The Global Demise of Springs Ecosystems: An Unrecognized Ecological Crisis

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INTRODUCTION

The demise of springs ecosystems is a global, but largely unrecognized environmental crisis. Springs are among the most biologically and socio-culturally diverse and productive ecosystems on Earth, yet are among the most intensively used and altered ecosystems (Stevens and Meretsky 2008). We estimate that 0.5-1 million springs exist in North America (Fig. 1). Springs are point-sources of biodiversity, providing essential habitat for approximately 20% of the endangered species in the U.S. and untold hundreds of rare species. Springs often function as keystone ecosystems (Perla and Stevens 2008), playing a disproportionally large role in adjacent upland ecosystems. With enormous significance to indigenous cultures, springs also provide ca $10 billion/yr in bottled water sales in the US. The demise of springs ecosystems is a global, but largely unrecognized environmental crisis. Despite their obvious values and attributes, estimates of ecological impairment of springs exceeds 70% in Arizona, Florida, and other U.S., states due to groundwater overdraft, pollution, and geomorphic alteration for domestic or livestock water use. Alteration of springs ecosystems has become a national and global environmental crisis, warranting local, national and global conservation initiatives.

The science of ecosystem ecology arose through Odum's (1957) study of Silver Springs, Florida. However, springs ecosystem ecology and integrity has been largely ignored by the public, the scientific community, and government agencies since that time. Neglect of springs is further demonstrated by the virtual absence of reference to springs in most contemporary texts and textbooks on national or global freshwater ecosystem health, wetland ecosystems, and water resource management. We reviewed existing literature and use data from our inventories of more than 500 springs throughout western North America to address the question of why springs have received so little attention. We report 6 primary reasons for the general disregard of these important ecosystems.

SIX REASONS FOR THE NEGLECT OF SPRINGS

1. Too Small to Study?

Most springs are small. The median area of 298 springs in western North America is 236 m^2, and the average area was 1036 (2317 sd) m^2, with few springs larger than 0.2 ha. While several prominent U.S. springs have flows >10m^3/s, most have flows of 0.1-1.0 L/s or less. Thus, springs fall below the scale of most landscape mapping efforts. We mapped 35,000 named springs in the conterminal U.S (Fig. 1), but detailed mapping in Arizona and Wisconsin indicate those states each contain $\geq$ 9,300 springs, and that likely < 1 in 10 springs are named or mapped. Arizona, the nation's second driest state has the highest density of springs (0.032 springs/km^2).

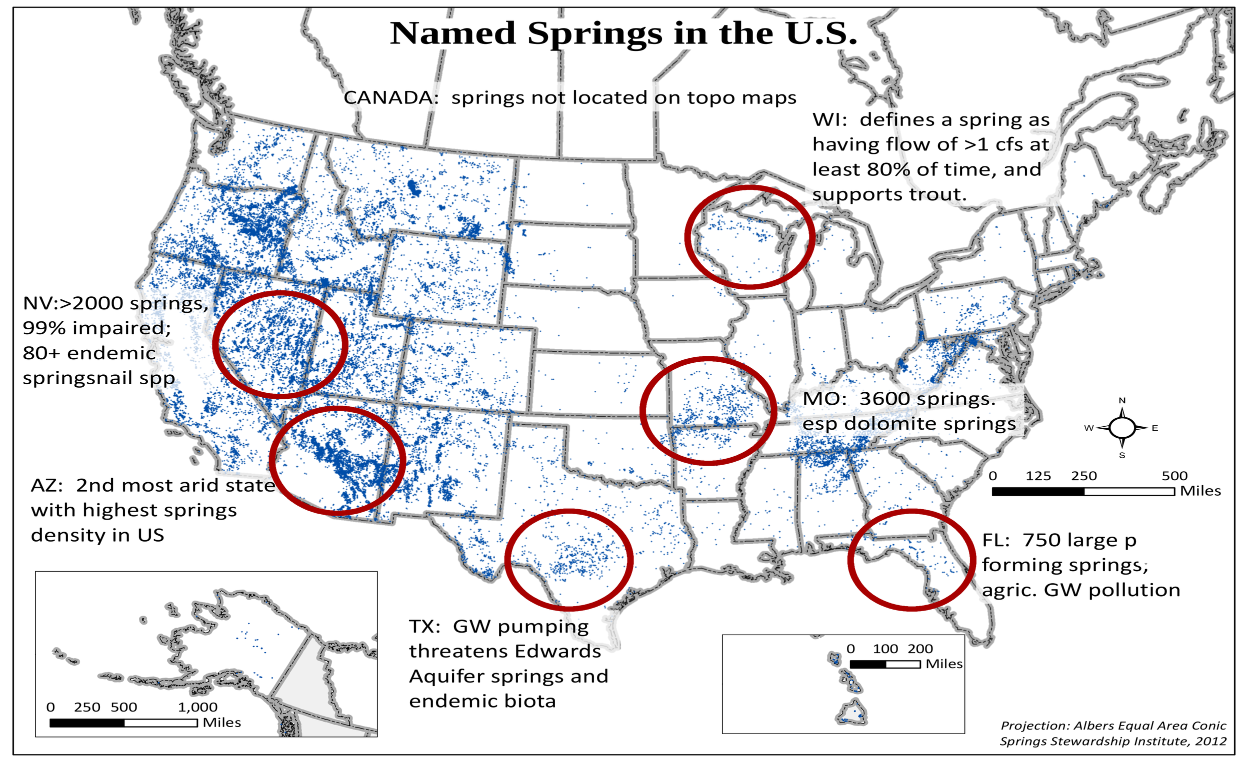


Fig. 1: Map of the named springs of North America north of Mexico, with notes on springs in specific regions (Stevens and Meretsky 2008).

2. Limited Detectability

Springs commonly emerge at geologic contacts or under heavy vegetation, limiting detection, particularly in remote sensing efforts. Strong moisture gradients from the springs to uplands make springs more apparent in arid regions; however, springs in temperate regions similarly host a rich array of rare and endemic taxa, including orchids and other wetland plants, mollusks, insects, fish, amphibians, and several mammals (Fig. 2).

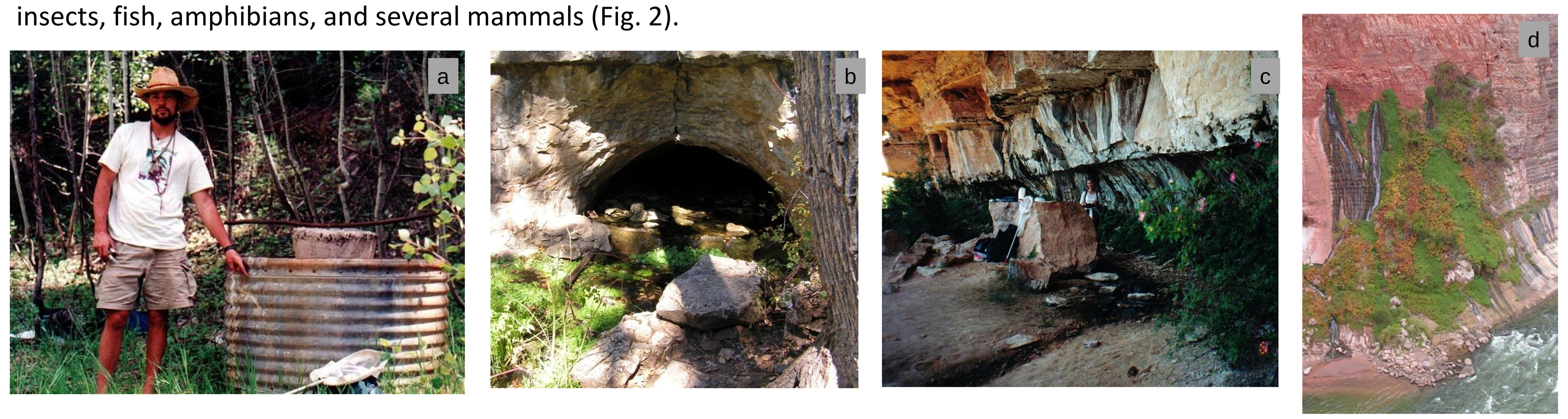


Fig. 2: Springs that are difficult to detect: a) capped or forest springs, b) cave mouth springs, c) hanging gardens emerging beneath overhangs, d) gushet springs that emerge from cliff faces.

3. No Lexicon of Springs Types

Until recently, the absence of a lexicon has precluded discussion of springs types and their distribution. Springer and Stevens (2008) defined 12 distinctive types of terrestrial springs, of which several also appear to be common subaqueous forms (Fig. 3). We note that the high biological diversity of springs is due, in part, to the co-occurrence of up to 13 different microhabitats at springs, each with its own unique assemblage of taxa. This microhabitat mosaic further contributes to the biological complexity of springs ecosystems.

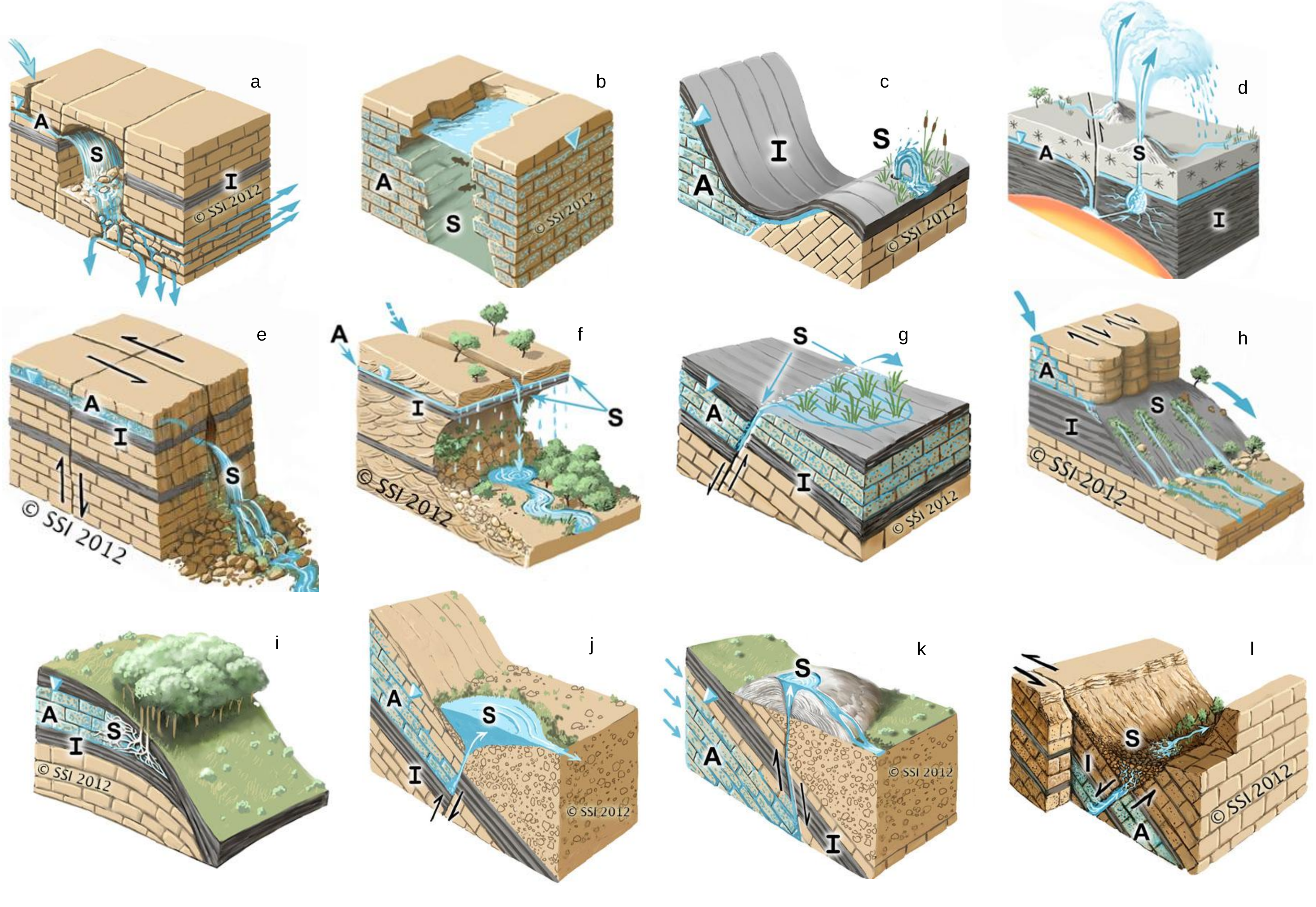


Fig. 3: Types of terrestrial springs , based on geohydrology and the sphere of discharge (Springer and Stevens 2008): a) cave; b) exposure, c) fountain, d) geyser, e) gushet, f) hanging garden, g) helocrene (fem, wet meadow), h) hillslope, i) hypocrene, j) limnocrene, k) mound (travertine), l) rheocrene; A – aquifer; I – impermeable stratum; S – source (after Springer and Stevens 2009).

4. Closely Guarded, Degraded Secrets

Springs are often closely protected by land owners, who may feel threatened that sharing information about their water supplies or springs biota will result in loss of rights. Unfortunately, numerous unsustainable resource practices contribute to springs ecosystem degradation, such as groundwater overdraft, focused livestock grazing, and hydrologic fracturing. Consequently, springs loss is on-going, and may be accelerating due to practices. Jealous guarding also thwarts efforts to educate springs stewards about better ways to manage their highly valued resources. Such attitudes limit access to, inventory and assessment of, and research on springs.

5. Too Complex?

Springs ecosystems are the result of linkage between subterranean and surface processes (Fig. 4). Physical and hydrogeologic processes control springs emergence and water quality, but microclimate and ecological processes (e.g., productivity, soil and microhabitat development, and biogeographic processes) organize the springs ecosystem and the goods and services provided. Improved understanding of springs ecosystem ecology requires dialogue between hydrologists and ecologist, communication that does not presently exist. In addition, more conversation is needed among private users, and Tribal, state, and federal managers. Unfortunately, water resource policy and legislation typically only distinguish groundwater from surface water, and springs fall "between the legal cracks" (Nelson 2008).

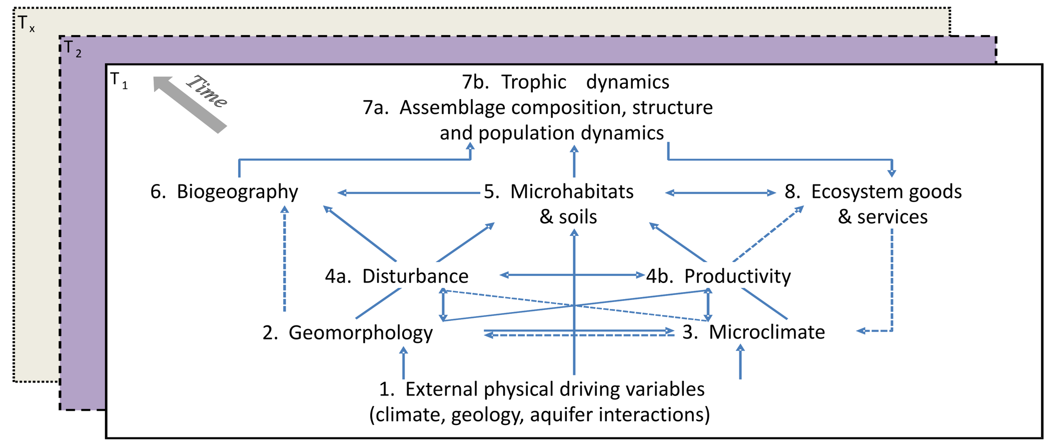
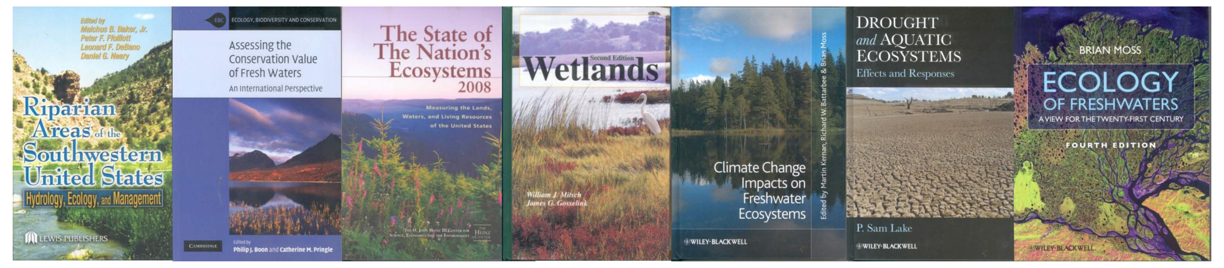


Fig. 4: Springs ecosystem conceptual model (Stevens and Springer 2004).

6. An Ignored Topic

Our review of recent scientific literature and textbooks on aquatic ecosystem ecology and conservation over the past decade reveals a conspicuous absence of attention to springs. Major texts on wetland ecology and the state of the nation's aquatic ecosystems contain little to no mention of springs (Fig. 5a). Only 4 books have been written on springs since 1990, of which two are devoted exclusively to springs biology, one solely to springs hydrogeology, and only one focused on springs ecology, ecosystem structure, and conservation – and that only in arid regions (Fig. 5b).

5a



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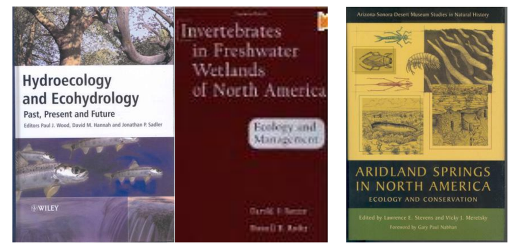

Fig. 5: Aquatic-wetland literature that: a) does not address springs ecology; or b) discuss to some or much extent springs or springs biota (Botsoneau et al. 1998 is not illustrated).

CONCLUSIONS

Despite their obvious significance to groundwater security, ecosystem ecology, conservation biology, and cultural and economic well-being, springs have been broadly ignored as research subjects. The lack of scientific attention to springs has contributed to inadequate management and education about these important ecosystems, and has helped lead to their degradation, across the nation and the world. Such lack of attention also has retarded springs rehabilitation efforts. The Springs Stewardship Institute was created to bring more scientific attention to the ecology and management of springs, and we provide guidance, inventory, assessment, rehabilitation, monitoring, and research tools for those seeking to learn about and better manage springs and springs taxa, or who are interested in research on springs ecology.

For more information about springs ecology , visit www.SpringStewardship.org

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