Section 2.0
Watershed Assessment and Stream Ecology

Summary

A watershed assessment examines the physical, chemical, and biological components of the watershed and the impact of human activities on those components. Watershed components combine to create a complex and dynamic array of habitats and processes, particularly within and adjacent to streams. The health of the stream, streamside plant communities, and the animals living in both depend on how well those components and processes function. Society, too, depends heavily on the function and values provided. Lands adjacent to streams are the most productive and diverse components of the western landscape, but are also disproportionately impacted by human activities. The assessment establishes the watershed's current condition, evaluates the reasons for that condition, and suggests remedies for conditions adversely affecting the watershed and its rivers and lakes.

This section explains the purpose and process of watershed assessment, discusses concepts in stream ecology that guide watershed assessments, and discusses watershed and stream functions and values.

Watersheds, Watershed Functions, and Watershed Assessment

A watershed is an area of land within which all water drains to a common point, such as a stream, a lake, or the ocean. Other terms used include drainage basin and catchment. As such, a watershed can be relatively small or large depending on the area of interest (REO 1995). The South Arkansas River watershed is 212 square miles, 0.8% of the Upper Arkansas River in Colorado (28,268 square miles) (CWCB 2011b).[1] Figure 2-1 illustrates the position of the South Arkansas River watershed within the larger Arkansas River basin.

Watersheds—in particular, wetlands, streams, and streamside ("riparian") areas—perform a variety of functions and provide a number of values.

- **Functions** refers to physical, chemical, and biological components and processes. These include ground water recharge and discharge; flood flow alteration; shoreline stabilization and sediment removal; retention and transformation of nutrients, toxins (e.g., metals, pesticides), and pathogens; fish, wildlife, and waterfowl habitat; and habitat for plant and animal species of concern.

[1] The Upper Arkansas River in Colorado represents 11.5 percent of the entire Arkansas River basin (245,500 square miles) that drains into the Mississippi River at Napoleon, AR (USGS 1987).

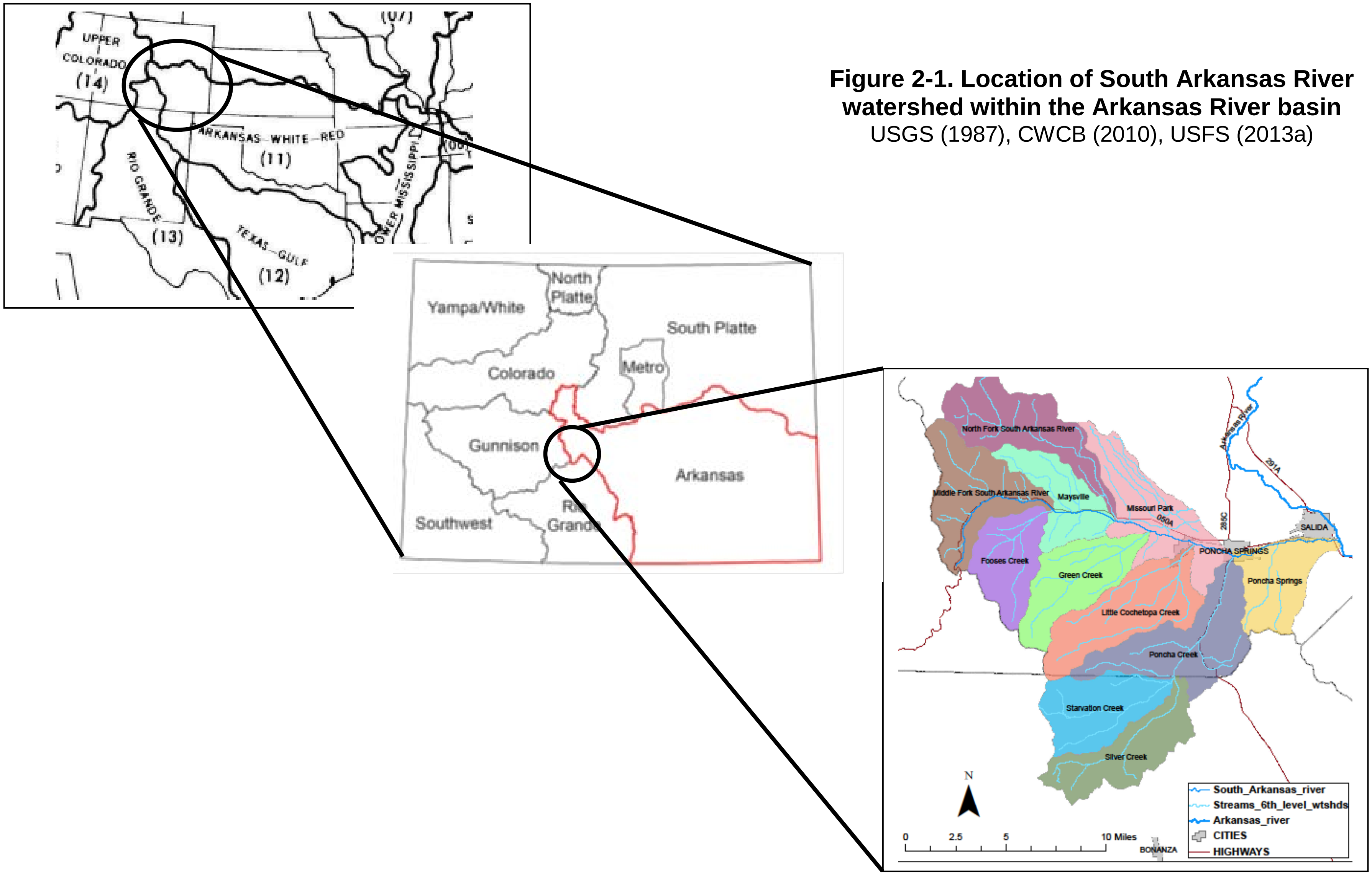

Figure 2-1. Location of South Arkansas River watershed within the Arkansas River basin
USGS (1987), CWCB (2010), USFS (2013a)

- **Values** refers to those functions that society considers beneficial. These include economic contributions (e.g., water, hunting); health and safety (e.g., flood attenuation, pollution control); historical and cultural significance; education, research, and scientific opportunities; and aesthetics and recreation (e.g., birding) (USACE 1999, Mitsch and Gosselink 2007, ASWM 2006).

A watershed assessment examines the physical, chemical, and biological components and processes occurring in the watershed, and the human influences on those components and processes. General zones of analysis common to watershed assessments include uplands, floodplains and riparian areas, and the stream channel (OWEB 1999, CWAM 2005).

- **Physical components** include climate, geology, topography, soils, hydrology, and channel and floodplain features. **Physical processes** include weathering, erosion, runoff and flow regime, and stream channel behavior.
- **Chemical components** include temperature, pH, dissolved oxygen, turbidity, nutrients, minerals, and pollutants such as metals, pesticides, and petroleum products. **Chemical processes** include the pathways by which chemical components and pollutants are stored, transferred, and transformed.
- **Biological components** include native plant communities; wildlife, fish and aquatic insects; threatened and endangered species; and non-native plants and animals. **Biological processes** include the many ways in which the watershed's living elements interact with each other and with the physical and chemical components (CWAM 2005, USEPA 2013a).

Human influences include the direct, indirect, and cumulative effects of development and other changes in the use of land and water that: (1) alter stream channels, such as through straightening and confinement; (2) alter stream water quality, such as excess sediments and nutrients; (3) alter stream flows and channel processes, such as through dams and water diversions; and (4) decrease and fragment in-stream and streamside habitat (REO 1995).

Last, reviewing past watershed activities and events, whether natural or as a result of development, is important to understanding current watershed health (Harding et al. 1998).

The Watershed Perspective

Although watershed problems such as poor water quality or loss of fish habitat are usually related, they are often approached in isolation from one another. Such a fragmented approach is frequently a consequence of a fragmented system of legal and regulatory responsibilities. For instance, the U.S. Army Corps of Engineers is responsible for water supply and flood control, state and federal public health agencies oversee water quality, and state and federal wildlife agencies are responsible for habitat and rare species issues (Poff et al. 1997). These conditions make it difficult to manage a river system in an integrated fashion (Karr 1991).

The watershed perspective is intended to promote a comprehensive approach to natural resource management by examining the condition of and the relationships among all watershed natural resources in the context of regional and local social and economic factors (NRCS 2007b). Specifically, a watershed assessment is intended to:

- establish a baseline of current watershed conditions;
- determine how well watershed components and process are functioning;
- analyze the reasons for that level of functioning, that is, which components and processes have changed or are missing and why; and
- develop a list of actions and management options to address the problems identified (OWEB 1999, USEPA 2003a, CWAM 2005).

The specific components of this watershed assessment that are detailed in the table of contents were established after examining watershed assessments and assessment protocols used by federal and state agencies and non-profit organizations (CRAM 2012, CWAM 2005, CWP 2005, MDEP 2009, MDNR 2005, Platts et al. 1987, OWEB 1999, Prichard 1998, REO 1995, USEPA 2003a, VARN 2007, WDNR 2011, Wild Utah Project 2006, Winters and Gallagher 1997).

Several assessment methods and procedures have been developed to specifically address stream and stream corridor conditions. Components and protocols from these methods have also been used in this assessment, including those developed by Rosgen (1996), the hydrogeomorphic assessment (HGM) (Brinson et al. 1995), proper functioning condition (Prichard et al. 1998), Wyoming Habitat Assessment Methodology (Quist et al. 2006), Basin-Wide Stream Habitat Inventory (Winters and Gallagher 1997), Stream Visual Assessment Protocol (NRCS 1998), and rapid assessment methods applied to riparian habitat in the southwest U.S. (Wild Utah Project 2006).

Watershed Functions and Riparian Ecology

Watershed components at larger scales—climate, topography, geology, and soils, influence components at smaller scales—vegetation and stream channel features. These large- and small-scale components create and sustain a complex array of conditions and habitats that are integrated by the flow of surface and subsurface waters across the watershed. How that water moves is fundamental to the health and functioning of in-stream and streamside habitats (Gregory et al. 1991, Pringle et al. 1988) (Figure 2-2). Thus, similar to the concept of landscape, the stream and its valley can be viewed as a “riverscape” (Fausch et al. 2002, Allan 2004).

Fundamental to the creation and maintenance of in-stream and streamside conditions is the seasonal change in stream flow that characterizes undisturbed watersheds—from spring runoff to spates from summer thunderstorms and late season low flows. Poff et al. (1997) coined the phrase “natural flow regime” to refer to the seasonal cycles of flows that create the physical template of the stream such as point bars and meander bends, pools and riffles, oxbows and backchannel areas, ridges and swales, fallen

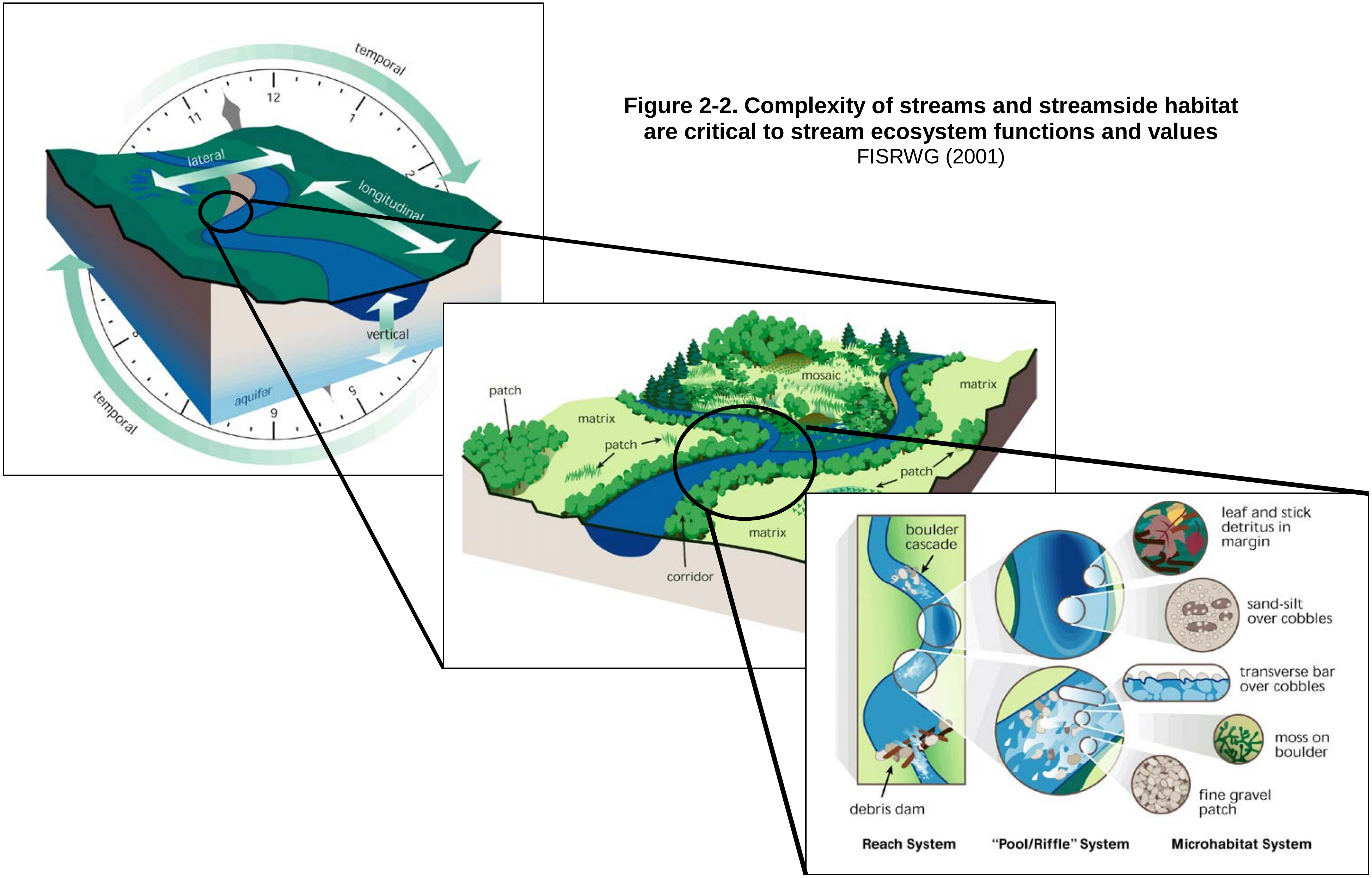

Figure 2-2. Complexity of streams and streamside habitat are critical to stream ecosystem functions and values
FISRWG (2001)

trees, and debris dams. In particular, those authors noted the importance of both high- and low-flow events because these "often serve as ecological 'bottlenecks' that present critical stresses and opportunities for a wide array of riverine species."

These habitats and the processes that create and sustain them support many different plant communities that are, in turn, critical for the organisms that depend on the stream and stream corridor, such as: for trout, riffles for breeding and pools for protection; for important early colonizers like cottonwood seedlings, barren, sunny areas for germination; for grazing ungulates, willows and wetlands for food and cover; and for breeding birds, mature cottonwood galleries for food and nest sites (Townsend 1989, Allan 1995, Wu and Loucks 1995, Wiens 2002).

Riparian/Wetland Habitat and Buffer Functions

The riparian zone is that area adjacent to the stream that is regularly or periodically influenced by flowing water. The types, abundance, and distribution of riparian habitats are ecologically critical for the proper flow of water, nutrients, materials, seeds, and animals (Wiens 2002). The ability of riparian areas to provide various functions and values depends on its position in the watershed; its width and undisturbed length ("connectivity"); the composition and density of vegetation present; topography and the type of soils present; and climate (Fischer and Fischenich 2000, Baird and Wetmore 2006, Johnson and Buffler 2008).

Watershed position. The effectiveness and importance of riparian areas increases as the size of the stream decreases. Thus, riparian areas provide proportionally greater functions the higher one moves in a watershed.

Width and connectivity. In general, the wider a riparian area is ("buffer"), the more functions it provides and the better it performs those functions, such as removing sediments or excess nutrients. Connectivity refers to how continuous the habitat is along the river corridor, both laterally (extending away from the channel) and longitudinally (extending along the length of the channel). Gaps in the corridor and lack of separation from adjacent land uses reduce connectivity (Belsky et al. 1999) (Figure 2-3). In some instances, a

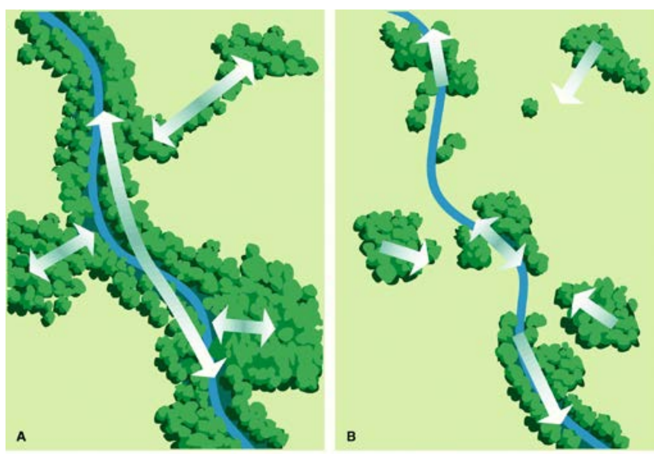

Figure 2-3. Width, connectivity, and composition are important components of riparian corridors (FISRWG 2001)

long, continuous buffer may provide more benefits (e.g., moderating stream temperature, providing corridors for wildlife) than buffer areas that are wider, but fragmented (Weller et al. 1998).

In general, the importance to wildlife of riparian areas and their components varies among species. Generalist species such as crows and raccoons easily co-exist with people in many different situations and habitats, lessening the value of specific habitat elements. Other species, though, have exacting requirements that determine the suitability of an area (Odell and Knight 2001, Fraterrigo and Wiens 2005). For example, the endangered Southwest willow flycatcher (*Empidonax traillii extimus*) requires a minimum habitat size and specific shrub composition for nesting (USFWS 2013a).

Vegetation. A mix of native trees, shrubs, and herbaceous plants well-adapted to site conditions provide the most riparian functions and values. This mixture provides different rooting depths that hold the soil and stream bank together as well as habitat and other resources for different wildlife uses. A variety of species also allows the area to respond as site conditions change and as plant survival ebbs and flows over time.

Topography and soils. The faster runoff moves, the less materials carried in the runoff have time to settle out (e.g., sediment) or to interact with plants and soils (e.g., nutrient absorption and transformation). Thus, steeper riparian slopes allow runoff to reach adjacent waterbodies more quickly and with more materials. Characteristics that improve the soil's ability to hold and transform runoff include depth, high organic content, complex structure, and diverse particle size (Lewis et al. 2003).

Evaluating whether buffer width, connectivity, and composition are sufficient depends on the function being considered and the nature of the areas adjacent to the buffer. Some benefits may be achieved with a buffer only a few feet wide others require thousands of feet (Table 2-1). Evaluation of various buffer components is important because it provides insights into what may be needed to address the impacts of disturbance and to guide subsequent restoration efforts.

Table 2-1
Riparian Buffer Requirements for Selected Riparian Functions

Riparian Function	**Recommended Buffer Width** (ft)
Wildlife	100 to 1,640
Flood attenuation	65 to 490
Water quality	15 to 100
Stream stabilization	30 to 65
Insect production	30 to 100
Detrital input	10 to 30

Adjacent land uses. The types and extent of disturbance and land uses in areas adjacent to riparian zones influence whether a buffer will function well (FISRWG 2001). For instance, a multi-lane highway will disturb wildlife more than a gravel road or pedestrian path (Wenger 1999). The time of year also influences the suitability of a buffer because many species are more sensitive during mating and nesting periods (Hammitt and Cole 1998).

Importance of Riparian Vegetation

Vegetation in riparian areas such as cottonwoods, willows, alder, and sedges is often subject to frequent disturbance from flooding, scouring, erosion, and deposition. At the same time, many of these species are dependent on these same forces for various lifecycle needs. For instance, the creation of barren areas like point bars are critical for the germination of cottonwoods seeds (Friedman et al. 1995, Rood et al. 2003). Riparian vegetation also exerts considerable reciprocal influence on smaller streams. It resists stream forces by anchoring the stream banks and streamside soils, and by slowing flood flows by increasing roughness and friction. Slower flows are less erosive and also tend to drop finer sediments in the riparian zone, providing a water-clarifying function. To function properly, stream banks and floodplains must be vegetated and relatively undisturbed (Belsky et al. 1999).

Importance of Headwater Streams

Headwater streams begin where precipitation and surface runoff first coalesce to form a defined channel. This initial channel is referred to as a first-order stream. First- through third-order streams are most frequently categorized as headwater streams.[2] Such streams comprise roughly 75% of the stream miles in many drainage networks (Meyer et al. 2007). Given this prominence, headwater streams are often compared to capillary blood vessels or the finest branches in the lungs as a way to describe how connected those streams are to the landscape (Lowe and Likens 2005). For instance, headwater streams contribute disproportionately to groundwater recharge and act as a refuge for fish during both critical life stages (e.g., eggs, fry) and times of the year (e.g., summer heat) (Lowe and Likens 2005, Meyer et al. 2007). Perhaps most importantly, headwater streams are “crucial for sustaining the structure, function, productivity, and bio-complexity of downstream ecosystems” (Wipfli et al. 2007). This crucial role begins with leaves falling into the stream.

Headwater streams are narrow and often enclosed beneath a canopy of vegetation, most often willows but also grasses and sedges in some habitats. This reduces the light reaching the stream and limits the growth of aquatic plants like algae, the primary production that is normally at the base of the food chain in many aquatic systems. Instead, it is the leaves that fall into the stream that provide the primary source of energy at the base of the aquatic food web in headwater streams (Allan 1995).

[2] See Footnote 1, Section 1.0, Introduction to the South Arkansas Watershed, for more information on stream order.

Once in the water, components in the leaves that dissolve easily begin to leach out as the surface is colonized first by aquatic fungi and then by a variety of bacteria, algae, and protozoa. Together these organisms are referred to as periphyton. These organisms alter the structure and chemistry of the leaves, making them more palatable and nutritious to organisms next in line in the food chain (Allan 1995). Cummins (1974) presents the picture of the leaves as crackers and periphyton as peanut butter. Organisms next in the food chain include micro-invertebrates such as rotifers, midge larvae (chironomids), and water fleas (*Daphnia* sp.), and larger macro-invertebrates such as aquatic insects and larvae, crustaceans (amphipods), snails, and annelid worms. These organisms scrape and shred the leaves for food (Allan 1995). The resulting organic matter that is consumed and excreted represents more than 95% of the material transported and used downstream. The shredders and scrapers also provide prey for predatory insects and fish (Cummins et al. 1989, Richardson and Danehy 2007, Wipfli et al. 2007) (Figure 2-4). Thus, the ability of headwater streams to transform organic matter into more usable forms is fundamental for the health of downstream ecosystems (Meyer et al. 2007).[3]

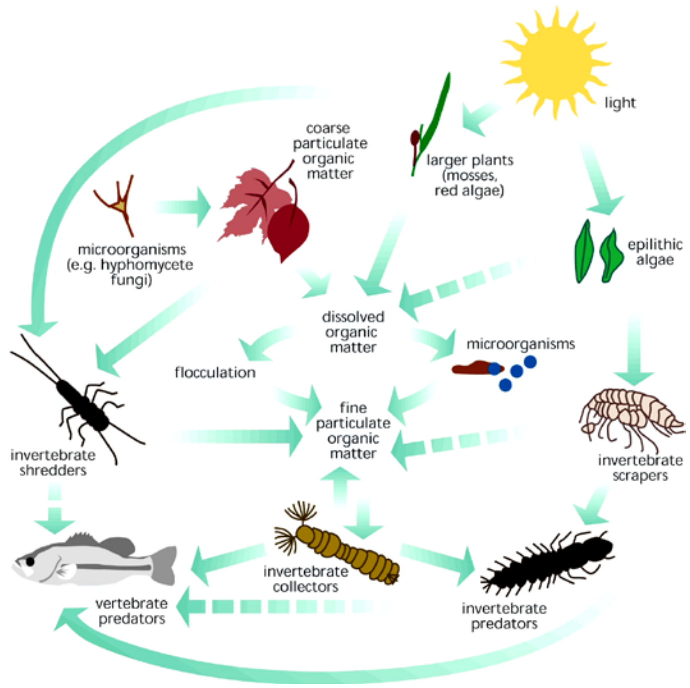

Figure 2-4. Diagram of foundation of aquatic food chain in headwater streams (FISRWG 2001)

South Arkansas River as a Headwater Stream

At the western end of the project corridor, the South Arkansas River is a third-order stream. It becomes a fourth-order stream when joined by Green Creek, and a fifth-order stream at its confluence with Poncha Creek. The river's fairly rapid increase in stream order is an indication of the density of headwater segments in the tributary network that

[3] Wood in the form of fallen trees and limbs also represents an external ("allochthonous") source of consumable organic material. Many of the same processes discussed here also apply to wood, although degradation and use of woody debris in the aquatic food web occurs over decades and centuries. The role of woody debris in stream structure and function is also discussed in Section 10.0, Channel and Floodplain Processes.

.

feeds the main stem of the river. For the sake of this discussion, the South Arkansas River in the project corridor is considered a headwater stream.

Conclusion

Given the preceding discussion, one way to bring perspective to the assessment of the South Arkansas River watershed is to consider the following.

- The water in streams and rivers represents about 0.0001% of the water on the earth (Allan 1995).
- Riparian and stream ecosystems represent about one percent of the surface area of arid lands in the western United States, but are considered the most productive and diverse components of the western landscape (Kattelmann and Embury 1996, Knud-Hansen 1986).
- Riparian and stream ecosystems are especially important in the arid West by virtue of the water provided to plants, animals, and people. However, less than 20% of potential riparian habitat in the western United States remains (Belsky et al. 1999). Others have estimated that 90-95% of cottonwood-willow habitat in the lower montane zone and high plains of the Rocky Mountains has been lost (Windell et al. 1986).
- According to the Colorado Natural Heritage Program, “species richness of montane and subalpine riparian areas in the Southern Rocky Mountains [is] as rich or richer than riparian ecosystems in the southwest, central, and northeast portions of the United States, and [has] higher species richness than most temperate North American forests” (CNHP 2009).
- Riparian areas in the Intermountain West frequently have greater species diversity of plants, birds, and other vertebrates than adjacent upland communities. For example, as many as 50% of bird species in some western states are found primarily in riparian vegetation (Knopf et al. 1988), and many upland species depend on riparian areas for critical feeding, breeding, and nesting habitat (Brinson et al. 1981).

More details regarding the components of watersheds, stream ecosystems, and the South Arkansas River specifically are discussed in the following sections of this assessment.

- Section 3.0, History, Development, and Land Use
- Section 4.0, Geology, Topography, and Soils
- Section 5.0, Climate and Precipitation
- Section 6.0, Hydrology and Flow Regime
- Section 7.0, Vegetation
- Section 8.0, Wildlife, Fish, and Aquatic Invertebrates
- Section 9.0, Water Quality
- Section10.0, Channel and Floodplain Processes

Restoration goals and recommendations for the South Arkansas River and watershed are discussed in Section 11.0, Establishing Watershed and Riparian Restoration Goals.

The river is the carpenter of its own edifice.

Leopold (1994)

This page intentionally left blank.