## Chapter 11

# Summary and Conclusions

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## Introduction

Summaries and conclusions of each chapter are compiled here to provide a "Quick Reference" guide of major results and recommendations for the UVR. More detail can be obtained from individual chapters.

## Summaries and Conclusions

### *Chapter 1. Introduction*

A number of management issues which were raised in this chapter that were addressed in the rest of the report. Specifically, the research and monitoring documented here were conducted on behalf of the Prescott National Forest to assess the impacts of grazing on the watershed condition of the uplands and on the channels of riparian corridor of the UVR. This has been the primary land use issue on Prescott National Forest lands. Of particular concern to the Prescott National Forest is the impact of land management activities on the spikedace (*Meda fulgida*), a small fish species that is part of the native fish fauna of the UVR. The spikedace is a Federally listed threatened species, occurring in only four isolated stream and river systems in Arizona. Despite the lack of definitive evidence of any direct links between current grazing activities and stocking levels and declines of spikedace populations, the focus of regulatory and environmental concern has continued to be grazing and its potential impacts on watershed condition. Thus, one focus of the monitoring and research reported in this publication is watershed condition and immediate channel impacts.

### *Chapter 2. Historical and Pictorial Perspective of the Upper Verde River*

Repeat photography was used to display the vivid texture of the UVR's vegetation, channel, and valley landscapes and to contrast the historical 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 greater breadth for understanding the larger perspective of the area and its habitats. A principal objective was to provide a broad understanding of historical influences that are 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 influenced 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 had long lasting consequences on the evolution of riparian and aquatic habitats in the UVR.

## *Chapter 3. Verde River Hydrology*

In this chapter, the geology and hydrology of the UVR were examined with special reference to the peak flows that form river geomorphology and habitat, and baseflows that support the aquatic fauna and riparian vegetation. Research is being conducted by a number of non-governmental organizations, as well as state, and Federal agencies to improve understanding of the UVR. Flows in the river are mostly stable baseflows due to steady contributions of groundwater flow from the Big Chino and other aquifers making this river unique in Arizona. Like other stream systems in Arizona, the UVR is subject to rare, episodic flood flows that rise three to four orders of magnitude above its baseflows. While drought can have an impact on the steady baseflows of the river, the overwhelming future impact on the sustainability of UVR perennial flow is urbanization of the Prescott and Chino Valley areas.

## *Chapter 4. Watershed Condition*

When examined at a coarse scale of analysis, the TES discussed in this chapter can suggest which sub-watersheds may be contributing unusually high amounts of fine sediment. Such information can direct field monitoring to validate whether or not tributaries are inducing sedimentation of the main river. A comparison of current sediment yields relative to natural yields suggests that priority areas for reducing soil loss lie in the lower portions of the UVR watershed (Grindstone Wash/UVR hydrologic unit), the lower portion of Sycamore Creek watershed, and the Williamson Valley. Because the differences in soil losses calculated using the Universal Soil Loss Equation under current and hypothesized “natural” conditions are largely attributable to differences in ground cover, it is important to validate the relationships between ground cover and soil erosion for particular areas rather than relying on questionable assumptions.

The watershed assessment prepared by the Prescott National Forest suggested that the Tri-Canyon area (Hell Canyon HU) represented the greatest departure from potential, in contrast to this analysis. The impaired rating for the Hell Canyon HU was apparently based on the high percentage of unsatisfactory/impaired soil condition ratings as well as the abundance of very coarse substrates in the tributary channels. Historical watershed degradation that induced a flashier watershed condition would account for the geomorphic condition of the channels and the widespread occurrence of unsatisfactory soil conditions. Because historical accounts of flash flooding in the UVR watershed and its tributaries extend to an early date, the potential to improve watershed conditions, particularly in steep, rocky, and relatively arid areas, may be naturally quite limited.

The upland soil units of the UVR watershed have a range of watershed conditions that reflect the geology and semi-arid nature of the Prescott National Forest.

There are units that have very skeletal and unproductive soils and that show evidence of significant erosion in the geologic past. However, linkages between these erosion processes, land management, and channel geomorphology are tenuous at best.

## *Chapter 5. Channel Morphology*

Measurements of channel morphology and application of channel classification have become a common tool for describing variation in rivers. The Rosgen (1996) classification system was applied to geomorphic data collected at 138 locations on the UVR from 1997 to 2000. The results showed that this segment of the river is dominated by gravel-bedded alluvial channels (B-, C-, and E-type) across a continuum of entrenchment. While channel typing in itself is not a sufficient basis for evaluating channel stability, the lack of braided channels (D-type) is consistent with more detailed studies that describe the UVR as hydrogeomorphically stable. Channel typing reveals that the river has a distinctive combination of low slope and low sinuosity. Due to the river's distinctive qualities, changes in riparian vegetation and aquatic habitat will occur at scales that are finer than that used for channel classification. Managers and researchers should adapt their sampling methods to focus on understanding such fine-scale changes in the river.

## *Chapter 6. Woody Vegetation of the Upper Verde River: 1996-2007*

This chapter presents a quantitative description of the woody vegetation of the UVR based on 56 permanently established and monumented sampling sites. The UVR contains a large diversity of woody species (62) and plant associations. The plant associations found in the UVR contain species that are common to other streams of the Mogollon Rim region of the Southwest. However, one notable difference is the relatively high frequency and abundance of upland woody species found in close association with obligate riparian species on the Verde River. The presence of many facultative and upland species is attributed to the general absence of obligate species until circa 1980. Large cottonwood stands or willow thickets were absent until post-1993. Essentially, nearly all woody obligate (e.g., cottonwood) and facultative (boxelder) species established within the floodplain can be dated to 1993. Mature stands of velvet ash, Arizona walnut, and netleaf hackberry are common along the historical high water mark, in and amongst talus boulders. Brock (1987) characterized the riparian vegetation as a shrub community dominated by seepwillow, with interspersed species of velvet ash, Arizona walnut, Gooding's willow, Utah juniper, velvet mesquite, and desert willow.

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

## *Chapter 7. Spatial and Temporal Variation in Streamside Herbaceous Vegetation of the Upper Verde River: 1996-2001*

In this chapter, patterns of vegetation are examined in relation to major geomorphic and geologic attributes along the river. Specifically, this analysis examines how streamside vegetation in different reaches changed during the period of stable flows. A clearer picture of the ecology of the river is provided by better understanding longitudinal and temporal vegetation variation, and plant interactions within highly dynamic areas of the river, Along most reaches, the UVR is only moderately confined by valley walls, which allows low-gradient B- and C-type channels to develop (see Chapter 5). This analysis showed that some confined reaches with B- and C-type channels experienced considerable changes in streamside vegetation (e.g., Muldoon 13), while sites in the unconfined E-type channels of Verde Ranch were relatively stable. These changes may be undesirable for several reasons. Weedy aquatic species tended to increase while species associated with stable streambanks decreased. The weedy aquatic species crowd out native herbaceous plants and may provide increased cover for predatory nonnative fish. The changes may also induce channel narrowing retention of organic sediments that decrease the quality of habitat for native fishes.

## *Chapter 8. A Preliminary View of Water Quality Conditions of the Upper Verde River*

Water quality data collected on the UVR were not comprehensive or continuous, and involved only two sites chosen for their ease of access and security, not for any scientific concern. However, the preliminary data collected for two stations from April 2000 to March 2001 suggest that all parameters (i.e., temperature, dissolved oxygen, pH, conductivity, turbidity, and total suspended solids) are consistent with warm water standards for the Southwest. The parameters are also well within the normal range of conditions for native fish such as the spikedace.

## *Chapter 9. Fish and Aquatic Organisms*

The primary intent of this chapter was to summarize for land managers: (1) what is known, (2) what is not known, and (3) what the future research needs are to facilitate management to sustain native fishes in the UVR. Fish have been collected at seven long-term sites on the UVR since 1993. There has been a distinct decline in native fish species since the year after the 1993 flood, and there has been a parallel rise in nonnative fish species. Mechanical removal of nonnative fishes was not of sufficient intensity to have a significant effect with only an annual approach. Extensive streambank and in-stream vegetation reduced efficiency of removal, and limited treatment reaches (1 km or 0.6 mi) did not preclude movement of nonnatives into other sites.

The threatened spikedace disappeared from samples at seven monitoring sites within a few years after floods in 1992/93 and in 1995. The species has not been collected in the UVR since 1996 at the long-term sites and 1997 below one of the long-term sites at Black Bridge. Monitoring results demonstrate that the probability is high that spikedace species has already been extirpated from the UVR.

## Chapter 10. Research Recommendations

Chapter 10 summarizes the research recommendations formulated by the authors based on their experience and the information presented in this volume. The main topics are needs related to general hydrology, groundwater, vegetation, geomorphology, fishes, aquatic ecology, and water quality. Aside from topics such as aquatic ecology, where there has just been a minimum effort, the most important recommendation relates to fishes. Continued monitoring and research relative to the long-term fish/habitat database on the UVR is needed. The fish population database is a valuable resource because of its long-term nature, and because it is probably the most complete for any river in the Southwest. Specific research methods are not discussed since those decisions are left to the study plans of individual investigations. The chapter concludes with a brief discussion of funding sources for future research.

## Chapter 12. Information Sources

Information on the hydrology, geology, ecology, and management of the UVR can now be obtained from a number of web sites that are introduced in this chapter. The Southwest Watershed Science Team's web site provides reciprocal links to all of these sites (http://www.rmrs.nau.edu/awa/).