# CHAPTER 1

# Making the Connection—Watersheds

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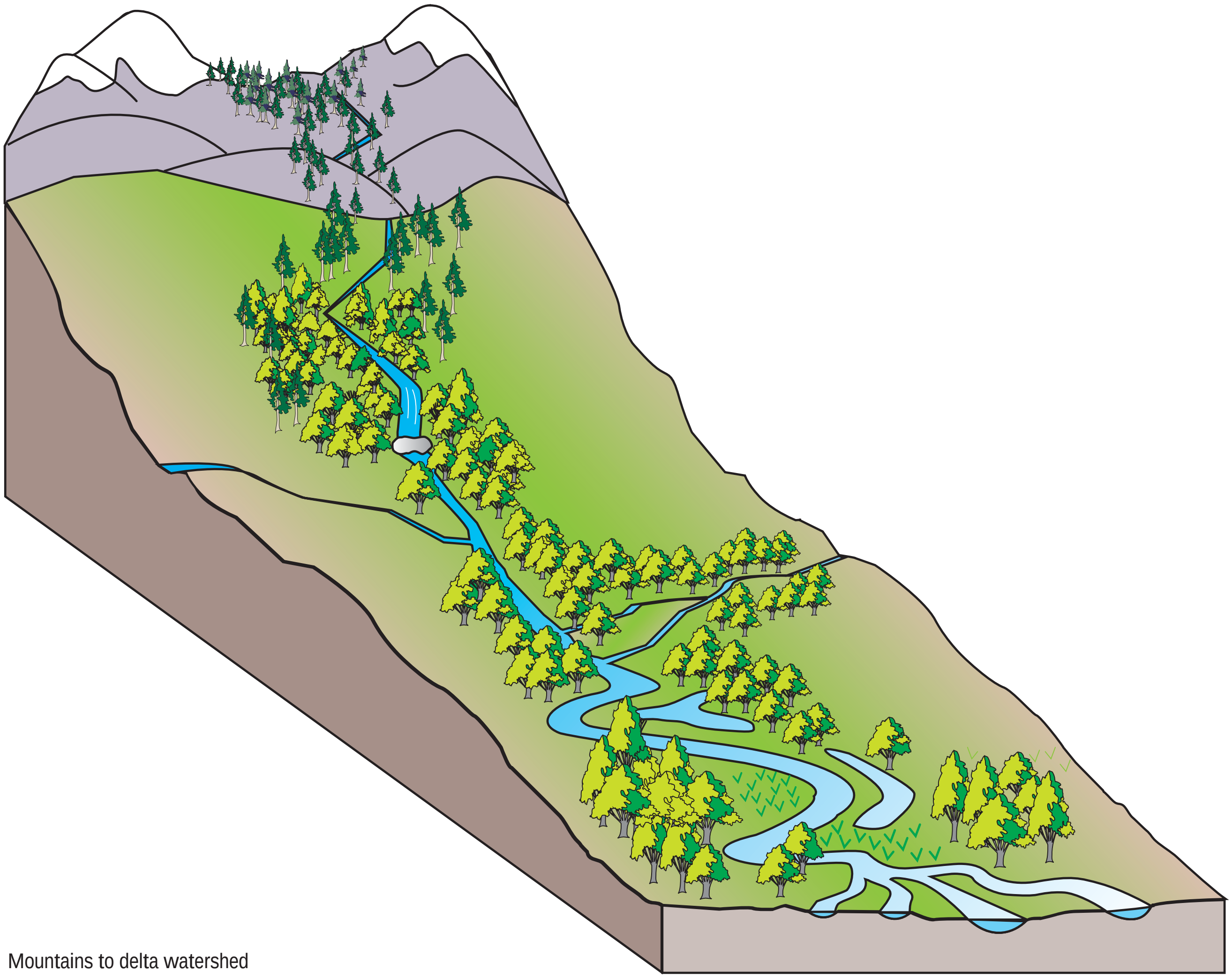
". . . Professor Noel Hynes of the University of Waterloo in Ontario was among the first to describe how links between the soil and vegetation in a watershed combine with local climate to produce the physical structure and biological productivity of streams." (Hynes 1975) (Ibid.)

Hynes' synthesis, the synergy between a river and its watershed, has been described in various ways. At first, the river-watershed relation was viewed along the longitudinal gradient of a river from its headwaters to the ocean (called the river continuum concept). (Ibid.)

More recently, researchers, naturalists, scientists, and other eco-explorers have begun to view the relationship of rivers from upstream to downstream, from upslope to downslope, and from canopy to subsurface. They are looking for clues to better understand the links among all of the natural systems that make up the watershed environment. Ward (1989) describes this multidimensional concept in four dimensions and makes a landscape connection for each: "longitudinal (upstream to downstream), lateral (floodplains to uplands), vertical (subsurface to riparian canopy), and temporal (because the other three dimensions are dynamic over time)." (Ibid.)



Mountains to delta watershed

This chapter not only provides a holistic view of how healthy watersheds function, but it builds a foundation for understanding why the links between upland and riparian and aquatic ecosystems are vitally important. It helps us to understand the impacts of a damaged watershed and why streambanks fail. It explains why we must look upstream and examine the activities of the entire watershed before any streambank stabilization or watershed restoration work begins. Without the watershed-scale perspective, the risk of undesirable effects dramatically increases.

## Origin and Purpose

Watersheds, as we know them today, are complex ecosystems composed of different land types ranging from dry desert landscapes to richly forested areas. These land types are connected by equally complex drainage networks of rivers and streams.

A watershed's topographic shape, sometimes referred to as a basin, was formed by tectonics and glacier activity more than 4 billion years ago. Natural erosion developed a complex drainage network. As the Earth's surface reached its saturation level during intense rainfall, water moved across the surface to form rills and gullies.

Gullies were incised to wider and larger channels, eventually becoming rivers and streams. Smaller streams are called first and second order streams while larger streams and rivers are third order and higher. This sophisticated network of streams sets up an elaborate and unique plumbing system that allows watersheds to collect discharge and transport both runoff and sediment through the system to lakes and oceans.

## Sediment and Runoff

Quantities of discharge and sediment are important because an imbalance in either affects the dynamics of the stream and, ultimately, the streambanks. Most watersheds receive their discharge from precipitation, including melting snow and subsurface discharge. When the infiltration capacity of the soil is exceeded, sheetlike flow called "sheet wash" occurs. Sheet wash picks up velocity and increases in depth as it flows. Erosion of sediment occurs when the shear stress of the water is sufficient to transport sediment. This sheetlike flow condition is often referred to as Horton overland flow. Horton overland flow causes the highest rates of hill slope erosion. (Mount 1995)

It is natural for banks to erode, it is integral to stream systems. The locations and rates of erosion are the main concern. Changes in flow direction and sediment rates can hasten erosion. These changes can often be traced to human activities.

Primarily, there are three ways for streambanks to erode:

1. **Hydraulic.** Water carries away bed and/or bank material because the shear stress of the flowing water is stronger than the shear strength or cohesiveness of the bank. (Fischenich 1989) "…Hydraulic failure is usually characterized by a lack of vegetation, high boundary velocities [swift high water], and no mass wasting at the toe of the bank." (King 1993) This generally occurs in noncohesive soils; glacial till is a good example.

2. **Geotechnical.** Gravity exerts a stronger force on the bank than the materials can withstand, and they slide. Its shear strength is compromised. In many cases, excess moisture retention is the cause of mass wasting (landslide) at the toe of the bank.

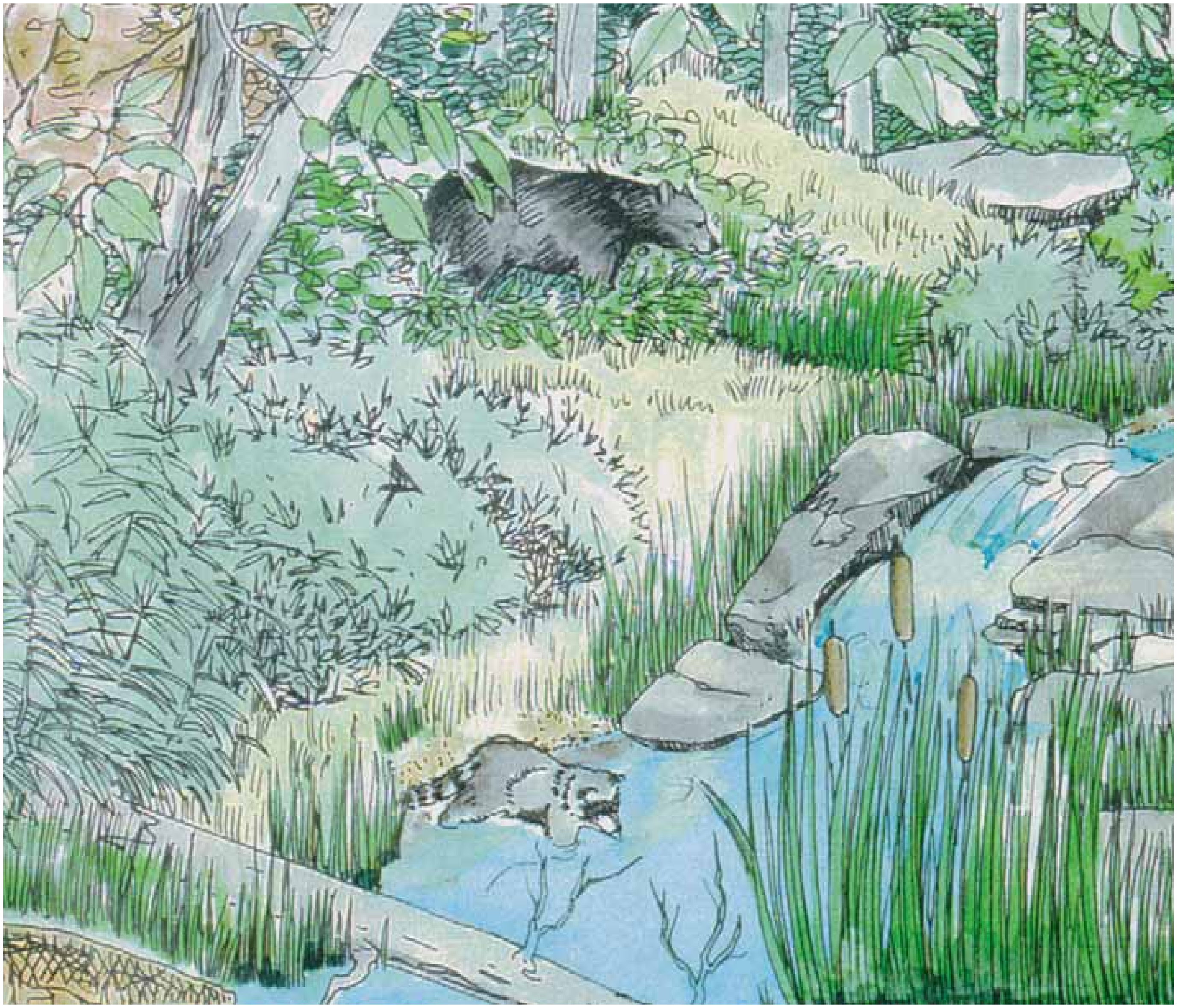
3. **Hydraulic and Geotechnical.** Bank failure caused by this combination is more likely to occur than either one alone. Examples include:

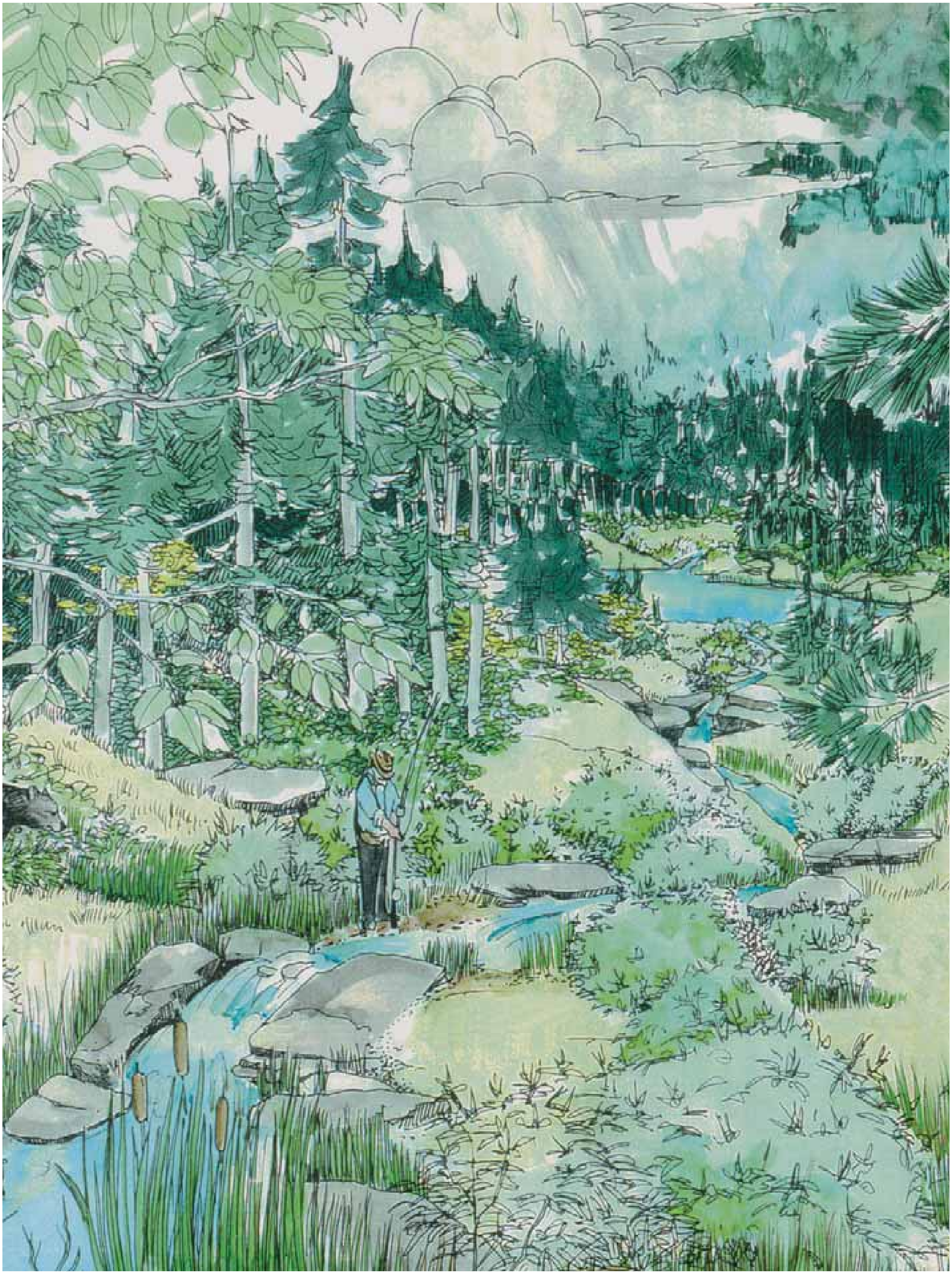
- Bed degradation and erosion, which lowers the bed so much that the banks become overly steep and fail (slide).
- Mass wasted material lying at the toe of a slope is washed away. (Fischenich 1989) (King 1993)

The infiltration capacity of various watersheds can vary widely according to the structural characteristics and makeup of the watershed. ("Stream Corridor Restoration" offers more detailed information on this topic. See the Bibliography for the complete reference.) Watersheds that are heavily forested with a range of vegetation types generally have high infiltration capacities. Trees, brush, and grasses intercept and dissipate the energy from raindrops. Raindrops that reach the ground unimpeded can dislodge soils and cause erosion. The presence of lush vegetation is generally associated with an abundance of organic materials above and below the surface and highly developed root systems that keep the soil structure porous and well drained. With surface and subsurface conditions like these, rapid infiltration causes a significant portion of the precipitation to end up as ground water. The ground water is later released as subsurface discharge into lakes, rivers, and streams.

Conversely, the infiltration capacity is relatively low for watersheds that are covered sparsely with vegetation. Their soil structure is poorly developed and poorly drained. For example, desert soils are generally non-porous and very susceptible to overland flow conditions.

Farming, mining, logging, grazing, building and road construction, and recreation activities may leave bare ground with nothing to intercept rainfall. Consequently, such activities have the potential to significantly disturb the ecological integrity (function and structure) of the watershed.





## Ecological Integrity

Without a watershed-scale perspective and a clear understanding of the dominant physical, biological, and human processes that regulate watershed ecosystem functions, there is considerable risk of undesirable side effects from restoration attempts and the application of streambank and lakeshore stabilization techniques. With a greater understanding of structure and function at the watershed scale, the consequences of restoration and stabilization activities become much more predictable. A watershed analysis should precede any stabilization work. (See appendix A for a more complete discussion of a watershed analysis and its benefits.) The analysis should, at a minimum, address the functional and structural characteristics of the watershed and generate answers to such basic questions as:

What erosion processes are dominant within the watershed (e.g., surface erosion processes or mass wasting)? Where have they occurred or are they likely to occur?

What are the dominant hydrologic characteristics (e.g., total discharge, peak flows, minimum flows, and water level fluctuation in lakes) and other notable hydrologic features and processes in the watershed (e.g., cold water seeps or groundwater recharge areas)?

What is the array and landscape pattern of plant communities, and what are the seral stages in the watershed (riparian and nonriparian)? What natural processes cause these patterns (e.g., fire, wind, and mass wasting)? How do different systems react to these natural processes based on their seral stages?

What are the basic morphological characteristics of stream valleys and segments and the general sediment transport and deposition processes in the watershed (e.g., stratification using accepted classification systems)?

What beneficial uses depend on aquatic resources occurring in the watershed? Which water quality parameters are critical to these uses?

What is the relative abundance and distribution of species of concern that are important in the watershed (e.g., threatened or endangered species, special status species, species emphasized in other plans)? What is the distribution and character of their habitats?

What current and past human uses (e.g., Forest Service management practices and private and public use patterns), on and adjacent to forest land, may be affecting the watershed?

## Healthy Watersheds

With what we know about watersheds and what disturbs them, let us briefly consider some benefits of healthy watersheds. “Healthy ecosystems [and watersheds] are resilient and recover rapidly from natural and human disturbance. Costanza (1992) defined a healthy ecosystem as one that is stable and sustainable in that it maintains its organization and autonomy over time and is resilient to stress. High biological diversity and habitat complexity provide much of the resistance and resilience exhibited by healthy watersheds.” (Williams and others 1997)

“Healthy watersheds exhibit a high degree of connectivity from headwaters to downstream reaches, from streams to floodplains, and from subsurface to surface. Floods can spread onto floodplains, where their energies are dissipated and silt from floodwaters increases soil productivity. High connectivity also enables fish and wildlife populations to move freely throughout the watershed, which increases their viability and facilitates transfer of nutrients from rich downstream reaches to less-productive headwaters.” (Ibid.)