Agua Fria Open Space Alliance, Inc.

A Brief Introduction to the Natural History of the Agua Fria River Basin

Physical Geography and Ecology of a Desert River Valley

11/1/2008

"The wildlife and its habitat cannot speak. So we must and we will." — Theodore Roosevelt.

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November 1, 2008

SUMMARY

This report provides references to books, articles and Internet information pertaining to some of the major physical and biological features of the Agua Fria River basin. Maps produced by U. S. Department of Agriculture Natural Resources Conservation Service (NRCS) are provided to show general distribution patterns. A great deal of useful information is available on the Internet, and Internet sources are given for most subjects. Unfortunately, Internet resources are often ephemeral. Documents containing useful information are frequently moved or removed from websites, and subsequent access becomes difficult or impossible. Because of this, Internet references often serve only as likely starting points for the pursuit of information. Likewise, this report itself is a product of AFOSA's ongoing investigations of open space, and will be updated periodically. Suggestions for additions and corrections sent to Garry F. Rogers (GRogers@SigmaXi.net) will be appreciated.

Full document (.pdf):	Brief Introduction to the Natural History of the Agua Fria River Basin
Maps (.pdf):	Land Management Geology Climate Soils Hydrology Precipitation Human Population

PHYSICAL GEOGRAPHY

The Agua Fria River channel runs south from the north slope of Glassford Hill just east of Prescott, Arizona to the Gila River west of Phoenix, Arizona. The river channel begins on the north slope of Glassford Hill, swings east around the city of Prescott Valley, and then on southward in a

meandering path through the central section of the basin. A series of maps produced by the U. S. Department of Agriculture, Natural Resources Conservation Service (NRCS) illustrates some of the subjects covered in this document. Internet addresses for NRCS and other resources are given in the reference section.

The Agua Fria River is fed by tributary streams flowing off the southwestern slopes of Mingus Mountain in the Black Hills in the northeast, the Bradshaw Mountains in the west, and the New River Mountains in the southeast. The surfaces of the stream channels are generally dry except for brief periods in spring and following summer rain storms. Steady subsurface flow of varying amounts occurs, and in some areas is forced aboveground by natural bedrock barriers. These areas of permanent above-ground flow represent less than 10% of total channel length within the basin.

The southern portion of the watershed south of Lake Pleasant opens out into the broad Salt River Valley. Here the river flows through urban and agricultural lands to its confluence with the Gila River, a tributary of the Colorado River. The upper portion of the basin north of Black Canyon City is the focus of the Agua Fria Open Space Alliance and this report. Land ownership, roads, and towns are shown on the map by the National Resource Conservation Survey (map).

The upper basin watershed covers approximately 1,000 square miles, and ranges in elevation from 7,528 feet at Mount Union in the northwest to 2,000 feet at Black Canyon City in the south. The basin was created by the dynamics of the Earth's crust and is underlain chiefly by igneous and metamorphic rocks. The surface geology is quite diverse (map), and ranges in age from relatively old Precambrian granitic and metamorphic rocks to recent volcanic materials and contemporary sediments. The variety of parent materials is often evident in the rocks embedded in the soils in the lower portions of the basin.

GEOLOGY

Surface geology of the Agua Fria basin is dominated by igneous rocks. Granite outcrops ranging in age from almost two billion years to a mere 15 million years are exposed in several locations. Metamorphic rock of various ages is also present along with younger sandstone and shale, and broad areas of volcanic rock 10 to 15 million years old. The Geologic Map of Arizona (Arizona Geological Survey, 2000) is a convenient resource. A section of the map redrawn by NRCS is included in the accompanying map set.

CLIMATE

The climate of the basin might be described as mild, arid and moderately continental moderated by periods of marine influence. Brief periods of winter temperatures below 0° F occur in mountains and northern valleys, and brief periods below 32° F occur in the southern valleys. Maximum summer temperatures range from just above 100 ° F in the north to as high as 120° F in the south. Annual precipitation ranges from a high of about 30 inches per year in the higher portions of

the Bradshaw Mountains to the west, to around 12 inches in the lower valleys in the south. The annual average across the entire basin is approximately 17 inches (map).

There is a distinct summer monsoon period that occurs between June and September, and there is snow across the entire basin though this is infrequent and light in the south. Reduced winter temperatures allow some accumulation of moisture, but overall there is insufficient precipitation to satisfy the evaporation potential. Thus, plants and animals of the basin must cope with periods of inadequate available moisture during the summer. Only along the stream channels, particularly those with permanent flow, is moisture available year round.

Critical climate information is lacking for the basin. Quantitative observations of water use by most of the vegetation types have not been made, and the somewhat comparable observations being made in the once extensive agricultural lands in the Salt River Valley to the south might soon be discontinued as farmland is covered by houses. From a narrow point of view the relative amounts of evaporation and transpiration by plants is of interest to people only as it serves agricultural needs for irrigation management. The value of the information for making management decisions across the broad expanses of naturally occurring vegetation of the basin has not been recognized. Thus, the hydrological consequences of vegetation change due to a variety of forces such as fire, weed invasion, grazing, and so forth are not known. This is typical of the treatment of natural resource information within the Agua Fria basin.

SOILS

"Below that thin layer comprising the delicate organism known as the soil is a planet as lifeless as the moon" (Jacks and White, 1939, quoted in Hendricks, 1985)

The basin's soils are shallow, dry and generally lacking in organic material. Best developed in the lower valley areas, they are nevertheless rocky everywhere, and tend to be coarse textured. Due to the dominance of crystalline surface rock, the soils are often studded with an interesting array of stones of a range of sizes. The stones tend to be rounded in the lower valleys where the sediments have been reworked by the Agua Fria River and the other streams.

Less than one-half of the Basin's soils have been surveyed and mapped in detail. General reconnaissance estimates indicate that there are eight soil associations made up of two or more soil series within the Agua Fria River Basin. The distribution of the associations is shown on the Arizona General Soil Map (Hendricks 1985). More than 60 of the state's 221 soils are included in the eight associations found in the Basin. Not all of these soils are classified to series, the sixth and lowest level of the soil taxonomic system. Characteristics of each of the soils are summarized by Hendricks (1985) (map).

Hendricks' Arizona soils map and the accompanying book provide general information on the Basin's soils. As with works covering other natural resources of the Basin the soil information is useful mainly for general management planning. Hendricks offers a caveat concerning the map that could be applied to all the other natural resource information for the region. "It is emphasized that

the Arizona General Soil Map is not a guide ... to specific soil uses in specific areas." (Hendricks 1985, p. 72) Hendricks advises users of the map to select areas that might be appropriate for a specific use and then carry out more detailed investigations.

Detailed maps of the portions of the basin that have been surveyed are available online from the Natural Resources Conservation Service (NRCS) of the U. S. Department of Agriculture (http://websoilsurvey.nrcs.usda.gov/app.) These maps can be associated with a variety of soil characteristics of important for planning for sustainable use (cf Olson 1981).

The eight associations shown on the state map are listed below with brief descriptions of distinguishing characteristics taken from the summaries provided by Hendricks (1985). Each is preceded by its letter-number symbol used on the map. Information on the uses of soil information is provided by Olson (1981). Information about each of the soil series included in each association may be reviewed in Hendricks work (link). The series mapped within the basin can be found at the NLCS site (link).

TS THERMIC SEMIARID SOILS Thermic Semiarid Soils have mean annual soil temperatures of 15 to 22 C (59 to 72 F). The difference between mean summer and mean winter temperatures is greater than 5 C (9 F) at a depth of 50 cm (20 in) or in shallow soils at the soil-bedrock interface. These soils receive 250 to 410 mm (10 to 16 in) annual precipitation. Elevations of Thermic Semiarid Soils range from low to intermediate. They cover about 5,966,410 ha (14,742,800 ac), or 20 percent of Arizona.
TS6 Lithic Torriorthents-Lithic Haplustolls-Rock Outcrop Association Shallow, cobbly and gravelly, strongly sloping to very steep soils and rock outcrop on hills and mountains.
TS12 Continental-Latene-Pinaleno-Association Deep, gravelly, medium to fine-textured, nearly level to steep soils on disseced alluvial fan surfaces.
TS15 Bonita-Graham-Rimrock Association Shallow to deep, fine-textured, nearly level to steep soils on plains, hills and mountains.
TS16 Penthouse-Latene-Cornville Association Deep, medium to fine-textured, nearly level to moderately steep soils on dissected fan surfaces and valley slopes.
MS MESIC SEMIARID SOILS Mesic Semiarid Soils have a mean annual soil temperature of 8 C (47 F) or more, but less than 15 C (59 F). The difference between mean summer and mean winter temperatures is greater than 5 C (9 F) measured at a depth of 50 cm (20 in) or at the soil-bedrock interface in shallow soils. The mean annual precipitation on these soils ranges from 250 to 460 mm (10 to 18 in). Their elevation is intermediate. Mesic Semiarid Soils cover about 5,328,080 ha (13,165,500 ac), or 18 percent of Arizona.
MS7 Cabezon-Thunderbird-Springerville Association Shallow to deep, gravelly, cobbly and stony, fine-textured, nearly level to very steep soils on basaltic plains, mesas and hills.

MS9 Lonti-Balon-Lynx Association Deep, moderately fine and gravelly, moderately fine and fine-textured, nearly level soils on floodplains and undulating to steep valley slopes and plains.
MH Mesic Subhumid Soils Mesic Subhumid Soils have a mean annual soil temperature of 8 C (47 F) or more, but less than 15 C (59 F). The difference between mean summer and mean winter temperatures is greater than 5 C (9 F). The mean annual precipitation is more than 410 mm (16 in). These soils are at intermediate elevations. They cover about 2,021,270 ha (4,994,500 ac), or 7 percent of Arizona.
MH2 Lithic Haplustolls-Lithic Argiustolls-Rock Outcrop Association Shallow, gravelly and cobbly, moderately coarse to moderately fine-textured, gently sloping to very steep soils and rock outcrop on hills and mountains.
FH FRIGID SUBHUMID SOILS Frigid Subhumid Soils have mean annual soil temperatures lower than 8 C (47 F). The difference between mean winter and mean summer soil temperature is more than 5 C (9 F) at a depth of 50 cm (20 in) or at a bedrock contact in shallow soils. The mean annual precipitation is more than 410 cm (16 in), with one-half or more usually falling during the winter and early spring months as snow, sleet or rain. These soils are at elevations mostly more than 1,970 m (6,500 ft) on the Colorado Plateau and in a few of the high mountains of the Basin and Range Province. They cover about 2,093,110 ha (5,172,000 ac), or 7 percent of Arizona.
FH1 Mirabal-Dandrea-Brolliar Association Moderately deep and deep, gravelly and cobbly, moderately coarse and fine-textured, gently sloping to very steep mountain soils.

HYDROLOGY

Summary information and references to pertinent literature for the Agua Fria River Basin are provided by the University of Arizona NEMO group (Levick et al. 2006) and also in the Arizona Water Atlas produced by the Arizona Department of Water Resources. The Basin's average rainfall of about 17 inches does not produce much surplus water for surface or underground storage. Lynx Lake in the north and Lake Pleasant in the south are the largest surface water bodies. Small stock ponds are scattered throughout the basin. A few of these are spring fed and are more or less permanent. Others are temporary or are maintained by groundwater pumping.

The Agua Fria and its tributaries are intermittent over most of their courses. Over all, only about 10% of the channels of the Agua Fria River and its major tributaries are perennial. These stretches of permanent flow occur along portions of the streams where impermeable bedrock forces subsurface groundwater flow into the streambed.

Most of the soil moisture accumulated in the Agua Fria River basin during winter evaporates or is used by plants during spring and early summer. Some water percolates downward below the reach of plant roots and is stored in groundwater aquifers. Soil moisture accumulation during summer is limited because runoff and stream flow after intense summer rains is rapid, and thirsty plants and evaporation use up most of the rest of the incoming water. The rate of runoff and the amount of sediment carried into and down the stream channels is influenced by the nature of the slopes—their steepness, soil texture, and vegetation cover. Watershed is a term used to refer to the slopes within the basin, and the term "healthy watershed" means that the natural vegetation cover is undisturbed and as continuous as it can be under the influence of the prevailing climate. Thus, soil surfaces are protected from raindrop impacts, unimpeded surface wash, and do not exhibit excessive erosion.

Geological units of importance to groundwater storage in the Agua Fria basin are basin-fill sands and gravels, conglomerates, volcanic rocks, and igneous and metamorphic rocks. The main groundwater-bearing units are the basin-fills and conglomerates. The water-bearing ability of the crystalline igneous and metamorphic rocks depends on their degree of fracturing, and most wells in these areas have very low yields. Present-day drainage systems and underlying groundwater aquifers are the result of faulting and isolation by impermeable rock (Wilson, 1988).

The relatively thin sedimentary deposits transmit some water into underlying rocks. In some areas sediments absorb more winter precipitation than can soak into underlying rock before seeping laterally into stream channels. The slow discharge of this water maintains perennial flow in about 10% of the Basin's larger stream channels (map).

Groundwater storage within volcanic rocks is restricted to cinder beds and fractures. Some springs and seeps contribute small amounts of surface water but most are not perennial. An exception is Castle Hot Spring on the southern skirts of the Bradshaw Mountains which produces a flow of about 200gpm from underlying Precambrian rocks. In general, however, conglomerates occurring throughout the basin contain the largest volume of groundwater.

ANIMALS

In preparation for field work in the basin AFOSA prepared checklists for the major groups likely to be seen in the basin. No previously prepared checklists for the Agua Fria basin were found, but lists for small locales within the basin, and larger areas that include the basin are available. The brief introductions to each group given below principally serve to mention pertinent books, articles, and websites listed in the References section. Examples of general internet sources that included multiple groups are Arizona Game and Fish Department, Arizonensis, NatureServe and Southern Arizona Data Service.

BIRDS

The Agua Fria basin covers such a wide range of habitats from high mountains in the north to low deserts in the south that the majority of the birds that can be seen anywhere in Arizona will

occasionally be seen in the Basin. Moreover, there are no reports listing the birds present in most locales within the basin. In preparation for field work in the basin

American Bird Conservancy, Partners In Flight, Audubon Society (website addresses are included in the References) and others provide information about bird conservation and protection needs. For many species there is a strong need for more frequent observations. Useful field guides and websites are listed in the references.

The principal sources for the list are the printed and online lists provided by the American Birding Association, Arizona Bird Committee (ABC), American Ornithologists' Union (A.O.U.), Audubon Society, and the maps in the Arizona Breeding Bird Atlas (Corman, Troy E. and Cathryn Wise-Gervais 2005). The A.O.U. checklist includes 2,046 bird species that can be seen in North and Central America. It is updated annually in the July edition of ***The Auk***. The ABC list provided in Wikipedia.org narrows the focus to Arizona, and is a useful authority for the state.

BUTTERFLIES AND MOTHS

According to Glassberg (2001), butterflies and moths tend to be found in specific habitats. Certainly many of them have well known associations with particular plants that are used for food, egg laying and caterpillar feeding. Many species can be seen along the Agua Fria River and other streams in the Basin. One of the most common is *Nymphalis antiopa* (Morning Cloak, a True Brushfoot) often spotted near the river in all months of the year. Species common during summer months near the river are Swallowtails, Whites, other True Brushfoots, and Monarchs.

Species found within Yavapai County include 295 (40%) of Arizona's 735 species of butterflies and moths, and eight percent of the 3,600 species found in the United States and Mexico. The list was derived from the Butterflies and Moths website (Opler, et al., 2006). The website is continually updated. Additional species lists and a discussion of the standardization of common names are provided by the International Lepidoptera Society at http://tils-ttr.org. More information can be found on the website of the North American Butterfly Association and by following the many links listed on the Butterflies and Moths website.

FISH

Twenty of Arizona's 36 fish species are threatened or endangered as defined by the U.S. Endangered Species Act. Additional species whose survival is in question are listed on the Arizona Game and Fish website. Further information is provided by Dale Turner and Michael List (2007), and by Nelson *et al.* (2004).

MAMMALS

Mammals are pictured and described in many field guides and websites (e.g., Kays and Wilson, 2002, Hartson, 1999, National Wildlife Federation, Arizona Game and Fish Department). Species that are often seen in the Basin include Elk, Antelope, Mule Deer, Javelina, Beaver, Raccoon, Rabbit, Coyote, Skunk, Squirrel, Valley Gopher, bats, and numerous smaller rodents. Elk and Mule

Deer tend to be present mainly in the mountains, foothills, and upper valley areas, but occasionally visit the streams in the valley floors. Widespread, but less frequently seen species are the Gray Fox, Bobcat, Badger, Cougar, Black Bear, Ring-Tailed Cat, Porcupine, and Muskrat. The tracks and scats of all mammal species are encountered more often than the animals themselves. Several field guides to tracks and scats such as the one by Halfpenny (2000) are available. Mammal conservation status can be found on the NatureServe and Arizona Game and Fish websites.

REPTILES AND AMPHIBIANS

A guide to the taxa within this group is provided by Stebbins (1966), Bishop (1962), and others. Species lists for Arizona's reptiles and amphibians have been placed on the internet by Thomas C. Brennan (2008). Many reptile and amphibian species may be declining or disappearing in the Agua Fria River Basin. Declines among these groups of species are being reported from all parts of the globe and throughout the United States. Biologists and conservation activists are racing to find the causes. Conservation efforts and research progress can be reviewed on internet sites published by a number of the organizations given in the references. A partial list includes: Partners in Amphibian and Reptile Conservation, U.S. Fish and Wildlife Service, International Reptile Conservation Fund, Global Amphibian Assessment, International Reptile Conservation Fund, NatureServe, and the Amphibian Conservation Alliance.

In many instances the balance of nature has been disturbed by the spread of competitive species. The problem with invading species that displace natives is quite evident among the frogs. One only needs to visit a pond within the Basin on a summer night to hear the bellows of the American Bullfrog, an aggressive species that eliminates and replaces natives. An article on the National Geographic website outlines the problems this native of the eastern United States is causing worldwide and especially in the American Southwest. Many of the activities of humans have had negative effects. For example, the tiger salamander in Arizona was more or less restricted to ephemeral lakes and stock tanks on the Navajo Reservation and adjacent areas of the Colorado Plateau until the middle of the 20th Century. For many years this group has been crossed with species from other regions due to harvesting, mixing, and distribution during the summer monsoon months by fish-bait dealers. More information is available from the references given above.

PLANTS

Plants are the primary producers of food, fiber, and shelter used by animals. They are the foundation of Earth's food chain and they are the most characteristic visible feature of open space. Plants also play an essential role in moderating the environment. They contribute to the weathering and break up of surface rocks into small particles, they add organic acids and debris to the rock debris to help form soil, they protect the soil providing wind breaks and by intercepting rainfall and by slowing runoff, erosion and flood damage.

Numerous sources are available that provide useful information about the plants of the Agua Fria basin. Online lists of plants and related information are available from Arizona Game and Fish Department, Arizona Vascular Plant Herbarium, Natural Resources Conservation Service (NRCS), and NatureServe. References for special groups such as weeds are also available (Parker and Hamilton 1972, Whitson 2006).

VEGETATION ECOLOGY

Vegetation of the Agua Fria River basin watershed is made up of slow-growing drought tolerant plants that are often widely spaced. Small forests of great beauty and diversity are present at the highest elevations in the Bradshaw Mountains to the west and Black Hills to the east. Woodlands and shrublands composed of Pinyon and Juniper trees, evergreen Oaks, and shrubs cover the intermediate mountain slopes. Patches of shrubs and expansive desert grasslands cover the broad sloping valley floors.

Riparian vegetation with dense stands of cottonwood trees, willows, mesquite, salt cedar, and numerous other tree, shrub, and herb species occurs in narrow ribbons along perennial and intermittent streams throughout the basin. Riparian habitat covers less than one percent of the surface area of the basin and yet it is the most critical source of water, food, and cover for the basin's native animals. Researchers have found that the majority of the animals living in the basin are fully or partially dependent on riparian habitats.

Vegetation makes up the most critical part of the habitat of birds and many other animals. Indeed, you could say it IS the habitat for all higher orders of Animalia. Plants are the primary producers of food, fiber, and shelter upon which animals depend, and they protect the soil surfaces from erosion. Being rooted in place, plants cannot seek shelter or flee from danger. Thus, the vegetation found at any particular location tells the story of climate, soils and environmental history including drought, fire, flood, animal grazing, and so forth. The methods used to read the story are referred to as Vegetation Ecology.

The larger categories of the vegetation in the Agua Fria River Basin are covered by Brown's 1973 and 1982 maps and the photographs and lists of dominant plants and animals accompanying the 1982 map. A more detailed map of Arizona vegetation has been produced by the U. S. Geological Survey GAP program (). The U.S. Forest Service provides information on the change over time and space in the condition of the Southwest's major vegetation types and the ecological processes that shape those types. (U.S. Forest Service 2007, and see Küchler 1975, 1988, Mueller-Dombois and Ellenberg 1974). Other information is available from a variety of sources (e.g., Gori, D.F., and C.A.F. Enquist. 2003). As vegetation mapping and monitoring is the first field project being undertaken by AFOSA, the subject of vegetation ecology is covered in a separate report.

Conservation status is unknown for vegetation associations in the Basin. Element two of the Arizona Game and Fish Comprehensive Wildlife Strategy describes the statewide condition of Arizona's terrestrial and riparian/aquatic habitat types on the basis of the 1:500,000 scale vegetation map by Brown (1973), but since no vegetation maps at the association level have been made, the presence of rare, threatened, or endangered associations cannot be determined. Thus, within the Agua Fria River Basin the specific relationships and dependencies between the associations and animals that inhabit them are unknown.

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