purpose of this analysis is to establish an understanding of paleohistoric conditions using reconstruction studies from the Verde River and the region. The paleohistoric events, especially climate (Ni and others 2002), and human influences, of the late Nineteenth Century have had strong influences on the current and potential ecological states of the habitats of the UVR.

Geologic History

The Verde River and the Mogollon Rim are believed to have established during the Oligocene epoch of the Paleogene period, 27.4 to 37.2 million years ago (Ma) (Pierce and others 1979). During the following Miocene epoch (7.4 to 27.4 Ma), the Verde River was interrupted by tectonic and volcanic events in the Hackberry Mountain–Thirteen-Mile Rock volcanic center a few miles southeast of Fort Verde (Elston and others 1974; McKee and Elston 1980; Menges and Pearthree 1989; Nealy and Sheridan 1989; Elston and Young 1991). This resulted in a closed basin, during which Miocene volcanoclastic, clastic, and evaporite sedimentation occurred to form the Verde Formation (Nations and others 1981). Between the Miocene and Pliocene, extensive sedimentation occurred within the Verde Basin until the breaching of the volcanic-tectonic dam during the Quaternary period (<3.6 Ma), which eroded much of the Verde Formation (Nations and others 1981). The depth of the Verde Formation is unknown but is estimated near 960 m (3,150 ft) or roughly a top elevation near 2,000 m (6,560 ft) (Nations and others 1981).

The UVR is largely situated within the Chino Basin and the Verde Basin (fig. 2.1). One can surmise that the extensive sedimentation that occurred during the Miocene epoch within the Verde Basin likely reached elevations upstream to include the Chino Basin. Sullivan Dam lies within the Chino Basin at an elevation of about 1,325 m (4,350 ft). Some sediments reside as terraces or mesas (see

Figure 2.1—The Cenozoic basins of the Transition Zone between the Colorado Plateau province and the Basin and Range province. The basins are identified by color and letters: brown (GW) = Grand Wash Basin, dark blue (H) = Hualapai Basin, green (C) = Chino Basin, red (V) = Verde Basin, orange (P) = Payson Basin, light blue (T) = Tonto Basin, and yellow (SC) = San Carlos Basin (adapted from Nations and others 1981).



Chapters 3 and 4). Hence, the paleogeology of the UVR suggests that the basin sediments are different from those of the Middle or Lower reaches of the Verde River, as well as from other streams and rivers of Arizona.

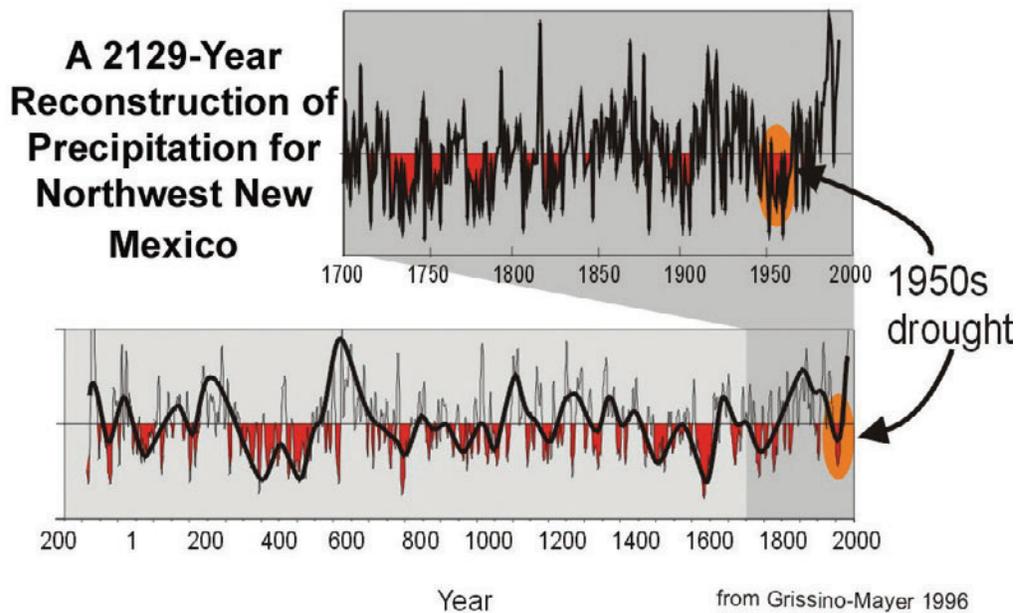
The paleogeology and local physiography have influenced the current character of the Verde River (Twenter and Metzger 1963; House and Pearthree 1993). The depositional history is important for understanding the current and changing conditions of the watershed and riparian corridor. Hydrologic processes, such as flooding and channel incision, have been occurring over several million years and are witnessed by the 90 to 150 m (300 to 500 ft) of incised tributaries and the Verde River canyon below Perkinsville. Pleistocene floodplain terraces are evident at various locations about 45 m (150 ft) above the present-day valley floor. Open valley forms account for about 75% of the landscape types, with the remaining 25% classified as confined reaches with high canyon walls and limited floodplain.

Climate, Floods, and Drought

The climate in central Arizona is undoubtedly influenced by the varied mountainous topography and the formidable Mogollon Rim. Precipitation in the region is bimodal, with intense monsoonal storms in the summer that are linked to tropical Pacific events and cooler winter storms linked to northern Pacific Ocean events (Philander 1990; see Chapters 1 and 3). The climate varied substantially during the Twentieth Century (Hereford and others 2002), but more so during the paleo period (Swetnam and Betancourt 1998).

Grissino-Mayer (1996) reconstructed more than 2,100 years of precipitation in the Southwest from tree-ring records (fig. 2.2). His climate reconstruction is well corroborated with other studies (Swetnam and Betancourt 1990, 1998) that link the three- to five-year Southern Oscillation to the regional climate (Philander 1990). Essentially, greater rainfall occurs during El Niño years, with somewhat lesser rainfall in summer, and La Niña years produce an opposite consequence. These

Figure 2.2—This graph is a reconstruction of precipitation for northwestern New Mexico. The units are of standard deviation, with red color indicating drought periods. This graph was developed by the National Oceanographic and Atmospheric Administration's Paleoclimatology Center (http://www.ncdc.noaa.gov/paleo/drought/drght_grissno.html; adapted from Grissino-Mayer 1996).



fluctuations are linked to floods (Webb and Betancourt 1992; Ely 1997), drought cycles (Grissino-Mayer 1996), fire frequencies (Swetnam and Betancourt 1990; Grissino-Mayer and Swetnam 2000; Gray and others 2003), and periods of high reproduction of woody plants (Swetnam and Betancourt 1998).

Ely and Baker (1985) performed the first paleoflood reconstruction study on the Verde River and provided an in-depth inventory of paleoflood frequencies and magnitudes. By 1997, Ely and other scientists (Smith and Stockton 1981; Ely and others 1993; O'Connor and others 1994; House and others 1995; Ely 1997) produced a 5,000-year paleoflood chronology linking the occurrence of similar floods in other regional river systems of the Southwest in a pattern similar to the Verde River.

Ely (1997) noted three types of storms that generated large floods: North Pacific winter frontal storms, late summer and fall storms, and convective summer thunderstorms. The largest historic floods have been from winter storms (Smith and Stockton 1981; Ely 1997). High-magnitude floods coincided with periods of cool, wet climate such as those witnessed in the last 200 years (fig. 2.3). Ely (1997) further noted the occurrence of 15 large-magnitude floods on the Verde River within the past 200 years. This is a frequency much greater than that reported in the historic record, and it ranks third highest of 19 Southwestern rivers. Evidence from tree-ring records (Webb 1985; Ely 1992; Grissino-Mayer 1996) corroborate that the historical period between 1905 and 1941 (early 1900s) and in the latter half of the Nineteenth Century experienced a high frequency of high-magnitude floods (Ely and others 1993; Ely 1997). Ely (1997) and Baldys (1990) noted that the largest historic flood peakflow of $4,248 \text{ m}^3 \text{ s}^{-1}$ ($150,017 \text{ ft}^3 \text{ s}^{-1}$) at the Tangle Creek Gauge (#09508500) on the Verde River that occurred February 24, 1891 (fig. 2.4). This flood was slightly larger than the January 8, 1993, flood peakflow of $4,106 \text{ m}^3 \text{ s}^{-1}$ ($145,002 \text{ ft}^3 \text{ s}^{-1}$) at the same site. This would explain the scoured and eroded conditions seen in photographs from the early 1900s on the Verde and other regional rivers (e.g., Little Colorado, Salt, Bill Williams, and Agua Fria).

Examination of reconstructed paleoflood studies (Smith and Stockton 1981; Ely and Baker 1985; Ely and others 1993; Ely 1997; Klawon 1998; House and others 2001) and paleoclimate studies (Grissino-Mayer 1996) reveals high agreement (Figures 2.2, 2.3, and 2.4). There is also high agreement between historical floods

Figure 2.3—Actual and reconstructed stream flow of the Verde River below Tangle Creek (adapted from Smith and Stockton 1981).

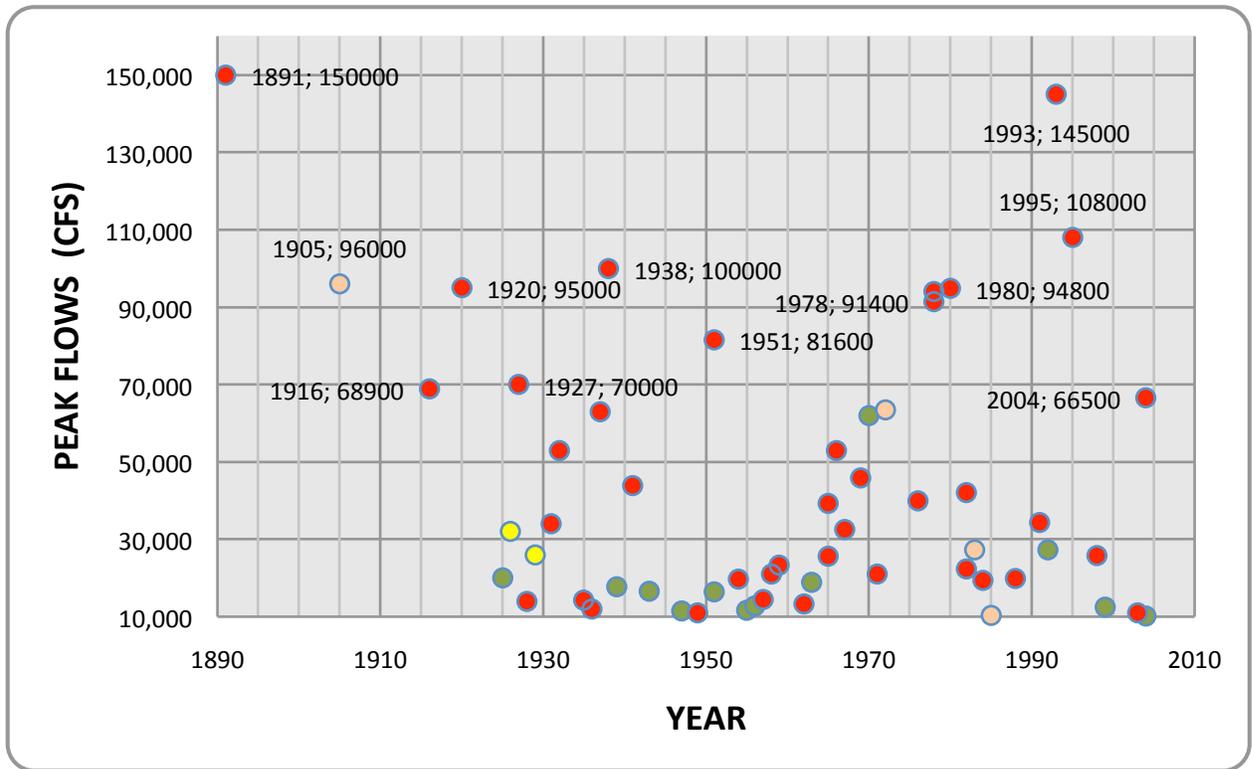
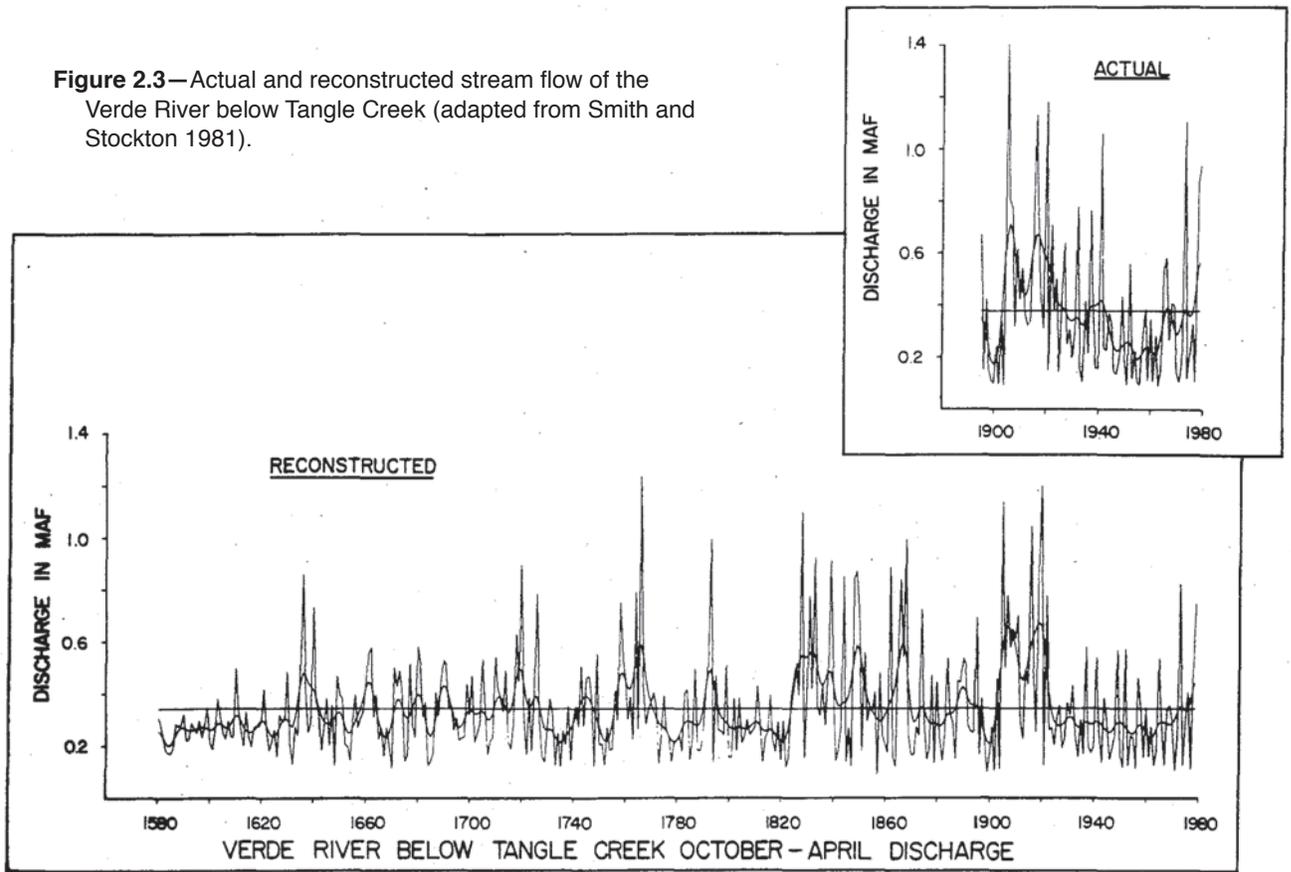


Figure 2.4—Peak flow events greater than 10,000 ft³ s⁻¹ (283 m³) at Verde River-Tangle Creek Gauge #09508500. Winter storms are depicted in red, spring in yellow, summer in green, and fall in orange. Data points between 1891 and 1932 are estimates (USDI Geological Survey 2005).

(Smith and Stockton 1981) and the regional climate (Blasch and others 2006) for the Twentieth Century. In addition, the paleoflood history of the Verde River is coincident with the other western streams of Arizona, (e.g., Bill Willams Basin; Enzel and others 1993; House and Baker 2001). This provides greater assurance that early photographs depicting highly eroded and barren conditions were likely due to floods and drought episodes.

Aside from winter floods, summer monsoon storms are an important source of moisture in the Southwest (Poore and others 2005), and they promote a unique climatic regime where summer floods are annual occurrences. Tropical-derived thunderstorms of the monsoon, as well as decaying tropical storms and hurricanes, may be intense enough to cause widespread flooding and erosion in desert rivers (House and Hirschboeck 1997). As with many Southwest rivers and streams, flow varies considerably from season to season, year to year, decade to decade, and century to century.

Robert Webb and colleagues also published studies of paleofloods on other Southwest rivers (Webb 1985; Webb and others 1988, 1991; Webb and Betancourt 1992). The paleo studies by Webb and his colleagues provided the best explanation to date about likely evolutionary conditions of Southwestern rivers and associated vegetation in the late Holocene (Webb and others 2007). More important, Webb and others (2007) provided a rationale for understanding long-term relationships among climate, hydrology, and riparian vegetation. Their extensive treatise renewed debate about the role of riparian gallery forests in Southwestern rivers.

Examination of paleodroughts (figs. 2.2 and 2.3) revealed that droughts within the Twentieth Century were relatively mild compared to droughts within the two millennia of paleoprecipitation described by Grissino-Mayer (1996). The 1950s drought, noted as the most severe within the region in modern time, was mild compared to droughts dating back to 2148 years B.P. In contrast, the duration of paleodroughts was several decades compared to one decade now, and their magnitude in terms of reduced precipitation and streamflow was two to three times that experienced in 1950 (figs. 2.2 and 2.3). The significance of the 1950s drought on the Verde River cannot be quantified in terms of biological changes, but the resulting intermittent flows in the headwater sections of the Verde River in 1954 certainly would have influenced riparian conditions (Wagner 1954). The period from the early 1960s to early 1990s is noted with significant departure from normal in winter flows and the recent wetter period from 1993 to present (see fig. 3.5). Smith and Stockton (1981) remarked that several periods of extended low flow have occurred during the past 400 years and appeared to have a recurrence interval of 22 years (fig. 2.3). The current floodplain and terrace vegetation community of the UVR is comprised of many mesic species (e.g., juniper, oaks, acacias, and other upland plants) indicative of prolonged dry periods and comparatively mild floods witnessed during this century as the plants are age-correct for the time period (see Chapter 6).

Concomitant with drought and flood studies are investigations that address the period of arroyo cutting in the Southwest. The arroyo development periods are important because many past and present-day environmental assessments have used channel erosion as a determinant of historic land degradation by humans in the Verde River watershed. Many assessments attributed overgrazing by cattle and other human activities to arroyo cutting (Antevs 1952; Cooke and Reeves 1976; Graf 1983; Bull 1997). However, recent examination of Quaternary geologic records by Waters and Haynes (2001) linked arroyo formation to the Holocene epoch of the late Quaternary (<11,700 years B.P.) and to changing post-glacial climate, vegetation, groundwater conditions, and human land use. Specifically, the authors

identified arroyo-forming episodes around 8,000 and 4,000 years B.P. Waters and Haynes (2001) further noted that arroyo formation appears to be linked to repeated wet-dry cycles, similar to other studies linked to the Southern Oscillation (El Niño-La Niña). The authors described the processes as dropping of water tables and reduced vegetation cover during dry periods (fig. 2.2), making sites susceptible to erosion. Subsequent wet periods induced flooding and initiated arroyo formation. Mann and Meltzer (2007) noted that incision occurred early in the Medieval Warm Period (1000 to 1300 A.D.) and aggradation ensued during the Little Ice Age (1350 to 1900 A.D.), followed by another incision cycle during this past century. Hereford (1993) also suggested that arroyo formation was related to periods of large floods. In the early Twentieth Century, Dellenbaugh (1912) cautioned that grazing wasn't the only probable cause of arroyo formation, but his interpretation was not widely accepted.

Today, the physical evidence identifying climate change as the principal factor inducing channel erosion is revealed in the works of several scientists (Webb and others 1991; Hereford 2002; Reheis and others 2005; Mann and Meltzer 2007; Chapin 2008) and are consistent with paleoclimate interpretations of pollen and packrat middens of the region (Reheis and others 2005). These processes have likely been operative on the Verde River Watershed and would explain historic sediment pulses from tributaries into the main channel, as well as recent erosion of terraces. In short, these sediment-channel dynamics are linked to the paleo-hydrology of the watershed, as previously discussed. Further examination of climate-sediment relationships could explain some residual effects on flora and fauna changes that have occurred on the UVR.

Vegetation

The biota of the Colorado Plateau during the middle (50,000 to 27,500 years B.P.) and late (27,500 to 14,000 years B.P.) Wisconsin time periods were very different from present day. Anderson (1993) attributes the differences to major climate changes associated with the last major glacial period. Areas once dominated by mixed conifers (late Wisconsin period 21,000 to 10,400 B.P.) are largely occupied today by ponderosa pine (*Pinus ponderosa*), a newcomer (<10,000 years B.P.). As the cold climate of the last glaciations ended, there was a shift toward warmer and wetter conditions (3550 to 2480 years B.P.), resulting in major shifts in vegetation upslope. Mixed conifer species and all lower-elevation woodlands and scrublands similarly retreated upslope to present-day elevations.

Oral accounts of UVR vegetation available from Nineteenth Century pioneers and settlers are insightful but not completely reliable. Brykit (1978, 2001) cites Spanish accounts that the Verde River was more “marsh-cienega”-like than typical stream conditions. Trees were scant and grass-like vegetation prevailed. Such references are most likely of the Middle Verde Valley where the landscape was most suitable for wetland conditions. Perkinsville, Bear Siding, Duff Springs, Bull Basin, Verde River Ranch, and a few other open valley areas upstream are sites that could have retained substantial wetlands. The presence of wetland vegetation and soil conditions at Duff Springs, Verde River Ranch, Al's Spring, and the Prescott National Forest “wetland” (fig. 2.5) have been verified by on-the-ground examinations.

Early accounts of Espejo's visit in 1583 to the mines at present-day Jerome noted the presence of “great groves of walnut trees” along the banks of the Verde River and most likely the confluence of either Sycamore Creek or Oak Creek (Farish 1915). Whipple and others (1856) quoted Antoine Leroux's description of

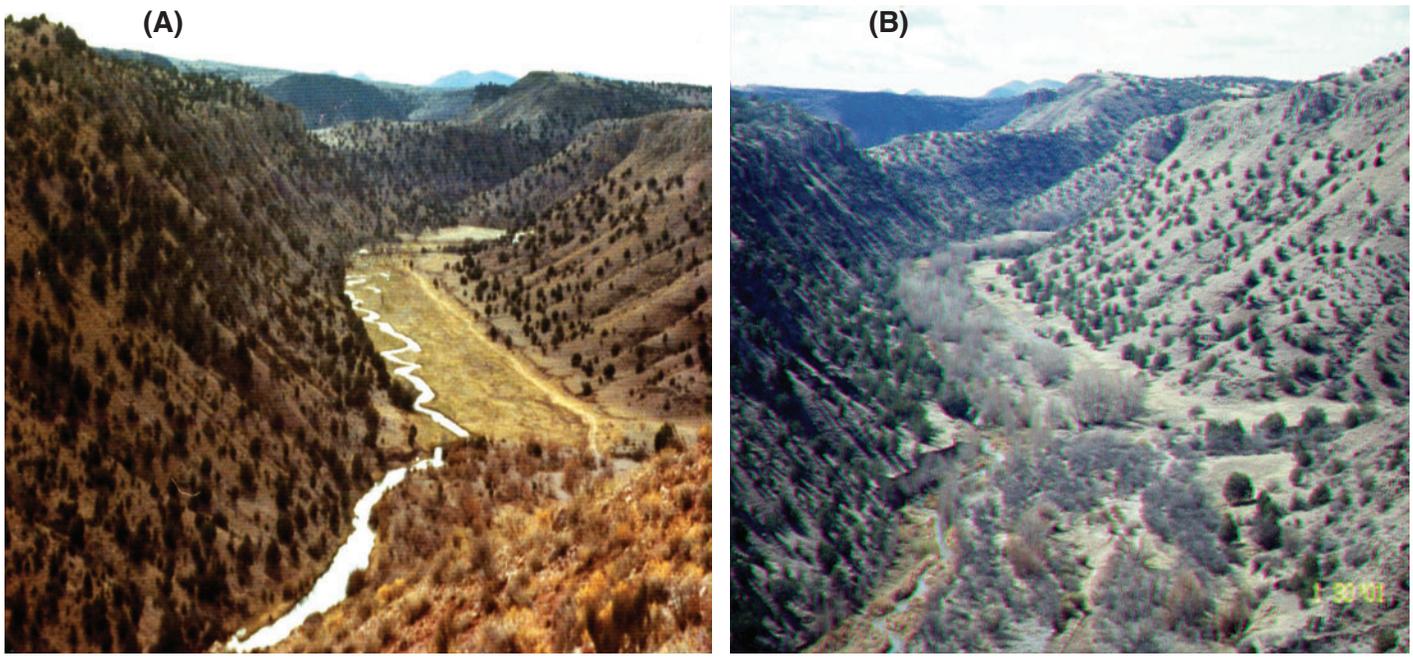


Figure 2.5—The 1979 photo (A) shows a stable wetland sedge meadow, while the 2001 photo (B) shows an invasion of woody species, e.g., tamarisk, and deeply incised channel. Woody vegetation on the floodplain is dated to 1993 flood. (Photo A by Prescott National Forest staff; Photo B by Alvin L. Medina.)

the Verde Valley accordingly: “The river banks were covered with ruins of stone houses and regular fortifications; which, he [Leroux] says, appeared to have been the work of civilized men, but had not been occupied for centuries. They were built upon the most fertile tracts of the valley, where there were signs of acequias and of cultivation.” Accounts of cottonwoods and willows occur in archeological studies (Fewkes 1896, 1898, 1912; Mindeleff 1896) and in Hinton’s (1878) travelogue. These accounts are limited to the Middle Verde and the tree stands are described as “scattered” and “confined to the immediate vicinity of the river” (Mindeleff 1896). This is surprising, considering the Verde Valley is several miles wide, and one would expect evidence of old groves around old channels. No mention of cottonwoods and other groves of riparian trees were found in historical records beyond Perkinsville. Walnut groves are likely, since they are facultative species that can occupy mesic habitats away from the river’s edge. Photographic evidence from the turn of the century in the Perkinsville valley shows an absence of cottonwoods and other obligate riparian woody plants (figs. 2.6, 2.7, and 2.8). These photos show the presence of a few and scattered large cottonwoods perched on the first terrace. Most cottonwoods evident today established along irrigation ditches on the south side of the river (fig. 2.8). The floodplain was devoid of obligate woody plants, except for a few facultative species (e.g., mesquite). These same photos illustrate the eroded channel conditions and terraces likely caused by the 1891 paleoflood noted by Ely (1992, 1997) and Ely and others (1993). It is implausible that livestock ate, or otherwise affected mature stands of cottonwoods and willows between the period 1890 to 1925, since no evidence of stands of trees was found in any historical photos for of the Perkinsville area or other locations. The small grove of cottonwoods in Perkinsville appear to be remnant survivors of floods, with an approximate age greater than 40 to 50 years based on their girth and height (fig. 2.7). Hence, the presence of extensive riparian gallery habitats or stands of cottonwoods, willows or other obligate trees is highly questionable over the last century for the UVR. This situation has been suggested for several Southwestern

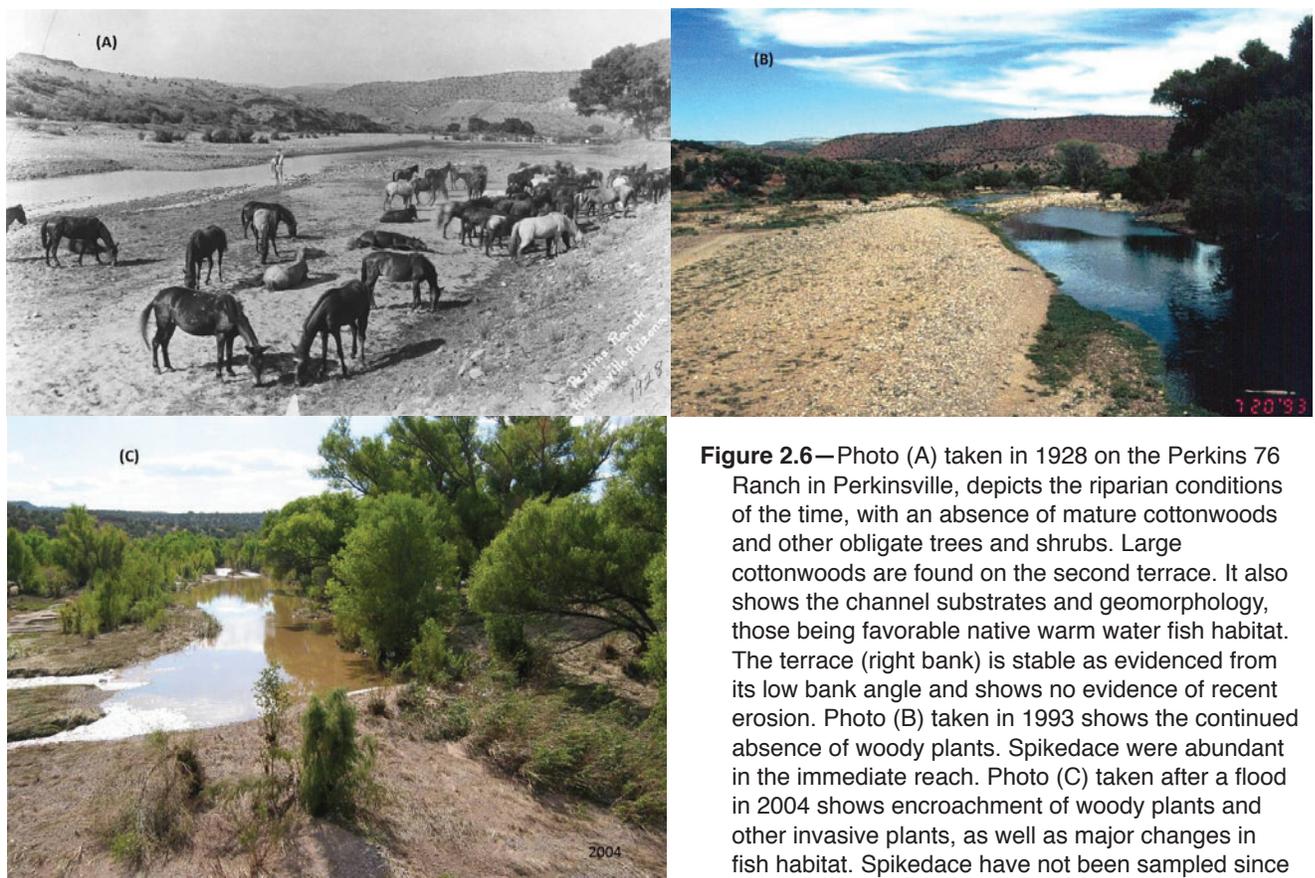


Figure 2.6—Photo (A) taken in 1928 on the Perkins 76 Ranch in Perkinsville, depicts the riparian conditions of the time, with an absence of mature cottonwoods and other obligate trees and shrubs. Large cottonwoods are found on the second terrace. It also shows the channel substrates and geomorphology, those being favorable native warm water fish habitat. The terrace (right bank) is stable as evidenced from its low bank angle and shows no evidence of recent erosion. Photo (B) taken in 1993 shows the continued absence of woody plants. Spikedace were abundant in the immediate reach. Photo (C) taken after a flood in 2004 shows encroachment of woody plants and other invasive plants, as well as major changes in fish habitat. Spikedace have not been sampled since 1997, despite removal of livestock grazing. (Photo A courtesy of the Sharlot Hall Museum, Prescott, Arizona; Photos B and C by Alvin L. Medina.)

ivers (Webb and others 2007), and in recent quantitative descriptions of riparian vegetation by Medina (see Chapter 6). This is not to say that cottonwoods (*Populus*), willows (*Salix*), and other obligate riparian woody species were absent from the basins. Pollen studies by Nations and others (1981) noted the presence of various genera from Miocene to Pleistocene. The most likely explanation for the general absence of gallery vegetation in the UVR prior to recorded history is severe paleoflooding and drought as evidenced by the paleoflood records and climate over the past 2,500 to 5,000 years (Smith and Stockton 1981; Ely and Baker 1985; Webb 1985; O'Connor and others 1986; Ely 1992, 1997; Ely and others 1993; O'Connor and others 1994; House and others 1995; Grissino-Mayer 1996).

In summary, major climatic changes are attributed to the last major glacial period (Anderson 1993). The paleoclimate before 8,000 B.P. was relatively cold and moderately wet with mixed conifer species dominant on present-day ponderosa pine areas. Climatic shifts also produced high variability in drought and flood frequencies and in magnitude. The period of early European occupation and settlement (1600s to 1900 A.D.) of the Southwest was marked with droughts and floods of high magnitudes. Essentially, conditions were harsh and chaotic. The largest recorded flood on the Verde River occurred in 1891 A.D., though many more paleofloods are apt to be discerned using modern technology (e.g., Lidar and HEC-RAS). Regionally, many rivers were subject to the same extremes, thereby setting the stage for a new climatically and hydrologically quasi-stable era where the growth of woody plants was favored across many rivers of the Southwest. Riparian vegetation as evidenced today was largely absent in the late 1800s and early 1900s on the UVR and attributable to large floods.



Figure 2.7—Photo looking south across the Perkinsville valley depicting the condition of the UVR circa 1920s. The river runs amidst a valley devoid woody plants and irrigated bottomland (ditches in foreground) where horses are seen grazing. Streamside vegetation was largely herbaceous and lacking woody plants. The floodplain morphology is a gentle “C” type channel with ample freeboard for flood waters to spread. A small grove of cottonwoods resided atop an older terrace. (Photo A courtesy of the Sharlot Hall Museum, Prescott, Arizona.)



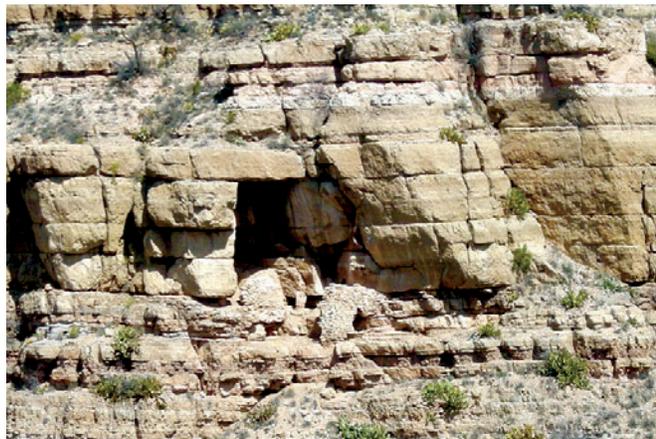
Figure 2.8—This photo was taken from the Perkinsville Road looking east and shows the homestead on the south side of the river. A stand of young cottonwoods, likely less than 10 years old, can be seen growing along the irrigation ditch. These same cottonwoods are seen in figs. 2.36 to 2.42. (Photo A courtesy of the Sharlot Hall Museum, Prescott, Arizona.)

Human Influences

Paleo-Indians—The UVR watershed and riparian corridor have been influenced by man for centuries. Archeological studies (Pilles 1981; Elias 1997) suggest the Colorado plateau and the Verde River Valley were likely occupied by paleo-Indians since around 14,000 B.P. Archeological studies of the Perkinsville sites confirm the UVR was occupied by paleo-Indians from Pueblo I thru Pueblo IV periods (Fish 1967, Fish and Fish 1977). The influence of hunter-gather nomadic groups was likely small. On the other hand, paleo-Indians of the Pueblo periods inhabited the river valleys (e.g., Verde Valley and Perkinsville Valley), building abodes, harvesting fish and game, and farming using extensive irrigation canals (Kayser and Whiffen 1966; Minckley and Alger 1968). Gladwin and Gladwin (1930) suggested that various paleo-Indians from the south and east (Salado), north (Tusayan and Hopi), and west (Havasupai, Yavapai, and Hualapai) also visited and inhabited the UVR valleys, as evidenced by lithic materials. The valleys of the Lower Verde River experienced agriculture as early as 750 A.D. and probably remained until 1450 A.D. (Van West and Altschul 1997). Pierson (1957) concluded that the Hohokam settled the southern reaches of Verde Valley prior to 1100 A.D., but then the valley was resettled during the drought of 1276 to 1299 A.D. (fig. 2.2) by the Sinaguans, who built the elaborate structures known as Tuzigoot and Montezuma Castle (Wormington 1977). These settlers farmed the Middle Verde Valley using extensive irrigation canals. Likewise, the Perkinsville Valley was also farmed, and several irrigation canals have been discovered (Kayser and Whiffen 1966; Fish 1974). The Sinaguans abandoned the Verde Valley in the early 1400s for unknown reasons (Pierson 1957).

As Fewkes (1896, 1898) suggested, it is reasonable to expect that the valleys of the UVR were occupied and farmed by paleo-Indians. In 1896, Fewkes noted pueblo ruins in Sycamore Canyon, Perkinsville (Baker's Ranch House), Hell Canyon, Granite Creek confluence, and Del Rio Springs. Kayser and Whiffen (1966) confirmed farming and extensive irrigation canals in Perkinsville. Extensive pueblo ruins can be observed at Bear Siding, Duff Springs, Prospect Point area, Bull Basin, Verde River Ranch area, 638 Road areas, the Prescott National Forest wetland area, and the Arizona Game and Fish Department property. All of these areas have open valleys with moderate to extensive floodplain terraces that could have easily accommodated farming. In addition, Fewkes (1896, 1912) noted several defensive structures (i.e., forts) and many cave dwellings (fig. 2.9) throughout the UVR. Mearns (1890) noted locations of several habitations as far west as Sycamore Canyon and many throughout the Middle Verde River area, but he did

Figure 2.9—Cliff dwelling located about 61 m (200 ft) above the UVR overlooking the Duff Springs area to the east. (Photo by Alvin L. Medina.)



not visit the upper reaches. Hence, considerable evidence exists that the UVR was largely occupied by paleo-Indians. It is also reasonable to expect their agricultural activities would have affected riparian conditions, including the exploitation of fish and wildlife for domestic uses.

Europeans—The Spanish explorer Antonio de Espejo was the first European to visit the Camp Verde area of the Valley during an expedition in May 1583 (Hammond and Rey 1966; Mecham 1930). Espejo's visit was brief—he was in search of mineral wealth at the location where the mines were established near Jerome. In 1598 A.D., Don Juan de Oñate sent his lieutenant, Marcos Farfán de los Godos, to further investigate the ore mines at Jerome (Pierson 1957). Munson (1981) reported that “Oñate crossed the Verde River in 1604 en route to the Colorado.” For about another 220 years, the Verde Valley remained unnoticed, except for the paleo-Indians of the area, until the arrival of French trappers to the Arizona Territory.

Historical accounts of European trappers in the Verde River are scant. Cleland (1963) noted that various trappers visited the Verde Valley, including Ewing Young, James Pattie, Pegleg Smith, George Yount, Milton Sublette, Kit Carson, Bill Williams, and Antoine Leroux. In 1826, Ewing Young was reported to have led a trapping expedition up the tributaries of the Salt River. Pattie encountered Young at the Salt River after coming down the Gila River and losing most of his party to Indian skirmishes. He joined Young on the Salt River while a separate party ascended the Verde River to its source (Pattie 1831; Cleland 1963; Hafen 1982, 1983). Three years later in 1829, Ewing Young and 40 men, including Kit Carson, ventured on another trapping expedition down the Salt River to the confluence with the Verde River, then up the Verde to the headwaters and onto the Colorado (Cleland 1963; Byrkit 1978). In 1854, Leroux is said to have discovered the paleo-Indian ruins of the Verde Valley in passing through the area but he made no mention of trapping (Fewkes 1898).

Considering the many miles of streams and rivers in Arizona that were supposedly traversed in search of beaver pelts, relatively small quantities of beaver pelts were reported in historical accounts (Hafen 1982, 1983; Despain 1997). Hamilton (1881) noted that beaver were found throughout the Sub-Mogollon region, including the Verde River and its tributaries. Coues (1867) reported that beaver were abundant in the Verde River, as well as in the many other waterways of Arizona. However, others (DeBuys 1985; Hoffmeister 1986) reported that streams were over-trapped from the headwaters to their confluences. Such exploitations led to trapping moratoriums in 1838 by Mexican authorities (DeBuys 1985) who detested trappers in Southwestern territories (Hafen 1983). Apparently, the Southwestern river otter (*Lontra canadensis sonora*) may have been similarly over-exploited (Huey 1956). The UVR, not unlike many other streams of the Southwest, was likely exploited for beaver from the mid-1820s through to settlement in mid-1860s (Pierson 1957). Leroux was part of other trapping expeditions in Arizona throughout the period from the mid-1820s through mid-1850s, when he visited Montezuma Castle. Likewise, Pauline Weaver, a noted mountain man, trapper, rancher, guide, prospector, and pioneer, was part of several expeditions in the Southwest (Pierson 1957). Weaver first visited the Verde Valley in 1829/1830 A.D. (Munson 1981), although others placed him in the Verde Valley in 1832 (Pierson 1957). He finally settled in the UVR valley, where he scouted at Fort Whipple in 1864. He was later assigned to Fort Lincoln where he died in 1867 (Despain 1997). Bill Williams was another trapper who lived in the area and was noted for his expeditions across the Southwest with other trappers (Favour 1962). Trapping by “foreigners” in Mexican Territory was eventually banned and limited

to Mexican citizens. Thereafter, illegal trapping and defrauding was common by trappers who commonly had their pelts confiscated (Weber 1971). It's highly likely that beaver were trapped thereafter as part of settlement activities during the late 1800s (Pierson 1957) and early to mid-1900s, as trapping was a common secondary source of income. In short, trapping in the UVR appears to have been limited as reported, probably to the general absence of beaver. This is consistent with the general absence of woody vegetation noted in previous sections.

Sand and Gravel Mining—Undoubtedly, the period from the 1880s to the present marked a period on the Verde River where a variety of human influences consistent with settlement activities occurred. Extraction of river products, e.g., sand and gravel, for construction of towns and businesses was in place since the mining industry in Jerome began expansion in the late 1800s. Extensive gravel mining of Verde River reaches near Tapco, Cottonwood, and the Camp Verde area was reported as early as 1910 (Simons, Li, and Associates, Incorporated 1985). Similarly, sand and gravel mining occurred on private lands in Perkinsville from the 1960s to 1970s. Remnant piles of rock and boulders traceable to sand and gravel extraction still remain on the Y-D Ranch. By 1989, sand and gravel mining was curtailed under order from the Environmental Protection Agency for violations of the Clean Water Act (Arizona Floodplain Management Association 1989). These actions resulted in limiting sand and gravel extraction activities on the Verde River.

Diversions—The settlement period of the late 1800s to early 1900s also initiated new water diversions throughout the Verde Valley and Perkinsville (Turney 1901, 1929; Alam 1997; NRCV Verde 2000). These diversions were, and continue to be, used for agriculture (Owen-Joyce and Bell 1983). As noted before, these same areas were extensively farmed by paleo-Indians. Arizona Department of Water Resources (1994) estimated that about 90% of summer flow in the Middle Verde River between Clarkdale and Camp Verde was diverted at one time for agricultural use. Some of these diversions are still in place today. One of the most notable diversions was the Peck's Lake diversion in 1920, which created a barrier and tunnel to provide water from the Verde River to the estuary/marsh. The barrier of Peck's Lake diversion dam has functioned much like a fish barrier, limiting upstream movement of fish to the UVR study area for decades. Alam (1997) reported 11 other diversions in the Verde Valley. These diversions have been implicated as threats to native fish habitats and populations (Girmendonk and Young 1997; USDI Fish and Wildlife Service 2005, 2007a, 2009). However, no scientific evidence exists yet linking significant decreases in native fish or habitats to diversions or determining whether diversions affect stream flow or hydrologic conditions (Moyle and Israel 2005; Industrial Economics Incorporated 2006). Roy (1989) documented entrainment of fish in two irrigation ditches of the Verde Valley, noting that exotic species, i.e., red shiners (*Cyprinella lutrensis*), smallmouth bass (*Micropterus dolomieu*), and rainbow trout (*Oncorhynchus mykiss*), were the most abundant fish found in the diversions. However, Ziebell and Roy (1989) noted that some fish, like the roundtail chub (*Gila robusta*), rarely used irrigation diversions on the Verde River. Reliable estimates of entrainment losses are lacking, despite observations of entrainment. Studies of trout suggest entrainment rates are relatively small (0.4 to 3.3%) at the basin level and constitute a relatively small loss compared to the total annual mortality (Carlson and Rahel 2007). Nonetheless, some entrainment losses are apt to occur wherever irrigation diversions exist, but their extent is debatable.

Impoundments—The UVR ecosystem has been impacted by indirect and direct effects of impoundments. Two large reservoirs—Bartlett and Horseshoe—constructed in 1939 and 1949 (USDI Bureau of Reclamation 2009a, 2009b),

respectively, have regulated flows and impeded aquatic wildlife (e.g., fish movements) from the Lower Verde River corridor to the UVR. In addition, these impoundments became regionally important for sport fishing, recreation, flood control, and water storage for agriculture and production of electricity for the Phoenix metropolitan areas (Arizona Department of Water Resources 2009). The impoundments have excluded fish movements across the Salt River and Gila River Basins.

On the UVR, King (2007b) reported that as early as 1884, a dam was built on Miller Creek to store water for the city of Prescott. Granite Dam was completed in 1899 on Granite Creek (King 2007b). Several other impoundments (e.g., Goldwater Lake, Lynx Lake, Watson Lake, and Willow Lake) were also constructed in headwater tributaries of the Prescott area. Other impoundments with 616,800 m³ (500 ac-ft) capacity (e.g., Hell's Canyon Tank) are located on tributaries north of the Verde River. Arizona Department of Water Resources (2007) listed several registered impoundments, including six impoundments of greater than 20 ha (50 ac) in surface area. Another 27 impoundments have storage volumes of 18,500 m³ (greater than 15 ac-ft). About 32 reservoirs have storage capacities rated between 2 and 20 ha (5 and 50 ac) of surface area, and another 2,328 stock ponds with up to 18,500 m³ (15 ac-ft) capacity are scattered across the UVR landscape. It's reasonable to assume that these impoundments have altered flow and bedload contributions to the Verde River over their years of service. Sullivan Dam, constructed in 1939, has probably most directly affected the hydrology and overall ecology of the UVR. Originally intended as another regional recreational lake with inflows from the Del Rio Springs, it quickly filled up with alluvium within three to four years of construction and currently remains a largely seasonal water impoundment. Sullivan Dam cut off access to headwater flows, and blocked natural bedload movement to the UVR perennial flow riverine system. The effects of 70 years of bedload-sediment deprivation can be viewed in deeply incised channels and eroded terraces throughout the UVR corridor. The cumulative effects of the Sullivan Dam and other impoundments on the hydrology and native fishery have yet to be assessed, but there is considerable evidence that impoundment disturbances have altered the UVR ecosystem considerably. Other efforts to harness the tranquil baseflows near the headwaters are yet evident at the Verde River Ranch, where a dam was constructed across the river sometime in the 1960s, only to be washed away or demolished. Several authors have referred to the Verde River as "the last free-flowing river" in Arizona (Beyer 2006; Marder 2009). However, this limited definition applies only to the segment between the confluence of Granite Creek and Horseshoe Dam, an approximately 160-km (100-mi) segment of the river. The designation of "the last free-flowing river" applies only if the many smaller diversions noted above are discounted. Today, perennial flow starts at springs near the Granite Creek confluence, rather than from the historical Del Rio Springs a short distance upstream. In short, the Verde River is not free flowing but rather limited to only segments, owing to its variety of channel diversions and impoundments.

Ranching and Grazing—The first permanent settlers to the Verde Valley arrived in January 1865 (Pierson 1957; Munson 1981). This event marked the beginning of cattle ranching in the Verde Valley. Livestock were produced to meet local needs of Army personnel at Fort Lincoln (name changed in 1868 to Camp Verde and later in 1879 to Fort Verde) and the settlers. The valley floodplain and terraces were suited for agricultural production of foods and forage for settlers and Army personnel at Fort Whipple in Chino valley (Pierson 1957) despite very marshy conditions. Outbreaks of malaria were attributed to wet conditions, typical of wetland environments (Munson 1981).

Livestock grazing of the UVR area began after the establishment of Fort Whipple in 1864. Ludington (2002) provides a historical account of this period:

“In 1864, President Abraham Lincoln sent an official party with military escort to establish the capital of the new Arizona Territory. Their first camp was at Del Rio Springs north of present site of the town of Chino Valley. A few months later the party moved to the forested area of present-day Prescott, where logs were readily available to build a fort, houses, and businesses. While at the original site, army doctor James Baker traded his horse and saddle to a squatter for his land claims along the Verde River. Baker and his partner James Campbell were soon running one of the largest cattle/horse operations in Arizona. They called it the Verde Ranch. The severe drought years of the 1890s, however, brought financial setbacks that forced the partners to sell.”

Early attempts to establish cattle ranches in the Williamson Valley were made by Stevens in 1864 (40 head) and H.C. Hooker in 1868, but these efforts were unsuccessful owing to Indian conflicts (McClintock 1916). Sheep were introduced into the watershed in 1876 by John Clark on Bill Williams Mountain (McClintock 1916). Bronson (1978) provided cattle numbers for various ranches in the upper Chino Basin during the 1870s, further suggesting that large herds were being sent to Arizona. However, most of the livestock were used to meet local needs. The presence of Fort Whipple would have increased the chances of establishment, despite frequent raids by Native American tribes, but little evidence exists to infer that the range was heavily stocked at that time (Bronson 1978). Brown (2007a) reported from oral accounts that James Baker’s 76 Ranch in Perkinsville was stocked with 10,000 head of cattle circa 1882, making the operation the largest cattle and horse operation in northern Arizona. This number of cattle was widely distributed in the watershed and not solely in Perkinsville, as range capacity was limited (see discussion below). However, troubled years lay ahead with prolonged droughts that saw many cattle perish, especially in 1891/1892, for lack of forage and water. Poor financial markets for livestock (1895), as well as personal problems left the 76 Ranch with relatively little stock, thereby forcing Baker to sell in 1898.

In 1900, Marion Perkins purchased the Verde Ranch from Baker and Campbell and arrived on the UVR at Perkinsville November 1, 1900, with his cattle herd (Ludington 2002). The expanse of the cattle operation was reported to extend from Granite Mountain to the west, to Ash Fork and Williams to the north, to Dugas to the east, and to Mayer to the south (Ludington 2002). This approximated about 91 km² (35 mi²) of open rangeland, inclusive of summer and winter range. The number of livestock of this operation is unreported for this period, although numbers were probably relatively low owing to the scarcity of precipitation as well as the relative poor distribution of water throughout the area at the time.

Talbot (1919) noted that range examiners performed a range survey of the present-day Limestone and Del Rio Allotments on the UVR encompassing 34,978 ha (86,433 ac). These rangelands were part of the southern portion of what was then the Tusayan National Forest, which was established July 1, 1910. Encompassing just over 569,635 ha (1,407,600 ac), it was later transferred to the Prescott National Forest October 22, 1934 (Davis 1983). Approximately 16.4% (5,765 ha or 14,245 ac) were classified as forage acres, with an estimated carrying capacity for these lands based on year-long use of 3.2 ha cow⁻¹ (8 ac cow⁻¹). Total annual carrying capacity for all Forest lands combined was estimated at about 12.6 ha (31.1 acres cow⁻¹). Non-forage acres were mixed pinyon-juniper woodland range with browse and annual forage. Cattle and sheep were grazed year-long on the UVR portion of the Prescott National Forest with an average stocking rate of 380 cattle and 1,730 sheep. These numbers were noted as being under the protective limits for the local District. Limiting factors to management included water, fencing, and range pests

(e.g., prairie dogs). Most range improvements were constructed during the 1930s. Contrary to popular belief for the times, Talbot's (1919) assessment indicated that range conditions were relatively fair, despite the drought conditions and poor animal distribution. The examiners noted that trend conditions were declining, but estimates for stocking capacity suggested that range conditions were not "highly degraded or devastated," as is often advocated in some literature. Declining range conditions during this time (1900 to 1920) were exacerbated by severe droughts and floods, poor livestock management practices, and lack of range improvements. Cattle stocking was fueled by demands for meat products to meet the nation's World War I (1914 to 1918) needs, mining industry requirements throughout the West, and new human population center expansions.

Today, stocking of the same range that was examined by Talbot (1919) approximates a small fraction of the estimates of 1919. Miller (1921) attributed the conversion of 4,050 to 6,070 ha (10,000 to 15,000 ac) of tobosa grassland to Utah juniper (*Juniperus utahensis*) to sheep grazing. Miller (1921) further noted that the average age of 20% of Utah juniper stands was fewer than 35 years; the remaining 80% was 13 years or less. He also noted the same phenomena for one-seed juniper (*J. monosperma*), citing seed size and lessened herbivory.

Despite the lack of stocking data, the period of the late 1880s through the early 1940s was marked with severe droughts (Webb 1985; Ely 1992; Grissino-Mayer 1996) and very intense floods (Ely and others 1993; Ely 1997) that contributed to overuse of rangelands. These climatic events were coincident with the influx of cattle and sheep and establishment of the ranching industry in the region. Early range scientists recorded the general overgrazing that was obvious in the region (Griffiths 1901, 1904, 1910). These assessments brought about major changes in land management and the start of range research in the West. Also coincident with range overgrazing during the same period was the exploitation of neighboring forests and woodlands for development (King 2007a). Forest products were in demand for the mining industry, railroads, and settlements within the watershed. These activities undoubtedly worsened the deterioration of the rangelands, as noted by range examiners (Talbot 1919).

Indirectly, trends in range conditions could be partially explained by economic factors. During poor markets, livestock operators were more likely to retain annual crops, thereby placing additional stress on overstocked rangelands. Local livestock production during the period of 1890 to 1910 was initially determined by the ability to successfully stock the range and maintain numbers in the face of adversities (e.g., Native American skirmishes, livestock thefts and depredations, and droughts). Some stock was produced for local needs, such as military fort and mining camp meat supplies, but stock that was produced for regional and national markets became susceptible to national economic recessions. The link between stocking strategies, climatic conditions, and national markets remains today. Another factor that likely affected range trends between the turn of the century and circa 1950 was the national policy of Congress and land management agencies to encourage settlement and development of States with public land (Nielsen 1972). This policy made it more difficult for land managers to administer grazing lands in accordance with carrying capacity principles.

Grazing Litigation—Litigation over livestock grazing in riparian habitats and federally listed fish and wildlife species in Region 3 has played a major role in the management of the riparian habitats and listed fish species in the UVR. The results of litigation have great potential to affect ecosystems and their components long term. Although well intended and supposedly based on best science available, litigation may not always yield the best of intended results. Despite

numerous appeals and lawsuits, native fish, such as the spokedace on the UVR, continue to disappear.

Livestock have grazed portions of the UVR since about the 1860s. Large numbers were introduced when cattle were imported from Texas to the Perkinsville area in 1895. Large-scale reductions in cattle numbers using the river occurred in the early 1900s (see previous discussion on ranching and grazing), and was accompanied by long-term monitoring of the uplands. Yearlong grazing use of the river continued until the 1980s. At that time the Prescott National Forest changed grazing use to seasonal or rotational, releasing yearlong grazing pressure on riparian plant communities in the river corridor. With the wholesale reduction in cattle numbers in the early 1900s, cattle numbers have declined considerably to the present (Rinne and Medina 2000).

In 1993, the Horseshoe Allotment (Y-D Ranch) voluntarily removed cattle from the river after a cooperative effort with Prescott National Forest to improve riparian conditions from the historic 1993 winter flood. Prescott National Forest surveys suggested that riparian conditions would likely improve within five years and the area could be restocked. Grazing on the Horseshoe Allotment had also been under contention by Forest Guardians for years prior to the voluntary temporary removal. Although National Environmental Policy Act (NEPA) analyses has since been completed for grazing on the allotment, grazing on the river was not considered at that time, and is not precluded pending approval of the NEPA analysis. In continuing efforts (1993 to 2010) to get research performed on grazing- fish relationships, Y-D Ranch and Verde River Ranch invited RMRS and Prescott National Forest to engaged in a collaborative group (UVR Adaptive Management Partnership [UVRAMP]), which became the conduit for communication and development of research plans. The hope was to provide management science-based guidelines for grazing the UVR. However, appeals to grazing riparian areas were impending and discouraged plan implementation.

In 1997, Forest Guardians (Forest Guardians v. U.S. Forest Service 1997) and the Center for Biological Diversity (Southwest Center for Biological Diversity v. U.S. Forest Service 1997) filed complaints against the U.S. Forest Service, Region 3, seeking an injunction and cessation of grazing on multiple allotments in Region 3, including four of the seven grazing allotments, Antelope Hills, Perkinsville, China Dam, and Sand Flat, in the UVR. Three grazing allotments, Horseshoe, West Bear-Del Rio, and Muldoon were not included in the litigation because the permittees had previously agreed with the Prescott National Forest to remove livestock from the river. Forest Guardians and the Center alleged failure by the U.S. Forest Service to comply with the Endangered Species Act (ESA) by failing to have completed ESA Sec. 7 consultation for livestock grazing effects on watersheds and riparian habitat affecting four listed species, loachminnow, spokedace, spotted owl, and southwestern willow flycatcher. These lawsuits placed livestock grazing of riparian areas in Region 3 at risk. Subsequently, the Arizona Cattle Growers Association (ACGA) and the New Mexico Cattle Growers Association (NMCGA) joined the lawsuit as interveners (CV-97-2562 PHX-SMM, CV-97-0666-TUC-IMR).

On April 16, 1998, Region 3 entered into a stipulated agreement with Forest Guardians and the Center (Southwest Center for Biological Diversity v. U.S. Forest Service, Forest Guardians v. U.S. Forest Service, ACGA, and NMCGA interveners 1998). The agreement required the U.S. Forest Service to exclude livestock from at least 99 percent of occupied, suitable but unoccupied, and potential habitat of the species identified in the Motion for Preliminary Injunction, "so long as the U.S. Forest Service complies with the terms of this stipulation for the duration of the ongoing grazing consultation." The ongoing grazing consultation was completed

on February 2, 1999. The consultation period essentially avoided a region-wide injunction over livestock grazing and gave the U.S. Forest Service time to come into compliance with the requirements of the ESA Section 7. At the time of the stipulated agreement, the West Bear-Del Rio allotment was the only allotment of the seven that had completed a NEPA assessment and Sec. 7 ESA consultation. Since then the remaining six allotments have completed NEPA assessments and ESA Sec. 7 consultation. However, none of the assessments included grazing of the river, thus effectively limiting livestock grazing, but not precluding if supported by future NEPA analyses.

The USDI Fish and Wildlife Service proposed designation of critical habitat for the spinedace several times (Federal Register 2000, 2010). The first proposal was on March 8, 1994 (Federal Register 1994) which was set aside by court order for failure by USDI Fish and Wildlife Service to analyze the effects of critical habitat designation under NEPA (Catron County Board of Commissioners, *New Mexico v. USDI Fish and Wildlife Service*, CIV No. 93-730 HB DNM 1994). On September 20, 1999 the Southwest Center for Biological Diversity filed suit against the USDI Fish and Wildlife Service for failure to propose a rule (*Southwest Center for Biological Diversity v. Clark*, CIV 98-0769) and the court ordered USDI Fish and Wildlife Service to finalize designation of critical habitat. The proposed rule was promulgated December 10, 1999, and a final rule was submitted April 25, 2000 (Federal Register 2000). It was subsequently challenged in court (NMCGA and Coalition of Arizona/New Mexico Counties for Stable Economic Growth *v. United States Fish and Wildlife Service*, CIV 02-0199 JB/LCS–D.N.M.) because the USDI Fish and Wildlife Service used a method for economic analysis deemed invalid by the U.S. Tenth Circuit Court. The proposed rule was rescinded on August 31, 2004. The USDI Fish and Wildlife Service re-proposed rules December 20, 2005 (Federal Register 2005), again in 2006 (Federal Register 2006), and a Final rule in 2007 (Federal Register 2007). The 2007 final rule was challenged on the basis that USDI Fish and Wildlife Service designated critical habitat without adequate delineation or justification (*Coalition of Arizona/New Mexico Counties for Stable Economic Growth, and others v. Salazar and others–D.N.M.*). The proposal was voluntarily remanded on May 4, 2009. Each proposal from 2000 to 2007 met and failed legal challenges, mostly on economic and science based issues. For example, the 2007 proposal excluded segments of the Verde River below the UVR study area “due to potential economic impacts,” still noting grazing as a threat but recognized nonnative fish as a threat for the first time (Federal Register 2007).

The 2010 proposed rule (Federal Register 2010) takes into consideration new information on distribution, e.g., Mangas Creek in southern New Mexico, and addressed flaws in previous proposals. However, livestock grazing is still cited as a major threat (Federal Register 2010, p-66489) because of adverse effects that may occur from watershed alteration and “subsequent changes in the natural flow regime, sediment production, and stream channel morphology.” This Report presents alternative views of watershed responses to other factors other than grazing, and that have similar consequences as those noted in the 2010 proposal.

Despite various litigation efforts on the UVR to protect listed fish, native fish populations continue to decline. Spinedace have not been found for over 10 years (see Chapter 9). Other minnows that were once common, such as speckled dace and longfin dace, also have become infrequent in fish surveys (see Chapter 9). Depressed populations of the latter are attributed to direct effects of nonnative fish (Desert Fishes Team 2004, 2006). The future of native fishes in the UVR and the Southwest has been well expounded by many fishery experts (Rinne and Minckley 1991; Rinne 1991a, 1999a, 2001a; Olden and Poff 2005; Rinne and others 2005a),

all of which note that native fish populations are down trending despite various legal and resource protection measures, and pleas for exclusion of livestock grazing of riparian areas (Desert Fishes Team 2004). On the UVR, the threat of litigation looms even across research efforts to understand fish-grazing-riparian relationships. To date, there have been no studies that addressed direct effects of livestock grazing on native fishes despite the continued urgency to resolve the controversies. However, many have recognized that nonnative fish in the UVR are the principal cause of depressed native fish populations (see Chapter 9; Desert Fishes Team 2004, 2006). In addition, litigation may force managers to employ conservative protection measures, such as livestock exclusion, that could cause unforeseen changes to the aquatic and riparian habitats over time and ultimately further limit opportunities to manage the UVR habitats for listed species.

Railroads—In 1912, the Santa Fe Railroad brought a spur line through the Perkins family ranch, creating Perkinsville Station and a siding for loading cattle (fig. 2.7). The United Verde and Pacific Railway originated in 1894 when United Verde Copper Company owner, Senator William A. Clark, constructed a narrow-gauge railroad from Jerome to Jerome Junction, which became Chino Valley in 1920 when the railroad ended service (McClintock 1916). The spur line was later decommissioned and became a roadway from Jerome to Perkinsville and Chino Valley. Much wood product was reportedly harvested from the vicinity of the spur to meet mining and community needs.

Mining and Power Development—The first mining camps in the Verde Valley were established in 1876 and were greatly facilitated by the introduction of railroads into the territory in 1882. Railroads were used to import coal to the region from New Mexico, providing coke to the mines and exporting ore (Munson 1981). The United Verde Copper Company was founded in 1883 (Munson 1981) and so began the industrialization of the area. A smelter was built in Jerome to process ore, thus marking another landmark of what was to be a significant change to the local environment of the Valley. Another narrow gauge railroad between Ash Fork and Prescott, known as “United Verde and Pacific Railroad” was constructed in 1894. By 1900 Jerome had become the fifth largest city in Arizona (Munson 1981).

The mining boom during the early 1900s created additional needs for electricity to power equipment and the new settlements. Originally, an oil fired plant provided power to the mines; but by June 18, 1909, electricity that was generated at the Fossil Creek Power Plant was being used to power mining operations at the United Verde Mine in Clarkdale (Munson 1981). By 1917, the need for an additional smelter warranted construction of another steam powered plant, built on a terrace of the Verde River upstream from Clarkdale, to provide power to other mining customers (Munson 1981). The power plants supplied electricity to the surrounding towns of Prescott, Mayer, Poland Junction, and Crown King, and they met 70% of the Phoenix power needs (Munderloh 2007). Brown (2007b) reported that smoke from the smelters in Clarkdale clouded the Camp Verde Valley, resulting in a decline of range plants. As early as the 1920s and 1930s, Verde Valley farmers organized to protest, document, and seek compensation from the effects of smelter emissions on crops (Verde Valley Protective Association, no date). The sulfur dioxide rained on the valley for several years until the smelters shut down in the 1950s (Byrkit 2001). Smelter slag deposited on an 18-ha (45-ac) site amounted to 18.1 million Mg (20 million tons) from the years 1912 to 1950. The slag still resides adjacent to the Verde River, although efforts are underway to reclaim precious metals from the slag material (Searchlight Minerals Corp. 2008). The off-site atmospheric deposition of heavy metals and metallic oxides on watershed rangelands is another unknown variable that complicates our understanding of present-day environmental conditions

for plants and animals. Byrkit (2001) noted that by 1910, Woodchute Mountain had been denuded by woodcutting and the effects of acidic sulfurous smelter smoke.

Fish Species History

Native Species Decline—The Verde River historically was home to many native fish species. Minckley and Alger (1968) identified paleo remains of five species of fishes on an archeological site in Perkinsville: *Pantosteus clarki* (Gila sucker), *Castostomus insignis* (Sonora sucker), *Gila robusta robusta* (roundtail chub), *Xyrauchen texanus* (humpback sucker), and *Ptychocheilus lucius* (squawfish). Some of these fish are present still, although in low numbers, while others were extirpated and some were repatriated (see table 2.1). Spikedace have not been confirmed on the Verde since 1997 (Rinne 1999a; see also Chapter 9). A single spikedace was reported in a 1999 fish survey but was unconfirmed and questionable. As of 2009/2010, no fish surveys have found spikedace, yet the species status is reported as extant (Robinson and Crowder 2009; Chmiel 2010a, 2010b, 2010c).

The native fish fauna (table 2.1) of the entire Verde River markedly changed with the introduction of 22 species of sport and forage fishes (Rinne 2005; Pringle 2009; see also Chapter 9). Stocking of Arizona's waterways began as early as 1880/1881 with the passage of an Act by the Arizona Legislature "for stocking the rivers and lakes of the Territory with carp and other varieties suited to the climate" (Hamilton 1881). The earliest recorded stocking of nonnative fish in the Verde River system occurred in 1938 (Pringle 2009). Upon the completion of Sullivan Dam at the headwaters, 10,000 blue gill (*Lepomis macrochirus*) were stocked in 1938 (Arizona Game and Fish Department 1938). An additional 2,500 bass (*Micropterus dolomieu* and *Micropterus salmoides*), 4,000 blue gill, and 15,500 channel catfish (*Ictalurus punctatus*) were stocked above Clarkdale and Peck's Lake. Rinne and others (1998) reported that more than a dozen nonnative species and more than 15 million individuals were stocked in virtually every tributary, stock tank, reservoir, and water body capable of sustaining fish on both public and non-public lands. From 1920 to 1995, nearly 560,000 nonnative fish comprising 14 species were planted in stock tanks within the Verde watershed (Pringle 2009). Sponholtz and others (1997) speculated that stock tanks might also contribute to introductions of nonnative fish during high rainfall events that cause overflow into the Verde River. Rinne (2005) further noted that by 1950, five records of nonnative fishes were noted for Oak Creek and Wet Beaver Creek (tributaries of the Middle Verde). By 1964, records doubled with 6 of 11 records from the main stem Verde and the number increased four-fold from 1965 to 1979. Since the 1970s, more intensive surveys revealed that the UVR was exceptional in retaining proportional abundance of native fishes compared with the Middle and Lower Verde River. The UVR harbored about a 4:1 ratio native to nonnative, while the lower reaches ranged from about 1:3 to 1:9 ratios (Rinne 2005; see also Chapter 9). Stocking of rainbow trout (*Oncorhynchus mykiss*) is a continued practice today in the middle Verde Valley in response to angler pressure (Pringle 1996). The Peck's Lake diversion barrier is an apparently effective obstruction to the upstream movement of trout, as trout were not found in the upper reaches.

Interest in the status of native fishes of the UVR did not peak until the early 1990s concomitant with regional implications of effects of livestock grazing and regional trends in native fish populations (Rinne 1999b, 2000, 2005). Land managers sought information about management of riparian areas and native fishes, while others (USDI Fish and Wildlife Service 1999) sought protection status citing grazing, introduced fishes, and water diversions. Long-term studies were

Table 2.1—List of native and introduced aquatic fauna on the Verde River over the last 75 years. Species identified with “*” are reintroduced and experimental. Spikedace were last evidenced in 1997 by Rinne (1999a). Speckled dace have become uncommon in recent years (Rinne and Miller 2006). Roundtail chub were proposed for review in 2009 (USDI Fish and Wildlife Service 2009). (Adapted from Rinne 2005.)

| Status | Common name | Scientific name |
|------------------------|---------------------|--------------------------------|
| Extirpated | Gila trout | <i>Oncorhynchus gilae</i> |
| Extirpated | Colorado Pikeminnow | <i>Ptychocheilus lucius*</i> |
| Extirpated | Razorback sucker | <i>Xyrauchen texanus*</i> |
| Extirpated | Flannelmouth sucker | <i>Catostomus latipinnis</i> |
| Extirpated | Loach minnow | <i>Rhinichthys cobitis</i> |
| Extirpated | Gila chub | <i>Gila intermedia</i> |
| Unknown | Spikedace | <i>Meda fulgida</i> |
| Present | Desert sucker | <i>Catostomus clarki</i> |
| Present | Sonora sucker | <i>Catostomus insignis</i> |
| Present | Roundtail chub | <i>Gila robusta</i> |
| Present | Speckled dace | <i>Rhinichthys osculus</i> |
| Present | Longfin dace | <i>Agosia chrysogaster</i> |
| Introduced | Rainbow trout | <i>Oncorhynchus mykiss</i> |
| Introduced | Brown trout | <i>Salmo trutta</i> |
| Introduced | Brook trout | <i>Salvelinus fontinalis</i> |
| Introduced | Goldfish | <i>Carassius auratus</i> |
| Introduced | Common carp | <i>Cyprinus carpio</i> |
| Introduced | Threadfin shad | <i>Dorosoma petenense</i> |
| Introduced | Fathead minnow | <i>Pimephales promelas</i> |
| Introduced | Red shiner | <i>Cyprinella lutrensis</i> |
| Introduced | Golden shiner | <i>Notemigonus crysoleucas</i> |
| Introduced | Tilapia | <i>Oreochromis mossambicus</i> |
| Introduced | Northern pike | <i>Esox lucius</i> |
| Introduced | Smallmouth bass | <i>Micropterus dolomieni</i> |
| Introduced | Striped bass | <i>Morone saxatilis</i> |
| Introduced | White crappie | <i>Pomoxis annularis</i> |
| Introduced | Black crappie | <i>Pomoxis nigromaculatus</i> |
| Introduced | Green sunfish | <i>Chaenobryttus cyanellus</i> |
| Introduced | Bluegill sunfish | <i>Lepomis macrarchirus</i> |
| Introduced | Mosquitofish | <i>Gambusia affinis</i> |
| Introduced | Channel catfish | <i>Ictalurus punctatus</i> |
| Introduced | Flathead catfish | <i>Pilodictus olivaris</i> |
| Introduced | Yellow bullhead | <i>Ameiurus natalis</i> |
| Other introduced fauna | Otter | <i>Lontra canadensis</i> |
| Other introduced fauna | Bull frog | <i>Rana catesbeiana</i> |
| Other introduced fauna | Crayfish | <i>Procambarus clarkii</i> |
| Other introduced fauna | Asiatic clam | <i>Corbicula fluminea</i> |

initiated by Rinne (2001a) and the Arizona Game and Fish Department (2000, 2002). Since 1994, fish surveys have been conducted on an annual basis jointly by the Prescott National Forest and RMRS, as well as Arizona Game and Fish Department. Specific surveys to locate spokedace were jointly performed in 2005 by USDI Fish and Wildlife Service, Arizona Game and Fish Department, and U.S. Forest Service (USDI Fish and Wildlife Service 2005), with no positive results of the presence of spokedace. Similar studies were performed in New Mexico, where spokedace were noted to decline over 18 years in the absence of livestock grazing on the Gila National Forest and Wilderness Area (Paroz and others 2006, Paroz and Probst 2007). These contradictory studies have not abated the controversy over grazing and native fishes.

The cumulative effects of nonnative fishes on native fish and ecosystem processes of the UVR are highly significant. Rinne (1999b, 2005; see also Chapter 9) documented the gradual disappearance of spokedace and present rarity (see Chapter 9) of native fishes on the UVR. A principal hypothesis that has been promoted universally in the Southwest is that livestock grazing is a major causative factor in the demise of native fishes and all fishes in general. However, Rinne (2005) and Rinne and Miller (2006) found no evidence to justify the hypothesis for the Verde River. Others have similarly tried to link grazing effects to native fish sustainability in Arizona and have obtained conflicting results (Robinson and others 2004). Rinne (1999b) examined the grazing-fish controversy and found little evidence in support of the hypothesis, noting that over 80% of the literature was not peer reviewed and the rest of the studies were fraught with design issues. The overwhelming evidence of 15 years of study on the UVR strongly suggests that other factors, such as predation by nonnative fish and other aquatic invasive species (e.g., bullfrogs and crayfish) and hydrogeomorphic changes in habitat conditions are operative in the decline (see Chapter 9). In addition, Rinne and Miller (2006) suggested that factors related to changes in hydrology and geomorphology in the UVR could be principal factors that caused habitat changes favoring nonnative fishes, thereby placing additional survival stress on native fish populations. Propst and others (2008) later identified similar factors for the Gila River watershed. Schade and Bonar (2004, 2005) noted that nonnative fishes have profound effects on native fish populations in the Southwest and note largemouth bass as the principal predator on the Verde River (Bonar and others 2004). Efforts to mechanically reduce populations of nonnative fishes have shown positive results (Rinne 2001b; see Chapter 9). However several other factors have to be addressed before any success can be declared (Rinne 2003a, 2003b; see also Chapter 9).

Repatriation of Native Fish—Various efforts to repatriate native fishes in Arizona have yielded poor results (Desert Fishes Team 2004) and have largely been a learning process, especially with razorback sucker and pikeminnow. Hendrickson (1993) reported that approximately 12 million fingerling razorback suckers (*Xyrauchen texanus*) were stocked into the Verde River between 1981 and 1991 with little or no success. Losses were assumed to be due to predation by nonnative fishes. Since 1991, 22,869 razorback suckers have been released into the Verde River by the USDI Fish and Wildlife Service (Hyatt 2004). In 1992, 11,231 Colorado pikeminnow (*Ptychecheilus lucius*) stocking-fry and fingerlings were stocked (table 2.2) in the UVR and Lower Verde River (Hendrickson 1993; Hyatt 2004). Hendrickson (1993) noted that after several years of failure to detect recruitment, stocking sites were relocated to sections of the UVR, including Perkinsville. These attempts were made to reduce predation on stocked fishes. Subsequent surveys failed to locate the stocked fish, which had likely moved or were transported downstream, where predation may have again become a factor

Table 2.2—Razorback sucker (XYTE: *Xyrauchen texanus*) and pikeminnow (PTLU: *Ptychocheilus lucius*) stocking from 1991 to 2003 by the USDI Fish and Wildlife Service on the Verde River. (Adapted from Hyatt 2004.)

| Year | Species | Location | Number stocked | Mean total length mm |
|------|------------|---------------------------|----------------|----------------------|
| 1991 | XYTE | Upper Verde River | 128 | 356 |
| 1992 | PTLU, XYTE | Upper Verde River | 222 | 330-406 |
| 1993 | XYTE | Upper & Lower Verde River | 1120 | 76-356 |
| 1994 | XYTE | Lower Verde River | 2204 | 324-386 |
| 1995 | PTLU, XYTE | Lower Verde River | 5837 | 305-432 |
| 1996 | PTLU, XYTE | Lower Verde River | 5961 | 254-362 |
| 1997 | PTLU, XYTE | Lower Verde River | 3818 | 287-477 |
| 1998 | PTLU, XYTE | Lower Verde River | 4036 | 305-330 |
| 1999 | PTLU, XYTE | Lower Verde River | 2364 | 381-406 |
| 2000 | XYTE | Lower Verde River | 2131 | 305-580 |
| 2001 | XYTE | Lower Verde River | 1574 | 300-440 |
| 2002 | PTLU, XYTE | Lower Verde River | 2248 | 300-350 |
| 2003 | PTLU, XYTE | Lower Verde River | 2427 | 330-400 |

(Jahrke and Clark 1999). Eventually, larger fish (12+ in) were stocked to overcome predation factors, but mostly in the Lower Verde River (table 2.2; Hyatt 2004).

Hyatt (2004) noted key observations about restocking razorbacks and pikeminnow:

- Since 1991, larger fish produced better results with recaptures, but introduction has been limited to 87 Colorado pikeminnow and 283 razorback suckers in the UVR.
- Recaptures were found near their original stocking areas on the Salt River, suggesting a high site fidelity relative to site introduction, but only one PIT-tagged razorback has been recaptured on the middle Verde River near Childs.
- Adult survival is at the low end and of short duration, with no recruitment.
- Continued failures to repatriate native fishes in the Verde River prevail owing to inadequate identification of causal factors such as predation (Marsh and Brooks 1989; Mueller 2003).

Rinne (Chapter 9) pioneered efforts to physically remove nonnative fish in the UVR. Physical removal may be the only reasonable choice to repatriate native fishes, as chemical treatments are currently controversial owing to their cumulative effects on aquatic organisms (Hubbs 1963; Minckley and Mihalick 1981; Magnum and Madrigal 1999; Dinger and Marks 2007; Hamilton and others 2009; Vinson and others 2010), human health risks (Tanner and others 2011), and general lack of success (Dawson and Kolar 2003). Successful reintroduction of native fishes is dependent on many factors that could have contributed to their current status. Mueller (2003) acknowledged that more than three decades of stocking endangered fishes in the Verde River has shown that unless limiting factors are accurately identified and adequately addressed, recruitment failure will continue to occur. Efforts are underway to repatriate native minnows, e.g., spinedace and loach minnow, on a segment of the UVR (USDI Bureau of Reclamation 2010). Dawson and Kolar (2003) assessed the utility of using chemical control in Arizona streams and concluded “chemical reclamations have not always been successful as indicated by reviews of hundreds of fish control projects with reported successes ranking from 43% to 82%.” Dawson and Kolar (2003) further noted that the

present arsenal of piscicides is not likely to be effective for controlling nonnative fishes in the southwestern United States, and that reclamation of habitats is required. This may be another controversial point since aquatic and riparian habitats have changed considerably in the last century in the UVR.

Exotic Aquatic Species—In addition to nonnative fish, other exotic aquatic fauna were also introduced by the State of Arizona (Arizona Game and Fish Department 2006), including crayfish (1940s) (*Orconectes virilis*, *Procambarus clarkii*), bullfrogs (*Rana catesbeiana*), otter (*Lutra canadensis lataxina*) (1981 to 1983), and Asiatic clam (*Corbicula fluminea*). The first three have turned out to be significant predators of native fish. Crayfish and bullfrogs were likely introduced as bait, sport, and food (Arizona Invasive Species Advisory Council 2008). Asiatic clams are filter feeders and generally abundant, but their role in the aquatic ecology of native fishes is unknown. Because of their relative abundance, they can affect stream nutrient dynamics through their effects on organic matter processing in streambed sediments (Hakenkamp and Palmer 1999) and consumption of phytoplankton (Phelps 1994). The clams are also known as bio-indicators of organic pollutants because they siphon large volumes of water on a daily basis, thereby concentrating dissolved or suspended contaminant that may be present in low concentrations in the water column (Doherty 1990).

Crayfish are omnivores (Dean 1969), and recent studies demonstrated that they are opportunistic, eating both plants and animals, including young snakes (Fernandez and Rosen 1996), lily pads, iris, insects, snails, tadpoles, frogs, baby turtles, fish eggs small fish, and other crayfish. They also are able to successfully compete with native fishes for food and cover (Carpenter 2005; Arizona Game and Fish Department 2006; USDI Geological Survey 2006).

It is unknown when or how bullfrogs were introduced into the Verde River but it was most likely during the turn of the century as a food item or as bait. Nonetheless, bullfrogs are abundant in the Verde River and have been attributed as a principal predator of sensitive species in Arizona (Rorabaugh 2008), leopard frogs (Sredl and others 1997; USDI Fish and Wildlife Service 2007b), garter snakes, endangered fish eggs and larvae (Mueller and others 2006; Witte and others 2008), and endangered fishes such as Yaqui chub and Yaqui topminnow (Schwalbe and Rosen 1988). In a study of southeastern Arizona herpetofauna, Schwalbe and Rosen (1988) commented that bullfrogs “eat anything they can get into their mouth.”

The Arizona river otter (*Lutra canadensis sonora*) type locality was from Montezuma Well (Rhoads 1898) and these otters are recognized as a distinct subspecies (Wilson and Reeder 2005; ITIS 2009). The Arizona otter were extirpated and replaced with a surrogate species—the North American river otter (*L. canadensis*) from Louisiana. The Arizona Game and Fish Department introduced the Louisiana otter into the UVR during 1981 to 1983 (Arizona Game and Fish Department 1995). An assessment in the past decade indicated that the otter are doing well (Raesly 2001). However, their food habits may stress the food web dynamics of the UVR, as they relate to native fish populations. Tesky (1993) reported collectively that their fish diets include “suckers (*Catostomus* spp.), redborses (*Moxostoma* spp.), carp (*Cyprinus* spp.), chubs (*Semotilus* spp.), daces (*Phinichthys* spp.), shiners (*Notropis* spp.), squawfish (*Ptychocheilus* spp.), bullheads and catfish (*Ictalurus* spp.), sunfish (*Lepomis* spp.), darters (*Etheostoma* spp.), and perch (*Perca* spp.)” Crayfish are also a mainstay food item when in abundance (Toweill and Tabor 1982). In general, otter are known to prefer slow-moving nongame fish, but they will eat other mammals, amphibians, insects, birds, and plants (Melquist and Dronkert 1987; Tesky 1993). As such, they pose a potential threat to other sensitive wildlife, aside from native fish, of the UVR (Toweill 1974; Melquist and

Hornocker 1983). However, otters are opportunistic and, by shifting their diets relative to abundance and availability, they could prey upon undesirable nonnative aquatic species such as crayfish, bullfrogs, and nonnative fish (Melquist and Hornocker 1983).

Pictorial Guide

The following section provides a visual montage of the UVR as well as some insights to changes in the river over the past 100 years. Figure 2.10 shows the photo locations as well as other features like main springs and tributaries.

Headwaters

Perennial flow of the Verde River originated from the Del Rio Springs at one time and flowed north along Del Rio Creek (Krieger 1965). The springs are located about 1.6 km (1 mi) south of Sullivan Dam, near the town of Paulden, Arizona. Flow from the springs has varied for the period of record from about 3.42

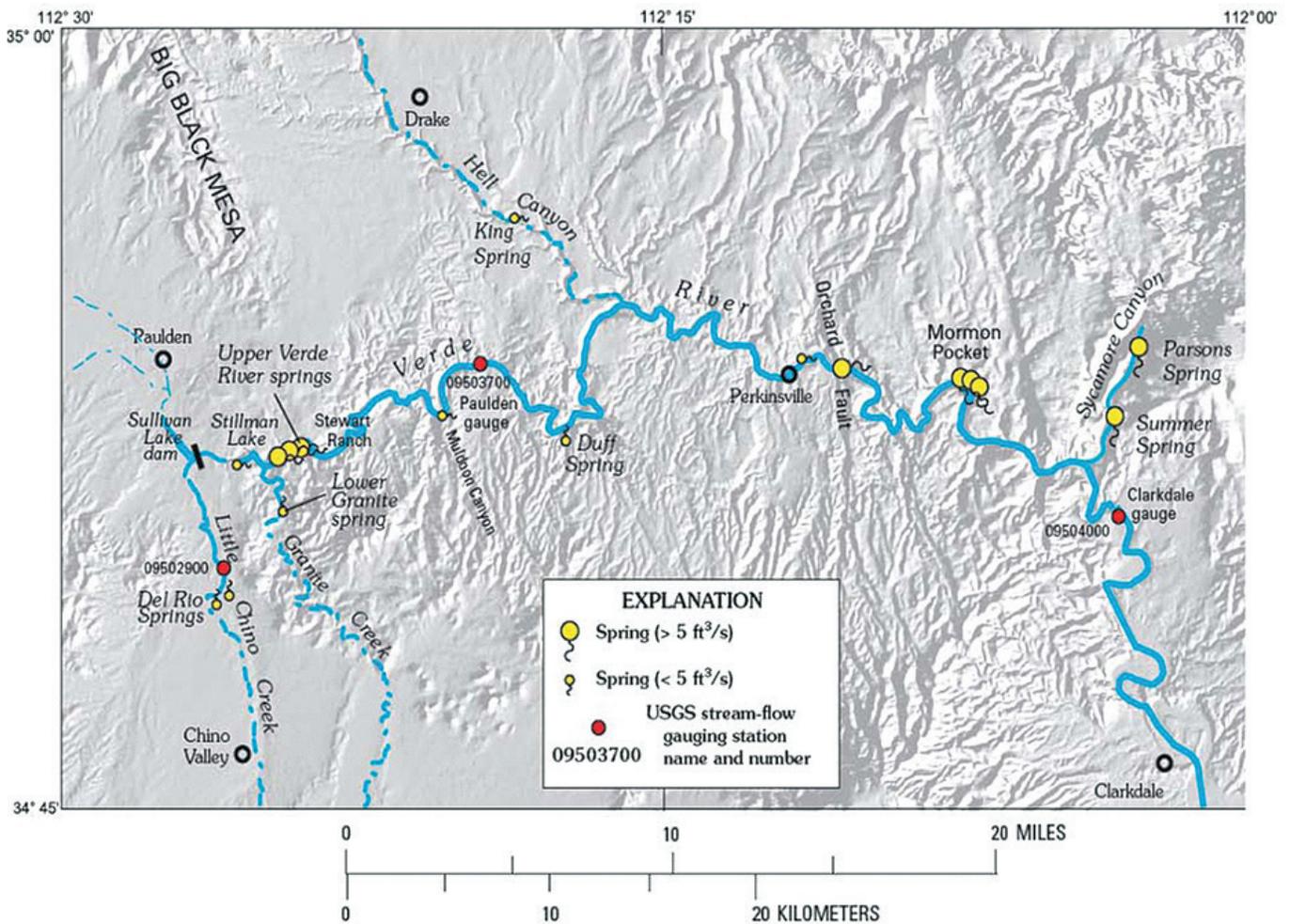
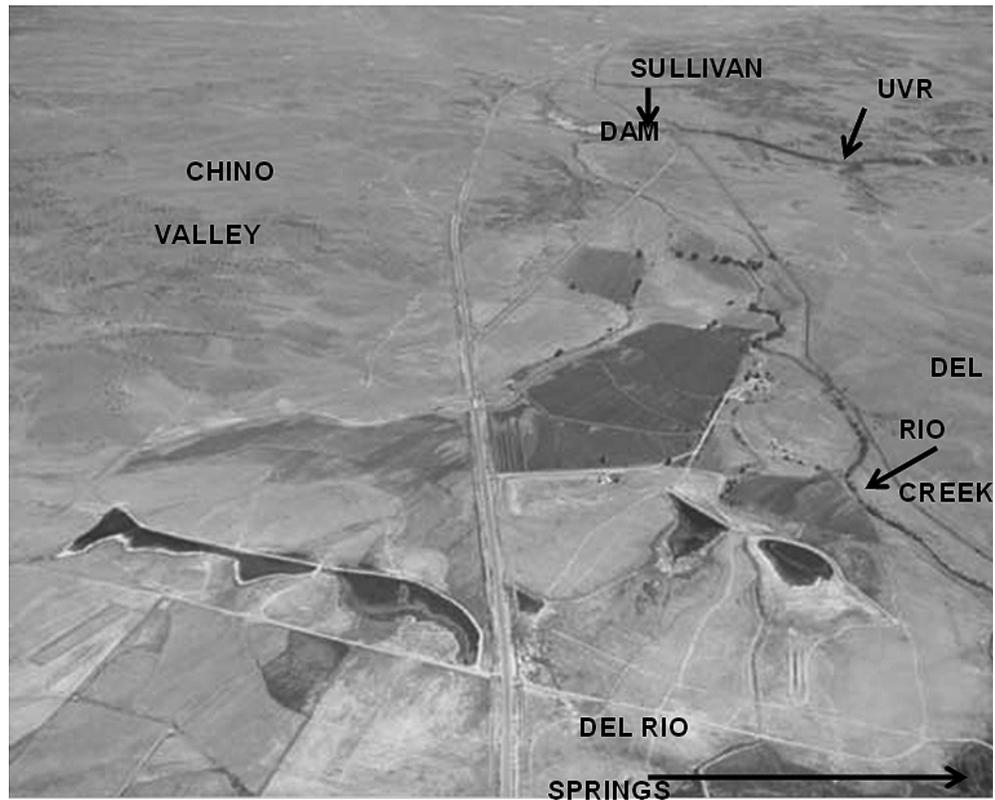


Figure 2.10—Location of known springs and photo points (numbers correspond to figure numbers; e.g., 6 = fig. 2.6 and 11 = fig. 2.11) along the UVR from Del Rio Springs and Granite Wash to Sullivan Lake to the Clarkdale gauge below Sycamore Creek (from Wirt and others 2005).

Figure 2.11—Aerial photo taken May 21, 1969, looking north from Del Rio Springs toward Sullivan Dam and the UVR (Sharlot Hall Museum call no. pb167f3i11).



$x 10^6 \text{ m}^3$ (2,773 ac-ft) in 1939/1940 to $1.74 \times 10^6 \text{ m}^3$ (1,410 ac-ft) in 1999 (Wirt and Hjalmarson 2000). Blasch and others (2006) reported that flow declined from the approximate $3.45 \times 10^6 \text{ m}^3$ (2,800 ac-ft) in the early 1940s to near $1.23 \times 10^6 \text{ m}^3$ (1,000 ac-ft) in 2003. The Del Rio Springs flow is artesian, seemingly a product of the greater artesian basin extending upstream for several miles (Remick 1983). Henson (1965) referred to this meadow-like drainage as “Cienega Creek.” Remnant wetland species still remain in localized areas.

Figure 2.11 is an aerial photo from 1969 that shows the general appearance of the landscape looking north of Del Rio Springs. The cienega habitat surrounding the springs is evident in the lower right corner of the photo. A dark line formed by cottonwood trees on the right side of the photo running to the top third of the photo marks the location of Del Rio Creek. Sullivan Dam is visible as a white and dark patch in the uppermost area, and the Verde River is the dark line running to the east. A few young cottonwoods dot the area and are still present but in poor condition (fig. 2.12). Evidence of old cottonwoods is lacking for the area.

A primary source of seasonal overland flow to Sullivan Dam and the Verde River is from the Williamson Valley and the Big Chino Wash tributaries. These tributaries are located a few miles upstream to the west. The area is known for the large Big Chino aquifer that provides spring-fed sources to the Verde River (Wirt and Hjalmarson 2000; Blasch and others 2006). The valley is extensively farmed (fig. 2.13) with irrigation water originating subsurface from artesian water sources or pumped and distributed on the surface from shallow wells. Many locations retain a variety of sedges, rushes, and spikerushes.

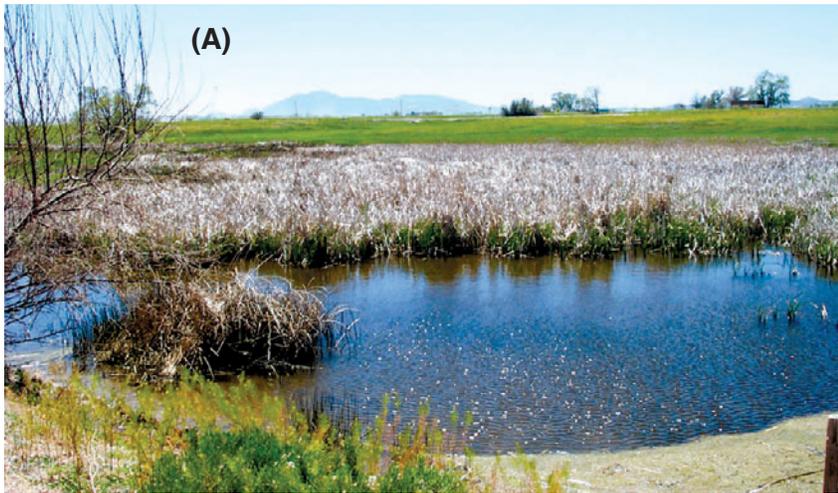


Figure 2.12—Ground view of Del Rio Springs showing riparian vegetation and the current condition of the cottonwoods seen in the aerial photo of fig. 2.10. The photos, taken on September 9, 2008, illustrate (A) the lack of woody plants around the wetland site of the springs, and (B) the condition of the cottonwoods. (Photos by Alvin L. Medina.)

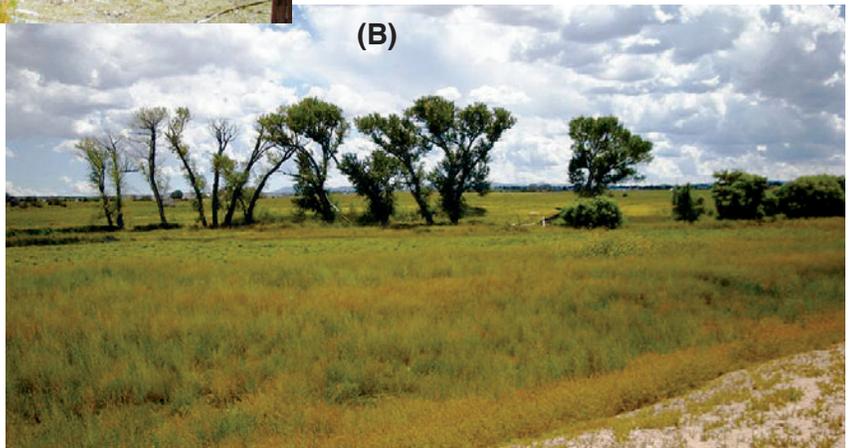


Figure 2.13—Aerial views of the Williamson Valley to the west of Sullivan Dam showing the agricultural area (Upper photo courtesy of the USDI Geological Survey; bottom photo by Michael Collier.)



Sullivan Dam—The City of Prescott acquired the land for the development of Sullivan Lake from the Santa Fe Railroad in 1935. Shortly thereafter, construction of the dam ensued and was completed in 1939 (figs. 2.14, 2.15, and 2.16). By 1942, the lake had become significantly filled in with fine-textured alluvial sediments, and its capacity to store water was minimal. Sullivan Lake still served as a recreational area and was apparently stocked with fish as late as 1950s (Wagner 1954). Sullivan Lake was described by Wagner (1954) as “a shallow muddy water body that, from a fisheries point of view, could best be described as nondescript bullhead hole.” With a maximum depth of 2.4 m (8 ft), the lake lacked any productivity for fish and was recommended to be managed for waterfowl (Wagner 1954). Woody vegetation was lacking about Del Rio Creek despite perennial flow as evidenced in fig. 2.15. The dam is presently private owned.

Flood flows in 1993 completely overtopped the Sullivan Dam and nearly filled the gorge downstream (fig. 2.17). The concrete seal around the wall and boulders from the wall was eroded by flood overwash from this event and several subsequent flood flows (fig. 2.18). Trees have sprouted within the exposed boulders of the wall, further compromising the structure. Future floods could breach Sullivan Dam and restore the natural stream gradient in the now intermittent portion of the UVR. This process would initiate downstream movement of sediments that have been trapped above the dam since 1939.

Figure 2.14—A 1936 photo showing the early construction phase of excavating basalt rock for the base of Sullivan Dam. Perennial flow from Del Rio Springs was routed through a sluice box visible on the right side of the rock cut. (Photo courtesy of the Sharlot Hall Museum, Prescott, Arizona.)



Figure 2.15—Photo from 1937 showing the building of the Sullivan Dam wall. Note the scarcity of woody plants and the additional seasonal flow—probably runoff from Big Chino Wash and baseflow from Del Rio Springs. (Photo courtesy of the Sharlot Hall Museum, Prescott, Arizona.)





Figure 2.16—A 1939 photo of Sullivan Dam taken shortly after the completion of the dam wall. (Photo courtesy of the Sharlot Hall Museum, Prescott, Arizona.)

Figure 2.17—Flood runoff from the February 1993 storms going over Sullivan Dam. The reddish, sediment-laden water is characteristic of the soils from the Big Chino Wash high in the watershed. (Photo by Alvin L. Medina.)



Figure 2.18—This 2011 photo illustrates the current condition of the Sullivan Dam wall and minimal water storage in the remnants of Sullivan Lake. (Photo by Alvin L. Medina.)

Granite Creek—A major tributary that affects the headwaters of the UVR is Granite Creek. The creek originates in the Bradshaw Mountains southwest of Prescott and flows north toward its confluence with the UVR east of Sullivan Lake. It is intermittent over much of its reach, and the braided channel system is the major source of bedload for the UVR headwaters during infrequent storm events (Wirt and Hjalmarson 2000; fig. 2.19). Sand and gravel mining occurs in several locations in the Granite Creek channel about 5 km (3 mi) downstream from the location shown in fig. 2.19 and within 3 km (2 mi) of Granite Creek’s confluence with the UVR.

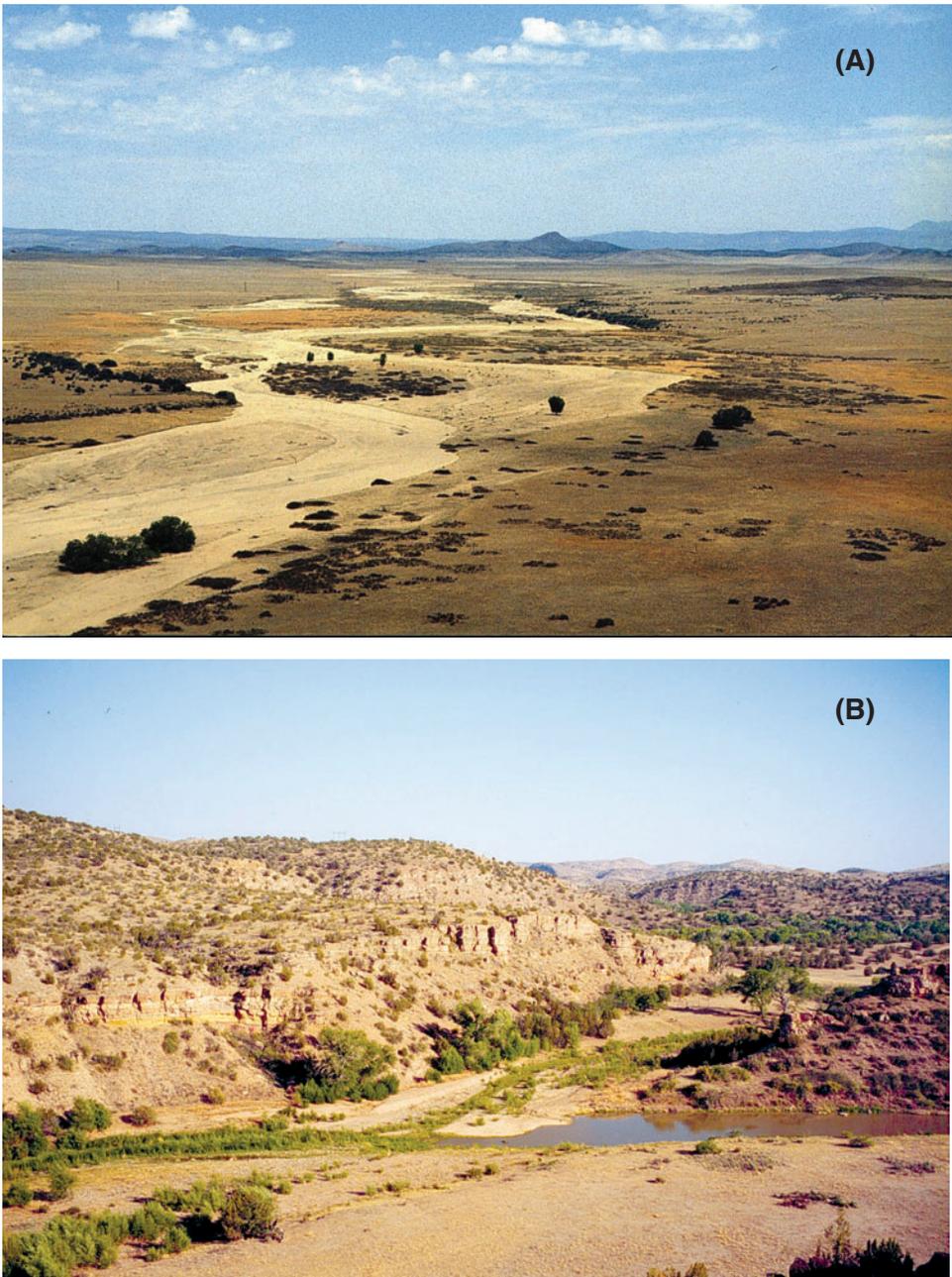


Figure 2.19—(A) aerial view of Granite Creek drainage in July 1997, looking north (downstream) towards the Verde River and (B) ground view of the confluence of Granite Creek (upper drainage) with the Verde River (flows right to left). The pool-like water feature in the lower right is referred to as Stillman Lake. The “lake” is formed by the sediment deposits at the confluence and the inflow from groundwater upstream. (Photos by Alvin L. Medina.)

Prescott National Forest Wetland—The boundary of the Prescott National Forest on the west is noted for the presence of a large historical wetland (fig. 2.5). The wetland was first confirmed in 1994 by the presence of hydric soil indicators (USDA Natural Resources Conservation Service 2006), and obligate wetland vegetation (i.e., sedges and rushes). The wetland was first photographed by Prescott National Forest staff in February 1979 (fig. 2.5A). The photo is notable because of the absence of woody plants along the channel. A photo from February 2001 (fig. 2.5B) shows the development of woody vegetation along the UVR due to stream incision that occurred during the 1993 flood. A June 1981 aerial photo (fig. 2.20) also shows the paucity of woody vegetation in contrast with the 2008 photo (fig. 2.21), which shows marked differences in woody plants and channel position.

In May 1979, Mr. James Cowlin provided ground views of the wetland (fig. 2.22A). The large tree on the upper left is a velvet ash with an understory of hackberry. Other important channel features in the 1979 photo are depth to water from the first terrace (right bank, 30 to 60 cm or 1 to 2 ft), channel width of about 3 m (9.8 ft), sand and gravel substrates, a gradient of <.01%, and pool-riffle sequences. A repeat photograph of same location in May of 2008 shows development of much different habitat conditions, with extensive growth of woody plants and cattails (fig. 2.22B). These vegetation changes have encouraged beaver to build dams on the floodplain (fig. 2.23) that have induced hydrologic and vegetation changes and created much different wetland habitats.

Figure 2.20—1981 aerial photo of the Prescott National Forest wetland showing locations of aquatic sites as dark blotches. The view is northerly with flow from bottom left to upper right. (Photo courtesy of the U.S. Geological Survey, Photo #503-30 6-6-1981.)



Figure 2.21—2008 aerial photo of the Prescott National Forest wetland contrasting woody vegetation and channel position changes since 1981 (Google, October 2008).

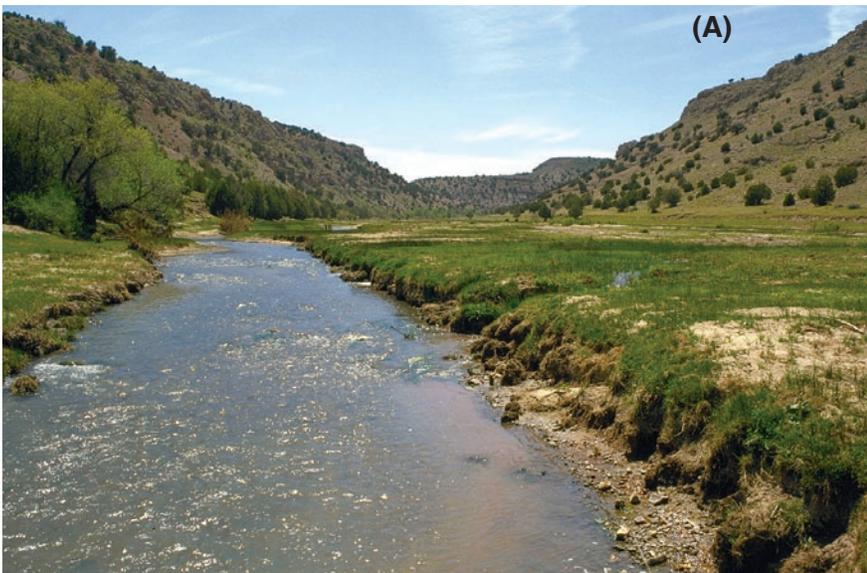


Figure 2.22—A May 1979 photo (A) showing the upstream view of the UVR wetland. (Photo by James Cowlin.) A May 2008 repeat photo (B) near the location of the 1979 photo showing occupation of mixed stands of the first terrace by cattails, cottonwoods, and willows. (Photo by Alvin L. Medina.)

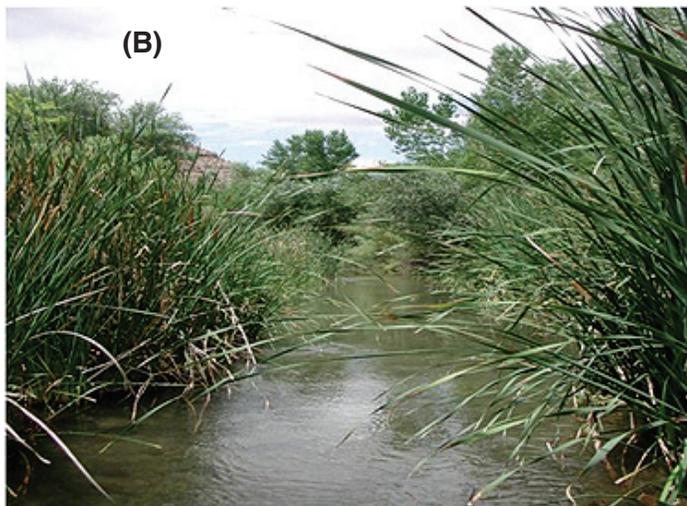


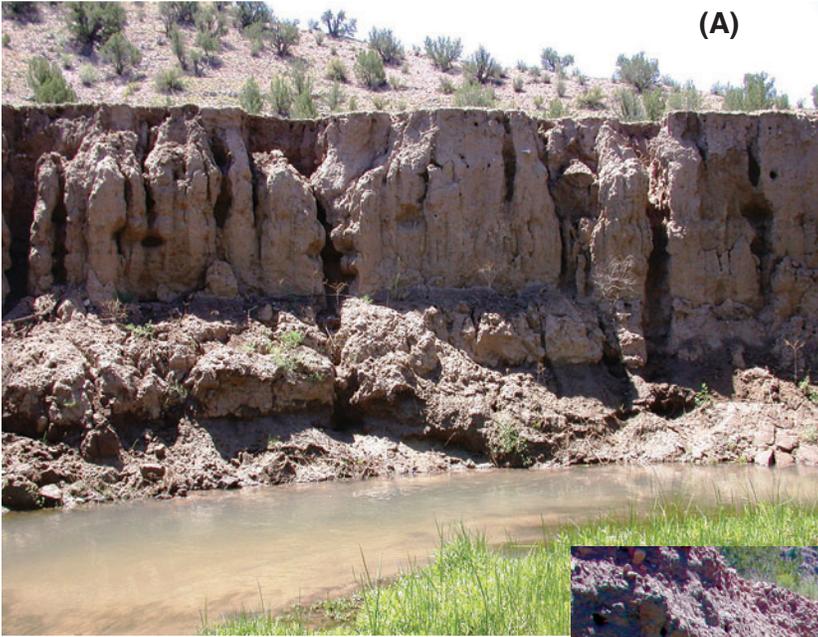
Figure 2.23—Lodge in a pool formed by beaver dam construction along the UVR near the Prescott National Forest wetland. (Photo by Daniel G. Neary.)



Channel Incisions—Concomitant with these changes are evidences of erosion of paleo and historical terraces as well as the modern floodplain (figs. 2.24 and 2.25). Eroded sediments wash downstream, spiraling through the aquatic system, causing a gray-green color of the water and impairing water quality for turbidity. This process is common throughout the length of the UVR.

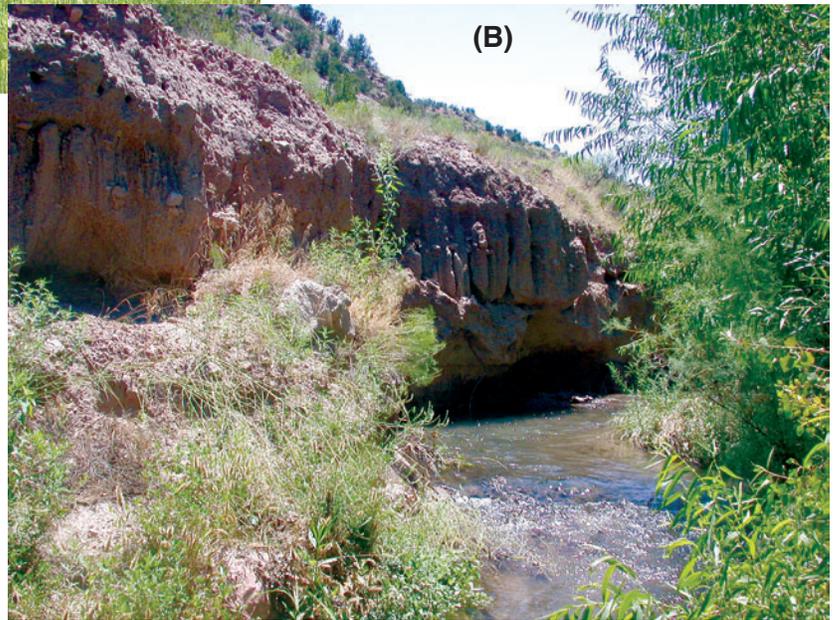
Terraces located above the wetland provide dramatic documentation of channel downcutting. The terrace in fig. 2.24 is about 5 m (16.4 ft) in height from the terrace level to the channel bottom. It is one of the paleoterraces documented by Cook and others (2010a, 2010b, 2010c) that date from A.D. 440 to 1650 and are composed of fairly uniform fine sediments (fine sands and silts). These terraces are major point sources of fine sediment for the UVR. Sediments are dropped into the river periodically during baseflows by bank sloughing (see fig. 2.24 center and fig. 2.25 lower left). During high flow events, large pieces of the terrace are frequently eroded. Most first terraces along the UVR are much lower in height (figs. 2.22 and 2.26). These terraces still contribute to the load of fine sediment in the UVR by bank collapse, but they do not match the magnitude of inputs from the large paleoterraces. Likewise, many small tributaries also contribute large amounts of bedload and fine sediments as they continue to headcut upstream as part of the adjustment to incision of the river (fig. 2.26).

Field documentation dates nearly all of the terrace erosions to 1993. The 1993 floods initiated the erosion of several paleoterraces throughout the length of the UVR. These terraces are a principal source of continued fine-grained sediment inputs and stream turbidity. The 1993 flood also caused the main channel to drop, thereby setting in motion the degradation of tributaries. An assessment conducted by Prescott National Forest and RMRS staff of post-flood conditions in spring and summer of 1993 identified countless tributaries in a “hanging” condition. Since 1993, these tributaries continue to adjust to the grade of the main stem by sloughing fine sediments. Grade adjustments up the UVR channel system are not yet complete on many tributaries and draws (fig. 2.25). Channel incisions of tributaries are another principal source of fine sediments to the UVR, and are commonly attributed erroneously to other land uses, e.g., grazing.



(A)

Figure 2.24—Photos A and B show typical paleoterraces located slightly upstream of the Prescott National Forest wetland. Rapid terrace erosion was initiated in 1993 and is now a major source of fine sediment. B is located downstream of the paleoterrace in A, showing active erosion of the terrace and the presence of tamarisk, Gooding willow, and assorted herbaceous weeds. (Photo by Alvin L. Medina.)



(B)



Figure 2.25—This tributary, located near Al's Spring, depicts the typical case of headcutting for many tributaries. (Photo by Alvin L. Medina.)

Figure 2.26—Example of smaller first terraces resulting from channel incision on the UVR. (Photo by Alvin L. Medina.)

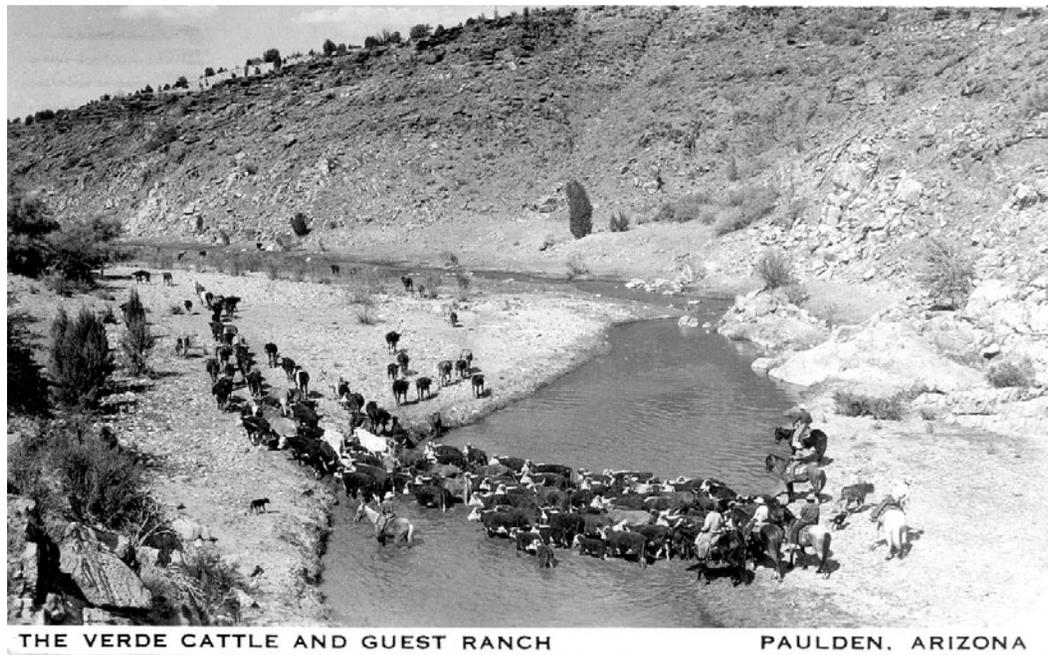


Verde Ranch

A number of photos and other records exist from the Verde River Ranch below the USDI Geological Survey Paulden stream gauge. The UVR has been important for the cattle raising operation at the ranch because it supplies water and supports forage growth during dry periods. Cattle grazing was certainly heavier in the 1950s (fig. 2.27), but vegetation was very sparse on steeper slopes that would not be grazed at all. The dark trees are juniper and lighter colored woody plants are upland shrubs. Other light colored shrubs on the floodplain, aligned linearly, are most likely seepwillow. Figure 2.28 shows the Ranch headquarters at the present time with a clearly defined riparian zone. The area shown in this figure contains some of the rarer E-type channels (Rosgen 1996).

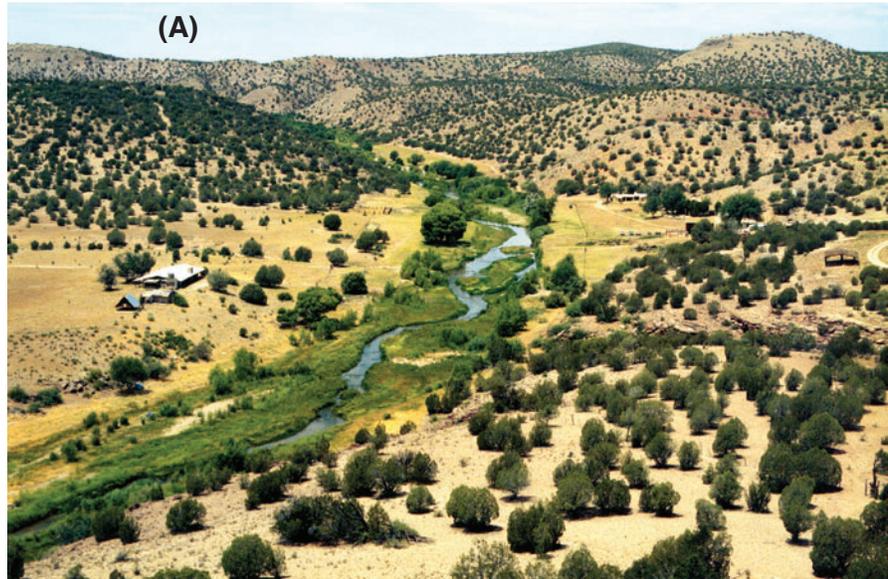
Figure 2.29 is an example of one of the few remaining historic wetland habitats in excellent condition. Where woody plants have encroached on streambanks, erosion around their trunks has created stream nick points and has generally destabilized the site. The streambanks shown in fig. 2.30 are occupied primarily by bulrushes, sedges, and rushes. These plant species are superior for stabilizing streambanks and dealing with the brutal impacts of episodic flood events. Woody species in close proximity to channels are often damaged or ripped out by episodic flood flows of the magnitudes experienced on the UVR. Figure 2.31 illustrates post-flood recovery by herbaceous plants adjacent to the stream channel. Herbaceous species have recovered well. The tree visible in the left side (fig. 2.31A) is the sprouting stump on the left side of fig. 2.31B. Note that no woody species recruits are visible in the 2003 photo. A similar trend is visible at another location on the Verde River Ranch (fig. 2.32). Recovery by herbaceous vegetation at an additional site was fairly swift two years after the 1993 flood (fig. 2.33A), and the site was still dominated by herbaceous vegetation on the 10th anniversary of the flood (fig. 2.33B).

Figure 2.27—Cattle drive in 1946 on the Verde River Ranch and an illustration of the riparian vegetation and geomorphological conditions at the time. (Photo courtesy of the Sharlot Hall Museum, Prescott, Arizona.)

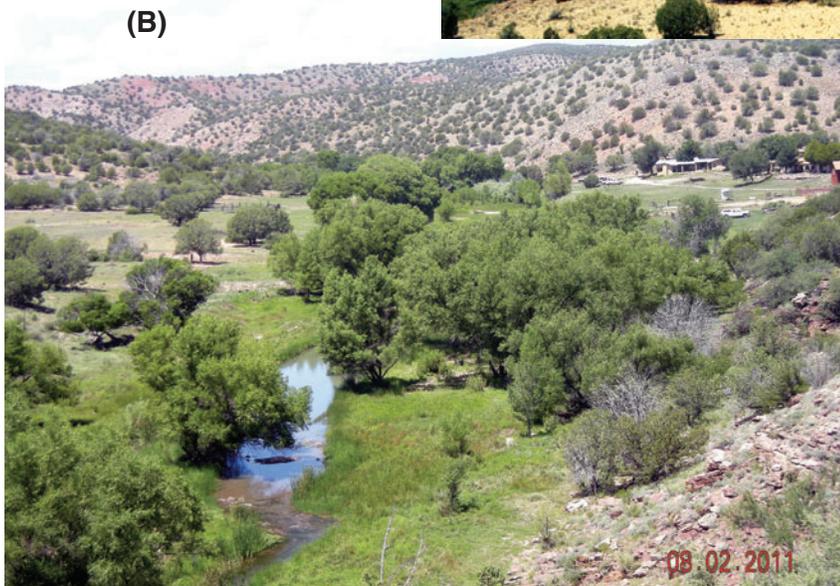


THE VERDE CATTLE AND GUEST RANCH

PAULDEN, ARIZONA



(A)



(B)

08.02.2011

Figure 2.28—Photo A is an aerial view of the Verde River Ranch headquarters below the U.S. Geological Survey’s Paulden gauge in March 1997. The wetlands, intact for many decades, provide a valuable reference of wetland habitats of time past. These wetlands have recently been at risk of channel erosion from encroachment of woody plants. Photo B, taken in July 2011, shows some changes in woody vegetation after selective removal of several cottonwoods from the active floodplain. Removal of cottonwoods restored the freeboard needed by flood waters to flow without inducing erosion of the wetland. (Photos by Alvin L. Medina.)

Figure 2.29—Wetland site with an E-type channel on the UVR located on the Verde River Ranch headquarters, downstream of the Paulden gauge. These sedge meadows were prevalent throughout the UVR corridor prior to woody plant encroachment. (Photo by Alvin L. Medina.)

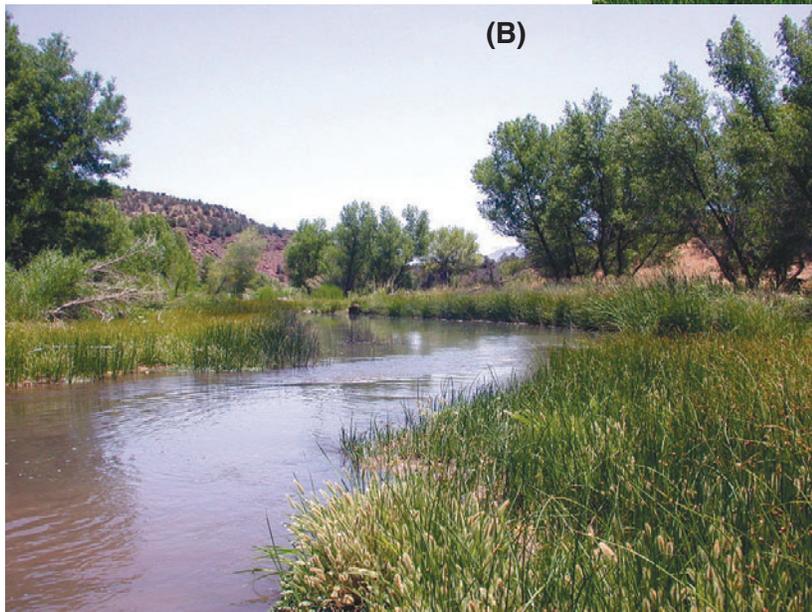
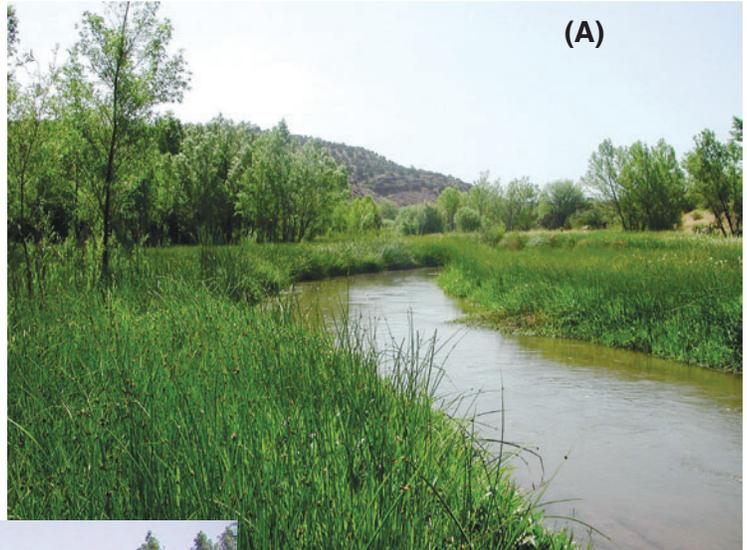


Figure 2.30—This wetland site on the Verde River Ranch referred to as “Little Slice of Heaven” because of its excellent wetland habitat condition. Several species of sedges, rushes, and spikerushes inhabit the streambanks and floodplain. (Photo by Alvin L. Medina.)

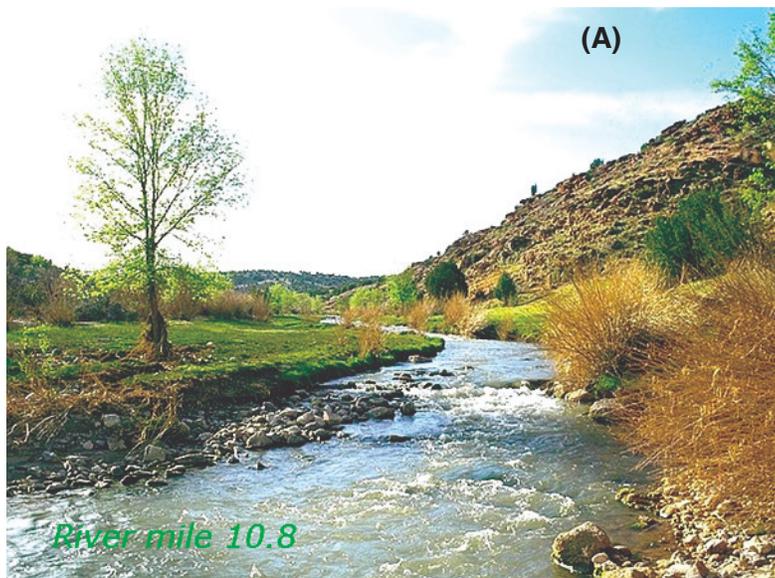


Figure 2.31—Comparison of UVR vegetation next to the channel a decade before (A: 1979) and after (B: 2003) the 1993 floods, Verde River Ranch. (Photo A by James Cowlin and photo B by Alvin L. Medina.)

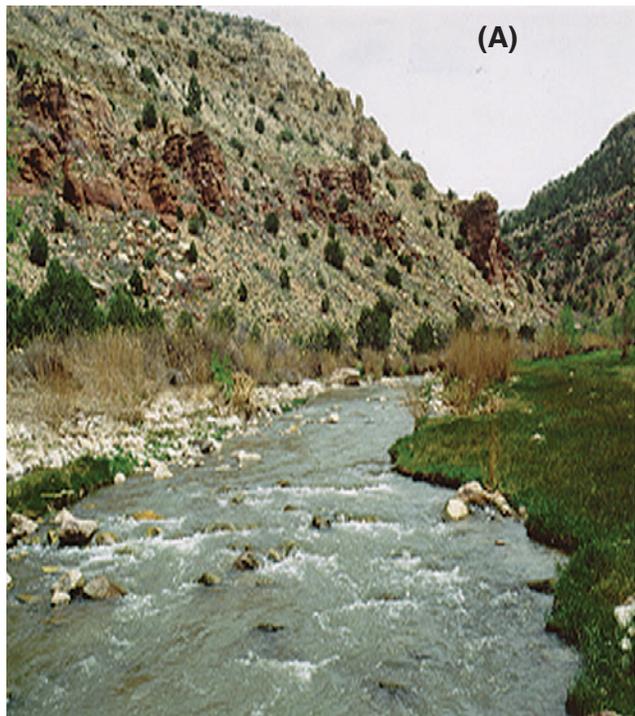
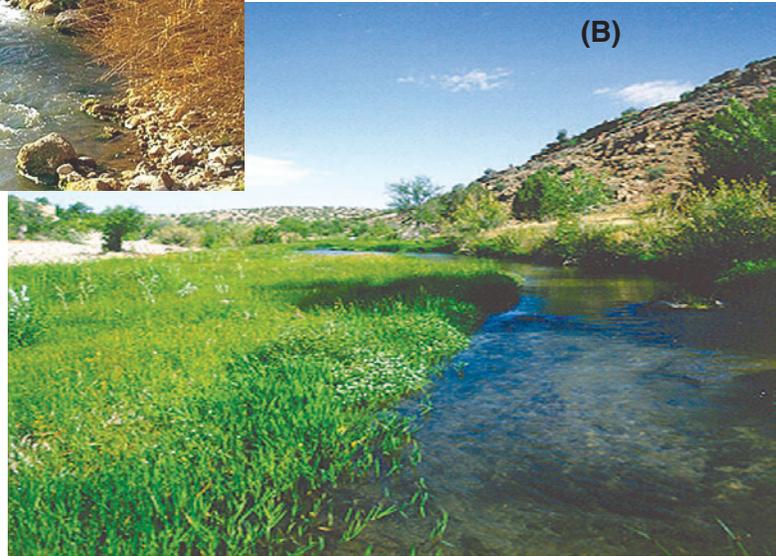


Figure 2.32—UVR vegetation recovery and channel narrowing and deepening at a second site a decade before (A: 1979) and after (B: 2003) the 1993 floods, Verde River Ranch. (Photos by James Cowlin and Alvin L. Medina.)



Figure 2.33—Herbaceous recovery
(A) 2 years and (B) 10 years
after the 1993 flood on the UVR.
(Photos by Alvin L. Medina.)

Bear Siding

Bear Siding has one of the long-term fish sampling locations discussed in Chapter 9. The photo from 1979 (fig. 2.34) shows a fairly sparse riparian vegetation community even before the 1993 flood. The flood of that year scoured the riparian zone even more. By 1998, in the absence of any large floods and shortly after grazing removal in 1997, a more substantial riparian flora had re-established itself (fig. 2.35).

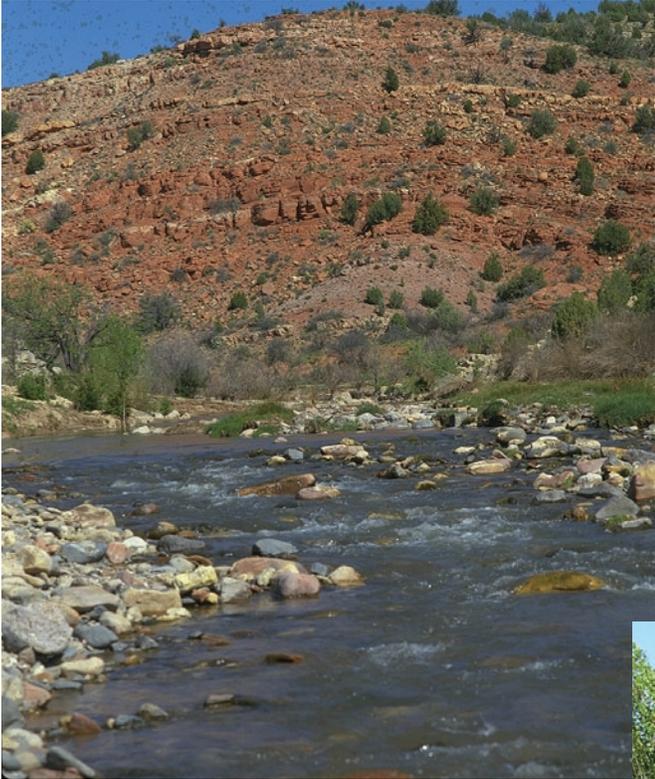


Figure 2.34—Photo of a fish study site at Bear Siding in May 1979. Note the vegetation, water color, channel substrates, and streambank conditions. The aquatic habitat is characterized as a typical C-3 type channel with interspersed riffles throughout the reach. (Photo by James Cowlin.)

Figure 2.35—Repeat photography of fig. 2.34 taken in February 1998. The exact location is inaccessible due to trees and deep water that obscure the view. Note the vegetative growth of nonnative plants, cattails, and tamarisk (right bank) on the active floodplain. The water is notably turbid, a gray-green color, and much different from the 1979 photo. The aquatic habitat consists of turbid, deep pools flanked by woody vegetation. The channel type is a C-6 with submerged riffles forming a glide-pool habitat. (Photo by Alvin L. Medina.)



Perkinsville

Perkinsville is one of the open valley bottoms in the UVR with bedrock constrained canyon sections above and below it. This area was a site of an early settlement with the establishment of the Perkins Ranch in 1900 and the construction of the Santa Fe Railway's Clarkdale to Drake spur line. This railway line is still operated by the Verde River Railroad. Note in the 1925 photo (fig. 2.36) the pinyon and juniper trees in the area are not very tall or vigorous. The riparian area is mostly free of vegetation except for the band of cottonwoods on the inside of the bend in the UVR at mid-photo. These most likely survived the paleofloods of 1891 and early 1900s and some may have been planted by the Perkins family or allowed to establish along newly constructed irrigation ditches (fig. 2.36) at the beginning of the Twentieth Century. Twenty-two years later, fig. 2.37 shows evidence of better plant growth due to wetter conditions in the latter part of the Century. By 1995, woody vegetation had expanded considerably on slopes adjacent to the UVR as well as along the channel (fig. 2.38). Another photo from 1925 shows the generally dry conditions and the sparseness of vegetation (fig. 2.39). Episodic floods kept the riverbanks scoured of vegetation (fig. 2.40). The trees that were present then were located back on second and third terraces, indicating the powerful effects of floods on woody vegetation (fig. 2.41). A repeat photograph of fig. 2.41 from 2003 shows that 78 years has resulted in a much expanded woody vegetation complex along the UVR channel, a narrower channel system, and greatly enhanced pinyon pine and juniper vegetation on the uplands (fig. 2.42). Most of the sediments in the channel are coarse gravels, cobbles, and boulders. There is no evidence of large amounts of fine sediments, which would be indicative of wide-scale and intensive erosion in the uplands.

At the downstream edge of the Perkinsville valley area is the "Black Bridge" on the Verde River Railroad (fig. 2.43) where the UVR goes into another canyon-bound reach. The channel appears to be in the same position in 2003 (fig. 2.43B) as it was in 1910 due to the influence of the solid rock wall which causes flow to divert toward the bridge. The point bar on the left seems to have the same coarse sediment composition although there is much more evidence of woody species recruitment on the bar and channel edges. The 2003 photograph indicates a greater clearance beneath the bridge than the photograph taken just after construction of the railroad in 1910. This could be evidence of channel down-cutting in the interim or movement of large amounts of channel sediments. The photo from 1910 shows that there was virtually no riparian gallery forest or other woody species before the railroad arrived (fig. 2.43A). The lack of trees could be due to a variety of causes, including scouring floods; drought; long-term use by Native Americans; or early European settler use of wood for buildings, fences, and firewood. Grazing was probably not the cause or there would be larger trees evident on the landscape. Grazing animals introduced into an area usually affect only seedlings or saplings.

Figure 2.36—A 1925 photo illustrating UVR riverine and upland conditions in the Perkinsville area. (Photo by Matt Tully.)



Figure 2.37—A 1947 photograph that depicts major changes in vegetation density and composition at Perkinsville since 1925. (Photo by R. King, U.S. Forest Service, Prescott National Forest, Photo #446116.)



Figure 2.38— This is a 2008 repeat photo of fig. 2.37. Cottonwoods established along old channels, but the floodplain is generally devoid of woody species, which are washed away by recurring floods. (Photo by Alvin L. Medina.)

Figure 2.39—A 1925 photo of the Perkinsville area illustrating the drought conditions of the time. Of special significance is the absence of obligate riparian trees and shrubs. Two clusters of very large cottonwoods are evident survivors of paleofloods. Other woody vegetation are facultative upland species, e.g., mesquite. (Photo courtesy of the Sharlot Hall Museum, Prescott, Arizona.)



Figure 2.40—A 1925 photo showing the magnitude of seasonal floods on the UVR at Perkinsville. (Photo courtesy of the Sharlot Hall Museum, Prescott, Arizona.)



Figure 2.41—A 1925 photograph of the Perkinsville area looking northwest along the Santa Fe Railroad (Verde River Railroad) toward the Station (light colored buildings in the upper right quadrant). (Photo courtesy of the Sharlot Hall Museum, Prescott, Arizona.)



Figure 2.42—A 2003 repeat photograph of the 1925 photograph (fig 2.41) of the Perkinsville area looking northwest along the Santa Fe Railroad (Verde River Railroad) toward the Station (light colored buildings in the upper right quadrant). Cottonwoods have established along old channels. This river segment of private land still remains a refuge for native minnows. (Photo by Alvin L. Medina.)



Figure 2.43—The “Black Bridge” on the Verde River Railroad downstream of Perkinsville. The photographs are from (A) 1910 and (B) 2003. (Photo A courtesy of the Sharlot Hall Museum, Prescott, Arizona; photo B by Alvin. L. Medina.)

Horseshoe Allotment

The Horseshoe Allotment is the grazing allotment that includes the Black Bridge and the south side of the downstream reach of the UVR for several kilometers. Figure 2.44A shows the condition of the UVR below the “Black Bridge” in 1925. The railroad runs along the right bank towards its terminus at Clarkdale. The repeat photo from 2003 highlights the stands of cottonwoods and willows, which have developed since the 1993 flood (fig. 2.44B). It also shows more extensive juniper growth along the UVR riparian margins and on adjacent slopes.

Figures 2.45 and 2.46 show a section of UVR channel in the Horseshoe Allotment demonstrating the scoured condition of the river bed after the 1993 flood. The subsequent photograph in 1999 shows the dense vegetation that developed in the years after the significant 1993 flood. That part of the UVR is now difficult to negotiate because of the woody and herbaceous plant growth. An additional series of photographs (figs. 2.47 to 2.49) documents vegetation changes in the UVR channel in the Horseshoe Allotment from 1994 to 1998. The distinctive mid-channel rock was

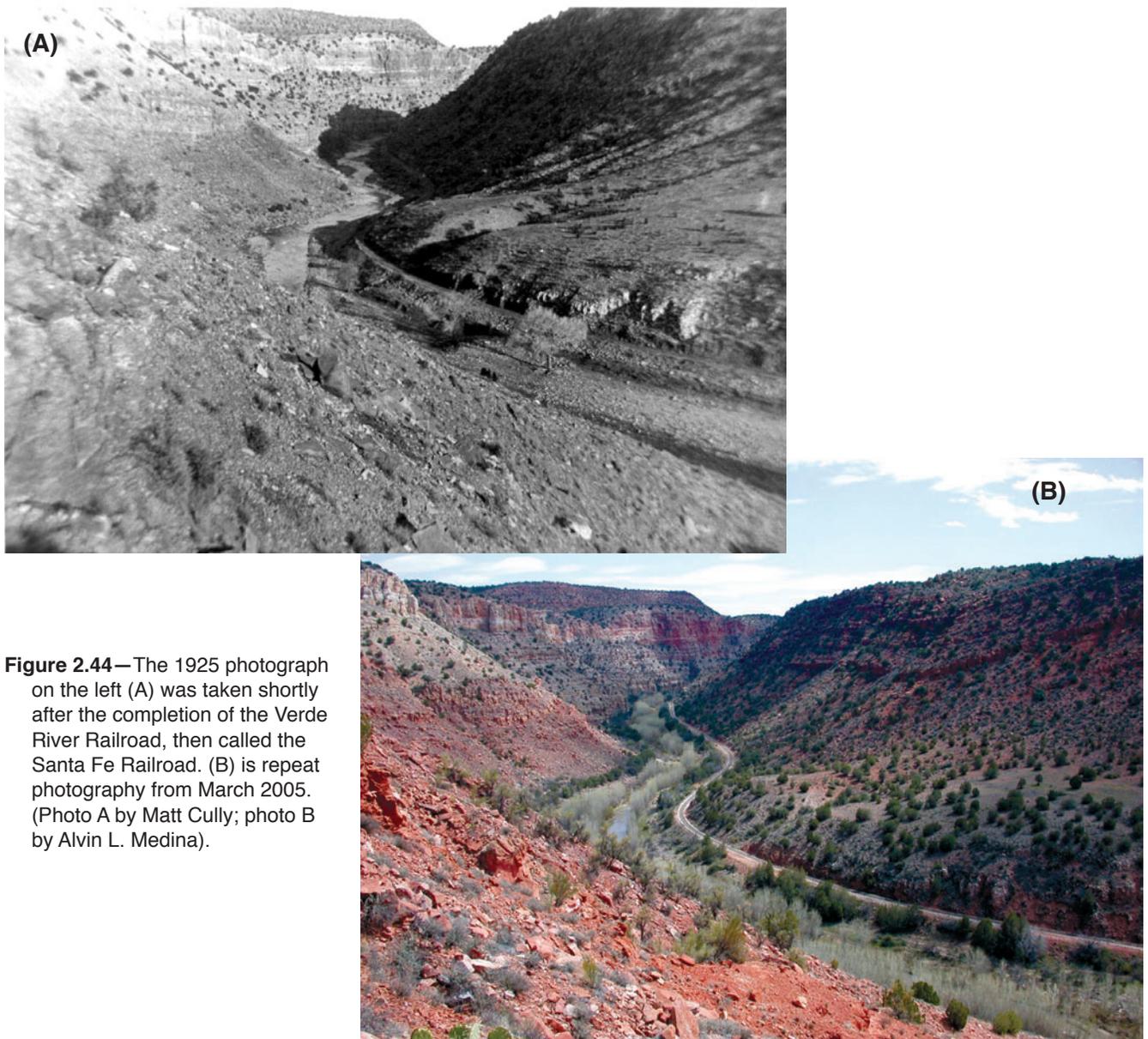


Figure 2.44—The 1925 photograph on the left (A) was taken shortly after the completion of the Verde River Railroad, then called the Santa Fe Railroad. (B) is repeat photography from March 2005. (Photo A by Matt Cully; photo B by Alvin L. Medina).

used as a reference point. The photo-series also shows how the UVR channel has narrowed and deepened.

One of the consequences of woody vegetation encroachment on the UVR channel is the formation of woody debris dams. Figure 2.50 shows young sycamore trees that were uprooted by a minor flood in 2005. These stems can be easily piled up by subsequent flood flows, creating a debris jam in the river. This process creates a risk of a debris dam backing up streamflow and then breaching during a flood event, creating a much elevated peakflow. Debris dam breach flows have a much greater impact on channel morphology and downstream structures like irrigation diversions, bridges, and residences (Cenderelli 2000; Ice and others 2004).



Figure 2.45—UVR channel in the Horseshoe Allotment after the 1993 flood. (Photo by Sharon and George Yard.)



Figure 2.46—UVR channel conditions near the area shown in fig. 2.44 in the Horseshoe Allotment in 1999, six years after the 1993 flood. (Photo by Sharon and George Yard.)



Figure 2.47—The “Otter Rock” in the UVR channel in the Horseshoe Allotment in 1994, one year after the large 1993 flood. (Photo by Sharon and George Yard.)



Figure 2.48—The “Otter Rock” in the UVR channel in the Horseshoe Allotment in 1996, three years after the large 1993 flood. (Photo by Sharon and George Yard.)



Figure 2.49—The “Otter Rock” in the UVR channel in the Horseshoe Allotment in 1998, five years after the large 1993 flood. (Photo by Alvin L. Medina).

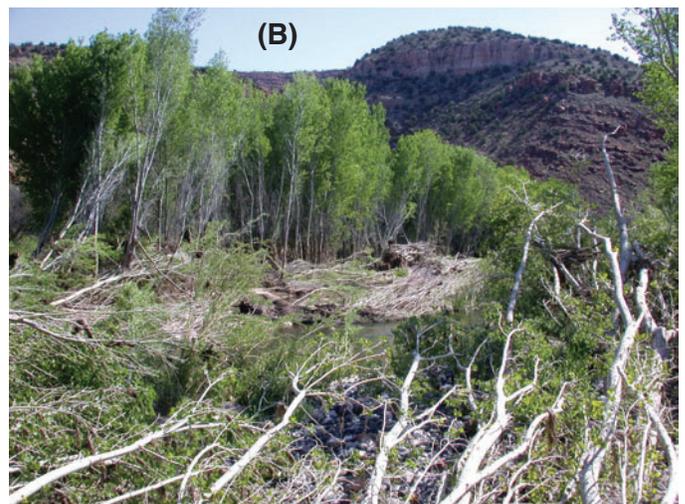


Figure 2.50—Photo A taken in July 2000 upstream of the otter rock site shows an established grove of cottonwoods and coyote willows, which were planted by the Y-D Ranch in 1994. Photo B, taken in July 2005 after a major flood, shows uprooted trees throughout the reach. Willows were also up-rooted and washed away into debris piles. (Photos by Alvin L. Medina.)

Antelope Hills Allotment and Sycamore Canyon

A set of photographs from the Antelope Hills Allotment further down the UVR demonstrates the changes that occur in river sediments and geomorphology with flood events. Figure 2.51A shows a straight reach of the UVR in 1979 that was characterized by shallow water and gravel and cobble bedload materials. It was a very long riffle reach. During the 1993 flood, this reach was scoured out and deepened. Now it is a deepened pool dominated by fine-textured sediments (fig. 2.51B). In addition, the riparian vegetation has changed completely in the 27 years separating the photos. These photographs indicate the high degree of dynamics of the river in changing both aquatic habitats and riparian vegetation.

A section of the UVR just above the confluence with Sycamore Creek also demonstrates the dynamic nature of the UVR. The reach in fig. 2.51A in 1979 was dominated by gravel and cobble bars. The river meandered through these deposits in a series of glides, runs, and riffles. During the 1993 flood, this reach was scoured out into a big, deep (2 to 3 m or 6 to 10 ft) pool, but it still contained a substantial amount of gravel-sized particles. By 1996, this section was completely filled in with sand-sized and finer sediments (fig. 2.51B). Figures 2.52 and 2.53 show the type of gravel bars and channel substrates that are left in the channel after flood events. In the absence of floods, these coarse sediments become embedded in fine-textured sediments and lose their habitat value to native fishes.

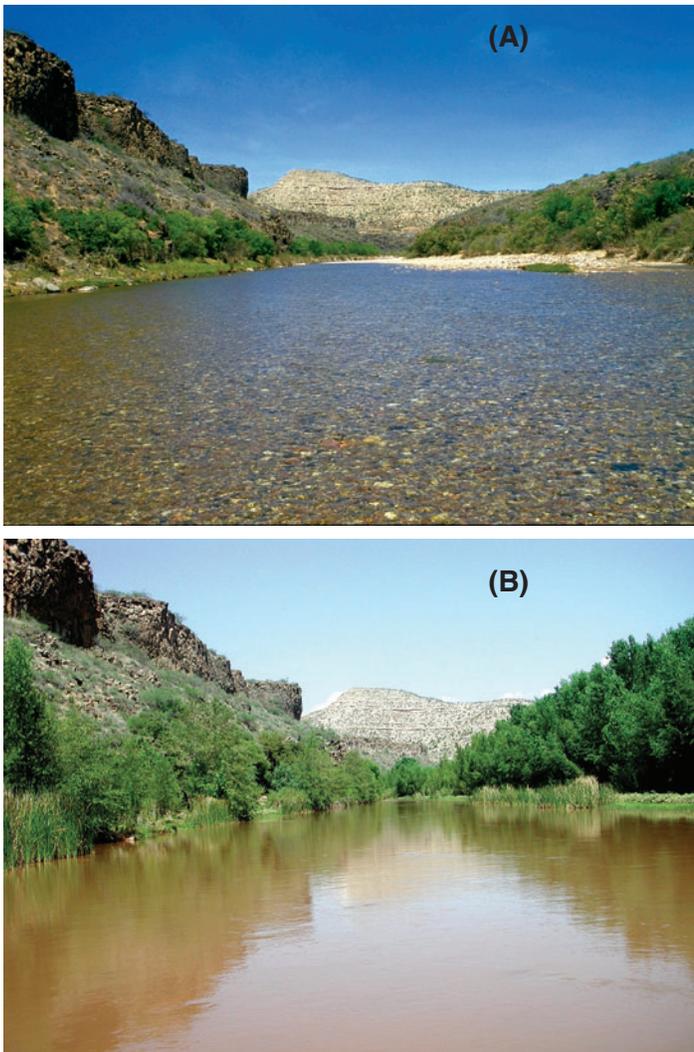


Figure 2.51—(A) 1979 photo of the UVR in the Antelope Hills Allotment, and (B) the same site in 2009. (Photo A by James Cowlin; photo B by Alvin L. Medina.)

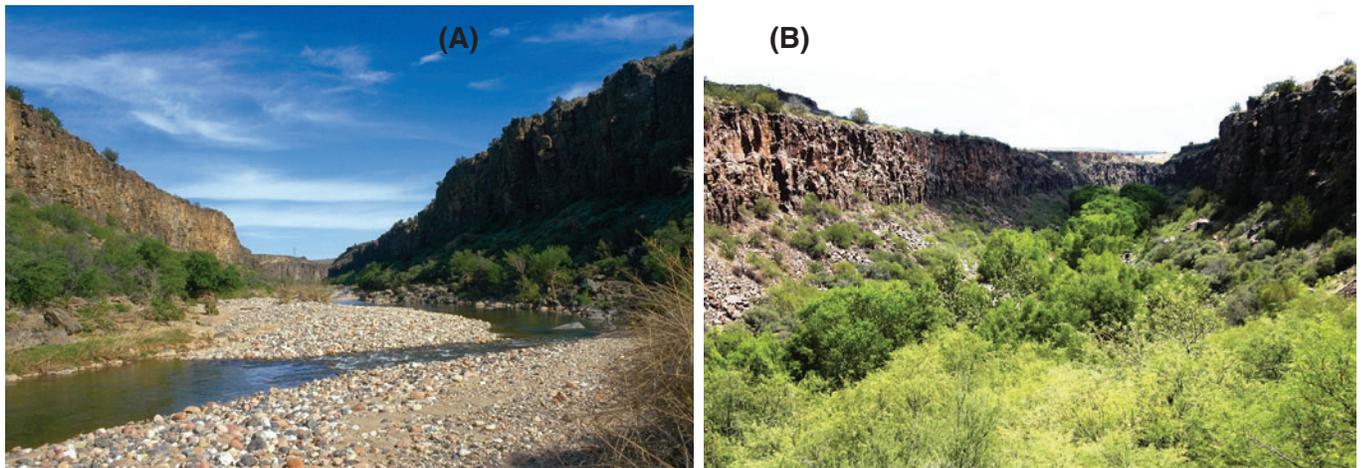


Figure 2.52—UVR below Sycamore Canyon at the Clarkdale gauging station in (A) 1979 and (B) 2005. The exact photo location in B is obscured by woody vegetation requiring an oblique aerial view of the canyon. The channel conditions are much different from the pool-riffle habitats shown in A. These have been replaced by deep glides, with submerged riffles and the channel winds about the maze of trees. (Photo A by James Cowlin; photo B by Alvin L. Medina).

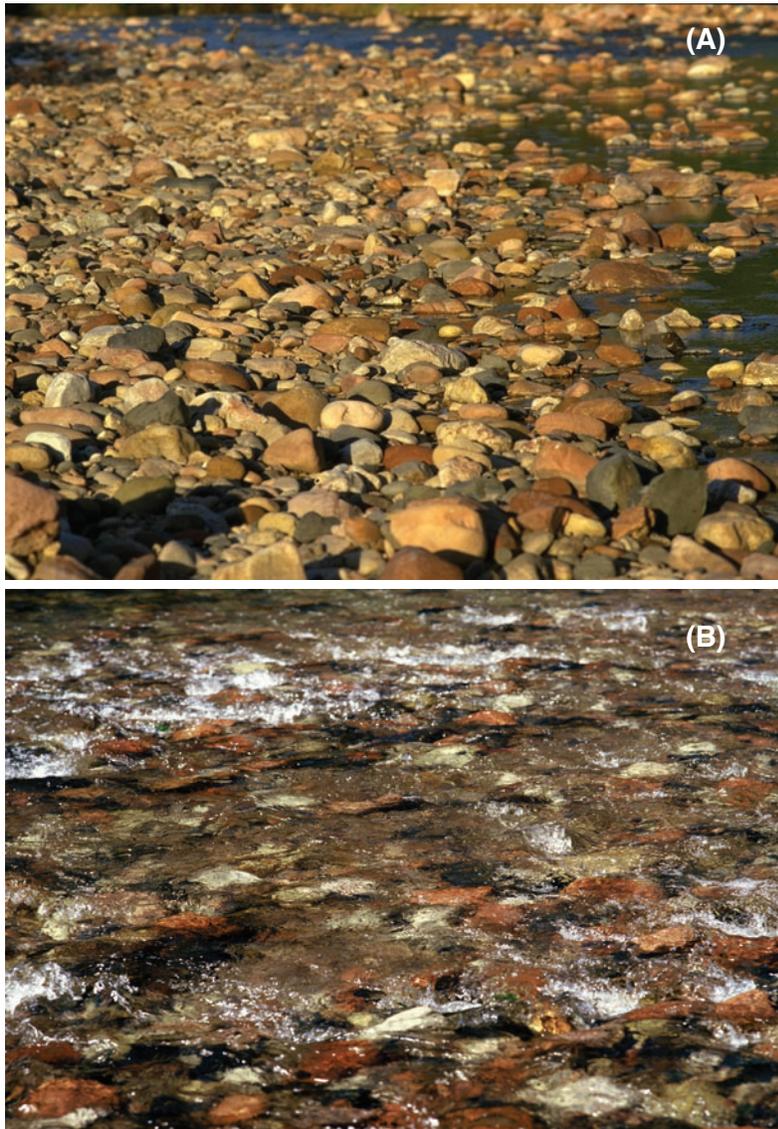


Figure 2.53—Photos of coarse cobble substrates (A) near Sycamore Canyon. These stream habitat conditions are favored by native fishes. Photo B is a reference condition for the reach in 1979, which is much different from the present. (Photos by James Cowlin).

Discussion

Vegetation Changes

Vegetation in the riparian zone of the UVR has gone through considerable change since the earliest photos from 1910. The riparian habitats are dynamic and will continue to change with future disturbances. Photographs highlight the cycle of scour and revegetation going on in the UVR's riparian zones. It is evident that climate-related events are the main drivers of vegetation dynamics, but human activities have also contributed to the changes that have been observed in the river over the past century. Cumulative and sequential effects of Sullivan Dam since 1939 on the channel dynamics that subsequently changed channel conditions, which led to changes in vegetation communities. Patterns of grazing, largely unknown, over 100+ years and recent changes to zero grazing have affected the sustainability, composition, and succession of plant communities. Major changes in recreation, e.g., from open access throughout the corridor to limited access, have further affected how the river functions and changes. Lack of information about how to manage riparian vegetation has largely resulted in a conservative approach to historical uses. In short, the vegetation of the Verde River is much different in composition, structure, and diversity than it was 100, 50 and 25 years ago, as evidenced on other Southwestern streams (Webb and others 2007). Chapters 6 and 7 of this volume present assessments of the current status of UVR riparian vegetation and will facilitate future research efforts. Of significance is how vegetation has changed over time and spatially in response to disturbance from hydrologic factors, such as Sullivan Dam. These hydrologic changes undoubtedly had direct and indirect effects on aquatic habitats and fish. The exact processes remain to be defined.

UVR Hydrologic Changes

The wet and dry cycles of the Southwest have strong influences on the geomorphology, hydrology, and ecology of the region's rivers (Grissino-Mayer 1996). Past climates have been dominated by these oscillations and future climates certainly will be affected as well (Ely 1997). There is evidence that the Holocene epoch prior to European settlement was marked by a larger quantity and intensity of flood events than has been observed in the UVR in recent years. These events significantly affected the geomorphology and vegetation conditions of the UVR. As noted above, the effects of Sullivan Dam have cumulatively affected many other physical and biological components of the UVR ecosystem.

Ecological Changes and the UVR

Numerous hypotheses have been proposed about the relationships among UVR hydrological and ecological processes, current watershed condition, land management practices, and aquatic fauna (Haney and others 2008). Understanding these processes in their paleo, historic, and modern time frames is important for determining their impact on the UVR biological system. An intellectual evolution is required to avoid assigning cause-and-effect relations to only currently visible land management activities. Some processes that have been going on for thousands of years are still affecting the UVR (flooding, drought, arroyo cutting, vegetation changes, landscape-level erosion, etc.) and others are not. Human activities such

as exotic species introductions, groundwater pumping, irrigation diversions, live-stock management, and mining can produce effects as profound as, greater than, or much less than natural processes.

The following chapters deal with the topics of hydrology, channel morphology, watershed condition, woody vegetation, herbaceous vegetation, water quality, and fish fauna. Some of the questions that should be considered when reading through this report are:

- Is the current watershed condition of the UVR the result of Twentieth Century land management or long-term geologic processes?
- Is arroyo and gully cutting a modern problem or one that goes back well into the Pleistocene epoch?
- What is the role of paleofloods in channel geomorphic evolution and erosion processes?
- Are gallery woody forests in the riparian zone the natural vegetation form or just an artifact between destructive floods?
- Is there evidence of landscape-scale erosion that affects the productivity and sustainability of the native UVR ecosystems?
- What roles do invasive plants and aquatic fauna play in the ecology of the UVR?
- How have changes in the hydrologic equilibrium affected channel stability, vegetation, and aquatic habitats?

Management Implications

This chapter provided historical and geophysical perspectives on the UVR. The current vegetation conditions on the river are the result of pre-European stream-flows, past and present climate, a century of cattle grazing, and current land management activities. Paleofloods and droughts had far greater impacts on the riparian vegetation and channel geomorphology, as noted in other rivers of the Southwest (Webb and others 2007). Without the context of pre-Twentieth Century impacts on the river, it is too easy to attribute the currently visible conditions of the UVR to modern activities. All of the natural processes and management activities need to be considered holistically before making conclusions about current and future land uses and management activities. From the historical analysis presented here, it is apparent that the UVR has been impacted to a larger extent and intensity by hydrologic and erosion events that pre-dated modern land management. The interactions of the UVR and its surrounding landscape are far more complex than they appear at first glance. Simple cause-and-effect assumptions by land managers and technical staff should be avoided. Likewise, extrapolation of research or management results from other ecosystems or regions should be done with caution and knowledge of the risks of unintended consequences. However, Best Management Practices should always be employed to ensure the sustainability of both the river and upland ecosystems.

Summary and Conclusions

Repeat photography was used to display the vivid texture of the UVR's vegetation, channel, and valley landscapes and to contrast the historical and current

conditions. These contrasts are interpreted within the context of plant ecology and hydrogeomorphology to provide a comprehensive understanding of the changes that have occurred in the past century. In some cases, additional photographs provide greater breadth for understanding the larger perspective of the area and its habitats. A principal objective is to provide a broad understanding of historical influences that is necessary to comprehend the various physical and biological processes that govern present-day conditions on the UVR. Climate and land uses undoubtedly have affected the streamflow and sediment regimes, which, in turn, influence such factors as riparian vegetation and aquatic wildlife. Paleo-reconstruction studies of historical environmental conditions are utilized to put forward alternative descriptions of the Verde River for the period of record (1890 to present). Paleoecological data are useful for discriminating environmental changes between natural and cultural influences (Swetnam and others 1999). The introduction of livestock circa 1890 is an important event that is often cited as crucially influential on present-day conditions. However, many descriptions have been extrapolated from general sources that did not recognize climatic conditions during this period that may have long-lasting consequences on the evolution of riparian and aquatic habitats in the UVR. Vegetation descriptions are consistent with Webb and others (2007) with respect to historical changes and current dominance by woody vegetation.