Photo P79. Riparian habitat on the upper Verde River

Biological Inventory of the Verde Watershed

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This comprehensive Biological Inventory of the entire Verde River Watershed identifies the native and exotic vertebrate taxa that are present in this watershed. Their presence was assessed by: verified museum specimens, visual observations, or their geographic distribution and habitat requirements. Geographic distributions and habitat requirements were based on direct field experience and an exhaustive review of field guides, technical vertebrate journals and books, ecological and natural history literature, symposia proceedings, and scientific reports from government and private agencies.

Mammals, birds, and fish were identified to species with a single exception (the Dark-eyed Junco with three common subspecies or races found in the Verde Watershed and Arizona), while amphibians and reptiles are identified to subspecies. The identified species of the watershed are then compared with Arizona's total vertebrate fauna to assess the proportion of Arizona's species that are also found in the Verde Watershed. The report lists the taxa, presents a systematic and ecological classification, and evaluates the species significance for the upper Verde River.

I. The Watershed as an Ecological Landscape Unit

Watersheds are typically the basis for the ecological setting of regional landscapes (Naiman 1992). In other words, these are the critical ecological units for assessment, monitoring, and management. The geographic, hydrologic, geologic/physiographic, and climatic template sets the stage for physical, chemical, and biological processes. The resulting mosaics (i.e., landscape patterns) of biological communities and ecosystem dynamics we extend further as ecoregions or biotic communities (Bailey 1980, 1996, 1998, Brown 1982, Brown and Lowe 1994, Brown et al. 1998). Besides the characteristic plants, animals, and soils characterizing ecoregions, microbial (i.e., bacteria and fungi) and micro-flora-fauna communities are at the heart of ecosystem function for decomposition, nutrient cycling, nitrogen fixation, origination of food webs, and even photosynthesis. This ecosystem foundation consists of: bacteria, cyanobacteria (formerly blue-green algae), fungi, algae, lichen, protozoans, and

micro-invertebrates. These organisms are virtually invisible to the hiker and photographer, and challenging for ecologists to study on landscape scales. Plants, vertebrates, and macro-invertebrates are what the public and naturalists perceive in their outdoor experience, and these are more easily researched, especially on landscape and regional scales. Macro-invertebrates are casually defined as insects, spiders, mites, crustaceans, worms, etc. that are visible to the naked eye, approximately larger than 1mm (0.04 inches). Vertebrates are more familiar to both the public and ecologists: mammals, birds, reptiles, amphibians, and fish. A strong case can be made that vertebrates and plant communities can be used as excellent surrogates for the ecological setting of regional landscapes (e.g., Krzysik and Trumbull 1996). In other words, the diversity and species composition of vertebrate and plant communities parallel diversity and the overall ecological dynamics of the invertebrate, microbial, and micro-flora-fauna communities. Therefore, in terms of functional integrity and ecosystem viability, these provide a foundation for assessment, monitoring, and natural resources management.

II. Arizona Ecoregions and Biotic Communities

Arizona is globally recognized for its diverse biota, especially its vertebrate fauna, because Arizona has five major ecoregions with the additional influence of subtropical communities from Mexico. Four of these ecoregions extend substantially beyond Arizona into all five surrounding states (California, Nevada, Utah, Colorado, New Mexico) and Mexico. This impressive spatial size and continuity is critical for regional biodiversity and ecological integrity. These four ecoregions are: Colorado Plateau, Mojave Desert, Sonoran Desert, and Madrean Evergreen Woodland. The fifth ecoregion, Arizona-New Mexico Mountains, is predominantly found in Arizona, but extends a short distance into New Mexico. The Madrean Evergreen Woodland, based on major isolated mountains surrounded by desert grasslands is commonly acknowledged for its global significance (DeBano et al. 1995).

The Nature Conservancy defines these a little differently, three are the same, one is renamed, and the fifth is divided into two ecoregions (Figure E2). The Madrean Evergreen Woodland is called "Apache Highlands South," and the Arizona-New Mexico Mountains is divided into two components. The higher elevation conifer forests along the Mogollon Rim, San Francisco Peaks, and White Mountains are still referred to as "Arizona-New Mexico Mountains," while the piñon-

juniper woodland, chaparral and ponderosa pine forest and woodlands to the south are called "Apache Highlands North." Most of the Verde Watershed lies in the "Apache Highlands North" ecoregion, a good portion of its eastern watershed is in the "Arizona-New Mexico Mountains," and its southern extreme is in the Sonoran Desert. The northwestern edge of the Verde Watershed is adjacent to the Colorado Plateau and is close to the Mojave Desert. Some of the fauna in the southeastern portion of the Verde Watershed is influenced by the important Apache Highlands South (Madrean Evergreen Woodland) biota.

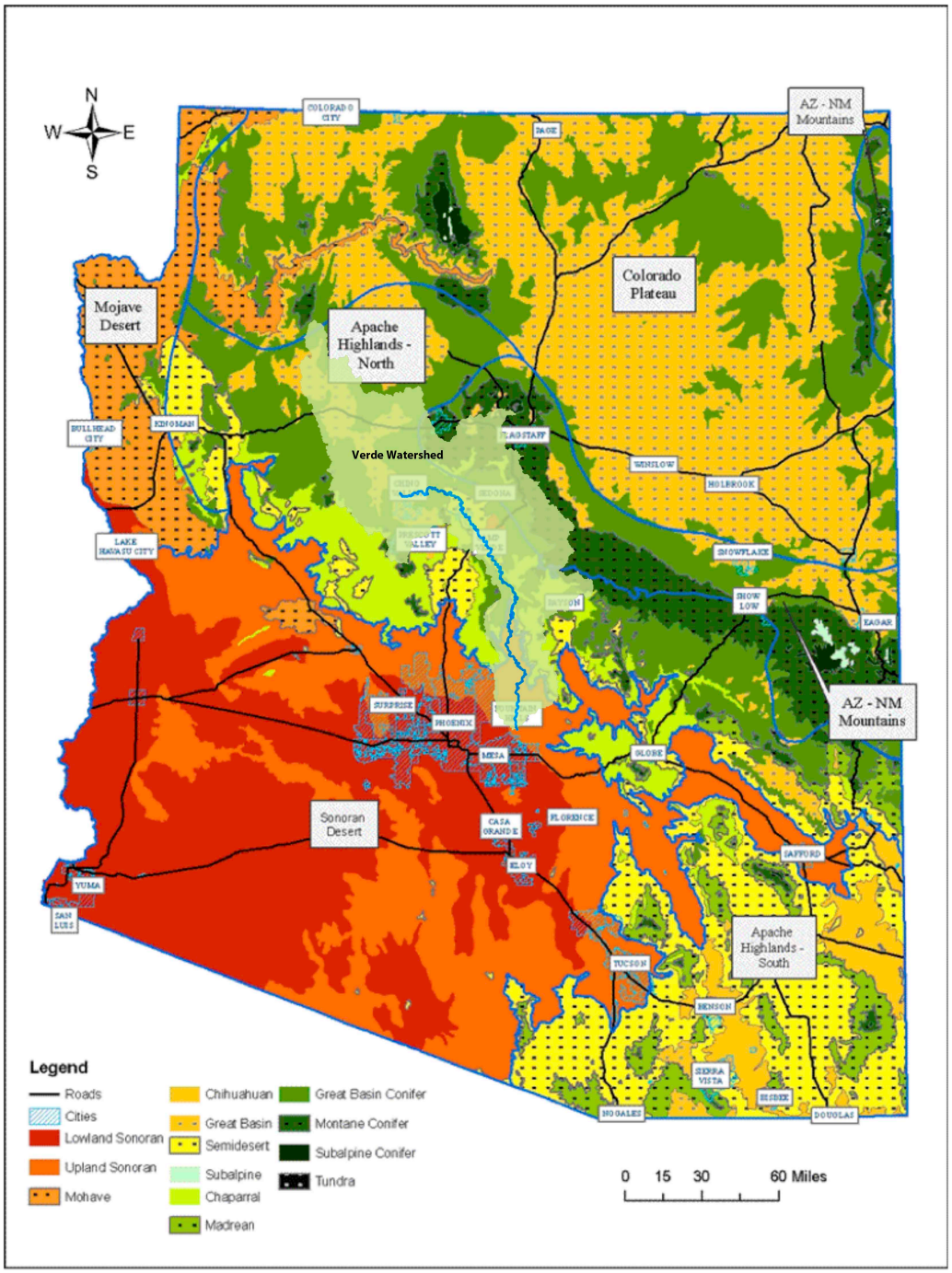


Figure E2. Arizona ecoregions (Nature Conservancy model)

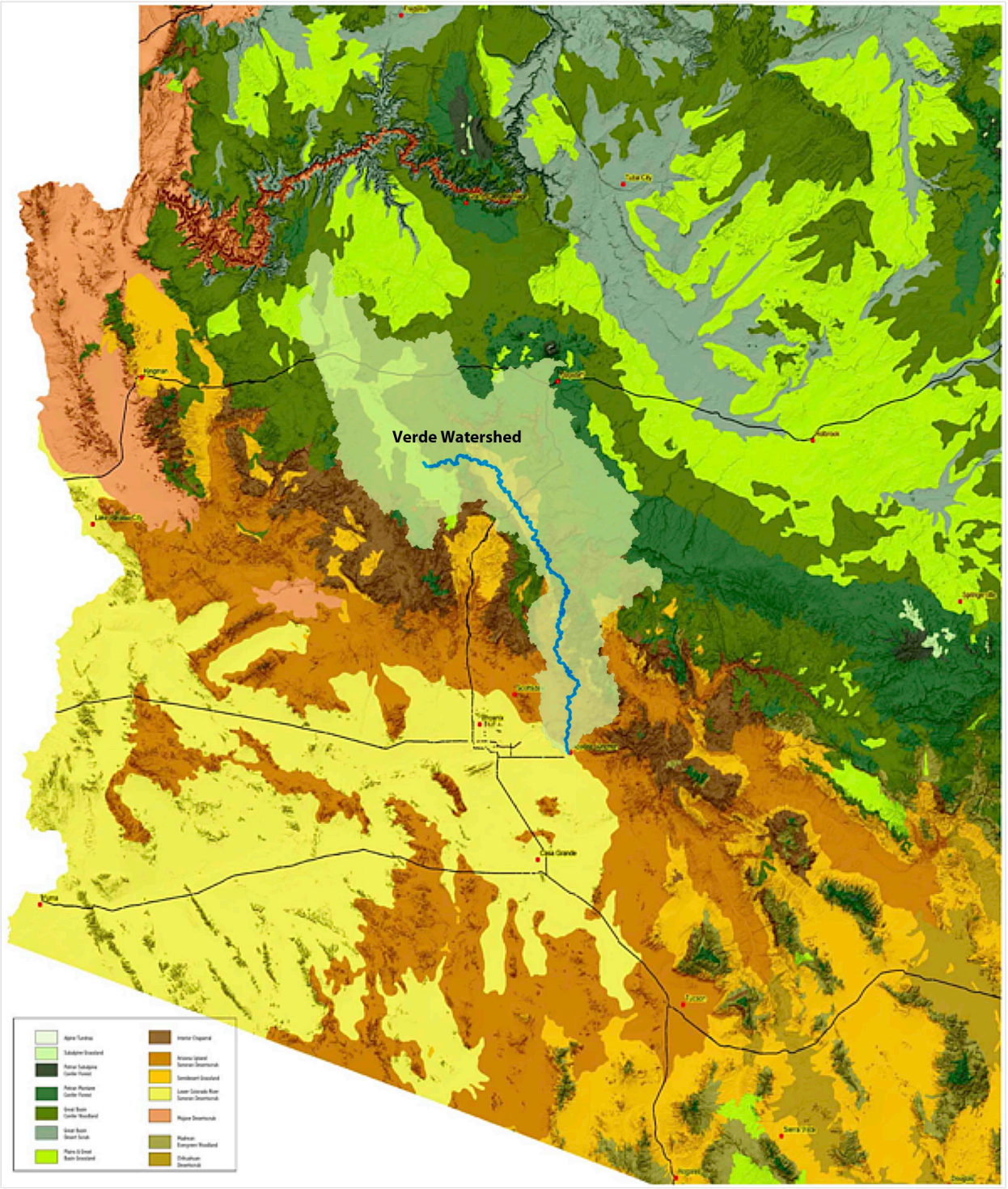


Figure E3. Biotic Communities of Arizona

The Brown and Lowe (1994) Biotic Communities classification provides a more detailed vision of Arizona's vegetation; and clearly illustrates the complexity, patch mosaics, and landscape interconnectedness of central Arizona and the Verde Watershed (Figure E3). This classification has been used a great deal in land management, has stood the test of time, is relatively accurate, and is based on major plant species.

Six Biotic Communities make up the Verde River Watershed, described below in decreasing size order (Figure E4). These classifications are primarily based on trees, shrubs, and grasses. The description of this vegetation below is based on Brown (1982), Finch (2004), and Krzysik (personal observation).

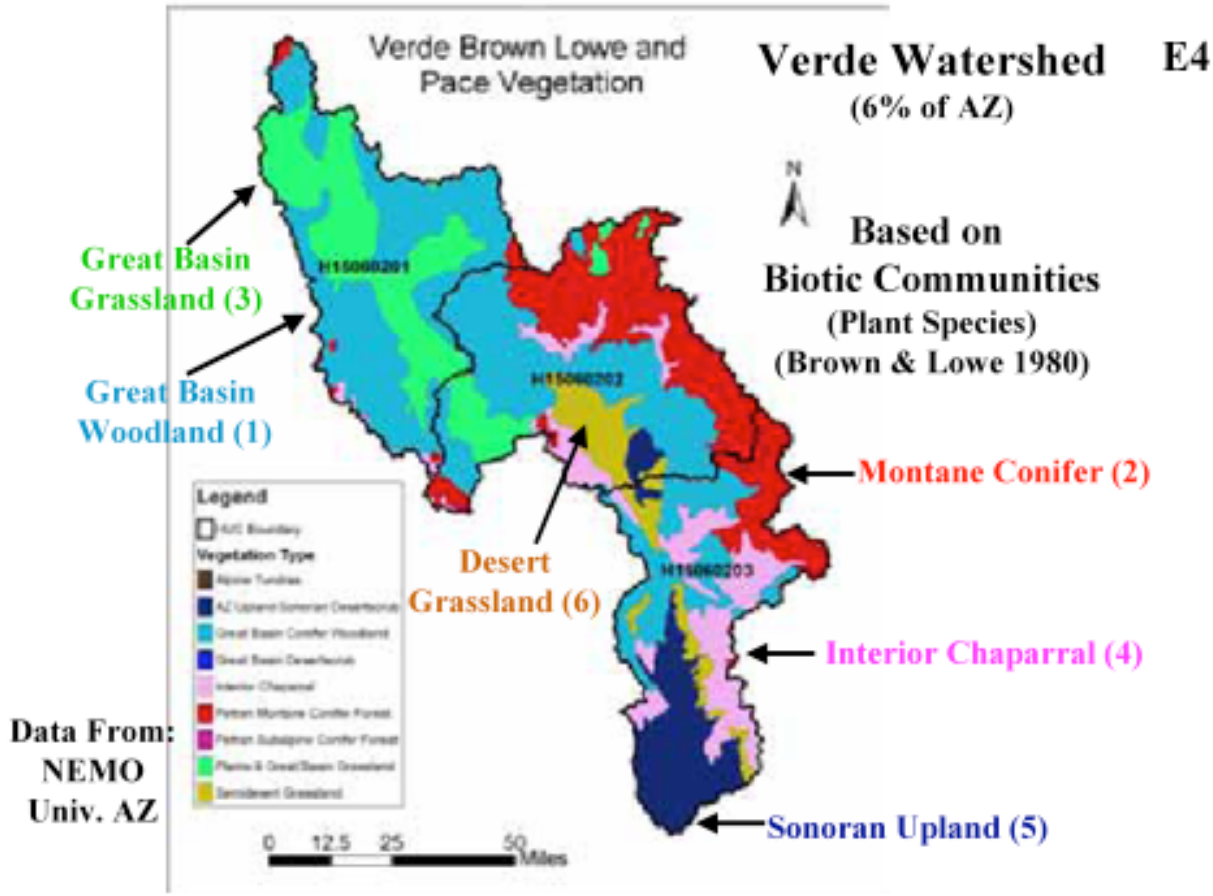


Figure E4. Verde watershed biotic communities

A. Great Basin Woodland

This is the Piñon-Juniper Woodland of relatively small, scattered trees. The most common tree is Utah juniper (*Juniperus osteosperma*), but there can also be one-seed juniper (*Juniperus monosperma*). These species are difficult to tell apart and may interbreed. The associated species, particularly at higher elevations is Colorado piñon pine (*Pinus edulis*). This species has paired needles. In the central portion of the watershed some trees have both single and paired needles, and may represent a hybrid swarm with the more western distributed single-leaf piñon pine (*Pinus monophylla*). Common shrubs include: cliffrose (*Cowania mexicana*), Apache plume (*Fallugia paradoxa*), red barberry (*Berberis haematocarpa*), skunkbush (*Rhus trilobata*), catclaw mimosa (*Mimosa biuncifera*), snakeweed (*Gutierrezia sarothrae*), and four-wing saltbush (*Atriplex canescens*). Typical grasses include: blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), galleta (*Pleuraphis jamesii*), indian ricegrass (*Achnatherum hymenoides*), western wheatgrass (*Agropyron smithii*), junegrass (*Koeleria cristata*), muhly grasses (*Muhlenbergia* sp), dropseeds (*Sporobolus* sp), and three-awn grasses (*Aristida* sp).

B. Montane Conifer

The most common mountain forest tree in the Verde watershed is ponderosa pine (*Pinus ponderosa)*, often growing in pure stands. At higher elevations, in canyons, and on north slopes community associates added are: Douglas fir (*Pseudotsuga menziesii*, not a true fir), white fir (*Abies concolor*), limber pine (*Pinus flexilis*), Gambel's oak (*Quercus gambelii*), and trembling aspen (*Populus tremuloides*). At the highest elevations in the watershed subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) appear, and more rarely Colorado spruce (*Picea pungens*), and bristlecone pine (*Pinus aristata*). A shrub understory is typically not prominent, but may include: fendler ceanothus (*Ceanothus fendleri*), smooth sumac (*Rhus glabra*), creeping mahonia (*Berberis repens*), Arizona rose (*Rosa arizonica*), currents (*Ribes* sp), elderberry (*Sambucus* sp), and snowberry (*Symphoricarpos* sp). Some grasses develop in open areas and include: mountain bluegrass (*Poa fendleriana*), Arizona fescue (*Festuca arizonica*), squirreltail (*Sitanion hystrix*), Pringle needlegrass (*Stipa pringlei*), muhly grasses (*Muhlenbergia* sp), and brome grasses (*Bromus* sp).

C. Great Basin Grassland

Typical grasses of the Great Basin Grassland include: blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), galleta (*Pleuraphis jamesii*), indian ricegrass (*Achnatherum hymenoides*), junegrass (*Koeleria cristata*), plains lovegrass (*Eragrostis intermedia*), wolftail (*Lycurus phleoides*), dropseeds (*Sporobolus* sp), needle grasses (*Stipa* sp), and three-awn grasses (*Aristida* sp.). The Great Basin Woodland and Grassland share many species of grasses. Typical shrubs in these grasslands are also similar and include: snake weed (*Gutierrezia sarothrae*), rabbitbrush (*Chrysothamnus* sp), skunkbush (*Rhus trilobata*), catclaw mimosa (*Mimosa biuncifera*), and four-wing saltbush (*Atriplex canescens*). Common yuccas are bear grass (*Nolina microcarpa*), and small soapweed yucca (*Yucca glauca*). Junipers are commonly invading Great Basin Grasslands.

D. Interior Chaparral

The chaparral community is predominantly a well-developed shrub community with scattered trees. The characteristic species of this biotic community is turbinella oak (*Quercus turbinella*), widely occurring in both tree and shrub forms. Characteristic shrubs include: pointleaf manzanita (*Arctostaphylos pungens*), Pringlei manzanita (*Arctostaphylos pringlei*) mountain mahogany (*Cercocarpus montanus*), mountain lilac (*Ceanothus greggii*), skunkbush (*Rhus trilobata*), desert olive (*Forestiera neomexicana*), silktassel (*Garrya wrightii*), cliffrose (*Cowania mexicana*), Wright's buckwheat (*Eriogonum wrightii*), hollyleaf buckthorn (*Rhamnus crocea*), California buckthorn (Rhamnus californica), and catclaw mimosa (*Mimosa biuncifera*). . Agaves (*Agave parryi*) characterize the chaparral. Common yuccas present are banana yucca (*Yucca baccata*), bear grass (*Nolina microcarpa*), and sotol (*Dasylirion wheeleri*). Scattered trees may include Emory oak (*Quercus emoryi*), Arizona white oak (*Quercus arizonica*), piñon pine, alligator juniper (*Juniperus deppeana*), and ponderosa pine. Grasses are not dominant because of the high shrub cover, but may include: blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), hairy grama (*Bouteloua hirsuta*), mountain bluegrass (*Poa fendleriana*), longtongue bluegrass (*Poa longiligula*), plains lovegrass (*Eragrostis intermedia*), and three-awn grasses (*Aristida* sp).

E. Sonoran Upland

The Sonoran Uplands are characterized by the scenic landscape of large saguaro cactus (*Carnegiea gigantea*), foothills palo verde (*Cercidium microphyllum*), blue palo verde (*Circidiun floridum*). a broad diversity of *Opuntia* cactus, and ocotillo (*Fouquieria splendens*). Common *Opuntia* includes: buckhorn

(*O. acanthocarpa*), staghorn (*O. versicolor*), cane (*O. spinosior*), teddy bear (*O. bigelovii*), chain fruit (*O. fulgida*), pencil (*O. arbuscula*), and christmas (*O. leptocaulis*) chollas. The numerous dry washes that dissect the landscape are clearly outlined with arid-adapted trees and large shrubs: blue palo verde, ironwood (*Olneya tesota*), catclaw acacia (*Acacia greggii*), and velvet mesquite (*Prosopis velutina*). At ecotones of the upper Sonoran, additional species become apparent, such as crucifixion thorn (*Canotia holacantha*) on higher slopes, and creosote bush (*Larrea tridentata*), and Bursage (*Ambrosia dumosa* and *A. deltoidea*) from the Lower Sonoran.

F. Desert Grassland

The most characteristic grasses of the Desert Grassland are tobosa (*Pleuraphis mutica*) and black grama (*Bouteloua eriopoda*). Other species of grasses include: curly mesquite grass (*Hilaria belangeri*), bushmuhly (*Muhlenbergia porteri*), sacaton (*Sporobolus wrightii*), and burrograss (*Scleropogon brevifolius*). Other species present may include velvet mesquite (*Prosopis velutina*), catclaw acacia (*Acacia greggii*), catclaw mimosa (*Mimosa* biuncifera), ocotillo (*Fouquieria splendens*), creosote bush (*Larrea tridentata*), agave (*Agave palmeri*), sotol (*Dasylirion wheeleri*), and of course a very rich assortment of cacti species.

III. The Verde Watershed

The proposed Upper Verde River Wild and Scenic River is a vital component of a dynamic riparian corridor that links watershed-scale biotic communities from the extensive grasslands of the Big Chino watershed, through the Verde Valley alluvial basin and the lower Verde canyon reach that extends from below Camp Verde to the Salt River. Accordingly, the ensuing discussion addresses not only the proposed upper Verde River Wild and Scenic Reach but also the river-dependent and interdependent watershed-scale biotic communities along the entire length of the Verde River and its upland habitats.

Landscape corridors provide the most important habitats for many reasons: they are hot spots of regional biodiversity, maintain genetic integrity and ecosystem processes, and insure population viability and persistence (Holland et al. 1991, Hudson 1991, Noss and Cooperrider 1994, Forman 1995, Kadmon and Allouche 2007). Riparian corridors are particularly valuable for this landscape context (Warner and Hendrix 1984, Naiman and Decamps 1997, Naiman et al. 2005, Steiger et al. 2005), especially in the arid Southwest (Johnson 1989, Krzysik 1990, Baker et al. 2004, Stromberg

and Tellman 2009). Most populations occur as metapopulations (patchy distribution of subpopulations) in the landscape, and as local populations experience declines, habitat fragmentation, or even extinctions; recolonization and the maintenance of genetic variability require suitable dispersal routes (Avise and Hamrick 1996, McCullough 1996, Ritchie 1997, Hanski and Gaggiotti 2004).

The Verde Watershed is 6,622 square miles, representing 5.8 percent of the state of Arizona. Most of the watershed lies north and east of the river corridor because mountain ranges sharply delineate its southwestern boundary. Much of the Verde River is relatively pristine due to steep canyon walls and difficult access from rugged dirt roads and trails. The upper Verde and Big Chino watersheds were the last areas settled by the Europeans in the continental U.S. (Shaw 2006, Appendix A26).

Figure E5. Hydrography of the Verde River Watershed excluding the lower Verde River watershed. From Blasch and others (2006).

A. Big Chino

The northern end of the Big Chino watershed is within the southwestern Colorado Plateau about 23 miles north of Seligman within the extensive Great Basin Grassland of western Coconino County; the southern end is at Sullivan Lake. The uppermost headwaters of Big Chino Wash originate primarily from numerous ephemeral washes draining eastward from the topographic divide above the Aubrey Cliffs. South of Seligman, the Big Chino watershed extends northeastward across Big Black Mesa and into the Colorado Plateau. West and south of Seligman it includes the east flanks of the Juniper and Santa Maria Mountains, Granite Mountain, and the Little Chino Valley, including Del Rio Springs and most of the developed part of the Town of Chino Valley.

The Big Chino Verde Watershed consists primarily of Great Basin Grassland and Great Basin Woodland. There are five very tiny patches of Montane Conifer at the extreme north, southeast, and southwest extremes of this watershed unit. There are also two tiny patches of Interior Chaparral in the southwest portion.

B. Upper Verde

The Upper Verde watershed begins at Sullivan Dam and extends downstream to Clarkdale. It consists primarily of Great Basin Woodland, with significant contributions of Great Basin Grassland, Montane Conifer, and Interior Chaparral. There is a small patch of Desert Grassland in the southeast corner. The weakness of a large landscape/regional classification such as this is evident at smaller spatial scales. The Upper Verde has significant "Interior Chaparral" plant species well distributed in the "Great Basin Woodlands" Biotic Community.

South of the river this watershed reach extends from the Granite Creek drainage to the west to the Munds Draw drainage on the east. The Granite Creek drainage, by far the most extensive on the south side of this reach, extends south through Prescott and also drains the west flank of Woodchute Mountain (approx. 7,800-ft. elevation) at the far western end of the Black Hills. Munds Draw, which meets the Verde River at the east end of the Sullivan Dam – Perkinsville reach, drains the northwest flank of Woodchute Mountain.

The major tributaries draining to this reach from the north are, from west to east, Hell Canyon, MC Canyon, Grindstone Wash, Bear Canyon., and Government Canyon, all of which drain elevations in excess of 6,500 feet. Hell Canyon is the most extensive and includes the northeast flank of the southeast half of Big Black Mesa and the summit and south flank of Bill Williams Mountain (9,256-ft. elevation).

C. Middle Verde

The Middle Verde watershed begins at Clarkdale and extends downstream through the Verde Valley to Beasley Flat, just south of Camp Verde, flowing through the broad alluvial basin of the Verde Valley. The major tributaries draining westward to the Verde River in this middle Verde watershed are, from northwest to southeast, Sycamore Creek, Oak Creek, Beaver Creek, and West Clear Creek. Their drainages extend across the Mogollon Rim and into the southern Colorado Plateau. Headwaters tributaries of Sycamore Creek drain the southeast flank of 9,256-ft.-elevation Bill Williams Mountain, the south flank of 9,389-ft-elevation Sitgreaves Mountain, and the west flank of 12,633-ft.-elevation Humphreys Peak, which is north of Flagstaff.

The broad Verde Valley is bounded on its southwest side by the steep northeast flank of the Black Hills, the crest of which broadly parallels the river and generally stands about 3,000 to 4,000 feet higher.

The Middle Verde Watershed is the most biologically diverse watershed unit, in which all six Biotic Communities are present. The largest and ecologically most significant contribution comes from Montane Conifer. The Middle Verde also has large contiguous areas of Great Basin Woodland, Desert Grassland, and Interior Chaparral. The Middle Verde segment has the largest extent of Desert Grassland in the Verde Watershed. There is a significant patch of Sonoran Upland in its southwest portion and three small high elevation patches of Great Basin Grassland in its northern portion.

D. Lower Verde

The Lower Verde watershed begins at Beasley Flat and extends downstream to the Salt River. This is almost entirely a canyon reach, excepting a wider alluvial reach about ten miles in length at

Horseshoe Reservoir and a broad alluvial basin beginning about two miles southwest of Bartlett Dam and continuing to the confluence with the Salt River. Major tributaries are Fossil Creek and the East Verde River.

The Lower Verde Watershed is also very diverse, not only because it has five Biotic Communities, but especially due to the spatial extent of four of them. This segment is characterized by and has almost all of the Sonoran Upland landscape. Additionally, it has large landscapes of Interior Chaparral, Montane Conifer, and Great Basin Woodland. It also possesses three linear elevational patches of Desert Grassland.

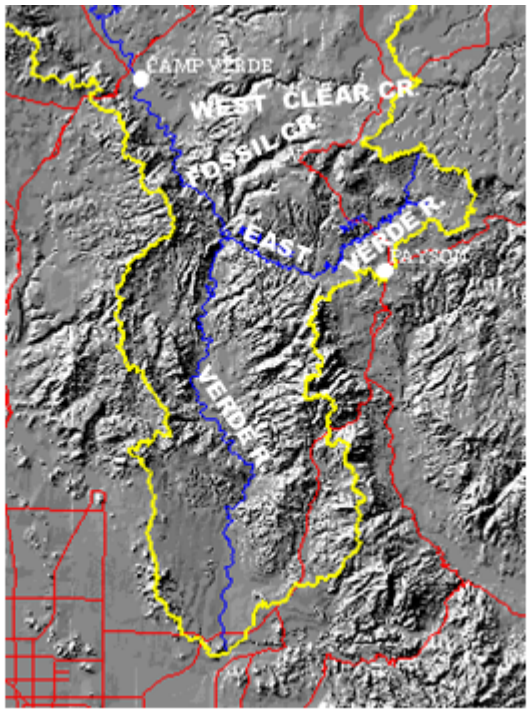


Figure E6. Lower Verde River watershed (modified from map prepared by NRCS and ADEQ).

IV. Climate Change and Biodiversity

The Verde Watershed as an integrated ecosystem represents a regional biodiversity center with habitat for federally listed and rare species. Two areas within the upper Verde are designated global Important Bird Areas (IBAs): Watson-Willow Lake Ecosystem and Upper Verde-Lower Granite Creek). The Verde River is one of the few remaining relatively pristine free-flowing rivers in the entire Southwest. Instream flows in the Verde and its tributaries possess significant native fish and aquatic insect communities (Blinn and Poff 2005, pages 519, 537).

Southwestern riparian ecosystems have been functionally severely degraded from diverse anthropogenic activities and land-use (Warner and Hendrix 1984, Rosenberg et al. 1991, Stromberg 1993, Busch and Scott 1995, Baker et al. 2004). The major future threats to these southwestern ecosystems is population growth and climate change (See *Climate,* proposal page 35). Significant physical and biological impacts now occur from anthropogenic climate change (Rosenzweig et al. 2008). These impacts will be particularly severe in arid regions with water resources (IPCC 2007, CCSP 2008).

Riparian communities in the Southwest are regional centers of biodiversity, critical for avian faunas, and very sensitive to watershed mismanagement (Krzysik 1990). Stream biodiversity itself directly reflects historical land use (Harding et al. 1998). Biodiversity possesses significant economic and noneconomic values (NRC 1999) and is integral in providing irreplaceable ecological services (Baskin 1997, Daily 1997).

Photo P28. View from cliff ruin shows "thin green line" bordering the riparian zone.

Dispersal capability is particularly important during climate change (Schneider and Root 2002, Lovejoy and Hannah 2005, CCSP 2008). Biological effects of current climate change have been well documented

(e.g., Rosenzweig et al. 2008). Severe droughts are predicted for the Southwest (NRC 1991, California Water Agencies 2005, IPCC 2007, National Academies 2007, Seager et al. 2007, CCSP 2008). Establishment of the UVWSR represents a critical opportunity to insure a significant biogeographical landscape riparian corridor through the heart of Arizona wild lands (Figure 5).

V. Riparian Communities

Riparian communities represent the biological, physical, and chemical transition zones between aquatic fluvial/hydraulic channels (including their floodplain) and the much more extensive uplands. These zones are typically very sharp in contrast, and more evident in deserts and semi-arid landscapes — the often cited "thin green line" in arid landscapes. The aquatic environment is typically included with the bank vegetation in the designation of riparian zones in the West, and in particularly in the Southwest (e.g., Lowe 1964). This definition is motibated by the broad range of instream flows from perennial to ephemeral and the close ecological dependency of channel flow and bank vegetation. Riparian and wetlands ecosystems usually have the highest biological productivity in the landscape (NRC 1995, Mitsch and Gosselink 2000, Naiman et al. 2005). This high productivity in turn contributes directly to high species diversity (Waide et al. 1999).

Many excellent overviews and discussions of riparian ecology, fluvial processes, disturbance, and management strategies are available (e.g., Warner and Hendrix 1984, Gregory et al. 1991, Naiman and Decamps 1997, Baker et al. 2004, Chambers and Miller 2004, Naiman et al. 2005). The Forest Service especially, but other federal agencies as well, have sponsored many riparian management symposiums, conferences, and workshops. Many of these were published in the Forest Service General Technical Report series (some of the best and relevant to the Southwest are: Johnson and Jones (1977), Johnson and McCormick (1979), Johnson et al. (1985), Abell (1989), Shaw and Finch (1996)). There is an incredible amount of information and institutional knowledge in these reports, but the older ones may be difficult to obtain. An excellent introduction and discussion of Arizona's riparian communities for the public is Zaimes (2007). Arizona Cooperative Extension of the University of Arizona also has an excellent interactive online version (Arizona Extension 2006).

A great deal of guidance is available for the restoration and adaptive management of riparian ecosystems (Briggs 1996, Baker et al. 2004, Naiman et al. 2005, Stronberg and Tellman 2009).

However, ecological monitoring is essential that is both biologically (Karr and Chu 1999) and statistically (Downes et al. 2002) valid, and incorporates hydrological dynamics among uplands, aquifers, riparian zones, and instream flows (Jones and Mulholland 2000, Dent et al. 2001, Williams and Scott 2009).

A. Classification

The classification of southwestern riparian habitats has been difficult because of the heterogeneity and patchiness of local geomorphology. The literature is extensive (e.g., Minckley and Brown 1982, Rucks 1984, Johnson et al. 1989, Hupp and Osterkamp 1996, Danzer et al. 2001, DeBano and Schmidt 2004, Stromberg et al. 2009). Perennial instream flows are probably the most significant character of riparian communities. On this basis, three general classes of riparian communities are particularly relevant: Hydroriparian with perennial stream flows, Mesoriparian with intermittent flows, and Xeroriparian with ephemeral flows. Although there is obviously overlap among these categories, this classification is useful for both ecological processes and management options. This terminology is relevant to an entire stream or segments of a given stream. Typically, as one goes downstream in a watershed, surface water is more perennial because ephemeral washes, low order small tributaries, and springs cumulatively provide more surface water and groundwater is more reliable.

Perennial means continuous surface instream flows, and is critical for fish and most aquatic invertebrates. Interestingly, the Verde native longfin dace can survive short-term disappearance of surface water (see Fish section).

Intermittent flows refer to seasonally predictable instream flows and are typically of relatively long duration. In other words, surface water is present most of the year, but dries up during the hot summer or by the fall. These streams may be perennial in a wet year, or dry up during a severe drought year. Some aquatic insects are able to complete their lifecycles under these intermittent flow conditions because of the duration of surface flow and predictability.

Ephemeral flows are unpredictable events of relatively short duration, lasting from hours to possibly a few months. Ephemeral flows are caused by precipitation and snowmelt. Only a few specialized invertebrates with brief lifecycles under specific conditions can adapt to ephemeral flows.

Ephemeral channels and even small washes are very important landscape elements for foraging birds, lizards, spiders, and insects. These channels and arroyos are closer to groundwater than the surrounding uplands; therefore, the riparian vegetation is in closer contact with ground water and the ephemeral pulses provide additional water. This is why riparian vegetation is visually so apparent and contrasts with the surrounding uplands. There may be additional species in this zone, of course, but even the upland species that occur along dry washes and roads are larger, more densely packed, and more vigorous and succulent in appearance. Water is more available and predictable to these plants. Therefore there are more herbaceous insects, especially sap feeders (Whitford 2002), in turn attracting predaceous insects and spiders, and so on up the food chain. Additionally, seed production increases for granivorous birds, rodents, and ants, plus more flower production for nectar feeders.

B. Importance of Riparian Ecosystems

The species richness, biomass, and wildlife dependency of riparian ecosystems are well documented. Water, food, and cover are mandatory requirements of wildlife and fish. Water is scarce in the Southwest landscape, so it is not surprising the riparian communities are so essential in the landscape not only for their resident species, but for migratory, traveling, and upland species as well. Riparian communities are important foraging, watering, and resting places for migratory birds, bats, and insects. Upland species frequently visit riparian areas for food, water, and shelter. This is particularly true during droughts and in the winter, and especially for large animals such as deer, elk, turkey, and mountain lions. Although Hydroriparian communities provide the best habitats, even Xeroriparian habitats are substantially richer in resources than typical surrounding uplands.

"Riparian communities are demonstrated to be regional centers of biodiversity and biomass" (Krzysik 1990). Arid riparian communities have the highest breeding bird densities in the U.S., up to four times that of moist forests (Krzysik 1990, Figure 1). Carothers and Johnson's (1975) estimate of 2118 breeding birds in 100 acres of an Arizona cottonwood-willow riparian zone is the highest concentration of breeding birds measured in the continental U.S.

Riparian communities spatially occupy a tiny fraction of the landscape, but nevertheless they represent ecological value far in excess of their spatial representation in the landscape. "They tend to

be small relative to other communities, but possess an importance and biological interest totally disproportionate to their limited geographic occurrence" (Minckley and Brown 1982). Babcock (1968) reported that there were 279,600 acres of riparian area in Arizona, with 36 percent along the Gila River. The Gila River and its associated habitats have a long history of human disturbance; since 1968 it has lost significant riparian zones to agriculture and other human impacts (Rea 1983, McNamee 1994). Residential expansions, agriculture, livestock grazing, mining, roads, and recreation (especially off-highway vehicles) have destroyed or significantly degraded riparian habitats all over Arizona (Fradkin 1981, Stromberg 1993, Briggs 1996, Stromberg et al. 2004, Stromberg and Tellman 2009). Therefore, based on the 1968 riparian extent, less than 0.38 percent of Arizona's landscape (total land area is 114,000 square miles) is riparian habitat.

Babcock's assessment of riparian extent was mainly based on Fremont cottonwood-Goodding's willow gallery forests. These are the most elegant and noteworthy riparian communities in Arizona and the Southwest. However, these forests are restricted to large floodplains in broad valleys (Minckley and Brown 1982, Stromberg 1993, Lite and Stromberg 2005). The Verde River is predominately restricted in a narrow canyon, and generally does not provide adequate habitat for these magnificent riparian forests (although there are small areas in lower Granite Creek and near Perkinsville Ranch). Cottonwood-willow gallery forests are commonly noted as the most rare forest type in North America (e.g., Johnson 1989). Southwest riparian forest ecosystems are tied for fourth place as the most endangered of the 21 most endangered ecosystems in the U.S. (Noss and Peters 1995). Their endangered ranking was mainly based on their large number of threatened and endangered species, but the authors may have underestimated the extent of habitat disturbance. Of course, since the mid 1990s Arizona's riparian areas have been substantially degraded. Over 70 percent of the threatened or endangered species in Arizona and New Mexico were closely associated with or completely dependent on riparian habitats (Johnson 1989).

The high ecological and habitat values of dry washes, arroyos, narrow canyons, steep channels, hillside cuts and breaks, mini-coves, and broken ridges cannot be overemphasized. They provide the patch mosaics and microhabitat elements so critical for niche partitioning in ecological communities for both plants and animals. Riparian lizard species richness was higher in a natural watershed (Hassayampa River) than in a comparable flood-controlled watershed (Salt River), as a direct result of the greater availability of microhabitat components and subsequent niche partitioning (Krzysik

1990). Habitat patchiness and pattern is one of the most important components and drivers of local and regional landscape biodiversity. There exists a substantial literature base (Forman and Godron 1986, Noss and Cooperrider 1994, Forman 1995, Bissonette 1997, Pickett et al. 1997, Gutzwiller 2002, Scott et al. 2002).

C. Threats and Impacts

Much of the Verde River is relatively pristine, because of steep canyon walls and difficult access from rugged dirt roads and trails. The Upper Verde watershed was one of the last areas settled by the Europeans in the continental U.S., 1850s (Shaw 2006). Nevertheless, there are several small municipalities along the river: Pauldin, Perkinsville, Clarkdale, Cottonwood, and Camp Verde. The sprawling eastern suburbs of Phoenix are rapidly encroaching on the south end of the Verde. Despite's its seclusion for most of its length, and the numerous conservation efforts to protect it, the Verde River has been listed as one of America's most endangered rivers (American Rivers 2006). There are numerous threats to the Verde, but the major one is human population growth with its inevitable increase in ground water pumping as Prescott, Prescott Valley, Chino Valley, Paulden, and other municipalities actively plan for increased growth. Urbanization and the associated dynamics between aquifers and surface waters are a significant detriment to the integrity and viability of Verde Watershed ecosystems (Poff et al. 1997, Wilson and Carpenter 1999, Dent et al. 2001, Roach et al. 2008). Arizona's water laws, which do not recognize that surface and ground water are continuous, exacerbate the problem (Glennon 2009a, Marder 2009).

Riparian communities in arid landscape have been disproportionately impacted relative to their ecological significance and values. Water resources and management decisions are particularly critical in the Southwest, where surface water is scarce because of low precipitation, high evaporation and transpiration rates. Water resources management in the Southwest has been extremely contentious, unsustainable, and well documented (Bowden 1977, Worster 1985, Reisner 1986, Wilkinson 1992, Robbins 1994, Glennon 2002). Historically, water diversion and groundwater pumping for agriculture was a major impact. Now residential uses, exacerbated by extraordinarily high urban growth and rural sprawling, have significant water demands. In the future, reliable climate change models predict severe drought for the Southwest (see Climate Change section), dramatically compounding the threat. The combination of population growth and climate change manifests severely challenging water resources management not only in the Southwest, but throughout the

U.S. and globally (Postel 1997, 2000, Diamond 2005, Pearce 2006, Bergkamp and Sadoff 2008, Glennon 2009b, Mauser 2009).

D. The High Values of Verde Watershed Riparian Communities

A most important character of the Verde Watershed is that it is in the center of Arizona, a state composed of six ecoregions, based on The Nature Conservancy's classification. Five of these ecoregions significantly extend into five other states and Mexico. Thus the Verde Watershed is centrally located to providing regional spatial continuity and ecological integrity. Only the Apache Highlands North is restricted to Arizona. The Verde Watershed is made up of the components of three ecoregions: Apache Highlands North, Arizona-New Mexico Mountains, and Sonoran Desert. Additionally, the northwestern edge of the Verde Watershed is adjacent to the Colorado Plateau and is close to the Mojave Desert. Some of the fauna in the southeastern portion of the Verde Watershed may be influenced by the important Apache Highlands South (Madrean Evergreen Woodland biota.

Complimenting the central intersection of ecoregions by the Verde Watershed is the reality that riparian ribbons especially and also ridge lines are the most important landscape elements for the dispersal and movements of wildlife and indeed all biological organisms, as discussed earlier. Therefore, the Verde River, its associated riparian communities, canyon ridges, and adjacent habitats, represent the primary and central landscape corridor for biota movement, population and gene connectivity, and ecological integrity; thus integrating the rich ecoregional habitat mosaics of Arizona and the Southwest. Such landscape linkages, particularly the connection of ecoregions, are becoming more critical daily with accelerating climate change, and as wild and native landscapes are becoming more and more fragmented and distanced by agriculture and urban sprawl. Riparian zones are characterized by high habitat complexity and patchiness, and therefore, the increasing availability of ecological niches and in turn higher species richness. However, the relatively small landscape spatial extents of riparian zones translates to smaller total population sizes for each species. This unfortunate combination may increase local population extinction rates (Kadmon and Allouche 2007). Therefore, the maintenance of unfragmented and contiguous landscape riparian corridors is of paramount importance. Landscape corridors provide the most important habitats for many reasons: they are hot spots of regional biodiversity, maintain genetic integrity and ecosystem processes, and insure population viability and persistence (Holland et al. 1991, Hudson 1991, Noss

and Cooperrider 1994, Forman 1995). Riparian corridors are particularly valuable for this landscape context (Warner and Hendrix 1984, Naiman and Decamps 1997, Naiman et al. 2005, Steiger et al. 2005), especially in the arid Southwest (Johnson 1989, Krzysik 1990, Baker et al. 2004, Stromberg and Tellman 2009). Most populations occur as metapopulations (patchy distribution) in the landscape, and as local populations experience declines, habitat fragmentation, or even extinctions; recolonization and the maintenance of genetic variability require suitable dispersal routs (Avise and Hamrick 1996, McCullough 1996, Ritchie 1997, Hanski and Gaggiotti 2004).

E. Native Species

1. Large Trees

The magnificent Fremont cottonwood (*Populus fremontii*)-Goodding's willow (*Salix gooddingii*) gallery forests of the major floodplains of Arizona and the Southwest are not extensive in the upper Verde River. This is directly related to the narrow steep canyons without broad floodplains throughout much of the Verde River. Nevertheless, both species are present throughout the Verde watershed. Along Granite Creek, in the uppermost upper Verde, there is a nice stand of narrow-leaf cottonwood (*Populus angustifolia*)–willow forest.

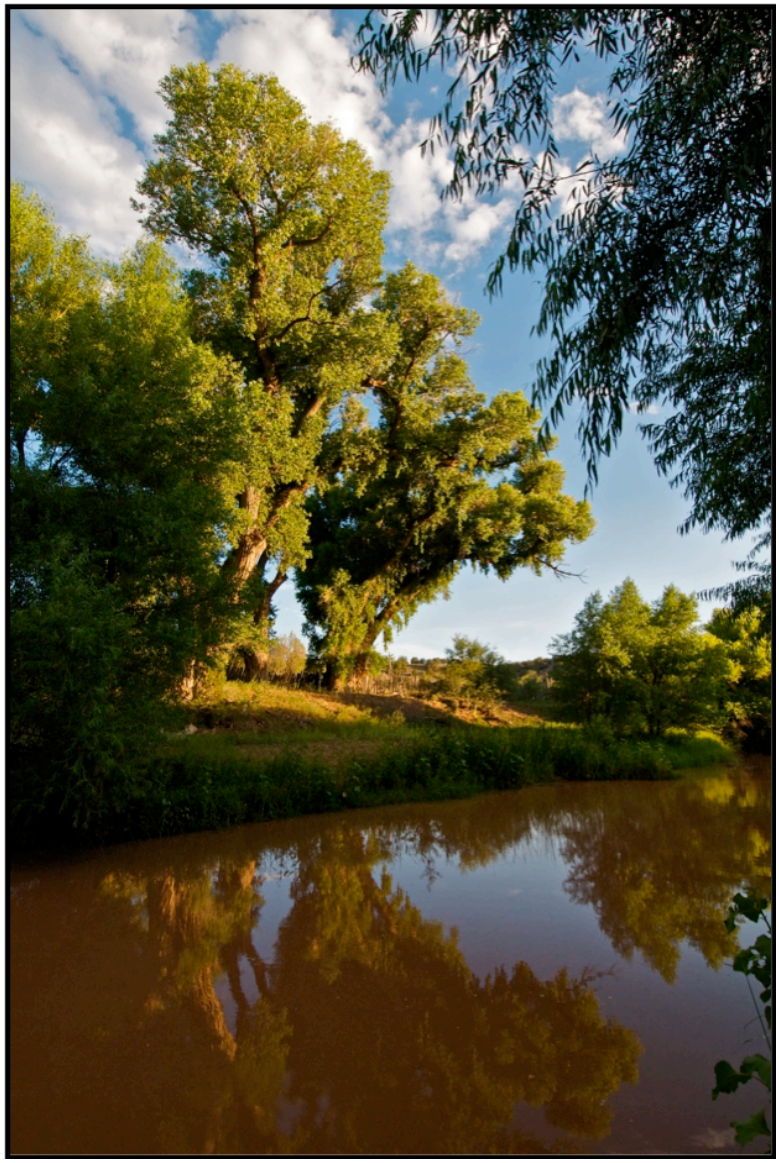


Photo P29. Cottonwood-willow forest at Perkinsville

Arizona alder (*Alnus oglongifolia*) and Arizona sycamore (*Platanus wrightii*) are large trees that occur in rugged cool canyons in the Verde Watershed. Gambel's oak

(*Quercus gambelii*) can form relatively pure stands on steep riparian slopes at higher elevations or very cool moist canyons.

Willows are the most ubiquitous and abundant trees and shrubs along the banks of the Verde River. At least four species of willow trees and shrubs predominate along the Verde River: Goodding's, coyote (*Salix exigula*), red (*Salix laevigata*), and arroyo (*Salix lasiolepis*). The codominant or subdominant trees are: velvet ash (*Fraxinus velutina*), box elder (*Acer negundo*), arizona walnut (*Juglans major*), and netleaf hackberry (*Celtis reticulate*).

Photo P31. Box elder, fall

2. Shrubs

Predominant shrubs in the floodplain are willows (*Salix* sp) and seep willows (*Baccharis* sp). Seep willows are not willows, but are composits (Sunflower family).

Just above the floodplain on higher terraces the predominant small trees and shrubs are desert willow (*Chilopsis linearis*) and velvet mesquite (*Prosopis velutina*). The desert willow is not a willow but is in the Bignonia family. The grass meadows in the higher terraces of the Verde River may have once been velvet mesquite bosques (woodlands) that were turned into meadows by early cattle ranchers. Also commonly found in this zone are Utah juniper (*Juniperus osteosperma*), four-wing saltbush (*Atriplex canescens*), and other upland species.

3. Other grasses and plants

Other grasses and plants in the watershed are describes as part of the Biotic Communities discussion on page 6.

4. Major Introduced Species in Riparian Zones

Tamarisk or saltcedar (probably *Tamarix pentandra* in the Verde) is the major invasive exotic riparian species of the Southwest, and forms tall shrub thickets along the banks of streams and rivers. Numerous programs are involved in its eradication.

Photo P30. *Tamarix* flowers

Tamarisk is found throughout the Verde Watershed, and in places may form dense patches. It is common but not dominant in the upper Verde; the Forest Service is now actively removing it from the riparian zone. A study comparing *Tamarix* infestations with altered stream flow regimes, concluded (Stromberg et al. 2007):

> "Stream-flow regimes are strong determinants of riparian vegetation structure, and hydrological alterations can drive dominance shifts to introduced species that have an adaptive suite of traits. Deep alluvial groundwater on intermittent rivers favours the deep-rooted, stress-adapted *Tamarix* over the shallower-rooted and more competitive *Populus* and *Salix*. On flow-regulated rivers, shifts in flood timing favour the reproductively opportunistic *Tamarix* over *Populus* and *Salix*, both of which have narrow germination windows. The prevailing hydrological conditions thus favor a new dominant pioneer species in the riparian corridors of the American Southwest. These results reaffirm the importance of reinstating stream-flow regimes (inclusive of groundwater flows) for re-establishing the native pioneer trees as the dominant forest type."

There is a small stand of pure Siberian elm (*Ulmus pumila*) in the upper Verde Watershed. This tree is expected to be uncommon, but widely distributed in the watershed because it has been extensively planted in residential uplands.

Russian olive (*Elaeagnus angustifolia*) is a small tree that forms dense tall shrub patches. It has attractive silvery foliage and has been used in ornamental landscaping. There are several patches along the upper Verde River.

VI. Vertebrate Biodiversity

The presence or absence of a given species or population within a geographically spatial extent of landscape is fundamentally dependent on the regional or large-scale geographic distribution range of the species and specific habitat selection by the species. Habitat selection results in the actual presence of individuals and breeding populations responding to the actual patch mosaics of biological, physical, and chemical attributes of ecosystems and their ecotones in the entire landscape. The reality of actually verifying the distribution and abundance patterns of ecological populations in the landscape is truly a daunting challenge for not only field logistics and sampling design, but for statistical inference (Seber 1982, Hayek and Buzas 1997, Krzysik 2002, Williams et al. 2002 , Thompson 2004, MacKenzie et al. 2006).

A large number of technical and specialized references and personal field experience were used to assess and classify the large-scale geographic range distribution and landscape and habitat preferences of the complete vertebrate fauna of the entire Verde River Watershed. Each vertebrate species, excluding fish, was characterized by three geographical and ecological classes: watershed segment occurrence, general habitat preference, and landscape occurrence. All classification parameters are presented below. The bird fauna of the Verde Watershed was additionally classified into breeding, migratory, or wintering species and a systematic taxonomic and ecological species grouping.

Vertebrate Watershed Segment Occurrences (4 classes), referred to Table V3 in some Figures. The watershed segments are defined as:

• Big Chino Watershed:

The uppermost headwaters of Big Chino Wash originate from a complex dendritic pattern of braided ephemeral washes in the extensive Great Basin Grassland of southern Coconino County. The washes originate from the Aubrey Cliffs to the west and mountainous terrain to the east. The northern end of the Big Chino watershed is in the vicinity of Red Lake, approximately 25 miles

north of Seligman. This area is bounded by the uplift of the Colorado Plateau that leads to the southern rim of the Grand Canyon. The downstream end is at Sullivan Dam.

- **Upper Verde Watershed:** Sullivan Dam to Clarkdale.
- **Middle Verde Watershed:** Clarkdale to Beasley Flat.
- **Lower Verde Watershed:** Beasley Flat to confluence with the Salt River

Vertebrate General Habitat Preferences (3 classes), referred to Table V2 in some Figures:

Obligate Aquatic-Riparian species require perennial aquatic and/or the associated riparian habitat. These species are therefore closely tied to the perennial riparian corridor in the Verde Watershed, although they can also be found traveling in Uplands habitats.

Facultative Aquatic-Riparian species prefer or possess more abundant populations in perennial aquatic and/or the associated riparian habitat, but they also occur in intermittent or ephemeral riparian and Uplands habitats.

Uplands species typically occur in a wide range or specific types of Uplands habitats: forests, woodlands, chaparral, grasslands, and deserts. Uplands species may also be commonly seen foraging, resting, traveling, overwintering, or escaping drought in riparian habitats.

Vertebrate Landscape Classification (5 classes), referred to Table V1 in some Figures

Verde: The characteristic and primary landscapes associated with the Verde River itself are: Riparian Forest and Shrubland, Piñon-Juniper Woodland, Ponderosa Pine Woodland and Forest, Chaparral, and Grassland or Meadow. Oak Woodland can be associated with any of these communities and may be important if not a critical landscape element because of acorn crops. These habitat mosaics also include the tributary channels, washes, springs, seeps, cliffs, ridge outcrops, boulder fields and talus slopes, and the topography and hills surrounding the river channel.

Highlands: Highlands signifies that the vertebrate species distribution closely follows the geographic physiography of the Arizona Central Highlands (i.e., Northern Apache Highlands) and the Verde Valley, often including the Southern Apache Highlands and/or White Mountains.

Mountains: Mountains represent the highest elevations found in the watershed, and they may be relatively far from the river itself. These communities range from Ponderosa Pine Forest, to mixed forests of ponderosa pine, douglas fir, white fir, trembling aspen, and Gambel's oak. Subalpine fir, Engelmann spruce, and Colorado spruce may occur at higher elevations. The mountains also contain high Meadows, Subalpine and Alpine Scrub.

Sonoran: The upper Sonoran Desert enters the Lower Verde Watershed. Some Verde Watershed vertebrates are restricted to this biotic community, and a few species barely enter it. Characteristic vegetation of this association is: saguaro, palo verde, ocotillo, and a significant diversity of *opuntia*, along with associated grasses.

Grasslands: There are three different grassland associations in the Verde Watershed. Two represent major biotic communities characterized by their geographic location and specific grass species, and these were identified in the Biotic Communities Section. The Great Basin Grassland predominates in the Colorado Plateau of northern Arizona and is typical of the Big Chino Watershed valley. Within the Verde Watershed, characteristic vertebrates are predominantly or only found here. The Desert Grassland predominates in the Southern Apache Highlands of southeast Arizona and patches of it extend into the Lower and Middle Verde Watershed. The third grassland represents relatively small patches of other habitat types (e.g., mesquite or desert willow thickets) converted to grass meadows by ranchers. These may be found on flats and benches on the banks of the Verde River or further upslope from the channel.

A. Mammals

The Verde Watershed possesses a rich mammal fauna in both family and species richness. Figure M1 shows the watershed distribution of the larger and more familiar mammal species. There is not much difference among the four portions of the watershed, but the Big Chino does have fewer species. Carnivores are particularly diverse with 17 species. The six ungulates include native collared peccary (javelina), pronghorn, mule deer, Coues' white-tailed deer, elk, and introduced non-native cattle. The remaining six species are common and widespread: beaver, muskrat, porcupine, eastern and desert cottontails, and black-tailed jackrabbit.

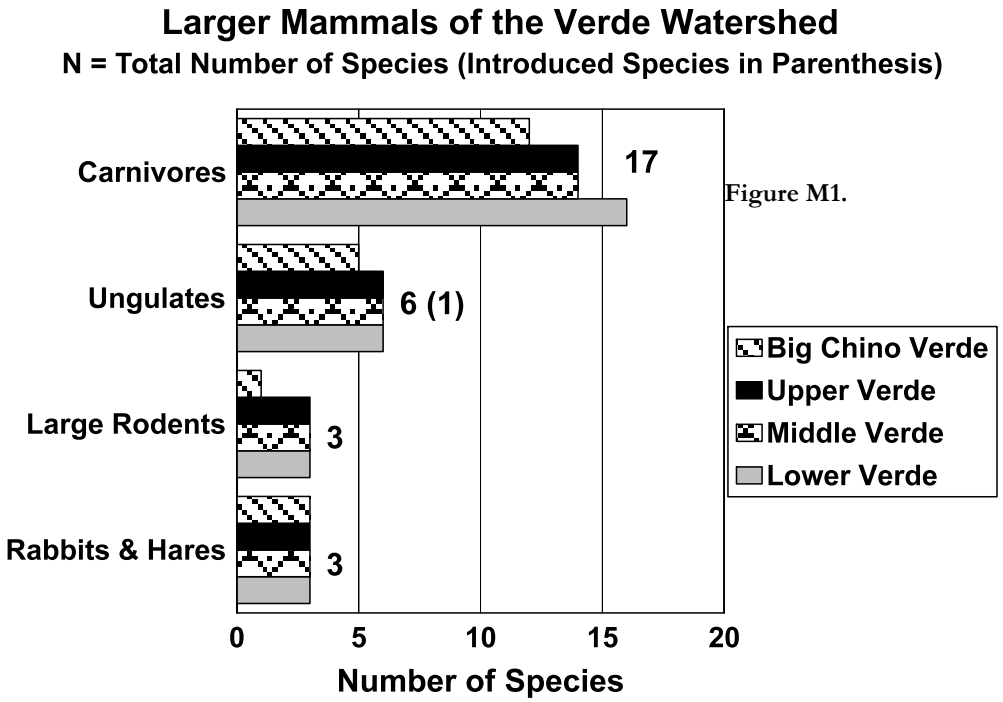


Figure M1.

1. By Habitat Type

Figure M2 shows the Verde large mammals association with three general habitat types: Aquatic-Riparian Obligates, Aquatic-Riparian Facultative, and Uplands.

Photo P55. Beaver dam on Granite Creek

Aquatic-Riparian Obligate mammals are two large rodents: beaver and muskrat; and four carnivores: river otter, raccoon, ring-tailed cat, and coati. Aquatic-Riparian Facultative mammals are predominantly carnivores, where they find abundant prey, water, and cover, especially during droughts and winter. Rugged cliff faces with rocky crevices and caves are important landscape elements.

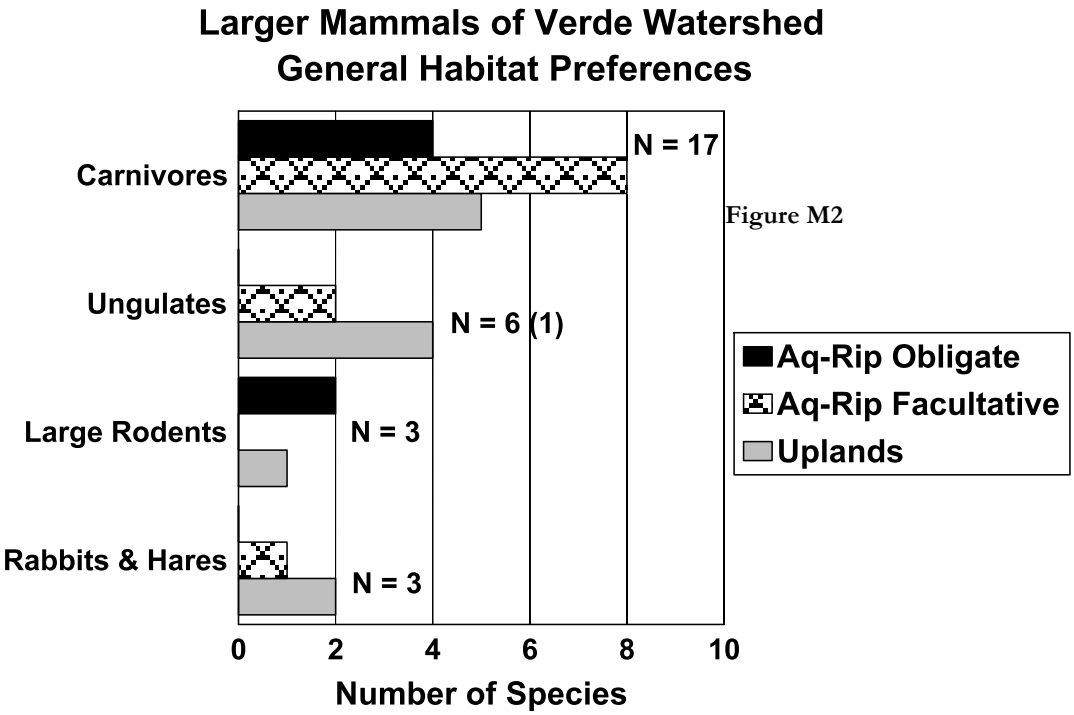


Figure M2

The eight carnivores in this habitat class are: gray fox, mountain lion, bobcat, long-tailed weasel, and four skunk species: striped, spotted, hooded, and hog-nosed. Mountain lions, bobcats, and skunks routinely use riparian corridors for landscape travel and dispersal. Other mammals preferring riparian habitat include collared peccary, desert cottontail, and cattle.

Riparian habitats for Uplands species may be particularly valuable during droughts and in the winter. There are a number of familiar Uplands large mammals: coyote, kit fox, black bear, badger, black-footed ferret, mule deer, Coues' white-tailed deer, elk, pronghorn, black-tailed jackrabbit, eastern cottontail, and porcupine. Although the porcupine is typically associated with forest landscapes, in Arizona it can be found in woodlands and scrub habitats. Coyotes, black bears, mule deer, and elk extensively use riparian habitats for food, water, cover; and very importantly, critical travel corridors. Black-tailed jackrabbits and desert cottontails are the two lagomorphs widely distributed in the Mojave and Sonoran Deserts, but they occupy different habitats. Jackrabbits evolved and are found in open scrub where forage may not only be sparse, but coarse and less succulent, and there is no surface water. They depend on their visual acuity, speed, and exceptional 3-dimensional spatial maneuverability to successfully escape predators. Desert cottontails are found in more densely vegetated habitats, which typically require water in arid ecosystems. They probably require both the more succulent vegetation and the denser cover to escape predators. The Eastern Cottontail is

found in the mountains and chaparral of Arizona. This is the same species found in almost the entire U.S. from the Dakotas and Texas eastward. The northern portion of New England is the exception.

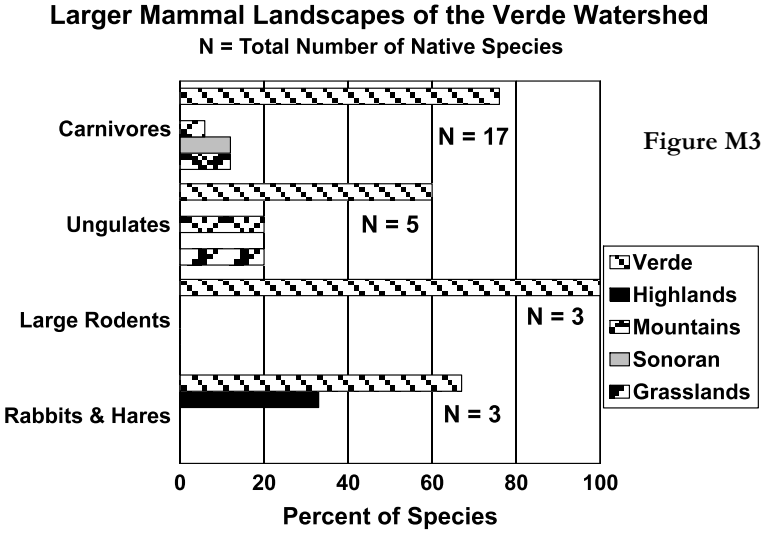


Figure M3

The Verde Watershed's large mammals are predominantly associated with the typical riparian, woodlands, and forests within the watershed, classified as Verde (Figure M3). The Big Chino Watershed has a unique and important Great Basin Grassland mammal fauna, and the continued existence of these species is dependent on the ecological viability and integrity of these grasslands. These mammal species are: pronghorn, black-footed ferret, kit fox, and three small mammals: Gunnison's prairie dog, spotted ground squirrel, and silky pocket mouse. Ferret and prairie dog interactions represent one of the more famous classic ecological models of predator-prey co-evolution dynamics.

Surprisingly, the only large mammal that shows a Highlands distribution is the eastern cottontail. Large mammals limited to the high mountains are the long-tailed weasel and Coues' white-tailed deer. Only two large mammals are tied closely to the Sonoran Desert in the Lower Verde. The coati, a component of North America's tropical fauna, is more typically found in extreme southeast Arizona, and the kit fox, which utilizes open arid grasslands/deserts at both geographic extremes of the Verde Watershed.

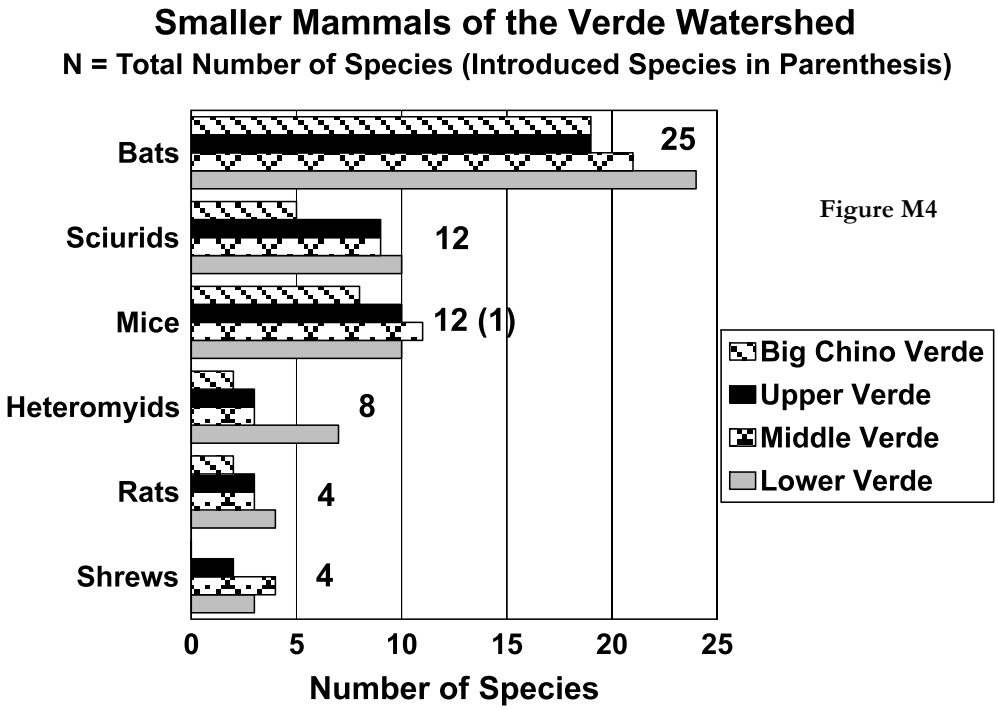


Figure M4

Figure M4 shows the Verde Watershed distribution of the smaller and undoubtedly less familiar mammal species. Three general patterns are apparent: 1) the high diversity of bats throughout the watershed (25 species); 2) small mammal diversity increases slightly going downstream in the Verde Watershed; 3) the Big Chino possesses fewer species of small mammals, as was also the case with large mammals. This downstream increase in diversity is due to the higher mountains present in especially the Middle Verde, but also the Lower Verde, and the Sonoran Desert in the Lower Verde. Sciurids (i.e., squirrels) include ground squirrels, tree squirrels, antelope squirrels, chipmunks, and prairie dogs. Pocket gophers belong to their own family, but were included in this classification. Mice include the familiar deer mice, voles, harvest mice, grasshopper mice, and the introduced old world House Mouse. Rats are in the same family as mice, but are larger and include woodrats (packrats), cotton rats, and the introduced old world rats (Norway rat, black rat). The house mouse was included in the Verde mammal fauna, because it does well in the wild, especially in riparian areas, even though it is more typically associated with residential and agriculture habitats. The old world rats were not included, because they are closely associated with urbanization or agriculture, and their status in Arizona is not well known. Heteromyids are the arid adapted kangaroo rats, pocket mice, and kangaroo mice. The latter only occur in Great Basin habitats northwest of Arizona, primarily in Nevada.

Figure M5

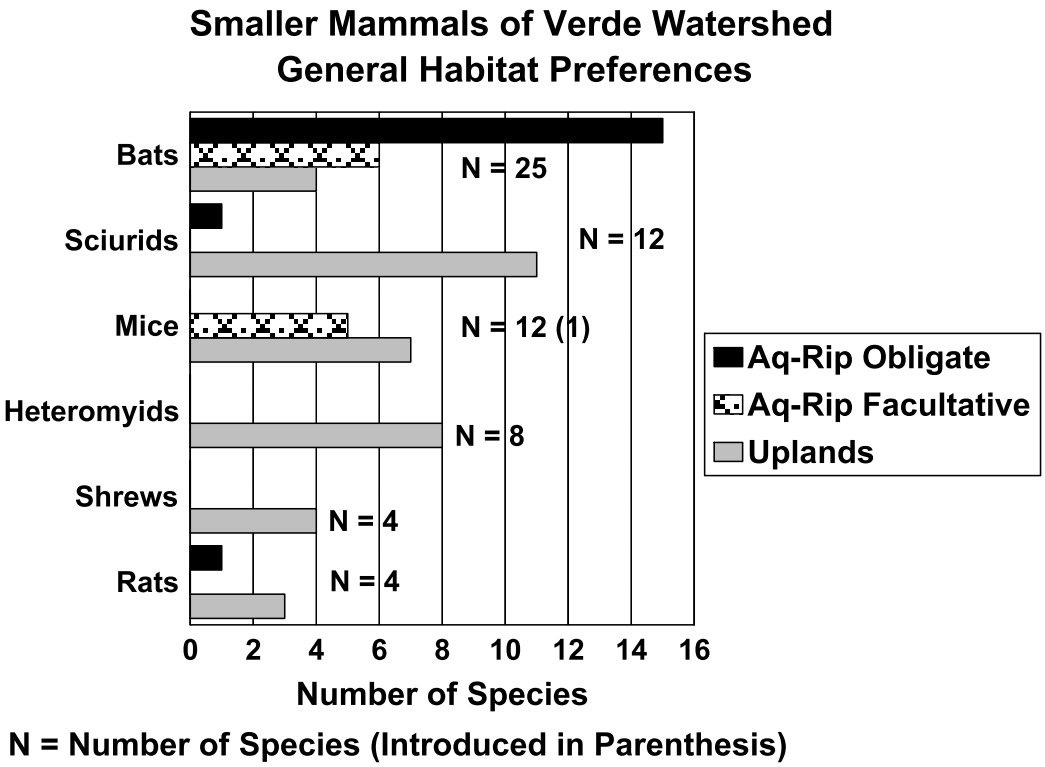


Figure M5 shows the Verde small mammals association with three general habitat types: Aquatic-Riparian Obligates, Aquatic-Riparian Facultative, and Uplands. Aquatic-Riparian Obligate small mammals are 15 bat species, Arizona gray squirrel, and Arizona cotton rat. Bats are strongly associated with perennial instream flows and riparian habitats, because of the predictable and exceptionally large supply of insects these habitats provide, and many bat species prefer drinking surface waters while on the wing. Additionally, riparian canyons provide cliffs, rock crevices, caves, and large trees with foliage and cavities for roosting. The Arizona gray squirrel (actually related to fox squirrels and not gray squirrels) is restricted to deciduous riparian forest.

The five mice species that are Aquatic-Riparian Facultative prefer dense vegetation such as heavy shrub cover: brush mouse, white-footed mouse, and house mouse; or dense grasses, western harvest mouse and Mogollon vole. Squirrels, Heteromyids, woodrats, shrews, and most mice are primarily Uplands species. Nevertheless, species in this habitat class that may be closely associated with Verde riparian habitats, higher terraces, and canyon landscape elements include: cliff chipmunk, rock squirrel, Botta's pocket gopher, woodrats, and even the Heteromyid rock pocket mouse. Pocket

gophers are found in friable sandy soils where they can easily burrow along in the substrate. The other six species (three woodrats) listed prefer rocky slopes, rock outcrops, or boulder ridges. The three species of Verde woodrats are widely distributed in the Verde Watershed, overlap in distribution, and are difficult to tell apart. The white-throated woodrat (the bases of the throat hairs are white not the tips) is the most abundant, widely distributed, and occupies the broadest habitats: cactus or yucca scrub, piñon-juniper or ponderosa pine woodlands, oak scrub, and chaparral. Stephen's woodrat prefers piñon-juniper woodland, while the Mexican woodrat is typically associated with the higher elevations in conifer forests.

Bats, mice, and rats are predominantly associated with the typical woodlands and forests within the watershed, classified as "Verde" (Figure M6). The broad species and ecological diversity of the Sciurids is clearly demonstrated in their broad distribution in watershed landscapes. The strong montane preference of shrews is evident. Shrews possess an extremely high metabolism, and are therefore strongly tied to predictable and persistent moist litter habitats and their invertebrate fauna. Surprisingly, the desert and arid grasslands adapted kangaroo rats and pocket mice are equally distributed between Verde woodlands and forests and the Sonoran Desert. However, recall the spatial extent of these two habitats in the Verde Watershed. The "Verde" habitat comprises most of the watershed, while the Sonoran reflects only a small portion that nevertheless possesses a significant Heteromyid fauna.

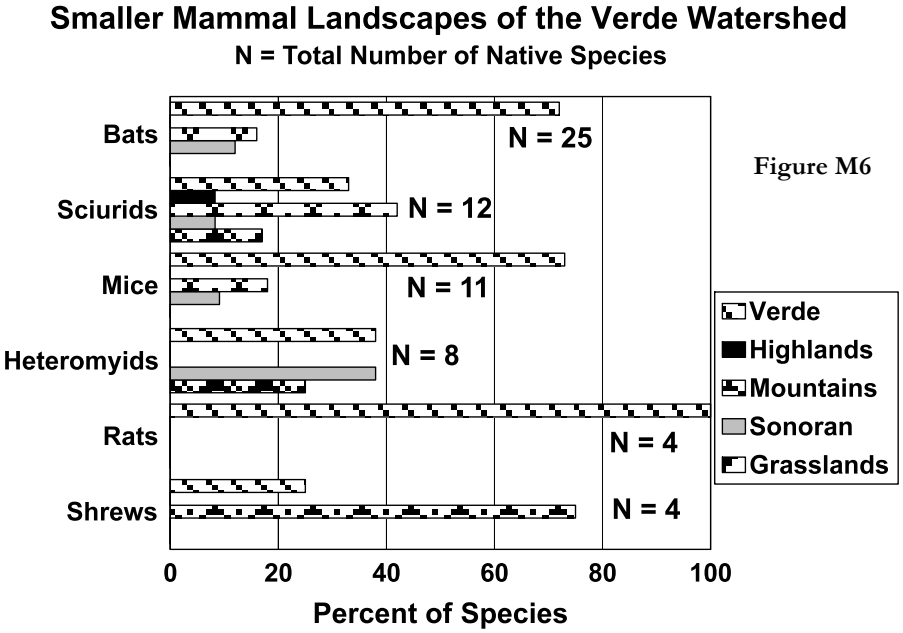


Figure M6

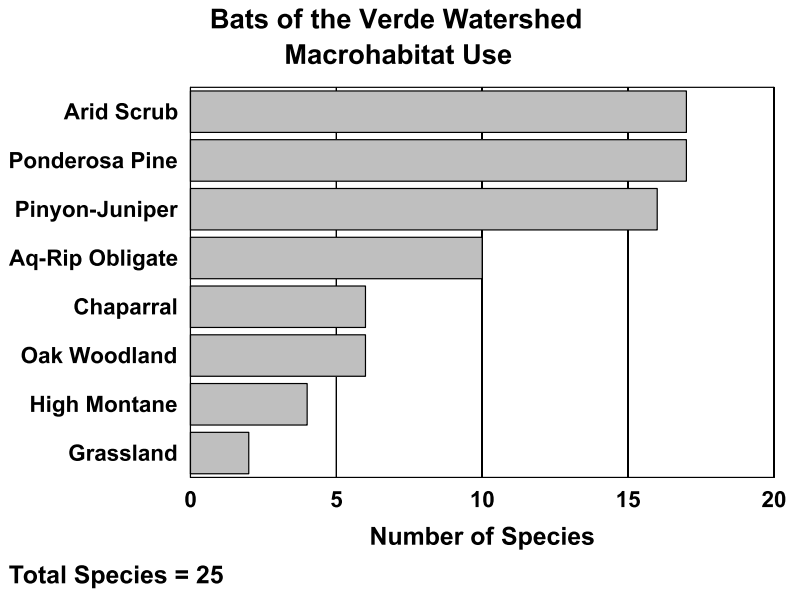


Figure M7

Figure M7 presents a macrohabitat classification for the 25 species of Verde Watershed bats, based primarily on Adams (2003). This figure and the data from Adams represent a broader landscape classification than Figure M5. For example, in Figure M7 most Verde bats are associated with Arid, Ponderosa Pine, and Piñon-Juniper Woodland macro-habitats. This is certainly true, but these species are also significantly associated with aquatic/riparian sites within these macro-habitats, and also canyons and rocky outcrops. Ten species (40 percent) of the Verde bat fauna are very closely tied to aquatic/riparian habitats. Only a quarter of the species are associated with either chaparral or oak woodland. While the high mountains of the Southwest and West do provide significant habitat for numerically a large number of bats, there are apparently relatively few species utilizing this ecological niche. Not surprisingly, grasslands typically have low bat diversity.

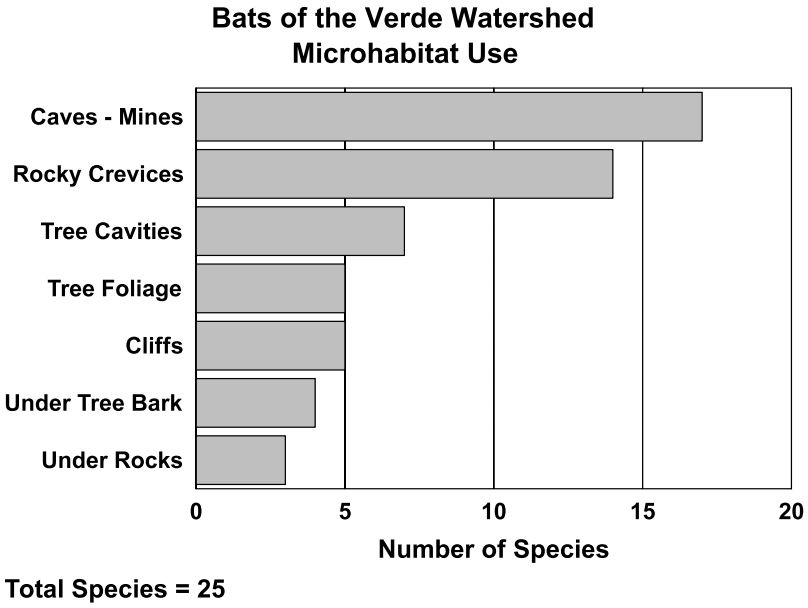
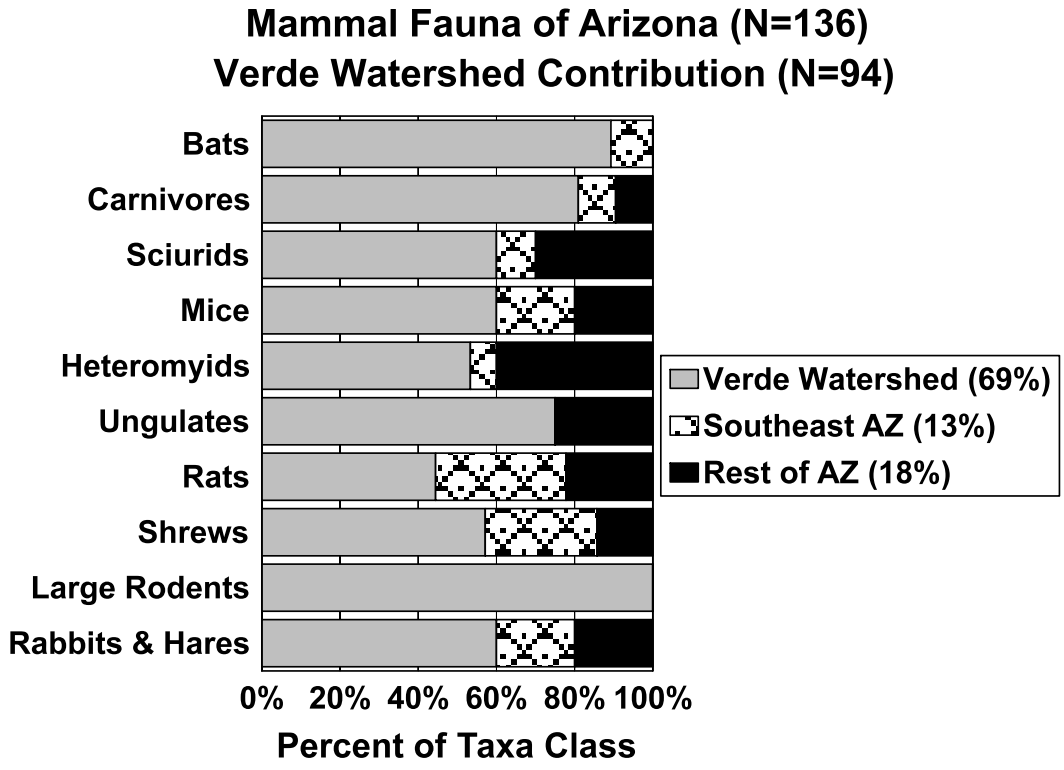


Figure M8

Figure M8 presents a microhabitat classification for the 25 species of Verde bats, based primarily on Adams (2003). Clearly, caves, abandoned mines, and rocky crevices are important roosting sites for the Verde bat fauna. Bats in the genus *Lasiurus* (western red bat, western yellow bat, hoary bat) are strongly tied to deciduous riparian forests where they roost in foliage, under bark, and in tree cavities, including woodpecker holes. The hoary bat also is associated with Ponderosa Pine forest. Other species using tree cavities include: silver-haired bat, pallid bat (an abundant and widely distributed southwest species), and many *Myotis* species (e.g., California, long-eared, long-legged). The western pipistrelle is a small abundant and widespread bat in the Southwest. It is one of three species to roost under a rock for shelter. It also uses abandoned animal burrows, and is often associated with cliff faces. Other bats roosting under rocks include long-eared myotis and western small-footed myotis. Yuma myotis may use abandoned cliff swallow nests, which are common along the Verde River. Four exceptionally high conservation value bat species are typically very closely associated with cliff faces: the very rare spotted Bat, the very large and uncommon greater mastiff bat, and the uncommon big and pocketed free-tailed bats.

2. The Contribution of the Verde Watershed to Arizona's Mammal Fauna

Figure M9



Verde Watershed Landscape is 5.8% of Arizona Land Area

The importance of Verde Watershed mammals to the entire Arizona mammal fauna is clearly demonstrated in Figure M9. Verde Watershed landscapes, despite encompassing only 5.8 percent of the area of the state of Arizona, possess 69 percent of Arizona's Mammal species. The rich vertebrate biodiversity of Southeast Arizona adds 13 percent to the Verde fauna. Many of these southeast species are subtropical and barely extend into the U.S. from Mexico. The relatively high mammal diversity contribution from the rest of Arizona (18 percent), is directly due to rodent species associated with arid Great Basin, Mojave, and Sonoran landscapes; the mountains on the Colorado Plateau;, and the White Mountains.

Bats

The Southwest, and particularly Arizona, is widely recognized and acknowledged for its rich bat fauna. Arizona has 28 bat species, and 25 of these are found in the Verde Watershed (See Figure M8). Therefore, the Verde Watershed at 5.8 percent of the state's area possesses 89 percent of its bat

fauna. The three species not found in the Verde belong to a subtropical fauna restricted to southeastern Arizona.

Carnivores

The Verde Watershed has 81 percent (N=17) of Arizona's carnivore fauna. The jaguar and ocelot in Southeast Arizona are transients from Mexico, but both were historically found in the Verde Watershed:. The red fox is found in the mountains on the Colorado Plateau in the northeast corner of the state, and the Mexican wolf was reintroduced into the White Mountains in the Blue River Watershed. This subspecies of grey wolf was also historically present in the Verde Watershed, and may again colonize its landscape.

Sciurids and Mice

The Verde Watershed has 60 percent (N=12) of Arizona's squirrel fauna. Most of the fauna not found in the Verde are in the mountains or grasslands of northern Arizona. Similarly, 60 percent (N=12) of mice are found in the Verde. The other species are restricted to grassland habitats in Southeast Arizona, the moist forests of the White Mountains, and one has a scattered distribution from north to south in the mountains of western Arizona.

Hereromyids

Pocket mice and kangaroo rats are arid scrub and grasslands adapted species. It is somewhat surprising that 53 percent (N=8) of Arizona's fauna are found in the Verde Watershed. However, five of these species are primarily or solely restricted to the Lower Verde and its Sonoran and Desert Grasslands habitats. The silky pocket mouse is found in the Great Basin Grassland of the Chino and Upper Verde. The rock pocket mouse inhabits the rocky slopes of desert mountains, primarily south of the Verde, but it does occur in the watershed from the Upper to the Lower Verde. Ord's kangaroo rat is the only Heteromyid that can be found in most of the watershed in grasslands and piñon-juniper habitats with sandy soils.

Ungulates

The Verde Watershed has 75 percent (N=6) of Arizona's ungulates. The desert bighorn sheep and wild burro (introduced) are found in arid mountains in the western part of the state. The desert

bighorn is doing well in the southwestern part of the state and some localities along the Colorado River.

Rats, Shrews, Large Rodents, and Lagomorphs

The Verde Watershed has 44 percent (N=4) of Arizona's rat fauna. Along with the Arizona cotton rat (found in the Lower Verde) three additional species of cotton rats are found in southeast Arizona. Two other Arizona woodrats are the desert packrat widely distributed in the arid landscapes of western Arizona, and the bushy-tailed woodrat in montane conifer forests of northern Arizona.

The reason that the Verde Watershed has 57 percent (N=4) of Arizona's shrew fauna is due to the high moist montane conifer forests along and above the Mogollon Rim. Two more shrews are found in the southeast and another in the White Mountains.

Arizona has no additional large rodents to add to the Verde Watershed's Beaver, muskrat, and porcupine. The first two are restricted to perennial rivers and streams, lakes, and reservoirs.

Verde's three lagomorphs (rabbits and hares) (60 percent) are also widely distributed in the state. Two additional Arizona species are Allen's jackrabbit in the southeast, and mountain cottontail widely distributed in the brushy mountains in northern, northeastern, and east-central (White Mountains) Arizona.

3. Introduced Exotic Mammals of the Verde Watershed

The Verde Watershed has four non-native species: cattle, house mouse, Norway and black rats. The first two species were included in the biodiversity analysis because they are present in the habitat. The two old world rats were not included, because they are closely restricted to residential and agriculture habitats and their status in Arizona is not well known. The house mouse is more associated with rural and agricultural settings and is typically found in and close to these landscapes. Cattle dramatically degrade habitats that were not originally subjected to intense grazing by large native herbivores. Cattle particularly severely inpact habitats, degrade water quality, and dramatically alter plant community compositions in riparian and arid landscapes (Ferguson and Ferguson 1983,

Fleischner 1994, Briggs 1996, Belsky et al. 1999, Donahue 1999, Sayre 2002, Chambers and Miller 2004, Clary and Kruse 2004).

Although there has been justification for cattle on the Great Plains as an ecological functional replacement for the American bison, the ecological damage cattle inflict in riparian and arid ecosystems has not been adequately appreciated outside the research community. Unlike our Great Plains, the Mojave and Sonoran Deserts did not evolve with extensive herds of large herbivore grazers.

Photo P32. Cattle grazing in the riparian zone is prohibited.

Cattle prefer riparian zones because of more succulent vegetation, water, and shade. Here they preferentially feed on young cottonwoods, willows, and native forbs while avoiding and making room for tamarisk (saltcedar). Grazing simplifies habitat structure, destabilizes banks contributing to bank erosion, reduces water quality, and compacts soils (Krzysik 1990). Compacted soils reduce rain infiltration and aeration of soils, interfere with seed germination and burrowing invertebrates, and increase surface runoff, which initiates rill and gully erosion. Tamarisk is a particularly strongly invasive, overpowering, and noxious weedy scrub-tree introduced from the Middle East.

Cattle and ranching operations have been in the Verde Watershed since the late 19th century. The significant damage that cattle do to aquatic and riparian ecosystems has been well documented for over a century. This includes: pollution, eutrophication, siltation, bank destabilization and erosion, loss of cottonwood and willows, loss of rare forbs and other vegetation, and degradation of microhabitat complexity. However, what may also be one of their most significant and destructive ecological impacts and not widely appreciated is that they attract cowbirds. Brown-headed cowbirds closely coevolved with the American bison, but as the bison disappeared they readily adapted to hanging around cattle and horses. Cowbirds forage on the insects stirred-up by large grazing

mammals, benefit from the open habitats produced by grazing, and feed on the seeds and insects associated with cow patties and horse dung. Cowbirds are brood parasites and lay their eggs in the nests of other bird species, almost always with devastating results for native songbird populations, especially Neotropical Migrants and species not in the original native range of the American bison (Robinson et al. 1995, Smith et al. 2000). Cowbird nestlings are aggressive and develop quickly, typically winning the competition for food at the nest or ejecting their smaller nest mates.

4. Extinct Mammals in the Verde Watershed

Four mammals historically found in the Verde Watershed are currently extirpated in the watershed: grizzly (brown) bear, grey wolf, jaguar, and ocelot. There were actually two subspecies of grey wolf in the Verde Watershed: the southern Rocky Mountain or Great Basin wolf in the north, and the Mexican wolf in the south. The majority of Arizona grizzly bears were in the White Mountains, and to a lesser extent along the Mogollon Rim. Nevertheless, the largest one documented west of the White Mountains was killed in 1922 in the vicinity of Bear Canyon–Government Canyon (Brown 1985), in the middle of the upper Verde. In 1925, a Grizzly was killed at the headwaters of Hurricane Creek, Mount Baldy, White Mountains, and in that general area the last grizzly in Arizona was killed in 1939 (Brown 1985).

The Mexican wolf has been reestablished in the White Mountains, and its repatriation has been with mixed success (Holaday 2003). The Mexican wolf may eventually find its way into the Verde Watershed. The southern Rocky Mountain wolf, typically found from the Mogollon Rim and northward is extirpated in the U.S., but there is a reliable museum record (1923) from as far south as Aguila Arizona, south of the Verde Watershed (Hoffmeister 1986).

Jaguars are occasionally sighted in extreme southeastern Arizona. These individuals are thought to range from the Huasabas-Sahuaripa population in Sonora Mexico, and therefore travel from 140-200 miles, a dispersal distance documented for male mountain lions (Brown and Gonzalez 2001). Historically, jaguars were in the Verde Watershed, ranging as far north as the Grand Canyon, Santa Maria Mountains, and Bloody Basin, but were apparently not common (Hoffmeister 1986). Ocelots are small and very secretive, and were rarely seen in Arizona. One was taken in a predator trap at Camp Verde in 1932 (Hoffmeister 1986). A reliable witness and experienced outdoorsman claimed

he sighted an ocelot along Wet Beaver Creek in the late 1990s (personal communication). However, most modern sightings of ocelots are escaped captives.

B. Amphibians and Reptiles

Amphibians and reptiles are collectively known as herpetofauna or herps. United States amphibians are salamanders and anurans. Anurans are frogs, toads, and spadefoots. Arizona reptiles consist of chelonians, lizards, and snakes. Chelonians globally represent turtles, tortoises, terrapins, and sea turtles.

Amphibians and reptiles are ecologically, physiologically, behaviorally, and even anatomically closely connected and integrated to their environment, habitats, and biotic communities. Therefore, local or regional herpetofauna represent excellent ecological indicators and monitors of ecosystem: condition, integrity, trends, and disturbance trajectory. Some amphibians have evolved independence from even temporary surface water for reproduction, but these are primarily found in tropical or montane humid environments. Most amphibians still require perennial or temporary surface water to reproduce, including Arizona's fauna, with the single exception of the barking frog of southeast Arizona, a tropical relict. All amphibians and snakes, and almost all lizards are carnivores that are at or near the top of ecosystem food webs, making them susceptible to environmental toxins such as insecticides, fungicides, herbicides, and heavy metals, because un-metabolized substances are geometrically concentrated up food chains. Some lizards are herbivores. Chelonians by far have the most diverse food habitats, and depending on species they can be carnivores or herbivores and even scavengers, while juveniles are primarily carnivorous.

1. Amphibians

The arid West is impoverished in salamanders, with the greatest abundance and diversity found in the Appalachian Mountains in eastern United States, especially in its southern portion, but with important fauna evolution and diversity in the Pacific Northwest and the mountains of California (Petranka 1998, Duellman and Sweet 1999). The tiger salamander is the only species in Arizona, and indeed the only salamander found in the entire Great Plains region, with five western subspecies ranging from southern Canada into Mexico roughly between the longitudes of most of Arizona in the West and the Dakotas in the east (Petranka 1998, page 112). The tiger salamander is

the second largest species in North America (up to 7in. long) and spends most of the time in its underground burrow. It is typically only seen when large numbers driven by precipitation converge at ponds, quiet river pools or backwaters, or the historically recent cattle tanks for mass breeding episodes in winter to early summer. The Arizona tiger salamander ranges throughout the Central Highlands and the Colorado Plateau. The Sonoran tiger salamander is a relict population in San Rafael Valley grasslands and woodlands in Santa Cruz and Cochise counties in southeastern Arizona and adjacent foothills of the Huachuca and Patagonia Mountains, and in extreme northern Sonora, Mexico. The Sonoran tiger salamander was originally found near spring-fed marshes (cienegas) that dried up because of severe and rapid erosion by arroyo cutting caused by cattle overgrazing in the late 19th and early 20th centuries. Current major aquatic larval habitats are ponds and cattle tanks (guzzlers) created by ranchers for their livestock. The non-native barred tiger salamander is found in the southern portion of the state, and was probably introduced from New Mexico.

Amphibian genera represent a taxonomically stable nomenclature for classifying morphological, physiological, behavioral, and reproductive evolutionary responses to ecosystem adaptations. The use of amphibian genera as a metric of ecological taxa was very informative in assessing and characterizing ecosystem associations in the Midwest (combined states of Ohio, Indiana, Illinois, Missouri, Iowa, Michigan, Wisconsin, Minnesota) (Krzysik 1998). The partitioning and dependence of terrestrial, aquatic, riparian, and wetlands ecosystems in Midwest amphibians was similar to that of the entire amphibian fauna of the rest of the United States and Canada. This result was surprising, because of the abundance and diversity of Midwest's aquatic, wet, and humid ecosystems, including lakes, ponds, rivers, streams, floodplains, swamps, marshes, bogs, fens, springs, seeps, wet meadows, and extensive and very diverse riparian communities. Meanwhile, the United States possessed a much greater diversity of terrestrial ecosystems, topographic complexity and diversity, and elevation zones.

Most people profile Arizona as a "desert state," and would not consider it to possess a diverse frog and toad fauna. Nevertheless, Arizona's native anuran fauna includes 10 genera and 25 species, while the Verde Watershed (5.8 percent of Arizona's area) possesses 7 genera and 13 species. The Midwest possesses an incredible spatial extent and diversity of anuran landscapes and habitats. It would be informative to compare and contrast the anuran faunas of the Verde Watershed, Arizona, and the entire Midwest (8 states) (Table below).

	Land + Water (mi^2)	Land Only (mi^2)	Water Only (mi^2)
Midwest (8 states)	514,286	447,878	66,408
Arizona	113,998	113,635	364
Verde Watershed	6622	-----	-----
	Percent of Midwest	**Percent of Midwest**	**Percent of Midwest**
Arizona	22 %	25 %	0.55 %
Verde Watershed	1.3 %	1.5 %	-----
	Anuran Genera	**Anuran Species**	
Midwest	8	27	
Arizona	10	25	
Verde Watershed	7	13	
	Landscape Genera Density Index (10^6 x genera/mi^2)	**Landscape Species Density Index (10^6 x species/mi^2)**	
Midwest	15.5	52.4	
Arizona	87.7	219	
Verde Watershed	10,570	1963	

Despite the large differences in land and water area among the Verde Watershed, Arizona, and the Midwest, the number of anuran genera is similar. Indeed, Arizona has more genera than the entire Midwest, which is 4.5 times larger in area, and possesses 182 times the surface area of water, a major requirement of almost all United States Anurans. The landscape density of anuran genera and species is particularly illuminating, especially for Verde genera. The Verde Watershed, calibrated by landscape area, has 682 times the anuran genera density as the entire Midwest, and 121 times that of Arizona. Contrasting species densities, the Verde Watershed has 37 times that of the Midwest and 9 times that of Arizona.

Amphibians are undergoing severe widespread population declines and extinctions from local to national and global scales, sometimes in pristine landscapes (Green 1997, Lannoo 1998, 2005, Semlitsch 2003, Collins and Crump 2009). The major attributed causes are anthropogenic driven: climate change, habitat loss and degradation, landscape and habitat fragmentation, pollution, acidic deposition, deforestation and timbering operations, mining including heavy metals runoff, introduced species, and increased ultra-violet (from stratospheric ozone depletion). Pollution is primarily from agricultural pesticides, fertilizers, and endocrine disrupters, which are also found in residential runoff. Chytrid fungus infections have been implicated in many anuran population declines around the world. Chytrid fungus, other fungi infections, bacterial infections, and other diseases may be linked to climate change and other anthropogenic stressors, including dispersal by humans and introduced species. Nevertheless, in some anuran populations there is an absence of observable chytrid pathology (asymptomatic), even though individuals test strongly positive for chytrid fungus, including landscapes never visited by humans (Krzysik, publication in preparation). Introduced species are major contributors to local and regional population declines, such as in Arizona where bullfrogs and crayfish severely impact native populations. Trout introduced into historically fishless alpine lakes have eliminated numerous native anuran populations in the American West (e.g., Knapp et al. 2001, 2007).

2. Reptiles

Lizard and snake communities have successfully evolved to deserts and semi-arid environments on all continents (Bender 1982, Pianka 1986, Vitt 1991, Brown and Wright 1994). Arizona is widely recognized as a major biodiversity center for its lizard and snake faunas, especially exemplified by its rattlesnakes (Stebbins 1954, Lowe 1964, Fowlie 1965, Ernst 1992). Lizards and snakes will be discussed in more detail below. Contrasting the arid Southwest depauparate Chelonian fauna, the humid southeastern United States has the highest Chelonian species diversity in the world.

Arizona has only five or six native species of Chelonians. The desert tortoise is widely distributed in the Sonoran and Mojave Deserts of the Southwest, and the desert box turtle in southeast Arizona's grasslands is also an arid adapted species. The desert tortoise is an important indicator of ecosystem condition, a keystone species, and in critical need of conservation (Luckenbach 1982, Krzysik 1997, Morafka and Berry 2002, Van Devender 2002). Its burrows provide homes and hibernacula for hundreds of species of both vertebrates and invertebrates.

Despite Arizona's numerous rivers, only three species of native aquatic turtles, all mud turtles, are found in the state. The Sonoran mud turtle has a wide distribution from southeastern Arizona through the Central Highlands, and into Bill Williams River and Lower Colorado River. The southwestern and yellow mud turtles have a very limited distribution in southeastern Arizona. A population of northern painted turtle (formerly western painted turtle) in Apache County (east-central Arizona) may also be native.

3. Amphibians and Reptiles of the Verde Watershed

Figure H1

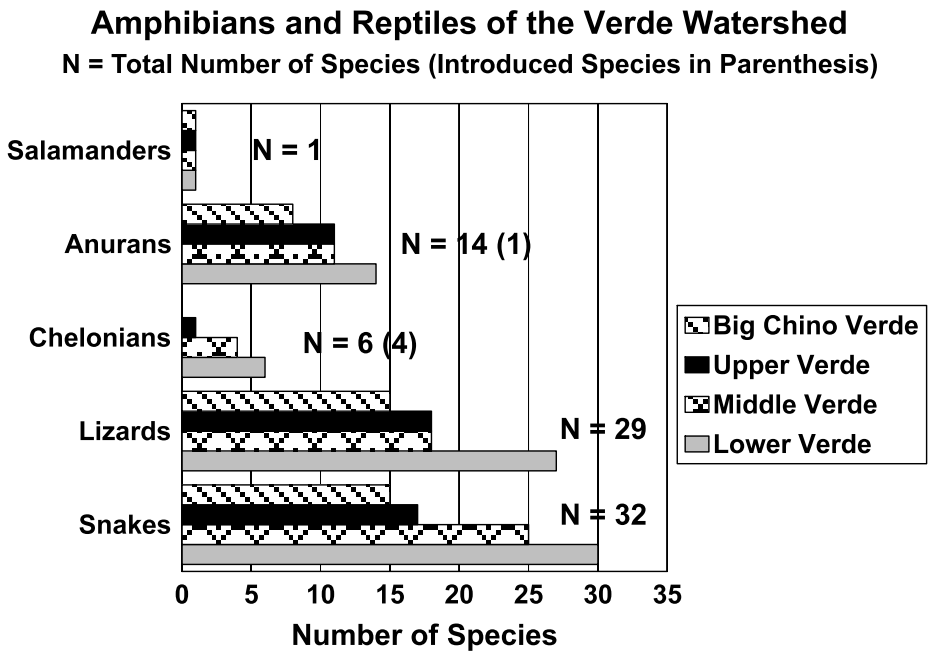


Figure H1 shows the herpetofauna distribution in the Verde Watershed. The Arizona tiger salamander is found throughout the watershed. Note that anurans, chelonians, lizards, and snakes all increase in species richness from the Big Chino headwaters to the Lower Verde. This is particular evident with lizards and snakes, and will be explored in more detail in the following figures. The introduced bullfrog is found throughout the watershed, and will be discussed in more detail under "Introduced Species."

There is an interesting ensemble of snakes found in the Lower Verde that extends into the Middle Verde: southwestern blind snake, southwestern blackhead snake, sonoran lyre snake, Arizona glossy snake, mountain patchnose snake, sonora whipsnake, red coachwhip, northern Mexican garter snake, and Arizona coral snake. All these species are characteristic of Arizona's rich southeast fauna and make their way up the Verde Watershed.

There are only two herp species with subspecies in the watershed: Clark's spiny lizard and Woodhouse's toad. Clark's spiny lizard is distributed in the Central Highlands and into southeast Arizona, Mexico, and extreme southwest New Mexico.: The plateau spiny lizard is found north of Payson in the Big Chino to Middle Verde, and the museum type specimen was collected from Granite Dells in Prescott. The Sonoran spiny lizard occurs south of Payson from the Lower Verde and southward. In this report, the two subspecies, Woodhouse's toad and southwestern Woodhouse's toad, were considered as a single species, because their respective population gene pools overlap broadly in Arizona.

Figure H2

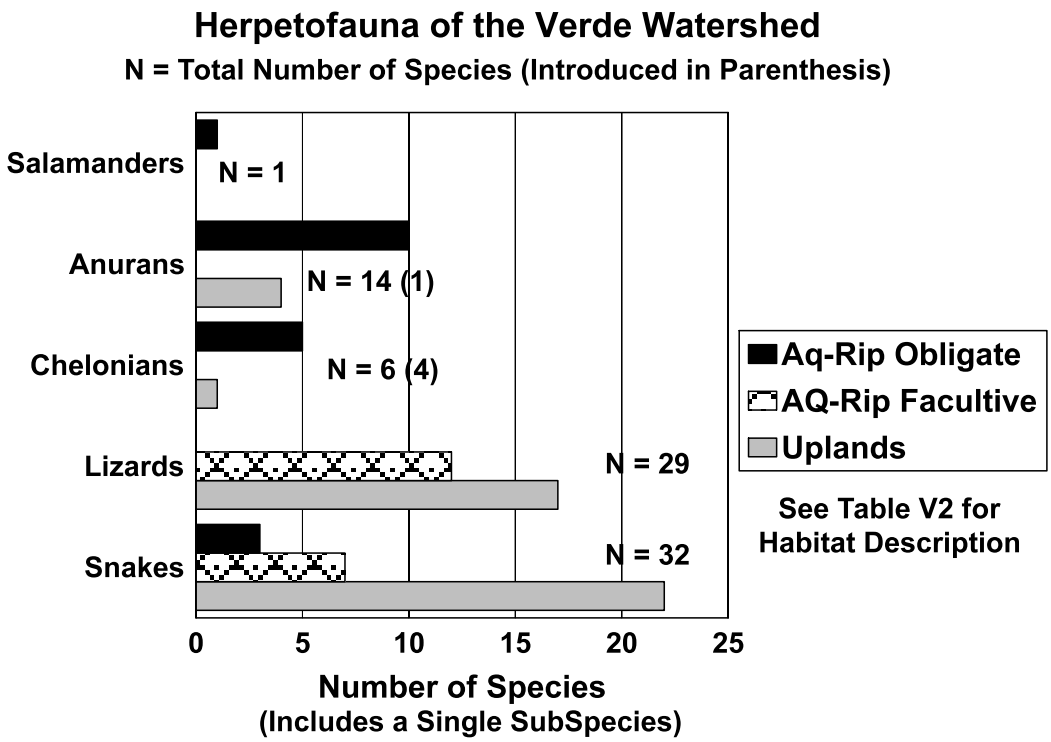


Figure H2 shows the Verde herpetofauna association with three general habitat types: Aquatic-Riparian Obligates, Aquatic-Riparian Facultative, and Uplands. Obligate species are only found in aquatic and/or riparian habitats, or require these habitats for reproduction or foraging. Facultative species may occur in both Uplands and Riparian habitats, but prefer or are more successful in Riparian habitats. Uplands species are predominantly found in upland habitats such as conifer forests, piñon-juniper or oak woodlands, chaparral, shrublands, grasslands, or deserts. Nevertheless, these species are often found in riparian corridors because of food, water, or cover resources, especially during droughts and in the winter. The canyon topography of much of the Verde Watershed provides rocky slopes, rock outcrops, boulder ridges, and their associated crevices, nooks and crannies. Therefore, many Uplands classified snakes, lizards, and mammals, may be quite common in the Verde's riparian ecological setting.

Tiger salamanders require surface water for reproduction and are partial to soils with at least some moisture. Most of the Verde's anuran fauna require humid conditions and permanent water or reliable temporary pools for reproduction. However, four are Uplands species typically depending on summer monsoons, or even intense winter precipitation, to provide temporary pools for their speeded-up reproductive cycle: New Mexico spadefoot, Couch's spadefoot, great plains toad, and Sonoran desert toad. These species have an extended breeding season from winter through fall, because of their strong dependence on adequate rainfall to form temporary ponds. Their egg-laying to tadpole transformation cycle typically takes several weeks. There are species of anurans that can accomplish this in a week.

Note that most of the Verde's chelonian fauna represent four exotic introduced aquatic turtles. These species would predominantly be found in the larger waters of the Middle and Lower Verde River, including Horseshoe and Bartlett reservoirs. Also suitable habitats in the Verde Watershed include ponds, lakes, and various impoundments. The red-eared slider has established itself in Montezuma Well, and the resident native Sonoran mud turtle has experienced a decline (Krzysik, publication in preparation).

Note that lizards and snakes especially are Uplands species in the Verde Watershed. There are no aquatic/riparian obligate lizards, but note that a large proportion of species are aquatic/riparian facultative. This is because of the increased abundance, diversity, and predictability of both

arthropods (insects, spiders, etc.) and microhabitat structure available in riparian communities; as well as increased opportunities for habitat partitioning (Krzysik 1990).

There are no water snake taxa (e.g., *Nerodia*, *Regina*) in the West, with the exception of two species barely ranging into the plains of Colorado and New Mexico. The western "water snakes" are in actuality garter snakes. Three aquatic/riparian species are characteristic and important in the Verde. Ranked by their behavior from most aquatic are: narrowhead garter snake, northern Mexican garter snake, and blackneck garter snake. Another important Verde Watershed species, the wandering garter snake, can be found far from water, but is more typically associated with aquatic habitats, and is the most abundant and widespread garter snake. A number of snakes are partial to the moisture and rocky retreats that river canyons provide: southwestern blackhead snake, regal ringneck snake, sonoran lyre snake, Arizona mountain kingsnake, and blacktail rattlesnake. The Arizona black rattlesnake, typically a species of montane pine forest and therefore an Uplands species, nevertheless is partial to canyon riparian settings.

Photo 33. Blacktail rattlesnake, found in Upper Verde River Wildlife Area

Figure H3

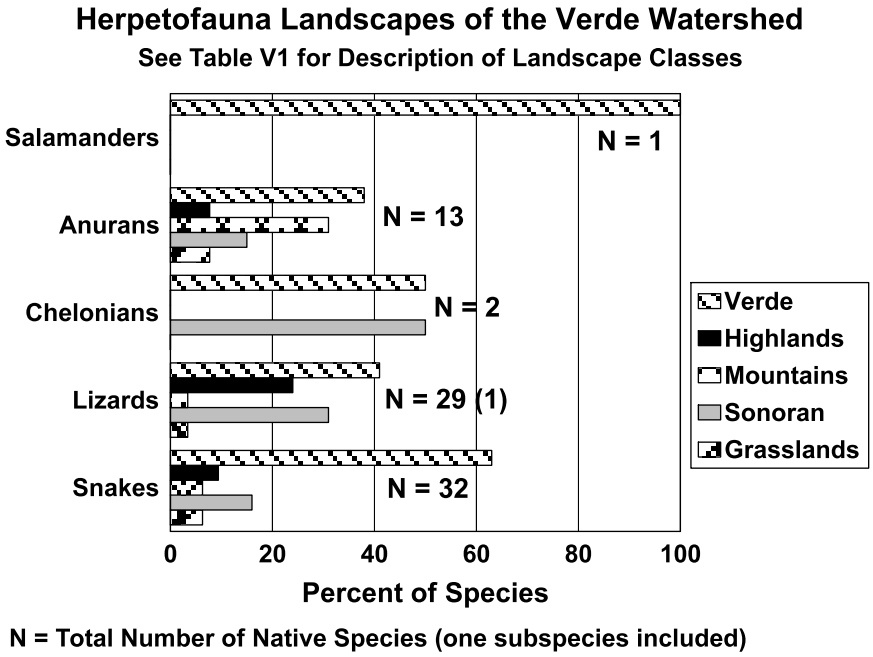


Figure H3 shows the Verde herpetofauna association with five landscapes of the Verde Watershed. Note that most of the herpetofauna is associated with the primary biotic communities of the Verde landscape, including the Arizona tiger salamander and Sonoran mud turtle. This is especially evident with the snake fauna. Lizards are important in the Highlands fauna, and therefore among Arizona's herps, best represent its Central Highlands: Arizona alligator lizard, southwest earless lizard, desert grassland whiptail, Gila spotted whiptail, great plains skink, and the two subspecies of Clark's spiny lizard, plateau and Sonoran spiny lizards. The Arizona mountain kingsnake and two riparian species, narrowhead and blackneck garter snakes are the Highlands snake species, but the Arizona black rattlesnake (classified here as Mountain) makes a distributional strong case for a Highlands species. The Arizona toad represents one of the best geographic distributions as a Highlands species.

There is a notable montane frog fauna: Arizona treefrog, boreal chorus frog, northern leopard frog, and Chiricahua leopard frog. Lizards and snakes, as expected, have a poor montane fauna. The predominant species is an Arizona montane specialist (barely ranging into New Mexico), the Arizona black rattlesnake. The Mountain patchnose snake barely enters the Lower Verde from its primary range in the mountains of southeast Arizona.

The variable skink has the unusual distribution of the Mogollon high elevation forests, through the Colorado Plateau and Great Basin Grasslands, preferring montane moist canyons. The Great Plains toad avoids the mountains and is partial to valley grasslands, and although occurring in most of the Verde Watershed it should be most prominent at the extreme ends of the watershed, the Sonoran scrub and Desert Grassland of the Lower Verde, and the Great Basin Grassland of the upper Big Chino. Besides the variable skink and the great plains toad, the upper Big Chino is characterized by two species that are only found in this part of the entire Verde Watershed, Utah milk snake and prairie rattlesnake. The prairie rattlesnake has the largest latitudinal distribution of North American rattlesnakes, ranging from southern Canada into northern Mexico in the Great Plains just east of Arizona. Until very recently, it consisted of two subspecies, with the Hopi rattlesnake possessing a very small portion of the range, primarily restricted to Arizona's Colorado Plateau. Based on molecular genetic data the two subspecies were determined to be conspecific.

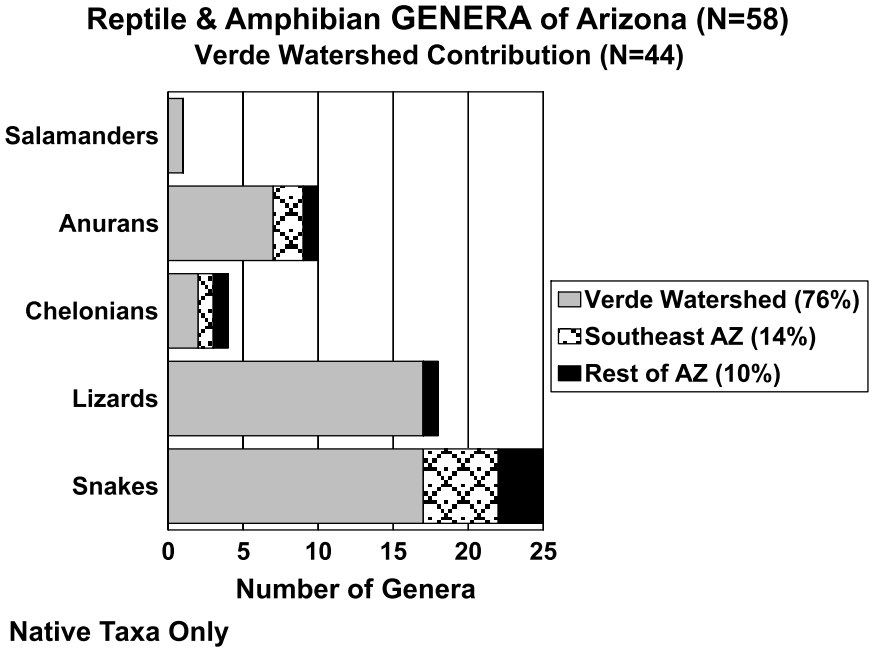
Lizards, as in the case of Highlands, characterize the Sonoran fauna, and consist of desert-adapted species: brush lizard, regal and southern desert horned lizards, Arizona zebratail lizard, desert iguana, chuckwalla, reticulate Gila monster, Tucson banded gecko, and Bezy's night lizard. The other Sonoran reptiles are also desert-adapted species: desert tortoise, western sandsnake, spotted and saddled leafnose snakes, tiger rattlesnake, and Sonoran sidewinder. Sonoran anurans are Couch's spadefoot and Sonoran desert toad. It was unexpected that snakes would be so poorly represented in the Sonoran fauna. This is undoubtedly due to the small landscape contribution of the Sonoran Desert to the Verde Watershed.

4. The Contribution of the Verde Watershed to Arizona's Amphibian and Reptile Fauna

Genera represent an important taxonomic metric that organizes ecological adaptations to the environment (Krzysik 1998). A relatively large number of genera translate to a large number of ecological opportunities in a given landscape. This was discussed above and exemplified with Arizona's anuran fauna. The Verde Watershed is home to 44 genera of reptiles and amphibians, representing 76 percent of the 58 genera found in Arizona, Figure H4 (note that only native species are included). Southeast Arizona, globally recognized for its herpetofaunal diversity, especially for rattlesnakes, only adds another 14 percent. Despite the large land area, diverse habitats, and

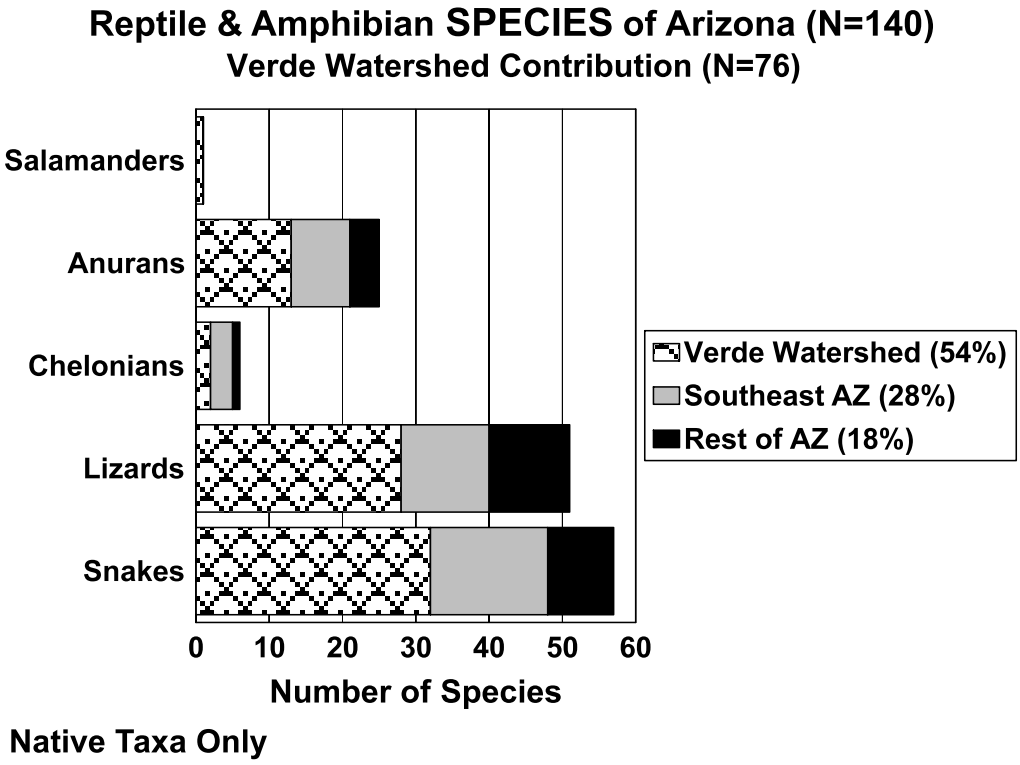
extensive topographic complexity of the rest of Arizona, these landscapes only add 10 percent to the herpetofauna genera already present in the Verde Watershed and Southeast Arizona.

Figure H4



Surprisingly, the Verde Watershed has 94 percent of Arizona's lizard genera. Arizona's only lizard genus not found in the Verde is *Uma* (Fringe-toed Lizards), a sand dune specialist with three California species, restricted to wind-blown loose sandy soils. Two of these species enter southwest Arizona. The Verde Watershed has 68 percent of Arizona's snake genera, while the southeast, globally known for its snake fauna, adds another 20 percent.

Figure H5

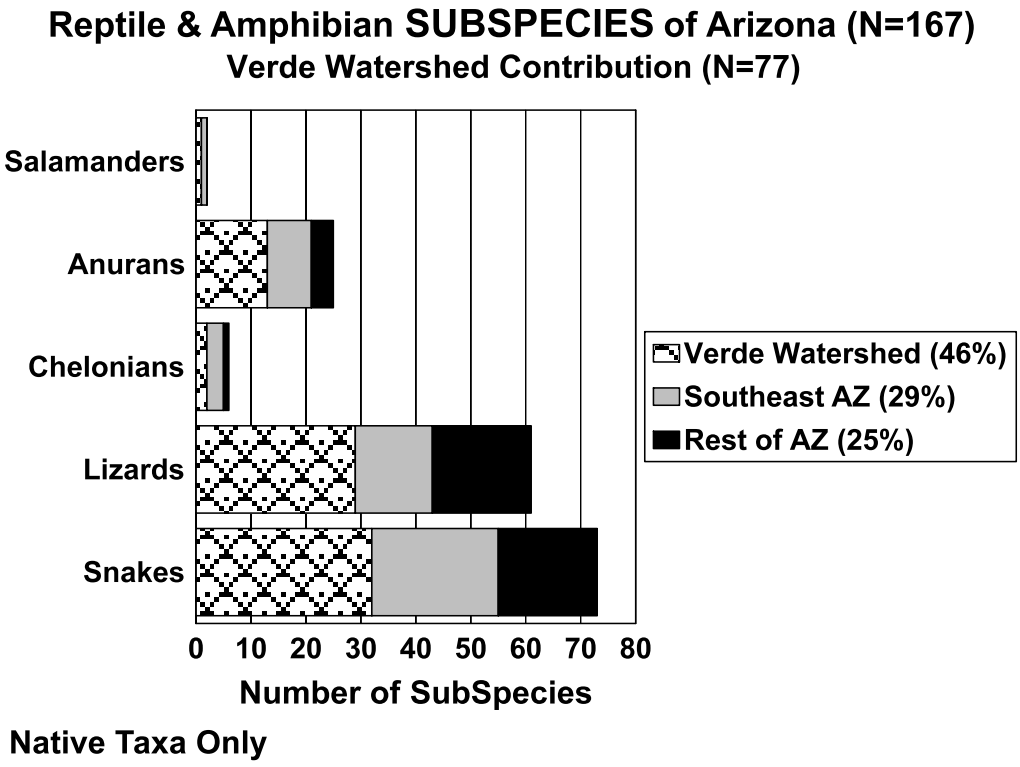


The Verde Watershed contains 54 percent of Arizona's amphibian and reptile species, while the southeast adds an additional 28 percent, and the rest of Arizona 18 percent (Figure H5). The rich diversity of southeast Arizona's herpetofauna, especially snakes, is thus clearly recognized at the species level. Note that the Verde Watershed dropped from 76 percent of Arizona's genera to 54 percent of the species. Although there are a number of factors involved, the number of species that a landscape possesses is ultimately tied to its spatial area. This is a well-established principle of island biogeography (MacArthur and Wilson 1967). The Verde Watershed with only 5.8 percent of Arizona's land area and therefore additionally, a smaller set of ecological landscapes and habitats predictably possesses fewer species. Nevertheless, it is noteworthy that the Verde is characterized by very high herpetofauna taxa richness at the genera level.

The Verde Watershed only has a single currently recognized subspecies, two subspecies of Clark's spiny lizard. Subspecies are geographically defined and spatially isolated populations or races of a given species. Subspecies are therefore, genetically separated by distance, discrete and major habitats,

or barriers such as mountains or rivers. When and where population boundaries of subspecies are in contact there is genetic introgression. The relative continuity of the Verde Watershed, exemplified by its riverine landscape corridor, and its small proportion in Arizona's landscapes (5.8 percent) would predict its low number of subspecies (i.e., isolated populations). Figure H6 nicely illustrates this. The Verde Watershed sample of Arizona's subspecies drops to 46 percent, the southeast adds 29 percent, and the rest of Arizona adds another 25 percent. These data particularly demonstrate the increase of snake and lizard subspecies (i.e., distinct spatial populations) that the arid landscapes of the Upper Sonoran, Lower Sonoran, Mojave, Great Basin, and Chihuahuan contribute. The geographical contributions are respectively, Sonoran from the south, Mojave from the west, Great Basin from the north, and Chihuahuan from the southeast.

Figure H6



5. Importance of Upper Verde to Amphibians and Reptiles

The public and even those familiar with the natural history of the arid Southwest do not appreciate the significance of Arizona's aquatic habitats for amphibians and reptiles. For example, the combined eight states of the Midwest with all their aquatic, riparian, and wetlands habitats possess 27 species and 8 genera of frogs and toads (anurans). Meanwhile, the Verde Watershed with 1.3 percent of the Midwest's landscape area possesses 13 species and 7 genera. Amphibian genera represent important ecological characteristics of regional landscapes (Krzysik 1998). The Verde Watershed, calibrated by landscape area, has 682 times the anuran genera density as the eight Midwest states and 121 times that of Arizona.

Two species of frogs are experiencing dramatic population declines and are protected in Arizona. The lowland leopard frog (*Lithobates yavapaiensis*) was once abundant and widespread in the Upper Verde Watershed, while the northern leopard frog (*Lithobates pipiens*) was very abundant and widespread in most of northern North America, ranging southward into the northern portion of the Verde Watershed. Disease, exotic species, and habitat destruction are responsible for their decline. The Upper Verde represents critical habitat for the restoration and maintenance of the lowland leopard frog.

Garter snakes are the aquatic snakes of the west, because species typically known as "water snakes" are restricted to central and eastern United States. Four of the five Arizona garter snakes are found in the Verde Watershed, including the Upper Verde. Two species, narrowhead and northern Mexican garter snakes are particularly rare and endangered, primarily because of habitat deterioration, but also exotic species. The Upper Verde represents critical habitat for the restoration and maintenance of their populations.

6. Introduced Exotic Amphibians and Reptiles of the Verde Watershed

Bullfrogs

The bullfrog is the largest native anuran in the U.S., and is native to the eastern part of the country. It has been widely introduced or escaped into suitable habitat in most of the western U.S., including Arizona and the Verde Watershed. This species requires calm weedy perennial ponds, lakes, rivers, streams, wetlands, or cattle tanks for reproduction, as well as adult habitat. It is a true riparian

dweller, spending all of its time at the water's edge, diving into aquatic vegetation or debris to escape predators. Its tadpoles are also large, and require over a year to transform into the adult, sometimes over three years in cold short growing seasons. Bullfrogs are good dispersers, and travel surprising distances to colonize new ponds. However, their dispersal and overland travels are strongly dependent on adequate rainy and very wet conditions.

Bullfrogs, like all adult frogs and toads, possess relatively large mouths and are voracious eaters, feeding on anything living that they can swallow. Native Arizona frogs and toads feed on a variety of invertebrates, especially insects. Because of their large size, bullfrogs can not only feed on insects and crustaceans, but on native frogs and toads, fish, small snakes and turtles, mice, and even birds and bats. Bullfrogs are well documented for their destruction of local anuran populations. Bullfrogs pose a threat to the biota and ecology of the Verde Watershed. Although bullfrogs are known to feed on crayfish, also a non-native undesirable species in the Verde River, it is not known what effect bullfrogs are having on Verde crayfish populations. The entire Verde Watershed has a reasonably high population of bullfrogs, which is bad news for the declining populations of native anuran species and other small vertebrates.

Turtles

Four introduced species of aquatic turtles are established in Arizona and in the Verde Watershed: red-eared slider, painted turtle, Texas spiny softshell, and common snapping turtle. The first two species, commonly kept as pets, become exotic introduced species when they escape, outgrow their homes, or the interests of their owners — some folks assume that they are doing their pets and nature a benefit by release "to the wild."

The red-eared slider is the best known and collected, and by far the most widely geographically distributed of the three currently recognized subspecies. Its native habitat is the Midwest, where it is abundant and widely distributed from Illinois to Texas. Until very recently the painted turtle was considered as four overlapping subspecies, and originally widely distributed from the Midwest throughout the east, with the exception of the southeastern coastal plain. These were: eastern, southern, midland, and western painted turtles. Recent molecular analysis has designated these into two full species, northern and southern painted turtles. The eastern, midland, and western subspecies have been combined into the northern species. A population of the northern painted

turtle near St. Johns in Apache County in east-central Arizona may be native. The Southern species is restricted to the southern Mississippi drainage. One or both species of painted turtles have been introduced to Arizona and the Verde Watershed.

The Texas spiny softshell is a river turtle native to the Rio Grande and Pecos Rivers of Texas and New Mexico. They were introduced into the Colorado and Gila Rivers around 1900, and have spread into perennial waterways even in the Sonoran and Mojave Deserts, especially through irrigation ditches. Although softshell turtles are kept as pets, they are ill tempered and quick to bite with very quick powerful sharp jaws.

The common snapping turtle is native to the entire eastern portion of the U.S. from the Dakotas to Texas. They are very aquatic, and as adults primarily feed on vegetation, dead or dying fish, and occasional small vertebrates. Where they are established, they can be found in virtually any aquatic habitat from small ponds and flood catchments to large lakes and reservoirs, rivers, streams, and swamps. They are excellent colonizers, and for an aquatic species they can disperse significant distances across land to find even small isolated ponds. They are aided, as are all aquatic turtles and frogs, by their ability to see polarized light reflected by water. The species' habitat is relatively shallow, calm water with vegetation, stumps or logs cover, brush piles, or undercut banks. Snapping turtles can even find home in quiet pools in mountain streams where most of the channel consists of cascades and extreme rapids.

They are only kept as pets by herp enthusiasts requiring a challenge, because their powerful jaws can inflict significant damage. Although they are pugnacious when out of water, especially smaller individuals, they do not attack or even readily bite when underwater. This explains how snapper hunters can search bare-handed in undercut stream banks, and after feeling the direction of their dorsal ridges, can extract them by their tail with little chance of getting bitten. The Snapping Turtle has mainly been found in the vicinity of Phoenix, and is probably in the Lower Verde and its reservoirs.

C. Birds

1. Classification Criteria

Vertebrate species (excluding fish) were classified by: watershed segment occurrence, general habitat preference, and landscape occurrence, as presented at the beginning of the vertebrate section. The bird fauna of the Verde Watershed was additionally classified into breeding, migratory, or wintering species and a systematic taxonomic and ecological species grouping. Breeding bird species were additionally classified as: permanent residents, short distance migrants, and Neotropical migrants.

Breeding Bird Species:

Permanent Residents typically remain in their specific habitats all year long and are non-migratory. However, some species change their habitat after nesting. Most of these habitat changes are short distance local movements. However, movements for some breeding species are longer, particularly from high elevation breeding grounds or during severe winters.

Short-Distance Migrants spend their winters in southern Arizona or northern Mexico. Common sites in Arizona include the Gila and Lower Colorado River Valleys, and the Sonoran Desert. Because of the complex topographic mosaics and steep gradients of elevation changes in central Arizona and the Verde Watershed, it is difficult classifying many species as either Permanent or Short-Distance (spring/summer) residents. Bird residence in central Arizona is often weather dependent and variable among years. Many montane breeding species migrate to lower elevations in valleys and deserts for the winter, often short distances.

Neotropical Migrants spend their winters in subtropical or tropical Mexico, Central America, or South America.

Migrating Bird Species

Migrating bird species are species that typically migrate through the Verde Watershed during their spring and fall migrations, and nest north of the Verde Watershed. These migrants breed from northern Arizona to the Arctic, depending on specific species. Occasionally, typical migrating species may nest in the Verde Watershed. An exceptionally large number of bird species have been documented migrating through and as casual visitors of the Verde Watershed because of its central location with respect to subtropical and tropical migration, and also because of the large number of dedicated bird watchers in central Arizona. The migrating species identified in this report are only those that are consistent and relatively abundant migrants through Verde's watershed.

Wintering Bird Species

Wintering bird species are species that typically over-winter in the Verde Watershed. Their Spring/Summer nesting grounds range from northern Arizona, U.S. north of Arizona, Canada, Alaska, and the Arctic. Occasionally, typical wintering species may nest in the Verde Watershed. As in the case of migrating birds, only those that are consistent and relatively abundant over-wintering species were included in this report.

Systematic and Ecological Classification

The complete avian fauna was classified into 13 categories based on systematic (taxonomic) and ecological associations. This classification is presented in Table B1.

Waterfowl	ducks, geese, loons, grebes, pelicans, cormorants, gulls, terns
Aquatic	herons, egrets, bitterns, ibis, rails, kingfisher
Shorebirds	sandpipers, plovers, killdeer, snipe, and relatives
Game	turkey, quail, grouse, doves, pigeons
Aerial	swallows, swifts, goatsuckers, nighthawks, whip-poor-will, poorwill
Raptors	hawks, eagles, vultures, owls
Hummingbirds	hummingbirds
Corvids	jays, ravens, crows, nutcracker
Woodpeckers	woodpeckers, sapsuckers, flicker
Flycatchers	flycatchers, phoebes, kingbirds
Large insectivores	cuckoo, roadrunner, shrikes, vireos, bluebirds, thrushes, tanagers, towhees, pipit, phainopepla, waxwings, starling
Small insectivores	warblers, chickadees, titmice, nuthatches, wrens, kinglets, gnatcatchers
Granivores (seed eaters)	sparrows, grosbeaks, finches, goldfinches, buntings, juncos, crossbills, horned lark, cardinal, pine siskin
Icterids	blackbirds, grackles, cowbirds, orioles, meadowlarks

Table B1. Systematic and Ecological Classes of Birds of the Verde River Watershed.

2. Avian Fauna of the Verde Watershed

Classification of the Verde avian fauna is essentially based on their biogeography. A number of species occurring in the Verde Watershed were not associated with the Verde River, its riparian habitats, and higher terraces; but were spatially more closely associated with high elevation montane forests, the Sonoran Desert, or grasslands of the Great Basin or Desert Grassland communities. The Highlands designation was used to assess species that solely or predominantly had their biogeographic distribution centered on Arizona's Central Highlands, the geographic backbone of the Verde Watershed. The Highlands distribution was a rough test for endemism. Importantly, all species classified outside of the "Verde Landscape" class were breeding species. All migrating and wintering species in the Verde Watershed were typically found in the "Verde Landscape." The primary information value of the landscape classes is to decipher the relative importance of the different landscapes as they pertain to the complete Verde Watershed bird fauna. Therefore, the majority of bird species directly fall into the "Verde" class, because of this biogeographic design.

The bird breeding, migratory, and wintering fauna of the Verde Watershed includes 270 species (Figure B1). Actually the dark-eyed junco consists of three subspecies in the Verde Watershed. The southwestern gray-headed junco is a breeding permanent resident of the montane forest in the Upper, Middle, and Lower Verde. Both the Rocky Mountain gray-headed junco and the Oregon junco are common wintering birds throughout the Verde Watershed. All of these subspecies are easy to identify in the field. Relatively recently, the two flicker species were considered subspecies. The gilded flicker is limited to Sonoran Desert scrub, typically using the giant saguaro for nest cavities, while the red-shafted flicker is found in both conifer and deciduous forests and woodlands throughout the Verde Watershed, using a wide range of montane to riparian habitats.

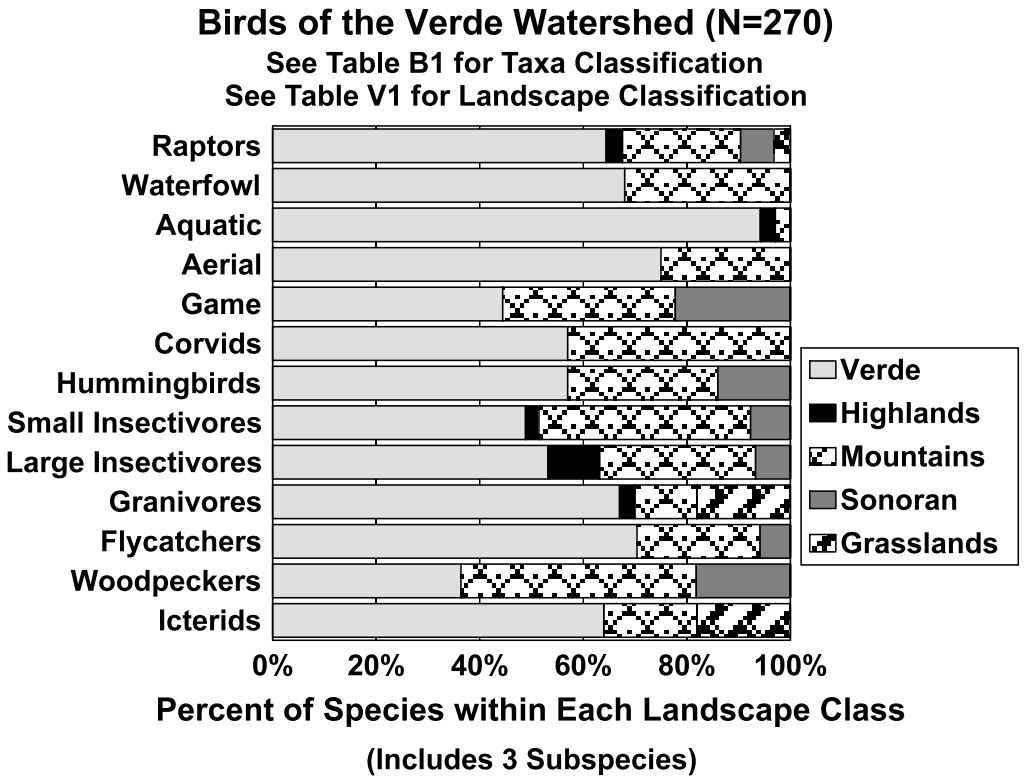


Figure B1

Most bird species, as discussed above, are associated with the "Verde" class. This is the major landscape of the entire Verde River and the ecological focal point for the entire watershed. The Verde landscape represents complex vegetation mosaics and transition ecotones that characterize the Verde River main fluvial channel (including Big Chino Wash), riverine riparian communities, lower order streams and washes, canyon topography, and the adjacent scrub and forest of higher terraces and rolling hills. At least half of bird species (49 percent of Small Insectivores) in 11 of the 13 bird classes are associated with the Verde landscape. In ranked order of Verde preference are: Aquatic species (94 percent), Aerial (swallows, swifts, goatsuckers, 75 percent), Flycatchers (71 percent), Waterfowl (68 percent), Granivores (sparrows, finches, grosbeaks, buntings, 67 percent), Raptors (hawks, eagles, owls, 65 percent), Icterids (blackbirds and orioles, 64 percent), Corvids (jays, raven, crow, 57 percent), Large Insectivores (vireos, thrushes, tanagers, towhees, 53 percent). Small Insectivores were approximately split between Verde landscapes (49 percent) and their rich montane forest breeding fauna (41 percent) in the high elevation Mountains of the watershed. Game species

were primarily in the Verde (44 percent), but also had significant faunas in the Mountains (33 percent) and Sonoran (22 percent).

Photo P35. Desert nesting bald eagle overlooks Stillman Lake.

All 13 classes had at least some species restricted to the high elevation mountains in the Verde Watershed (Figure B1). Woodpeckers were primarily in the forested Mountains (45 percent), but with significant faunas in both Verde (36 percent) and Sonoran (18 percent) landscapes. Corvids also scored high in the Mountains class with Steller's jay, Clark's nutcracker, and American crow. A number of Raptors were in the Mountains: osprey, sharp-shined hawk, goshawk, flammulated, owl, northern pygmy owl, northern saw-whet owl, and Mexican spotted owl. Nine breeding species of Waterfowl were also in the Mountains landscape: Canada goose, gadwall, green-winged teal, pintail, redhead, common merganser, eared grebe, western grebe, and Clark's grebe.

The Sonoran Desert in the southernmost portion of the Verde Watershed represented the smallest landscape portion of the watershed. Nevertheless, it possessed a number of species in 8 of the 13

avian classes. Species in the Sonoran were: white-winged and rudy ground doves, Harris's hawk, elf owl, Costa's hummingbird, Gila woodpecker, gilded flicker, brown-crested flycatcher, verdin, cactus wren, black-tailed gnatcatcher, Bendire's and curve-billed thrashers.

Species closely tied to the Grasslands landscape were primarily sparrows: Cassin's, rufus-crowned, Brewer's, vesper, lark, and grasshopper sparrows. Other species were: Ferruginous hawk, and two Ichterids, western and eastern meadowlarks.

Only a few breeding bird species were distributed closely along Arizona's Central Highlands. These were in five classes and the species were as follows: Common Black Hawk, Belted Kingfisher, Bridled Titmouse, Hutton's Vireo, Hepatic and Summer Tanagers, and Black-chinned Sparrow.

Figure B2 shows the allocation of Verde Watershed bird species by breeding status and general habitat preference. The majority of the watershed's fauna were breeding species (N=209, 77%), and most birds were closely tied to riparian habitats (N=176, 65%). There was a significant component of Uplands species (N=94, 35%), reflecting the Verde's rich montane conifer forest avian fauna. The Verde Watershed has 39 species of common and consistent migrants, nesting further north, and

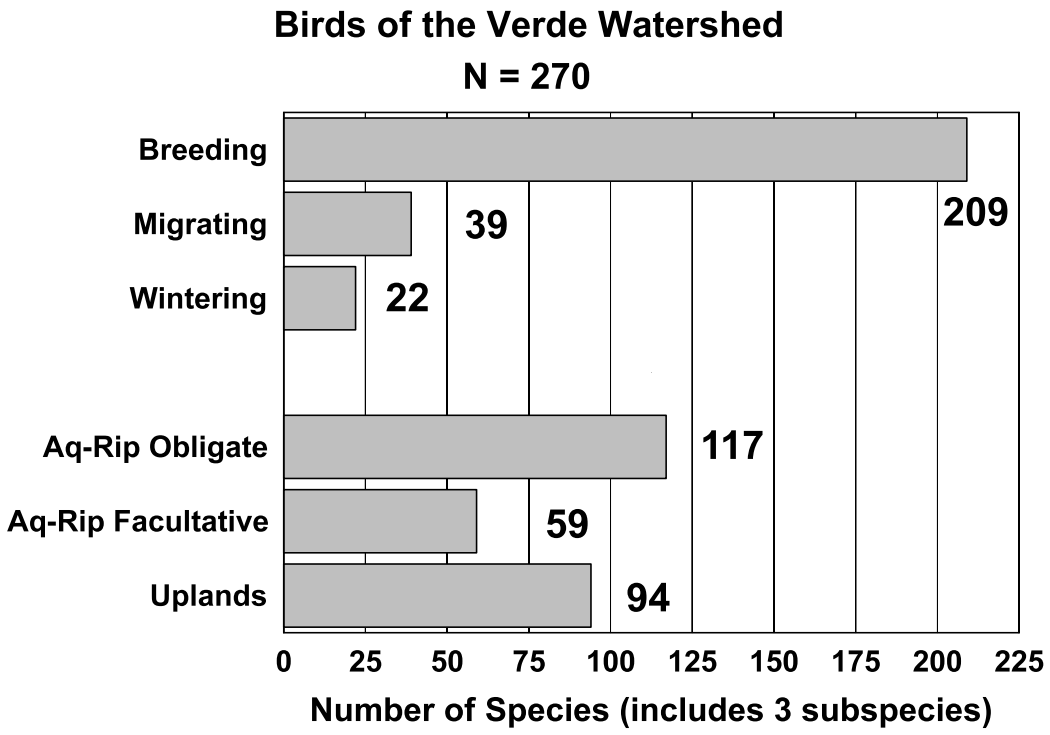


Figure B2

22 bird species (includes the two subspecies of Juncos) that typically over-winter. The data in Figure B2 do not include recorded vagrant or transient species, or migrants that are occasional or rare. Because birds are capable of long distance travels, off-course migrations, and are susceptible to high winds, storms, and unusual weather, any geographical locality accumulates a substantial list of bird species if these rare occurrences are included in a regional or local bird fauna. These data are reinforced by the large numbers of enthusiastic bird watchers constantly on the alert for unusual and rare sightings. It was decided to only include in the Verde Watershed reasonably common wintering and consistent migratory bird species. However, the few documented breeding species that are rare in the Verde Watershed were included, because these species are typically difficult to locate and may be more abundant than the data indicate. Additionally, climate change and its associated "global warming" have resulted in the northward breeding range extension of many bird species (Audubon 2009).

Figure B3 shows the 13 classes of birds from Table B1 classified into the three general habitat categories. Waterfowl and Aquatic species are all very strongly associated with Aquatic/Riparian habitats, as is expected. Nevertheless, Hummingbirds, Game, Aerial, Icterids, Flycatchers, Small Insectivores, and Large Insectivores are also closely tied to or prefer Aquatic/Riparian habitats. Hummingbirds were strongly associated with or preferred aquatic habitats. Aerial, Game, and Flycatchers were also associated with riparian communities, but not as strong as Hummingbirds. Although insectivorous species were well distributed among the three habitat classes, 57 percent were tied to aquatic habitats. Corvids were classified as strictly Uplands species, and Woodpecker and Granivore species were more prevalent in the Uplands. Nevertheless, many individuals in these three classes are often recorded in riparian habitats. Raptors and Granivores represent the most "generalist" classes, with their species using all three habitat types.

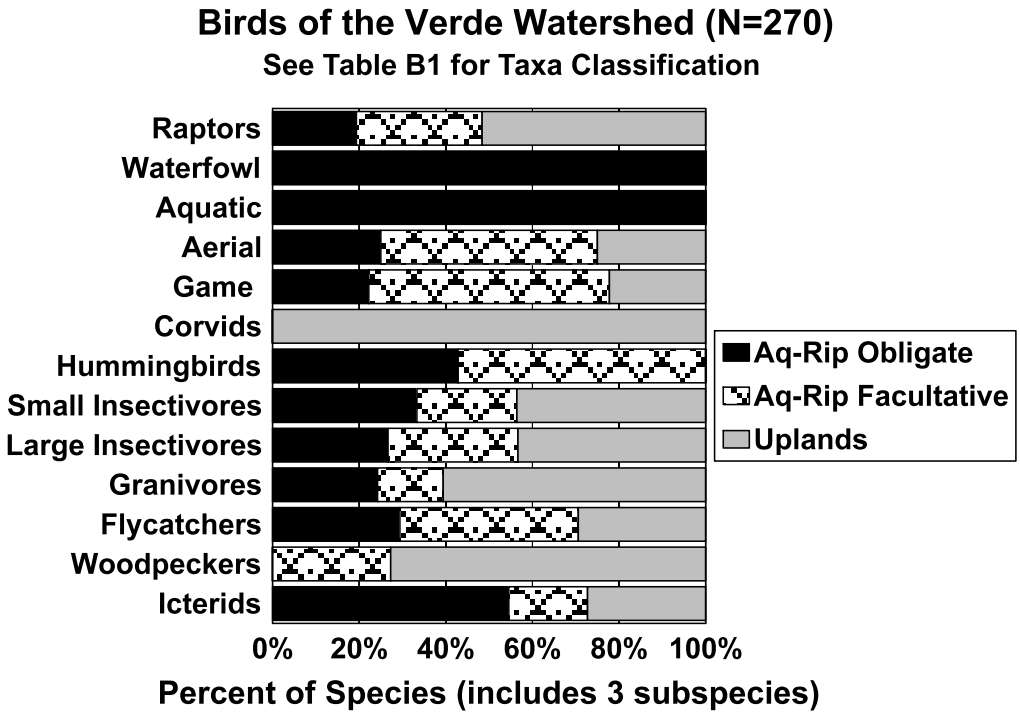


Figure B3

Figure B4 shows the breeding status of the Verde Watershed birds. All species in the classes Game, Corvids, Woodpeckers, and Icterids breed in the watershed. . The majority of Raptors, Aerial, Hummingbirds, Small and Large Insectivores, Flycatchers, and Granivires also are breeding species. Aquatic species with their large number of migratory Shorebirds passing through central Arizona is the only class where most species are non-breeders. Additionally, close to half of our Waterfowl are either over-wintering or migratory species. Other over-wintering taxa, in addition to Waterfowl, include Granivores (especially sparrows), and a few Raptors and Insectivores. Other migratory species include Hummingbirds, and a few Small Insectivore, Aerial, Flycatchers, and Granivores. Figure B4

Figure B5

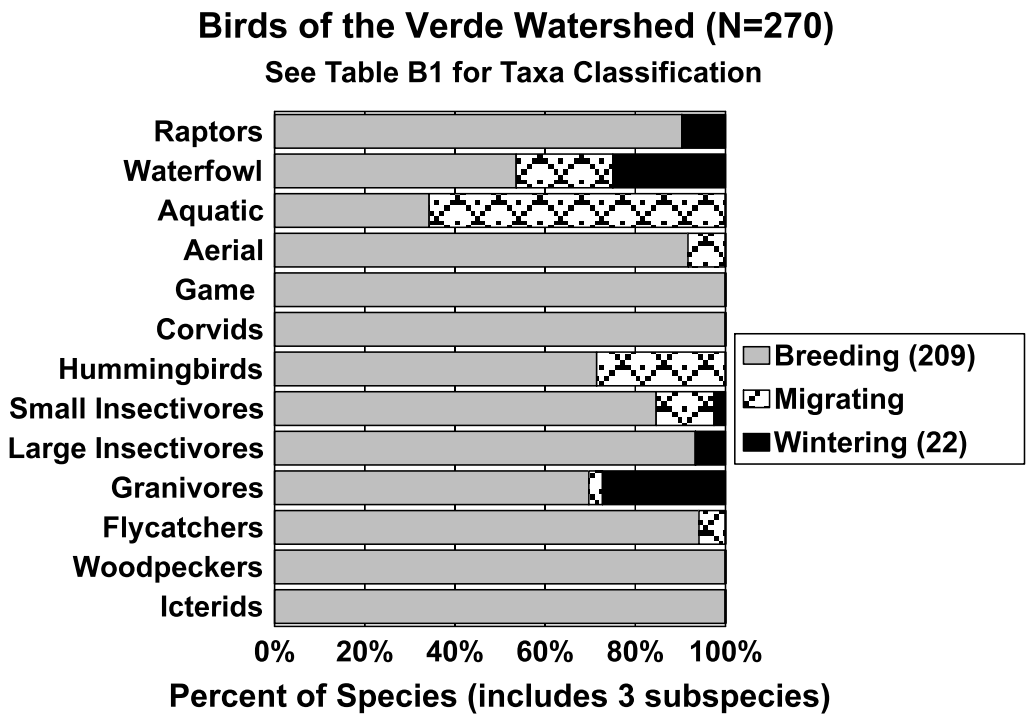
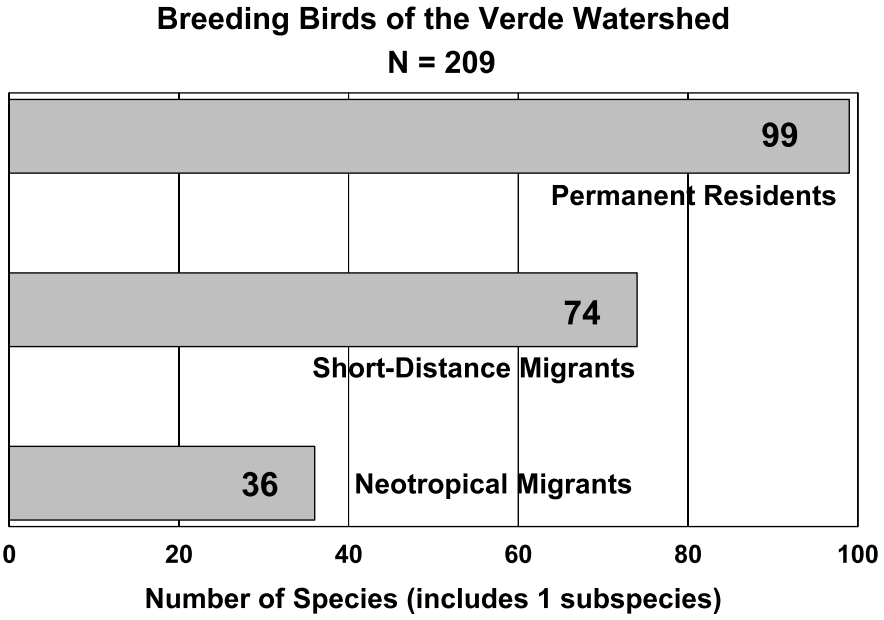


Figure B5 is an attempt to classify the residential status of Verde Watershed's 209 breeding bird species. Almost half of the breeding species were Permanent Residents (N=99, 47 percent). Short-Distance Migrants were little more than a third (N=74, 35 percent). Thirty-six species (17 percent) were Neotropical Migrants, a group that as a whole has experienced dramatic population declines in the last several decades. Apparently, a number of causes are involved: habitat destruction and forest fragmentation in both breeding and wintering grounds, cowbird brood parasitism, pesticides, climate change, and deteriorating migration habitat.

Figure B5a



All Corvids, and the vast majority of Game species, Woodpeckers, and Raptors are Permanent Residents (Figure B6). Aerial species are all migrants and have the largest fraction of Neotropical Migrants (55 percent). All Hummingbirds, and the majority of Flycatchers and Icterids are Short-Distance Migrants. Waterfowl and Aquatic species are approximately equally divided between Permanent Residents and Short-Distance Migrants. Our major 84 species of songbirds as a group (Small and Large Insectivores and Granivores) are: 49 percent Permanent Residents (N=41), 33 percent Short-Distance Migrants (N=28), and 18 percent Neotropical Migrants (N=15).

Surprisingly, these percentages are almost identical to Verde's total bird fauna. One would expect that these small birds, with the majority highly dependent on insects and other invertebrates, would represent a higher fraction of migratory species, especially Neotropical Migrants. Seven of the 13 classes possess species that are Neotropical Migrants, while 12 classes possess species that are Short-Distance Migrants. This undoubtedly reflects the southern geographical location of Arizona and therefore, its mild winters for over-wintering birds.

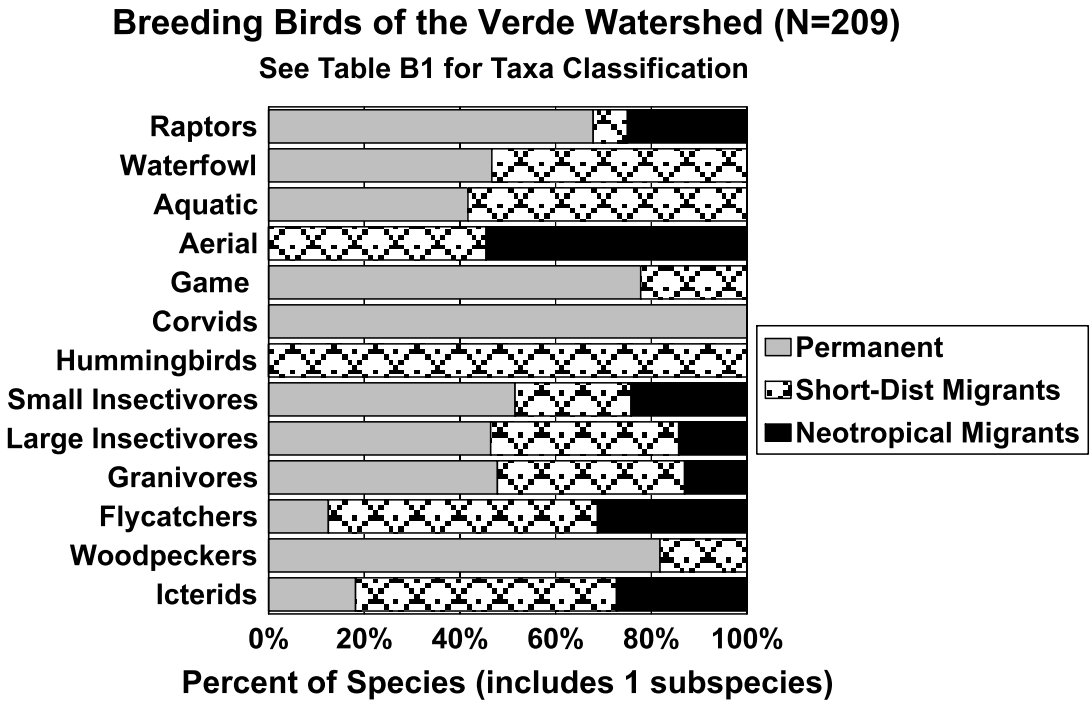


Figure B6

A number of our breeding songbirds are often casually considered Neotropical Migrants: Warblers, Flycatchers, Thrushes, Vireos, Tanagers, and Orioles. However, Arizona is geographically a southern state, so some of these species may actually be Short-Distance Migrants. Figure B7 examines this hypothesis. Warblers are our most numerous Neotropical Migrants (N=8), while all three Orioles and two of our three Tanagers are Neotropical Migrants. Most Flycatchers, Thrushes, and Vireos are actually Short-Distance Migrants. Interestingly, only five species of Warblers and a single Flycatcher migrate through the Verde Watershed to nest further north.

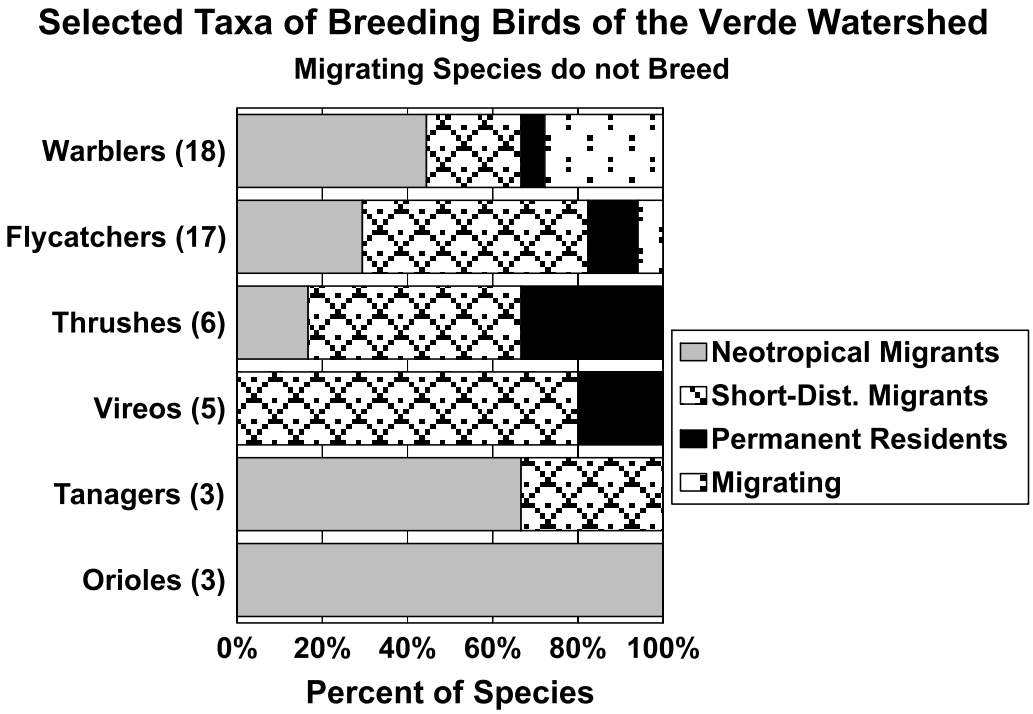


Figure B7

When defining Short-Distance Migrants it was discussed that it is often difficult classifying a Verde Watershed breeding species as either a "Permanent Resident"(PR) or "Short-Distance Migrant" (SDM). Two species of kinglets breed in the montane conifer forests of the Upper to Lower Verde Watersheds. Both species over-winter in the Big Chino Watershed, and also in the rest of the watershed. The golden-crowned kinglet was classified as PR, but often retreats to lower elevations, especially in harsh winters. The ruby-crowned kinglet was classified as SDM, because it typically over-winters at lower elevation habitats. But in mild winters the ruby-crowned kinglet may remain at its breeding ground.

A number of species are difficult to classify, because the wintering and permanent residences of their specific individual populations overlap closely, and they respond to weather conditions. Common PR classified examples include: western bluebird, American robin, spotted towhee, and red-winged blackbird. Common SDM classified examples include: brown-headed cowbird, Canada goose, common poorwill, burrowing owl, red-naped and Williamson's sapsuckers.

The yellow-headed blackbird (SDM) has a complex pattern of wintering, migrating, breeding SDM, and breeding resident in Arizona. The yellow-rumped warbler (PR) consisting of two subspecies in the Verde Watershed, the western U.S. (Audubon's warbler) and eastern U.S. and Canada (myrtle warbler), also has a complex distribution. The breeding subspecies in the Verde Watershed is Audubon's, while both subspecies may be found during migration movements and in wintering areas.

The phainopepla (PR) has an unusual bimodal breeding cycle with two nesting periods. In late winter and early spring it nests in desert riparian habitats, which coincides with the availability of mistletoe berries. Mistletoe is common parasitic of mesquite, acacia, and palo verde. In late spring and summer, phainopeplas nests in higher elevation open woodlands, foraging on available fruit, including mistletoe berries from turbinella oak. Phainopeplas also feed extensively on insects.

Anna's hummingbird (SDM) has typically been considered a PR in southern and coastal regions of the Southwest. However, in the last few decades, individuals strongly attracted by residential nectar feeders have breed further north and at higher elevations than in the past, occasionally even over-wintering. Currently, individuals commonly breed in the mountains in central and western Arizona, and are seen as far north as interior Southeast Alaska in the summer.

The Verde Watershed possesses a very rich breeding bird fauna in terms of both species and ecological roles, with raptors being among the most important (Figure B8). The Big Chino Watershed clearly demonstrates the fewest breeding bird species. This is particularly the case with waterfowl and aquatic species, but the Big Chino also has the fewest breeding species in the other five avian classes of Figure B8: Raptors, Aerial, Game, Corvids, and Hummingbirds. The Middle Verde with its high mountain lakes has the most species of Waterfowl and Aquatic species. The Lower Verde also has significant Waterfowl, while both Upper and Lower Verde have almost as many Aquatic species as the Middle Verde. Aerial feeding species are similar along the three perennial portions of the Verde Watershed. Game species and Hummingbirds predominate in the Middle and Lower Verde Watershed. The Lower Verde has six species of native doves (including Band-tailed Pigeon). Southeast Arizona, with 11 documented breeding species has the richest diversity of Hummingbirds in the entire U.S.

Figure B8

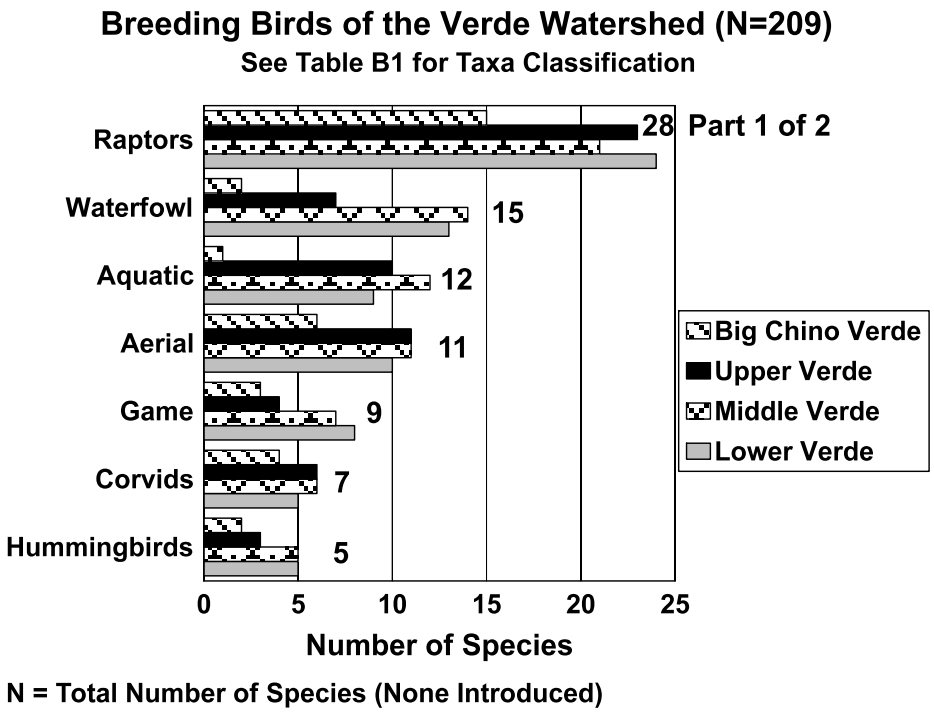
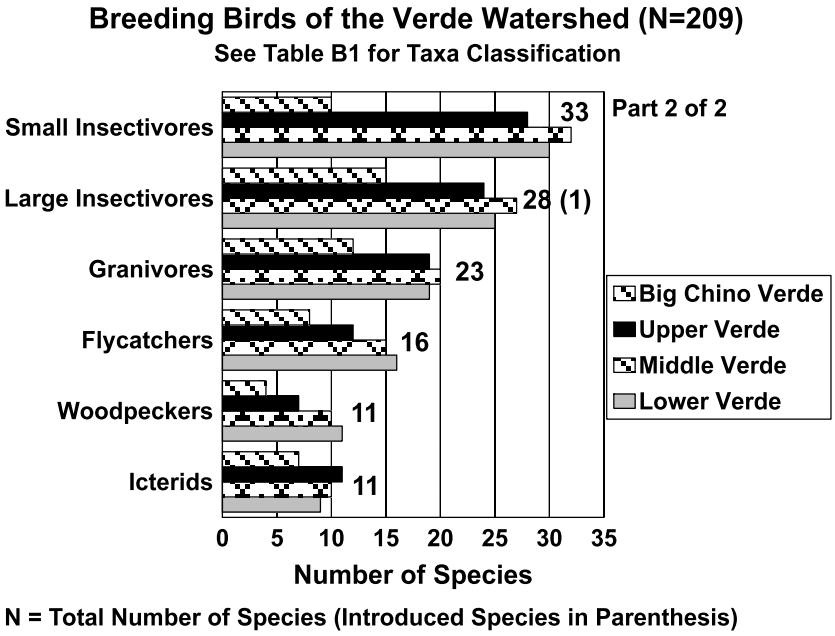


Figure B9 shows the remaining six classes of the Verde Watershed bird fauna. As in Figure B8, the Big Chino portion has the fewest breeding bird species in all of these six classes. This can be attributed to two factors: the perennial aquatic and riparian habitats of the Upper through Lower Verde River, and the higher elevation montane forests below the Big Chino Watershed. This is particularly the case of Small Insectivores (see Table B1), who as a class strongly depend on a predictable and abundant supply of insects associated with aquatic, riparian, and moist forest habitats. Note that the Upper, Middle, and Lower portions of the Verde Watershed are similar in the species richness of both Small and Large Insectivores and Granivores, but the Middle Verde is persistently slightly richer. This is because of the addition of songbirds that are higher elevation montane forest specialists. Flycatchers and Woodpeckers demonstrate a consistent increase in species richness going downstream in the watershed. Icterids (blackbirds and relatives) diversity is reasonable similar throughout the watershed, with the Upper Verde the only portion possessing all 11 species.

Figure B9



Figures B10 and B11 show the general habitat preferences of the 13 classes of Verde Watershed breeding birds. These data are very similar to those of Figure B3, except that Figure B3 depicted the entire avian fauna and included migrating and wintering birds, while B10 and B11 only represent breeding species. Breeding Waterfowl and Aquatic species are closely tied to perennial aquatic and riparian habitats. Hummingbirds, Swallows, Swifts, Goatsuckers, and Game species are highly dependent on aquatic and riparian habitats for reproduction. Jays, ravens, crows, and Clark's nutcracker typically breed in Uplands habitats. Hawks, eagles, and owls are very evenly split, exactly half requiring

Photo P34. Great blue heron at Wildlife Area

or preferring riparian habitats, while the other half are typically Uplands species.

Our breeding typical songbirds (Small and Large Insectivores and Granivores) show a pattern similar to the Raptors, splitting their species between requiring or preferring aquatic/riparian habitats and upland habitats. Flycatchers and Icterids (blackbirds, orioles) prefer wetlands and riparian habitats. Woodpecker species have a strong preference for forest uplands; but Gila, ladder-backed, and downy woodpeckers, while also occurring in upland habitats, show a preference for riparian communities.

Figure B10

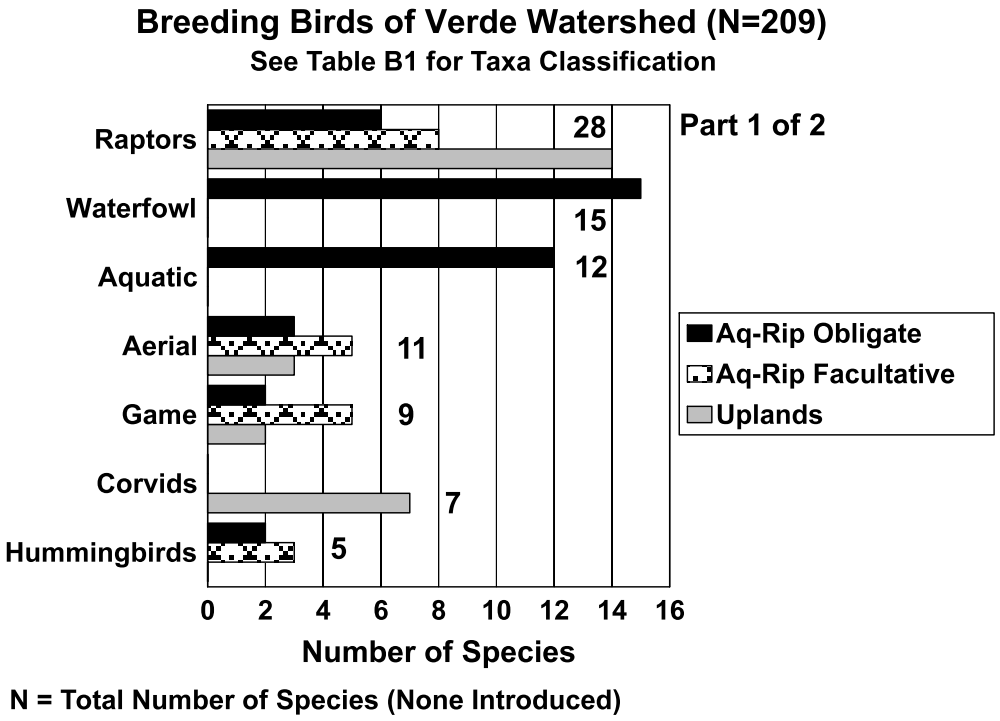
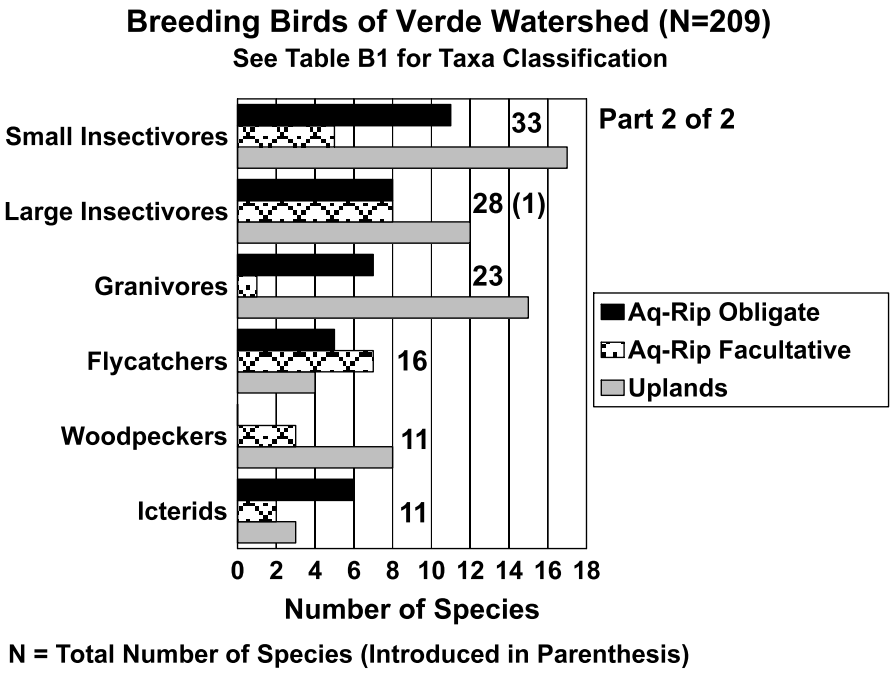


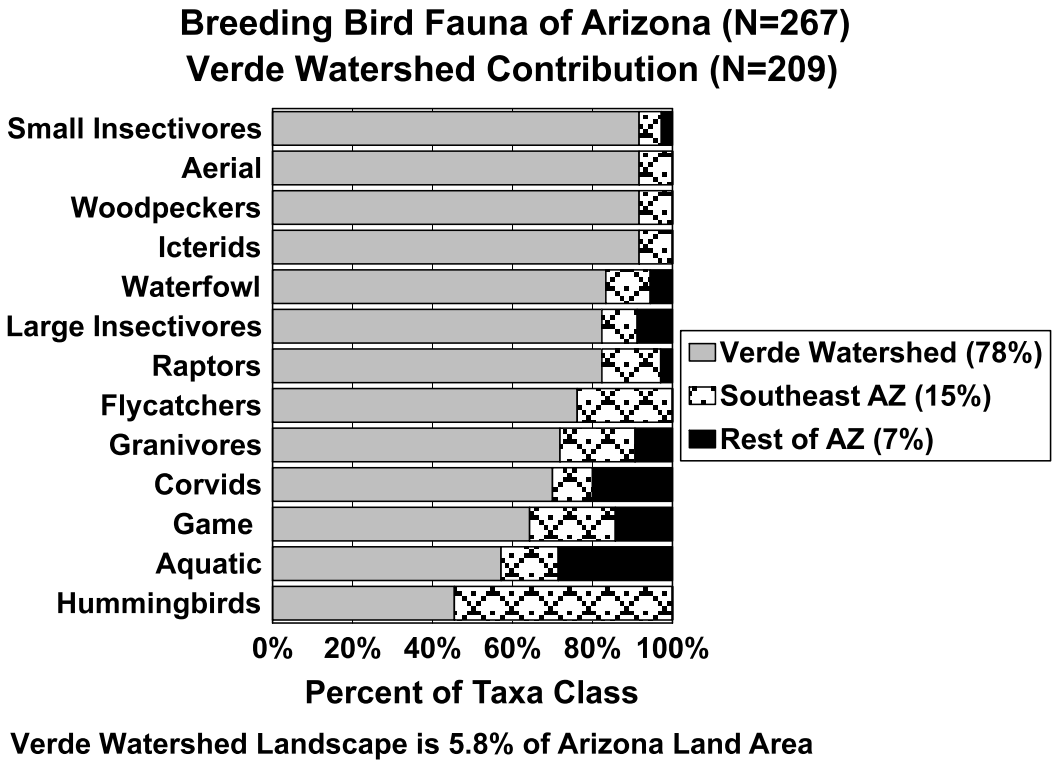
Figure B11


Breeding Birds of Verde Watershed (N=209)
See Table B1 for Taxa Classification
Part 2 of 2
Small Insectivores
Large Insectivores
Granivores
Flycatchers
Woodpeckers
Icterids
33
28 (1)
23
16
11
11
Aq-Rip Obligate
Aq-Rip Facultative
Uplands
0 2 4 6 8 10 12 14 16 18
Number of Species
N = Total Number of Species (Introduced in Parenthesis)

3. The Contribution of the Verde Watershed to Arizona's Breeding Bird Fauna

The importance of the Verde Watershed landscape to representing and maintaining Arizona's state bird fauna is clearly demonstrated in Figure B12.

Figure B12



Verde Watershed landscapes, despite encompassing only 5.8 percent of the area of the state of Arizona, possess 78 percent of the species that breed in the state. Only the Hummingbird class, essentially a subtropical and tropical group, has more breeding species outside of the Verde Watershed. Both riparian and montane forest ecosystems, in particular, provide the necessary breeding habitats for a substantial diversity and population sizes of Arizona's incredibly rich bird fauna. Nevertheless, only two species are primarily or only restricted to the Verde Watershed: wood duck (common) and winter wren (rare). This low endemism for such a rich bird fauna was anticipated, because the mountains of the Madrean Evergreen Woodland in Southeast Arizona and the White Mountains on the New Mexico border similar riparian and montane forests as the Verde Watershed, and therefore, share most of the bird fauna to varying degrees.

Southeast Arizona is globally recognized and visited as a bird watchers hotspot, and a rather large number of field guides are specifically devoted to this region. Fifteen percent of Arizona's breeding birds are only or predominantly found in the southeast corner. Eleven species of Hummingbirds breed in southeast Arizona, and five of these also in the Verde Watershed. The Colorado River, especially the Lower Colorado, is an important habitat for aquatic species, especially egrets and rails. Seven species of Corvids breed in the Verde, and three others are very local in distribution: gray jay in the White Mountains, Chihuahuan raven in the southeast, and black-billed magpie in the northeast extreme of the state on the Colorado Plateau. Nine game species of birds breed in the Verde Watershed, three other species breed in the southeast, while the chukar is found in the extreme northwest part of the state and the California quail in the White Mountains region. Both of the latter species are introduced exotics. Only 7 percent of Arizona's breeding birds do not occur in the Verde Watershed or in southeast Arizona, and none are present in five classes: Aerial, Woodpeckers, Icterids, Flycatchers and Hummingbirds (Figure B12).

4. Introduced Exotic Birds of the Verde Watershed

Exotic species of birds are almost non-existent in the native habitats of the Verde Watershed. The non-native species of the Verde Watershed are closely associated with human dominated landscapes, essentially residential and agricultural settings. The European starling was the only introduced species that was included in the bird biodiversity analyzed above. Although this species is significantly associated with urban, suburban, rural, and agriculture landscapes; it also does well in native habitats. Starlings compete with native species for nest cavities in riparian tree snags and Sonoran scrub saguaros.

The following species were not included in the biodiversity analysis. The house (English) sparrow and common pigeon (rock dove) are very abundant species associated with residential and agricultural landscapes, but apparently shy away from native habitats. The Eurasian collared dove is rather recently rapidly expanding its range in Arizona, and can probably (or soon will) be found throughout the Verde Watershed, associated with residential and agriculture land-use. It is becoming common in the Big Chino Watershed section. The peach-faced lovebird is restricted to the Phoenix area and may occasionally breed in the lowermost Verde Watershed. The ring-necked pheasant has been introduced in a number of areas of Arizona, including the Verde Watershed, as an upland game

species. The species is closely associated with agricultural landscapes, and its establishment has not been successful.

A number of native species are becoming increasingly attracted to and depend on residential or agricultural landscapes. The details are extensive and beyond the scope of this report. The increase in seed and nectar feeders; succulent cultivated vegetation with their arthropods, fruits, and flowers; and more abundant and predictable water availability; have all been major attractants. The importance of nectar feeders is a significant factor in the distribution and persistence of hummingbirds, especially for Anna's hummingbird. The current range extension of Anna's hummingbird, primarily a resident species in Arizona, over its historical distribution is significantly attributed to nectar feeders and cultivated vegetation.

The expansion or decline in agricultural landscapes directly effects bird populations. The large foraging flocks of blackbirds in agriculture and stock feedlots are well documented. Three native doves (Inca, common ground, ruddy ground) have become closely tied to residential and agriculture communities. All three breed in the Lower Verde Watershed, and the Inca also breeds in the Middle Verde.

5. Bird Extinctions in the Verde Watershed.

There are no known extinctions of birds in the Verde Watershed.

6. Upper Verde Watershed Important Bird Areas.

The National Audubon Society has the primary lead and administers the Important Bird Area (IBA) Program in the United States. BirdLife International started the IBAs program in Europe during the 1980s. The program is a global coalition based on partner organizations in over 100 countries. Typically, IBAs are identified and managed by local Audubon Chapters, conservation organizations, state and federal agencies, and even private landowners. The motivation for designating IBAs is the increasing threat to native biotic communities and populations, including birds and biodiversity, from habitat destruction and degradation, landscape and habitat fragmentation, and climate change.

The purpose of IBAs are to protect specific landscapes and habitats identified to possess significant ecological value for bird populations, but also areas important to regional biodiversity and ecological

processes. In order for sites to qualify as an IBA, they must satisfy *at least one* of the following criteria. The site must support:

- Species of conservation concern
- Restricted-ranges species
- Species vulnerable because their populations are concentrated in one habitat type
- Species, or groups of similar species (e.g., waterfowl or shorebirds) that are vulnerable because they occur at high densities due to their "congregatory behavior"

There are two IBAs in the Upper Verde Watershed:

1) The Upper Verde River Wildlife IBA consists of the headwaters segment of the Verde River and its riparian habitat from its headwaters downstream to the Prescott National Forest boundary, plus lower Granite Creek and its riparian habitat, from its confluence with the Verde River to approximately 1.5 miles upstream. This area lies within Segments One and Two of this proposal. Based on 12 bird surveys from April 2006 to November 2008, 136 species of birds were identified, and at least 4,929 individuals were documented in this IBA.

2) Watson and Willow Creek Lakes IBA includes Watson Lake, Willow Creek Lake, their "immediate surrounding uplands," and two miles of Granite Creek flowing into and out of Watson Lake, an area approximately 15 miles upstream from the study area. These IBA lakes are particularly valuable for migrating and wintering waterfowl and shorebirds. There are no comparable aquatic habitats within 60 to 300 miles, depending on direction of interest. Four to ten bald eagles are usually present in the winter. Typically, 50 pairs of wood ducks breed within the IBA. This species is uncommon in western United States, and restricted to scattered localities. In Arizona, breeding habitat of the wood duck is only found in the Verde Watershed. Significant rookeries of great blue herons and double-crested cormorants occur at Willow Lake. An additional great blue heron rookery is found at Del Rio Springs, near Sullivan Lake.

7. Significance of the Upper Verde for Birds

The Upper Verde River is important for a number of endangered and special concern species. The Arizona bald eagle nests primarily in the Lower Verde, but also nests in the upper Verde - nests have been documented near Perkinsville. Bald eagles are commonly seen during migration and over-wintering in the Upper Verde Watershed. The golden eagle nests in rugged canyons and cliffs

throughout the Upper Verde Watershed. Southwestern willow flycatchers and yellow-billed cuckoos have dramatically declined in the Southwest, because of severe riparian habitat destruction. Protecting and restoring the fluvial dynamics of instream flows and riparian habitats are essential for the recovery and maintenance of these species along with other riparian vertebrates. Yellow-billed cuckoos are documented breeding species in the riparian corridor of the upper Verde River. Although southwestern willow flycatchers primarily breed in the lower Verde, they are migrants in the upper Verde, and the restoration of natural hydrologic regimes and extensive dense willow riparian thickets would provide critical breeding habitat along the upper Verde River.

The avian biodiversity in both breeding species numbers and their broad representation in ecological guilds is significant in the Upper Verde Watershed (Figures B8 and B9). Referencing the entire Verde watershed, the Upper Verde has major representation of raptors, aquatic, aerial, corvids, small and large insectivores, granivores, flycatchers, and icterids in ecological guilds. Many of these small insectivores are riparian warblers which are suffering significant population declines from losing riparian breeding habitats in the Southwest, and wintering habitats in subtropical and tropical landscapes to the south. Additionally and importantly, the Upper Verde is a valuable component of the entire Verde watershed, because the Verde watershed provides an incredibly large representative proportion of Arizona's entire avian fauna (Figure B12); a fauna that is globally recognized. This is an unappreciated fact for both the public and natural resource managers.

D. Fish

The Verde River flows into the Salt River. The Salt River has its origins with the two major rivers that drain the White Mountains near the New Mexico border, Black and White Rivers. The Salt River flows into the Gila River, which empties into the Lower Colorado River approximately 25 miles north of the Mexican border. Therefore, on a watershed basis when assessing fish distributions, it would be in the fourth tier below three spatially larger watersheds, respectively in increasing size: Salt, Gila, and Lower Colorado watersheds.

Historically, these watersheds were ecological treasures for our unique Southwestern native fish populations, but their functional destruction was inevitable with ever increasing human land-use. This is excellently reviewed in Minckley and Deacon (1991) and Minckley and Marsh (2009).

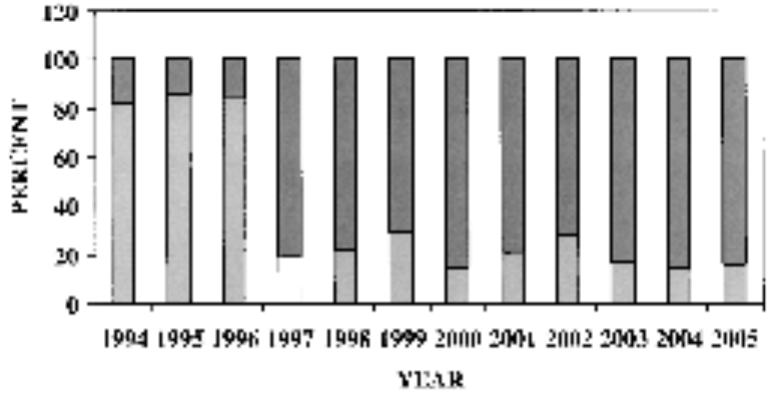


Figure 4. Relative components (%) of native (light bars) versus non-native (dark bars) species in the total fish assemblage in the Upper Verde, 1994–2005.

Figure F1. Data from Appendix 3.3

North American fish communities have been decimated by extinctions and severe native species population declines, but the Southwest region has disproportionately suffered the greatest losses (Miller et al. 1989, Williams et al. 1989, Minckley and Deacon 1991, Rinne 2004). Almost two-thirds (65 percent) of the 364 endangered, threatened, or special concern species of North America are found in six United States and three Mexican states of the Southwest (data from Williams et al. 1989). Depending on the specific stream, river, watershed, or specific time frame, the most serious impacts on native fish were caused by dams, aquifer drawdown, introduced exotic species, cattle grazing, mining, logging, pollution, or urbanization infrastructure (including roads and channelization). Currently in Arizona, including the Verde Watershed, loss of instream flows and nonnative fish species are the most significant stressors and responsible for most of the ecological impacts to native fish populations. Dramatic human population growth in Arizona with its associated urbanization and water pumping along with climate change are very serious both near and far future threats to native fish species. Introduced bullfrogs and crayfish also represent significant threats to native fish populations.

Significant natural flood pulses in the Verde River decimate exotic fish populations because they are not adapted to the suddenness and severity of arid region flooding events; native fish species have evolved behavioral, physiological, anatomical, and reproductive adaptations in the environmental chaos of severe floods. Adequate numbers of native fish survive even catastrophic floods to rapidly

colonize their respective microhabitats and niches in the absence of their exotic competitors and predators.

1. Native Fish of the Verde River Watershed

There were 14 species of native fish in the Verde Watershed (Table F1). Fortunately, there are current proactive efforts by state, federal, and private agencies to manage the Verde River native fish fauna, and repatriate species, that are declining or on the verge of extinction, back into their native habitats. All portions of the Verde River and its tributaries contain excellent habitats for repatriation of all of its 14 native species. The two most significant and serious challenges to Verde native fish are exotic fish species and increasing groundwater pumping from growing human population throughout the Verde watershed. Persistent and cumulative ongoing threats also include water diversions from the river, habitat disturbance, off-highway vehicles, cattle grazing, climate change, and local pollution.

Table F1. 14 Native Fish Species of the Verde River

Species	Upper Verde Watershed	Status(3)
Sonora sucker (*Catostomus insignis*)	common	Bureau of Land Management (BLM) Sensitive Species
desert sucker (*Catostomus clarki*)	common	BLM Sensitive Species
roundtail chub (*Gila robusta*)	common	Candidate; State Species of Concern; USFS and BLM Sensitive Species
longfin dace (*Agosia chrysogaster*)	present	BLM Sensitive Species
speckled dace (*Rhinichthys osculu)*	present	BLM Sensitive Species
spikedace (*Meda fulgida*)	rare, critical habitat	Threatened, with Critical Habitat; State Species of Concern; USFS Sensitive Species
Gila chub (*Gila intermedia*)	Williamson Valley Wash (1)	Endangered, with Critical Habitat; State Species of Concern; USFS Sensitive
loach minnow (*Tiaroga cobitis*)	Extirpated; reintroduced in Fossil Creek	Threatened, with Critical Habitat; State Species of Concern; USFS Sensitive Species.
Gila topminnow (*Poeciliopsis occidentalis*)	extirpated, present in springs and tanks	Endangered; State Species of Concern
woundfin (*Plagopterus argentissimus*)	extirpated	Endangered with Critical Habitat (not in Verde watershed); State Species of Concern
razorback sucker (*Xyrauchen texanus*)	extirpated, critical habitat, reintroductions in Upper, Middle and Lower Verde	Endangered, with Critical Habitat; State Species of Concern; USFS Sensitive Species

Colorado pikeminnow (*Ptychocheilus lucius*)	Extirpated; reintroduced in Middle Verde River	Endangered, State Species of Concern
headwater chub (*Gila nigra*)	not from upper Verde	Candidate C
	Historical: Wet Beaver Creek, Fossil Creek, East Verde River	Current: Lower Verde River tributaries: Deadman Creek, Fossil Creek, Webber Creek, Wet Bottom Creek, East Verde River
Gila trout (*Oncorhynchus gilae*)	not from upper Verde	Threatened; Federal ESA Candidate; Extirpated in Verde watershed
	Historical: Sycamore Creek, Oak Creek, Wet Beaver Creek, West Clear Creek, Fossil Creek, East Verde River	Current: New Mexico population, fish hatchery experimental introductions in Arizona
Footnotes:		
1. Also present in Spring Creek (Middle Verde), Walker Creek (Lower Verde), Red Tank Draw (Lower Verde)		
2. Collected historically at the mouths of Wet Beaver Creek (Middle Verde) and West Clear Creek (Lower Verde)		
3. Legal status based on USFWS R2 Arizona Ecological Services website, and Arizona Game and Fish Department Heritage Data Management System and the current USFWS Candidate species list (Appendix A9.19).		
The data above are from: Minckley (1973), Stefferud and Rinne (1995), Neary et al. (1996), Rinne and Stefferud (1996), Neary and Rinne (1997), Rinne et al. (1998), Weedman (1998), Rinne (1999, 2001), Bagley (2002), Blasius et al. (2003, 2004), CBD (2003), Marsh et al. (2003), Calamusso (2005), Carman (2006), USFWS (2007), Smith (undated).		

Sonora sucker, desert sucker, and roundtail chub are still relatively common in the upper Verde River. Longfin dace and speckled dace are present in low numbers in the upper Verde and some associated tributaries. Spikedace are very rare, but probably still present in the upper Verde.

These six species were historically very abundant and widespread native fish of the upper Verde River.

The longfin dace is the characteristic species of southwest desert rivers and streams, ranging from central Arizona far into Mexico. This species can survive high temperatures, loss of surface water, and even "sunburn" (Minckley 1973). The hot desert sun can evaporate surface waters, and longfin dace find wet microhabitats beneath rocks, wood debris, algal mats, or undercut banks. During the night as surface waters appear they become active and forage.

The speckled dace is the only native fish that has been able to naturally colonize all seven watersheds throughout the western U.S. It must possess outstanding dispersal ability and has a tendency to seek headwaters during flooding of intermittent and ephemeral channels. Speckled dace are found west of the Rockies in most of the U.S. from Canada to Mexico. Despite this wide distribution and high dispersal ability, the species exhibits strong genetic differentiation among populations.

The spikedace was historically both abundant and widespread in the Verde River. The spikedace along with the loach minnow are unique because they are both monotypic (the only species in their respective genus) and restricted to the Gila Watershed. Spikedace utilize currents less than three feet in depth, typically in the downstream ends of riffles and in eddies. They often frequent swift laminar flow shallow areas over sand and fine gravel. The breeding colors of males are the most spectacular of any Arizona native fish. AZGFD surveyed the upper Verde for spikedace in June 2009 and found no specimens (Appendix A3.13).

The loach minnow was historically collected in the Verde River at the mouths of Wet Beaver (Middle Verde) and West Clear (Lower Verde) Creeks, but recent surveys have failed to find this species in the Verde Watershed (e.g., Bagley 2002, Marsh et al. 2003). The loach minnow is a benthic species that possesses a similar ecological role as the extremely species-rich and very successful eastern darters (*Etheostoma* sp), which comprise over a hundred species (Kuehne and Barbour 1983, Page and Burr 1991). The loach minnow (as darters) often retreats under rocks. This behavior makes it difficult to document, and it has often been overlooked using traditional sampling techniques such as electro-shocking and seining.

The woundfin, another monotypic genera, was probably widely distributed in the Lower Colorado River Basin including the Verde River prior to 1900 (Minckley 1973). After this period it was extirpated from the Gila River Basin because of drought, erosion, dams, and water diversion (Minckley and Deacon 1968). Its last stand was in the increasingly disturbed Virgin River drainage, making it one of the most endangered fish in the U.S. The woundfin is a very unique fish with its lack of scales, flattened head, and its preferred habitat of swift silty currents. Dams were undoubtedly a major detriment to its survival, because dams are the major sediment trap in rivers and streams.

Prior to 1950, the Gila topminnow was probably the most common fish in the entire Gila Watershed, with the exception of higher elevations (Minckley 1973). This species was primarily a lower elevation and desert river species. Its former distribution and abundance in the upper Verde is unknown, and it currently is limited to springs and tanks in the Verde Watershed.

The Gila chub is restricted to tributaries in the Verde Watershed. Recent occurrences include: Williamson Valley Wash (Upper Verde), Spring Creek (Middle Verde), Walker Creek and Red Tank Draw (Lower Verde). The headwater chub was historically collected in Wet Beaver Creek (Middle Verde) and Fossil Creek and East Verde River (Lower Verde). It is currently restricted to tributaries and their headwaters in the Lower Verde (East Verde River and Deadman, Fossil, Webber, and Wet Bottom Creeks).

The Gila trout was noted by Minckley (1973) as historically present in at least six Middle and Lower Verde tributaries: Sycamore, Oak, Wet Beaver, West Clear, and Fossil Creeks, and East Verde River. However, the current taxonomic status of these trout is unknown, because they are based on faded museum specimens from 1888 and 1889 (Behnke 2002). The current range of Gila trout is limited to the upper Gila River drainage in New Mexico, and the San Francisco drainage along the New Mexico–Arizona border. Gila trout from these populations are currently being raised in fish hatcheries and transplanted as experimental populations.

The razorback sucker and Colorado pikeminnow are currently found in the Middle and Lower Verde River, maintained by experimental stocking.

2. Exotic Fish of the Verde River Watershed

There are 44 species of exotic alien vertebrates in the Verde Watershed, and fish represent 82 percent of these. There are 36 fish, four reptiles, two mammals, while birds and amphibians have only a single species each. Although there are at least five other resident exotic birds in the Verde, these were not included in the current analysis because they are closely tied to urban, rural, and agricultural landscapes. Also recall that the exotic Norway and black rats were not included in the analysis, because they are urban species and their status in the Verde watershed, indeed Arizona, is not well known. At least 42 species of exotic fish were introduced into the Gila Watershed, but probably six of these do not occur in the Verde River (Table F2).

Table F2. Exotic Species Currently in Upper Verde Watershed
smallmouth bass *(Micropterus dolomieu)*
green sunfish *(Lepomis cyanellus)*
red shiner *(Cyprinella lutrensis)*
yellow bullhead (*Ameiurus natalis*)
mosquitofish *(Gambusia affinis)*
common carp (*Cyprinus carpio*)
channel catfish *(Ictalurus punctatus)*
flathead catfish (*Pylodictis olivaris*)
largemouth bass *(Micropterus salmoides)*

At least 42 species of nonnative fish have been introduced into the Gila River Basin. Most of these species were documented in the Verde River. Rainbow trout are heavily stocked in the Verde River. Many of these species never established themselves or occur in low numbers. The six species identified with "Gila" are limited to the Gila River.

Table F3: Additional Exotic Species in Gila River Watershed
threadfin shad *(Dorosoma petenense)*
rainbow trout *(Oncorhynchus mykiss)*
brown trout (*Salmo trutta*)
brook trout *(Salvelinus fontinalis)*
cutthroat trout (*Oncorhynchus clarki*)
common carp *(Cyprinus carpio)*
goldfish *(Carassius auratus)*
red shiner *(Cyprinella lutrensis)*
redside shiner *(Richardsonius balteatus)*
golden shiner *(Notemiqonus crysoleucus)*
fathead minnow *(Pimephales promelas)*
bigmouth buffalo *(Ictiobus cyprinellus)*
smallmouth buffalo (*Ictiobus bubalus*)
black buffalo (*Ictiobus niger*)
flathead catfish (*Pylodictis olivaris*)
channel catfish *(Ictalurus punctatus)*
blue catfish (*Ictalurus furcatus*)
yellow bullhead (*Ameiurus natalis*)
black bullhead (*Ameiurus melas*)
mosquitofish *(Gambusia affinis)*
guppy *(Poecilia reticulata)* - Gila
sailfin molly (*Poecilia latipinna*) - Gila
Mexican molly (*Poecilia mexicana*) - Gila
yellow bass *(Morone mississippiensis)*
smallmouth bass *(Micropterus dolomieu)*
largemouth bass *(Micropterus salmoides)*
spotted bass *(Micropterus punctulatus)*
redeye bass *(Micropterus coosae)*

rockbass *(Ambloplites rupestris)*
warmouth (*Lepomis gulosus*)
green sunfish *(Lepomis cyanellus)*
bluegill *(Lepomis macrochirus)*
redear sunfish *(Lepomis microlophus)*
pumpkinseed *(Lepomis gibbosus)*
white crappie *(Pomoxis annularis)*
black crappie *(Pomoxis nigromaculatus)*
yellow perch *(Perca flavescens)*
walleye *(Stizostedion vitreum)*
northern pike (*Esox lucius*)
convict cichlid (*Cichlasoma nigrofasciatum*) - Gila
redbelly tilapia (*Tilapia zilli*) - Gila
Mozambique mouthbreeder (Tilapia) (*Oreochromis mossambicus*) - Gila

Currently, the upper Verde River has significant populations of introduced fish. The following species are the major taxa: smallmouth bass, green sunfish, red shiner, yellow bullhead, mosquitofish, and common carp. Smallmouth bass and green sunfish are active predators of small native fish, while red shiners are significant competitors/predators of spikedace and loach minnow, and probably other natives as well. Mosquitofish are the primary competitor/predator of the gila topminnow, but others as well. Yellow bullheads are generalist feeders and rather large, so contribute to predation of native fish. The main detriment of carp is siltation and substrate destruction as they severely disturb substrates searching for food and nest building. Channel and flathead catfish are also present in the upper Verde, but the extent of their population sizes and establishment depends on severe flood events. Because they can grow to large sizes, these two species of catfish can be significant predators on native species.

Our native fish fauna evolved with only a single major fish predator, the Colorado pikeminnow, and this species was primarily limited to the larger rivers or portions of streams. Southwest native fishes have not evolved behavioral adaptations to protect their eggs, larvae, and juveniles; because they relied on their development and growth in very shallow water at stream edges, which was essentially

predator free. The introduction of red shiners, mosquitofish, and other small fish through predation and direct competition dramatically impacted these once relatively safe breeding grounds.

The predominant historical predators of large native fish in the upper Verde River were bald eagles and ospreys, and they still feed a great deal on native suckers. Otters were probably not common in the upper Verde, and they do not deplete fish populations. Colorado pikeminnows were restricted to larger portions of the Verde. The smaller natives and juveniles had to fear primarily herons and kingfishers, and to a much smaller extent garter snakes. The mid-water column foraging of native fish, especially spikedace, exposed them to severe predation when smallmouth bass, green sunfish, and others arrived. An examination of the exotic species introduced into the Verde (Table F2) reveals that all these taxa coevolved with significant competitors and predators in the diverse fish communities of eastern and central U.S. Exotic fish introductions in the Southwest are well-documented to strongly negatively impact native fish species (Minckley and Deacon 1968, 1991, Minckley 1973, Miller et al. 1989, Williams et al. 1989, Rinne 2004). Besides exotic fish introductions, these researchers also stress that water management and drawdown, aquatic and riparian habitat destruction, pollution, and cattle grazing have also had serious and cumulative impacts on native fish communities.

Mosquitofish are small livebearers with high reproductive potential that have been released throughout the West in springs, cattle tanks, guzzlers, and private artificial ponds, even in severe environments such as the Mojave Desert. The justification has been mosquito control, but native fish are typically better at mosquito control. The little exotic has been well documented to be responsible globally for native fish extinctions and even ecosystem collapse (Hurlbert et al. 1972, Soltz and Naiman 1978, Courtenay and Stauffer 1984, Minckley and Deacon 1991). Finding mosquitofish under suboptimal conditions is not unusual, because the species has incredible biological, chemical, and physical environmental tolerance; including high and low temperatures, salinity, alkalinity, oxygen depletion, pollution, pesticides, and ecological competition.

VII. Biological Summary

The Verde River Watershed is located in three Nature Conservancy ecoregions: Apache Highlands North, Arizona–New Mexico Mountains, and Sonoran Desert; and associated with three others: adjacent to the Colorado Plateau, and close to and biologically interactive with Mojave Desert and Apache Highlands South (Madrean Evergreen Woodland). The Verde landscape is characterized by six of the well known Brown and Lowe Biotic Communities of the Southwest based on plant species, and represents a complex landscape mosaic of aquatic, riparian, montane, forest, woodland, chaparral, grassland, desert, and meadow ecological communities. The extraordinary global ecological value of the Verde Watershed is especially based on five features: 1) central regional location with respect to these six ecoregions, 2) value as an ecological landscape corridor, 3) high potential for native endangered fish repatriation, 4) high complexity of spatial landscape mosaics and microhabitats and 5) innate exceptional biodiversity, including resident, migratory, and wintering species.

These six ecoregions tie together the biota of six states (AZ, NM, CO, UT, NV, CA) and the country of Mexico. The Verde River, its tributaries, and canyon ridges form major landscape corridors in multiple centrally located ecoregions. The Verde riparian zone is far more ecologically important than the thin green line might imply; its influence extends far into the uplands. Many of the vertebrates in the watershed depend on the riparian habitat for some or all of their lifecycle. The upper Verde River is one of the last perennial, free-flowing, relatively pristine rivers left in the entire Southwest. The aquatic communities are diverse: lotic (fluvial or running waters), lentic (ponds and lakes), springs, seeps, sloughs and backwaters, marshes, and wet meadows. Important landscape elements include: dissected arroyos and ravines, dry washes, cliffs, boulder ridges, rock outcrops, talus slopes, gravel bars, and sandy alluvium.

Although the Verde Watershed represents only 5.8 percent of the total area of Arizona, it is home to 78 percent of Arizona's breeding bird species, 25 of Arizona's 28 bat species (89 percent), 17 of 19 carnivores (89 percent), and five of six native ungulates (83 percent), 76 percent of Arizona's reptile and amphibian genera, including 94 percent of lizard genera, and 68 percent of snake genera. The Verde Watershed is unexpectedly diverse in its anuran fauna. On a landscape area basis, the Verde

has 682 times the anuran genera density compared to the Midwest (combined states of OH, IN, IL, MO, IO, MI, WI, MN) and 121 times that of Arizona. Contrasting landscape area species densities, the Verde Watershed has 37 times that of the Midwest and nine times that of Arizona.

The Verde Watershed originally possessed 14 native fish species that evolved to the unique arid ecology and hydrology of Arizona and the Southwest. Only three of these are now relatively common in dwindling habitats, two are being actively managed, five are highly endangered, and four are extinct or almost so in their native habitat. The perennial flows of the Verde River plus its tributaries and springs represent perfect habitat – one of the best in Arizona – for repatriation of native fish and the associated invertebrates that will re-colonize suitable habitats.

Actions by public land managers reflect the ecological importance of the upper Verde. The USFWS focus plan for the study area envisions a restored functioning habitat replete with native fauna and flora. AZGFD has established the Upper Verde River Wildlife Area to restore the native fishery and promote public education. The Nature Conservancy has purchased the property surrounding upper Verde River springs to protect the habitat and the water quantity and quality.

Local citizens and businesses are aware and supportive of the ecological importance of the upper Verde. The Sierra Club leads popular guided field tours to educate citizens and monitors the Verde for water quality and quantity. Citizen volunteers assist PNF with fish counts, monitoring, and trailhead maintenance. Drake Cement hardens trailheads to prevent illegal OHV damage to the riparian corridor. The Prescott Audubon Society with state agency assistance established two Important Bird Areas in the upper Verde Watershed, and conducts bird monitoring on these IBAs. The upper Verde is an important research and educational resource. Graduate and undergraduate students alike publish research studies on the ecology, geology, and hydrology of the river.

The upper Verde is an extremely valuable and irreplaceable biological resource for not only the regional community, but also the entire Southwest.