RIPARIAN AREA MANAGEMENT

A Guide to Managing, Restoring, and Conserving Springs in the Western United States

Technical Reference 1737-17 2001

U.S. Department of the Interior
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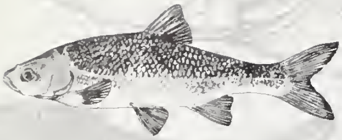

Tui chub

Limnocoris moapensis

Colligyrus greggi

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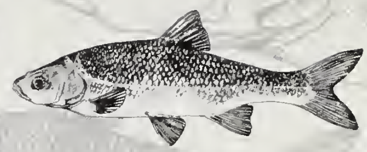


Tui chub

Limnocoris moapensis

Colligyrus greggi

Table of Contents

Page

Acknowledgments ... iii

I. Introduction ... 1

II. What is a Spring? ... 3

Physical Environment of Springs ... 5

Water Chemistry of Springs ... 6

Biotic Characteristics of Springs ... 7

III. Uses that Affect Springs ... 11

Physical and Chemical Disturbances ... 11

Diversion ... 11

Recreation ... 12

Mining ... 12

Pollution ... 14

Biological Disturbances ... 15

Introduced Species ... 15

Vegetation ... 15

Aquatic Animals ... 15

Terrestrial Animals ... 15

Native Species ... 17

IV. Spring Resource Management Goals ... 19

V. Spring Management Assessment and Priorities ... 23

VI. Spring Restoration ... 31

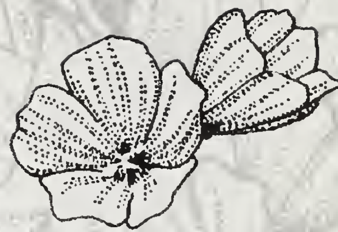
VII. Summary ... 39

Appendix A. Spring Ecosystem Ecology ... 41

Appendix B. Examples ... 47

Glossary ... 59

Literature Cited ... 61



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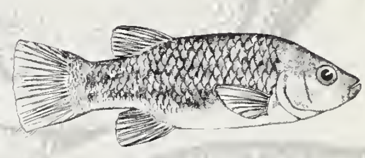


White River springfish

Columbia spotted frog

I. Introduction

Springs have played an important role in the human occupation of the Western United States. Emigrants who crossed and settled in arid regions of the country were dependent upon springs for water. Though these vital water sources were comparatively small, they were commonly developed to provide water for livestock, mining, and the burgeoning human population.

Springs have also provided important habitat for many species of wildlife and plants, and in fact, are vital to a number of unique plant and animal communities in the Western U.S. Early studies by Gilbert (1893), Wales (1930), Hubbs (1932), Hubbs and Kuhne (1937), Hubbs and Miller (1948a) and Miller (1943, 1948) described many unique fishes from springs, and studies since the mid-1980's have described a number of endemic spring-dwelling macroinvertebrates (primarily mollusks and aquatic insects) (Hershler 1998; Schmude 1999). Erman (1997) and Wiggins and Erman (1987) identified distinctive caddisflies of subalpine springs in the Sierra Nevada, along the western edge of the Great Basin. Surveys in other regions also document endemic mammals, amphibians, and plants from spring-fed wetlands (Sada et al. 1995) and Forester (1991) and Holsinger (1974) cited the importance of springs to ostracodes and amphipods, respectively.

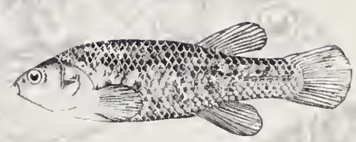
Unfortunately, as springs have been developed to enhance water availability for livestock, game animals such as chukar (*Alectoris graeca*) and bighorn sheep (*Ovis canadensis*), and humans, the associated riparian and aquatic habitats frequently have been altered due to trampling, diversion, channelization, and impoundment. Springs have also been affected by excessive ground-water use, as well as by the invasion and establishment of nonnative plants and animals. As a result, the current physical and biological characteristics of many springs bear little resemblance to their historical, unaltered conditions. Additionally, populations of plants and animals that rely on spring habitat have declined and many are now on the Federal list of threatened or endangered species.

Evidence showing the biological importance of springs continues to increase and general guidance is available to assist agencies in developing springs while maintaining biological diversity. However, these small wetlands have received limited management priority. Degraded habitat conditions (Sada et al. 1992), recent population declines, and species extinctions (Sada and Vinyard in press) all indicate that management changes are necessary to restore habitat integrity and prevent future extinctions and wetland deterioration (Williams et al. 1985; Erman and Erman 1990; Naiman et al. 1993; Shepard 1993).

The purpose of this technical reference is to provide information on the characteristics of springs in the Western

Pelocoris biimpressus

Tryonia protea



Pahrump poolfish

KEY FEDERAL POLICIES AND REGULATIONS DIRECTING SPRING ECOSYSTEM MANAGEMENT

All major Federal policies, Executive orders, and legislation to direct management of aquatic and riparian habitats are more fully described in USDI (1991). A number of additional State regulations are also applicable (e.g., water quality standards, water rights, etc.). Following are several key Federal policies and regulations:

- The Taylor Grazing Act of 1934 directs the Secretary of the Interior to end degradation of public lands (including riparian areas) by preventing overgrazing and soil deterioration and requiring orderly use, development, and improvement of natural resources on grazing lands.
- The Federal Land Policy and Management Act of 1976, 43 U.S.C. 1701 (FLPMA) provides overall guidance to the Bureau of Land Management for managing riparian and aquatic systems. Implementation of this guidance is to be accomplished through land use plans.
- The Federal Water Pollution Control Act of 1977 (Clean Water Act) provides for protection and improvement of water quality, including wetland areas.
- A 1992 Bureau of Land Management policy states that the goal of riparian-wetland area management is to maintain, restore, improve, protect, and expand these areas so they are in proper functioning condition for their productivity, biological diversity, and sustainability. The overall objective is to achieve an advanced ecological status, except where resource management objectives, including proper functioning condition, would require an earlier successional stage (USDI 1992).
- Interior Department Manual 520, *Protection of the Natural Environment*, directs preservation, protection, and acquisition of riparian-wetland areas, as necessary.

U.S. and to identify techniques for managing spring habitats that will allow use, maintain biological integrity, and rehabilitate or restore degraded habitats. Spring management goals are outlined and methods for prioritizing management actions are discussed.

In addition, this guidance is intended to facilitate implementation of a memorandum of understanding (MOU) pertaining to the U.S. Department of the Interior's Species at Risk Program for springsnail conservation. This MOU was prepared to facilitate cooperation and participation among The Nature Conservancy, Bureau of Land Management (BLM), Smithsonian Institution, National Park Service, Fish and Wildlife Service, and U.S. Department of Agriculture, Forest Service, to conserve springsnails and their habitats on Federal and TNC lands. The MOU was formally signed by representatives from these agencies during 1998.

The information presented focuses on habitats managed by BLM in the Western United States, excluding Alaska. It is intended to assist biologists, range conservationists, and other natural resource specialists in the development of conservation or land use plans. It does not, however, make specific water development recommendations. When water developments are constructed, the guidance in this document should be integrated with the recommendations in BLM Handbook H-1741-2, *Water Developments* (USDI 1990).

II. *What is a Spring?*

A spring is where water flows naturally from a rock or soil upon the land or into a body of surface water (Meinzer 1923).[1] Many springs exhibit a unique combination of physical, chemical, and biological conditions (Hynes 1970; Garside and Schilling 1979). Spring ecosystems include aquatic and riparian habitats that are similar to those associated with rivers, streams, lakes, and ponds. They are distinctive habitats because they provide relatively constant water temperature, they depend on subterranean flow through aquifers, and on occasion, they provide refuge for species that occur only in springs (Hynes 1970; Erman and Erman 1995; Hershler 1998; O'Brien and Blinn 1999).

Springs are replenished by precipitation that percolates into aquifers. The precipitation seeps into the soil and enters fractures, joints, bedding planes, or interstitial pore space in sedimentary rocks. Springs occur where water flowing through aquifers discharges at the ground surface through fault zones, fractures, or by flow along an impermeable layer (Figure 1A-F). They can also occur where water flows from large orifices that result when the water dissolves carbonate rock, enlarging fractures or joints to create a passage. Characteristics of regional and local

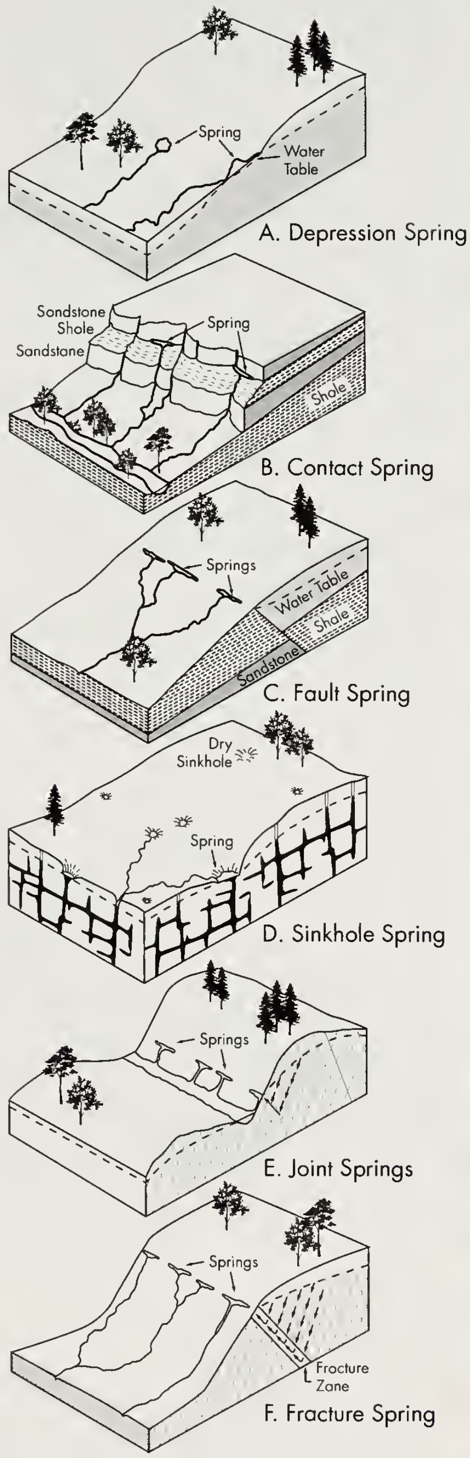
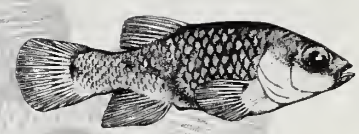


FIGURE 1. Types of springs. (*Fetter, C.W., Applied Hydrogeology, 4/E, © 2001, p. 249.* Adapted by permission of Pearson Education, Inc., Upper Saddle River, New Jersey.)

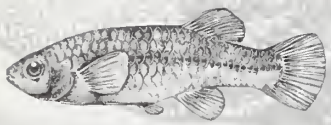


Devils Hole pupfish

Western toad

Lyogyrus pilsbryi

[1] This guidance is applicable to seeps as well as to springs. There is a fine distinction between seeps and springs. The term spring refers to an intersection of the ground-water table and the ground surface resulting in a spring. Sepps to not have an obvious localized spot from which water flows, but they are a subset of springs. Therefore, although the term "spring" is used alone thoughout this document, it implies both springs and seeps.


Big Bend gambusia


Tryonia clathrata


Inyo County star tulip

geology influence spring occurrence and flow rates. Springs are generally classed as gravity springs and artesian springs, with thermal springs typically being considered a type of artesian spring. Gravity springs are created by water that moves along an elevation gradient emerging at the surface. Depression springs, contact springs, and fracture and tubular springs are different types of gravity springs. These types of springs occur where the movement of water through permeable material is interrupted by an impermeable layer that directs water to the surface. This situation often creates a perched aquifer, with springs flowing along the contact with an impermeable layer (Figure 2). Artesian springs occur where the potentiometric level of the ground-water flow system is above the land surface and the water flows at the land surface under pressure either at the aquifer outcrop (Figure 3) or from fractures or faults (Figure 4). Water is sometimes forced to the surface along a fault from deep sources by thermal and pressure gradients. Aquifer outcrop springs and fault springs are the two main types of artesian springs.

Springs can be regional (long flow paths that are often interbasin) or local discharge points (short flow paths). Local springs are comparatively small, can have low flow, and are typically from shallow aquifers. The discharge from these springs often fluctuates either seasonally or in greater cycles, sometimes in response to local

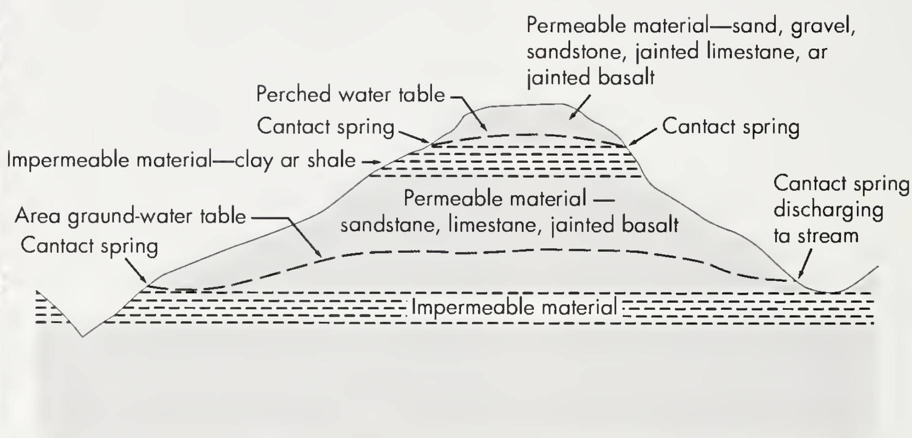


FIGURE 2. Typical contact spring.

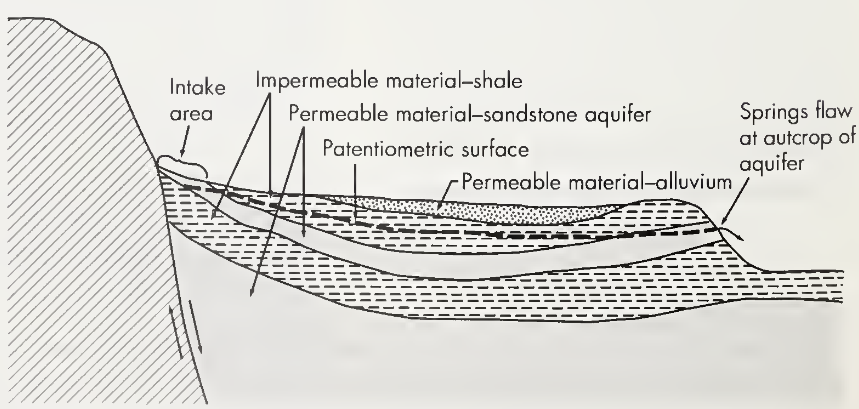


FIGURE 3. Artesian spring at outcrop of aquifer.

precipitation. Local aquifers are quickly recharged and water movement through them is comparatively rapid, resulting in waters that are low in mineralization. Springs supported by local aquifers are more likely to periodically stop flowing than springs supported by regional aquifers.

Regional springs are more typically high-flowing and are discharge points for aquifers covering hundreds of square miles. In the Great Basin, the majority of the high-flowing springs occur within the intermontane basins of the carbonate rock province and are often closely associated with outcrops of carbonate rock (i.e., limestone) (Mifflin 1988). Regional springs are typically of nearly constant discharge and can be more mineralized than local springs due to their long flow paths. Their temperatures can be cold or warm depending on the depth of circulation. Seasonal and annual variations in discharge from regional aquifer springs are usually limited, and they are comparatively stable aquatic environments. Regional springs rarely stop flowing, even during long droughts.

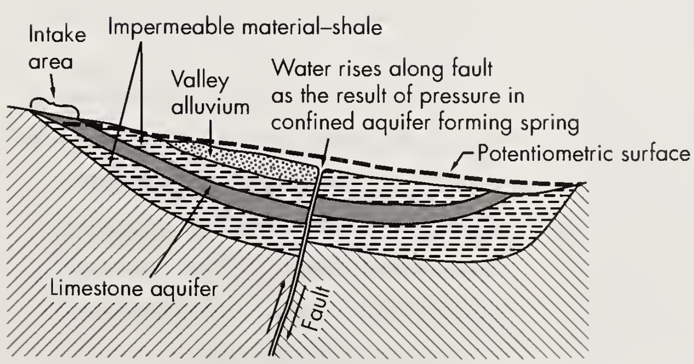
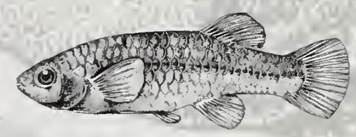


FIGURE 4. Artesian spring occurring along a fault.

Physical Environment of Springs

Springs occur in many sizes, types of discharge points, and locations with respect to topography. They occur in the highest elevations of mountainous areas to valley floors. Many springs found on lands managed by the BLM are small, provide limited aquatic habitat, and are intermittent in flow. They generally support limited amounts of riparian vegetation. However, some small springs do provide greater amounts of aquatic habitat, are permanent, and support larger riparian zones with greater species diversity. Springs are frequently categorized by the morphology of their source: *limnocrenes* are sources where water flows from large deep pools, *helocrenes* are marshy bogs, and *rheocrenes* flow into a confined channel (Hynes 1970). It is often difficult to categorize springs because morphology can be a combination of features from more than one of these categories.

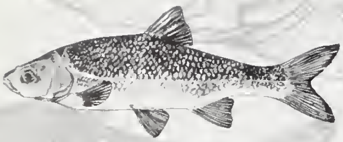
Springs vary in their physical and chemical conditions (see Hynes 1970; Garside and Schilling 1979). They can be cold (near or below mean annual air temperature), thermal (5 to 10 °C above mean annual air temperature) (van Everdingen 1991), or hot (more than 10 °C above mean annual air temperature) (Peterken 1957). The temperature of spring water is also an indicator of the flow path of water discharging to the spring and its recharge area. Shallow circulating ground water has temperatures generally within a few degrees of the mean annual ambient air temperature (Mifflin 1988).



Big Bend gambusia

Tryonia clathrata

Inyo County star tulip



Tui chub

Limnocoris moapensis

Colligyrus greggi

Higher temperatures are usually indicative of deeper, regional circulation, although some cool regional springs exist. Thermal springs gain their temperature increases when water comes in contact with or in close proximity to recently emplaced igneous masses, such as at Steamboat Springs, Nevada; Yellowstone National Park; and Geyser, California (Wood and Fernandez 1988). Thermal and hot springs are due to deep seated thermal sources, and are classed as volcanic springs or fissure springs (Milligan et al. 1966), which are types of artesian springs. Fault-related springs can also be thermal if they are from a deep source of water. This type of spring is common in the Great Basin, where mountain blocks are faulted along the margins, allowing water from deep sources to rise along the fault.

Springs may occur singly or in groups that can include dozens of habitats in various sizes and morphologies. Many springs are tributaries to rivers, lakes, and streams. A few are even the major source for a river, lake, or stream. However, most single springs below approximately 7,000 feet (2,100 m) on BLM lands in the Western U.S. are isolated from other wetlands and frequently flow a short distance on the surface before drying (Hendrickson and Minckley 1984). Many springs in this region stop flowing periodically on a seasonal basis or during times of drought. Some groups of mid- to low-elevation springs can support wetland areas with unique habitat and species (e.g., Ruby Marsh in northeastern Nevada, Ash Meadows in southern Nevada, Fish Springs in northwestern Utah, and San Bernardino Ranch in southern Arizona) (Hendrickson and Minckley 1984; Dudley and Larson 1976). Springs at higher elevations generally display greater fluctuations in flow rates and dry more frequently than regional springs or springs at lower elevations. However, they are generally less susceptible to impacts from dewatering at agriculture and mining operations. Some springs support mid- to low-elevation fens in the watershed, usually in large open areas or parks such as South Park in south-central Colorado. Some springs are the source for streams high in a watershed and provide a perennial water supply to lower elevation streams.

Water Chemistry of Springs

Springs may be highly mineralized, especially thermal springs and sometimes regional springs that have a very long flow path. Thermal springs in Utah have pH values ranging from 7.2–7.6 (Milligan et al. 1966). Springs in the Great Basin likely have similar pH values. Dissolved oxygen concentration is primarily a function of temperature and pressure; as temperature increases, the dissolved oxygen concentration decreases (Hem 1992). As a result, dissolved oxygen concentrations are frequently very low [less than 2 parts per million (ppm)] in hot springs and high (greater than 5 ppm) in cold springs. Electrical conductance may range from very low (near 0 microsiemens per centimeter) to very high (greater than 10,000 microsiemens per centimeter). Local low-flowing springs may freeze during winter, while the larger and warmer regional springs do not.

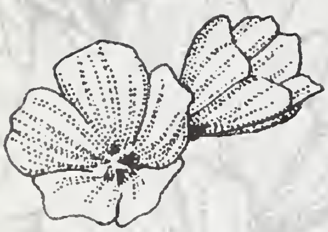
Biotic Characteristics of Springs

Ecological aspects of spring-fed aquatic and riparian systems in the Western U.S. have been studied less than lentic and lotic systems in the region. Spring ecology is described briefly here; a more thorough summary is presented in Appendix A.

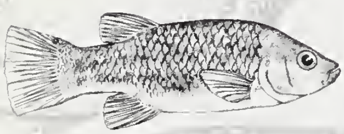
Studies of springs in other regions indicate that these wetlands are habitat for aquatic plants and animals, a water source for terrestrial animals, and a source of food and cover for birds, reptiles, amphibians, and mammals. Many of these habitats are also occupied by endemic vertebrates and/or macroinvertebrates. Riparian communities are generally composed of species associated with regional streams, rivers, wetlands, and lakes, and aquatic communities include species that are closely related to other regional wetlands. The aquatic biota of a spring is regulated by its chemical, biological, and morphological characteristics (van der Kamp 1995). Species that inhabit rheocrenes prefer flowing water and species in limnocrenes are more closely related to species that occupy lakes and ponds. Water temperature, dissolved oxygen concentrations, and other water chemistry components change downstream from the spring source. As a result, animal communities that occupy spring sources typically differ from communities in habitats further downstream. Many spring source species do not occupy downstream habitats where temporal fluctuations in water temperature and flow are greater (Erman and Erman 1990; Erman 1992), and endemic macroinvertebrates are usually more abundant near spring

SELECTED RARE PLANT SPECIES ASSOCIATED WITH SPRING SYSTEMS

STATE and SPECIES	COMMON NAME
ARIZONA	
Lilaeopsis schaffneriana	Huachuca water umbel
Spiranthes delitescens	Canelo Hills ladies tresses
CALIFORNIA	
Calochorthus excavatus	Inyo County mariposa lily
Carex albida	White sedge
Cirsium fontinale var. obispoense	Chorro Creek bog thistle
Cirsium hydrophilum var. hydrophilum	Suisun thistle
Sidalcea covillei	Owens Valley checkerbloom
COLORADO	
Aquilegia chrysantha var. rydbergii	Golden columbine
Botrypus virginianus ssp. europaeus	Rattlesnake fern
Epipactis gigantea	Giant hellborine
Mimulus eastwoodiae	Eastwood monkey flower
IDAHO/MONTANA	
Howellia aquatilis	Water howellia
Spiranthes diluvialis	Ute ladies tresses
MAINE	
Pedicularis furbishiae	Furbish lousewort
Platanthera leucophaea	Eastern prairie fringed orchid
NEVADA	
Centaurium namophilum	Spring-loving centaury
OREGON	
Ilamna rivularis var. rivularis	Streambank hollyhock
UTAH	
Asclepias welshii	Welsh's milkweed
Carex specuicola	Navajo sedge
VIRGINIA	
Cardamine micranthera	Small-anthered bittercress
Platanthera leucophaea	Eastern prairie fringed orchid
WASHINGTON	
Arenaria paludicola	Marsh sandwort
Sidalcea nelsoniana	Nelson's checker mallow
WISCONSIN	
Aconitum noveboracense	North wild monkshood
Iris lacustris	Dwarf lake iris
WYOMING	
Spiranthes diluvialis	Ute ladies tresses



Owens Valley checkerbloom



White River springfish

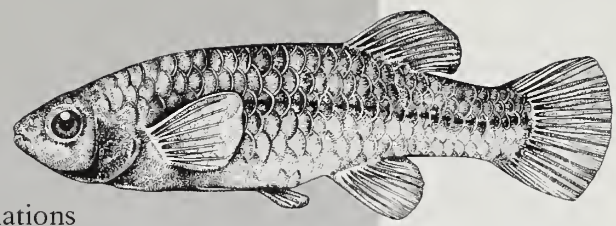
Columbia spotted frog

sources than they are in downstream habitats (Hershler 1998; Erman and Erman 1995). Communities in permanent springs generally include more species and more individuals than communities in ephemeral springs (Erman and Erman 1995). Species in ephemeral habitats are generally highly mobile (animals that can fly or crawl long distances) and adapted to establishing in impermanent and comparatively harsh habitats. Springs occupied by endemic species do not dry and they have persisted for thousands of years.

The physical habitat of a spring is the most important factor influencing its riparian and aquatic plant and animal communities. Riparian vegetation may be narrowly restricted to immediate boundaries of the aquatic habitat or may extend outward for substantial distances. Narrow riparian zones are typically dominated by sedges, grasses, and woody phreatophytes (e.g., willows, mesquite, etc.). Wider riparian systems are generally associated with spring provinces where water seeps outward from aquatic habitats, which saturates and creates hydric soils. In these provinces, riparian systems are characterized by marsh vegetation or expansive mesic alkali meadows. Riparian vegetation surrounding coolwater springs and springs with lower thermal temperatures consists of species typically found near regional streams, lakes, and marshes (e.g., willows, mesquites, sedges, and grasses). This vegetation may be dense at sites that have been minimally changed by impacting uses. Sites that have been highly modified generally have less diverse riparian communities, and they may include nonnative species and many species that are typically associated with upland plant communities. Aquatic vegetation in these systems is also similar to vegetation that occurs in streams, lakes, and marshes (e.g., green algae, duckweed, cattail, giant reed, etc.). Vegetation near hot springs is more distinctive because it consists of plants that are tolerant of highly alkaline and salty soils. Cyanobacteria (photosynthetic bacteria) is typically the most abundant aquatic vegetation in the springs. Habitat condition also affects aquatic vegetation communities. Green algae is frequently the dominant aquatic vegetation in degraded habitats. Habitats in better condition usually support a more diverse community that consists mostly of flowering plants, ferns, and calcareous algae.

Aquatic animal communities in springs consist of species that are closely related to those commonly occurring in other regional wetlands, as well as a diversity of endemic fishes, mollusks, and aquatic insects. Species that occur in these communities also vary in response to environmental conditions. Some species occupy only cool habitats while others occur only in thermal springs. Habitats with swiftly flowing water are preferred by some species and other species occur only in placid water. As in streams, substrate composition is an important habitat component. Some species prefer gravel and others prefer silt, sand, or cobbles.

Fishes



BLM Status: Many populations in the Western U.S. are listed as endangered, threatened, or of special concern by Federal and State agencies.

Distribution:

Fishes occur in many thermal and cold springs throughout the Western U.S. Most of their habitats are on valley floors where springs are large and persistent. Few high-elevation springs are inhabited by fish. A number of nonnative fishes have been introduced into these springs, resulting in the demise of many native fish populations. The number of introduced fish species currently exceeds the number of native fish species in Western U.S. springs.

Description:

Native fishes in Western U.S. springs are mostly in the killifish (Cyprinodontidae), minnow (Cyprinidae), poolfish (Goodeidae), and livebearer (Poeciliidae) families. There are also a few species in the sucker (Castomidae) and sculpin (Cottidae) families. Killifish, poolfish, and livebearers are usually less than 2 inches (5 cm) long, and suckers and sculpins are rarely longer than 8 inches (20 cm). Male killifish are often bright blue during spawning periods and parallel dorsal bands of yellow distinguish the heads of male poolfish. Livebearers, suckers, and sculpin are less colorful and are usually mottled silver, brown, green, or dark black, which effectively allows them to blend into their habitat. Many species occur in a small number of isolated habitats where they have persisted since the Pleistocene epoch. A number of studies have found that this isolation has allowed many populations to become morphologically and genetically distinct.

Reproduction:

Peak reproduction occurs during the spring, although spawning may occur throughout the year, primarily in thermal springs. Growth is rapid and sexual maturity of killifish, livebearers, and poolfish is usually reached within the first several months. Some minnows also mature within the first year, but maturity of most minnows, suckers, and sculpins is not reached until the second or third year. Killifish and poolfish deposit eggs on vegetation or soft substrate in calm water, and minnows, suckers, and sculpins broadcast their eggs in water flowing over larger substrates. Livebearers release their broods in quiet back waters.

Most of these fishes are short-lived (generally less than 5 years) with comparatively high reproductive capacities that may result in wide seasonal or annual changes in abundance. Variability is small where environmental variation is low compared to habitats with wide ranges in water temperature and discharge.

Food:

Spring fishes feed on aquatic invertebrates and algae. Specific foods eaten by each species (and often each population) change during the year in response to the abundance of items in their habitat. Killifish and poolfish feed mostly on algae and macroinvertebrates (e.g., ostracods, aquatic insects, and crustaceans), livebearers feed solely on aquatic macroinvertebrates, and most minnows and sculpins feed primarily on aquatic insects. Suckers glean insects, other macroinvertebrates, and algae from larger substrate.

Habitat:

Killifish, poolfish, and livebearers usually occur in slow-moving water with fine substrates and comparatively dense cover. Minnows, suckers, and sculpins usually occupy habitats with swift flows over sand, gravel, or cobble substrates.

Management Implications:

Spring-dwelling fishes are primarily threatened by establishment of nonnative fishes and macroinvertebrates and habitat alteration from diversion, excessive livestock grazing, and ground-water depletion.

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