SPRINGS STEWARDSHIP: AN EMERGING ENVIRONMENTAL CRISIS IN POINT-SOURCE BIO-CULTURAL DIVERSITY

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Springs Stewardship Institute
Improving the health and management of springs

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INTRODUCTION

Springs are among the most biologically and socio-culturally diverse and productive ecosystems on Earth and 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 habitat for rare species with approximately 20% of the endangered species and many hundreds of rare species occurring only at springs in the U.S. 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. Despite these many attributes, estimates of ecological impairment of springs exceeds 90% in several regions of the U.S., due to groundwater use or pollution and low or 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. Springs ecosystem ecology is remarkably understudied, and springs stewardship has been widely neglected. Here we present conceptual insights on understanding of springs ecosystem ecology, and methods developed for inventory, assessment, and improved stewardship by the Springs Stewardship Institute (SSI).

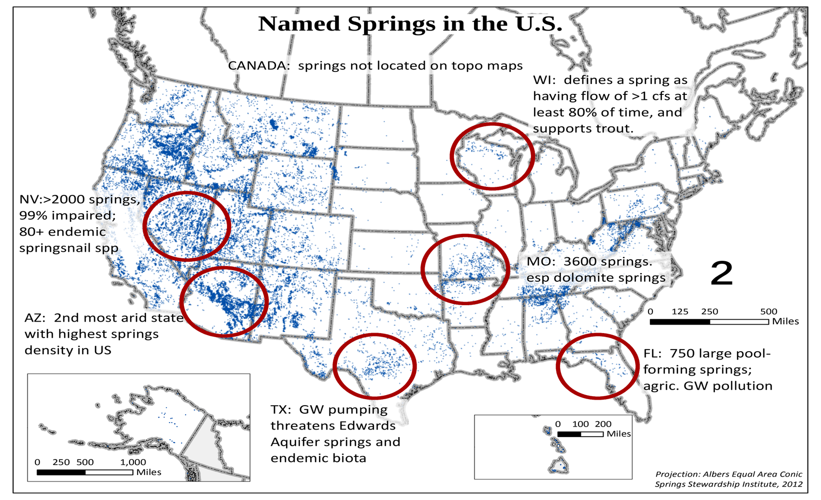


Fig. 1: Map of the named springs of North America north of Mexico, with notes on springs in specific regions.

CONCEPT MODEL

Springs arise from complex, physical (bottom-up) interactions between tectonics, aquifer hydrogeology, and landform position, which collectively influence disturbance and productivity, and the development of 12 springs types, each with up to 13 microhabitats (Stevens and Springer 2004, Springer and Stevens 2008; Fig. 2). Biogeographic processes influence colonization and ecosystem structure and function, which produce springs ecological goods and services, with potential for feedback into springs microhabitats. This conceptual model frames the inventory and assessment approach we used to understand stewardship options.

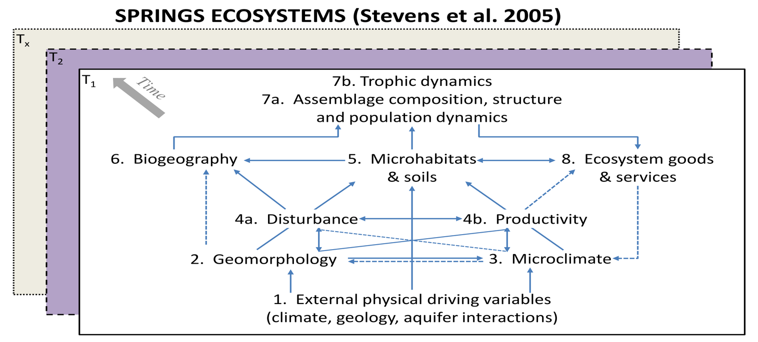


Fig. 2: Springs ecosystem conceptual model (Stevens and Springer 2005).

INVENTORY

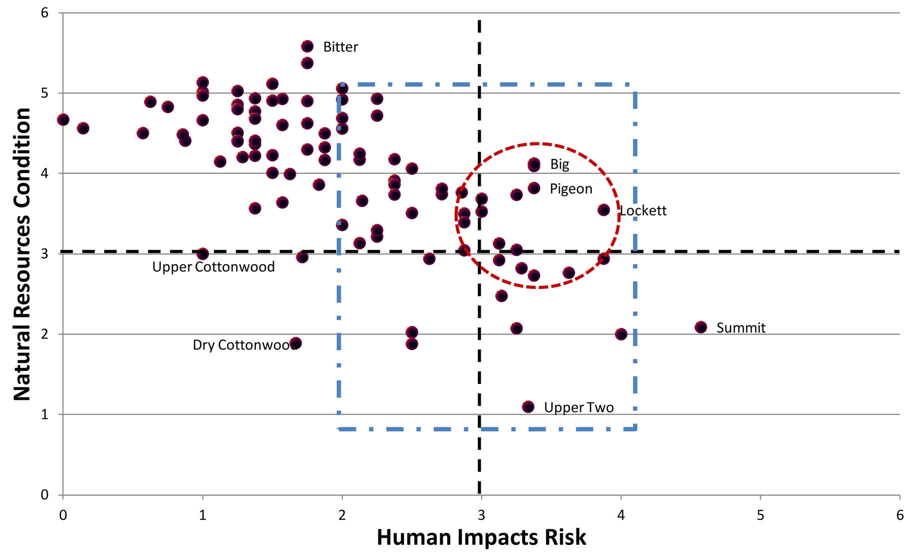
We incorporated several proposed springs inventory protocols to generate thorough and efficient, cost-effective inventory methods that apply to all types of springs, both terrestrial and subaqueous (www.springstewardship.org). Level 1 inventory involves georeferencing to clarify distribution and types. Level 2 involves a 1-3 hr visit by an expert team, including a geographer, hydrogeologist, and a biologist (Fig. 3). A sketchmap is prepared, and physical, biological, and socio-cultural and impacts data are compiled.

Fig. 3: SSI geohydrologist R.J. Johnson instructs interns about water quality measurements at Lockwood Spring, AZ.

ASSESSMENT

We developed a comprehensive springs ecosystem assessment protocol (SEAP) based on complex, physical (bottom-up) interactions. This protocol scores the condition or value to risk or recovery potential of the following variables: 1) natural resource variables (a. aquifer, flow, and water quality; b. geomorphology; c. habitat variables; and c. springs species variables); human impacts variables; and administrative context variables. Each variable is scored from 0 (low condition, low risk), to 6 (high condition, high risk). By comparing natural resource scores to human impacts, the SEAP provides prioritization of sites for management attention (Fig. 4).

Fig. 4: A comparison of ecosystem condition (or value) and risk for springs on the North Kaibab Forest, northern Arizona. Those springs circled in red have both high value and high risk scores, suggesting they may warrant management attention.



INFORMATION MANAGEMENT

Sound, secure, easy-to-use information management is essential for improving understanding and stewardship of springs, including recognition of rare springs types and monitoring. We developed a comprehensive, user-friendly springs inventory database that is available to anyone interested in springs management. This database is organized around georeferenced sites in relation to projects, and based on individual site visits to evaluate components of the conceptual model (Fig. 5). A more thorough description of the springs database is available at our website, and SSI offers trainings, in springs ecosystem inventory and assessment, as well as data management.

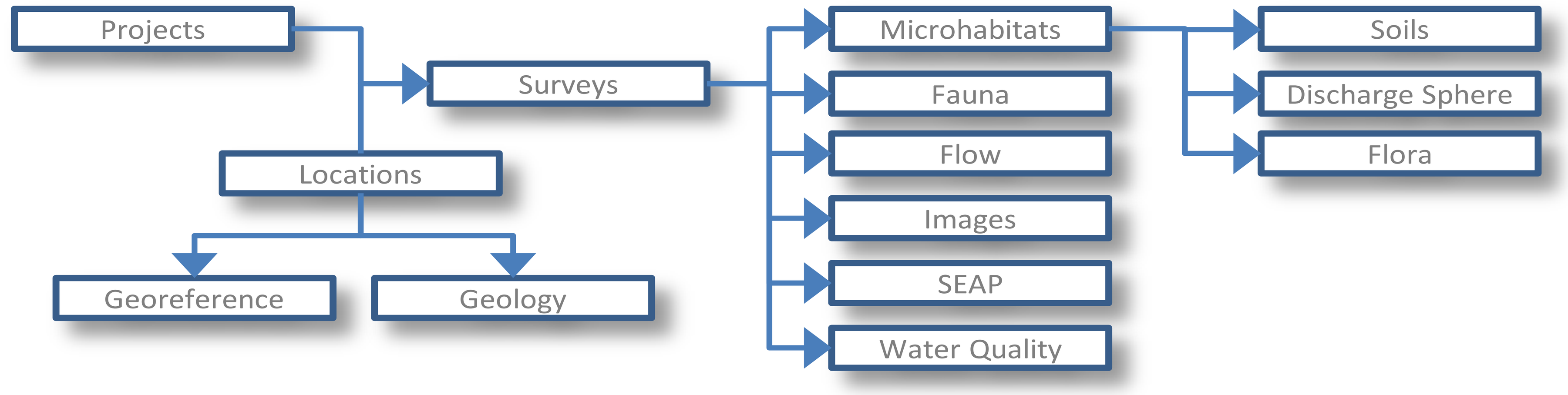


Fig. 5: Springs ecosystem information database structure.

SPRINGS MANAGEMENT

Systems management is most soundly based on the following formula:

Inventory → Assessment → Planning → Management → Monitoring

We recommend this approach to stewards interested in making springs management more intentional. While not all springs are managed for natural resources, we recommend that stewards manage for native species, natural ecosystem functions, and indigenous cultural values where possible, particularly related to the springs source areas. Consideration of the SEAP assessment promotes prioritized management and greater efficiency and cost-effectiveness.

MONITORING AND RESEARCH

Monitoring of springs has generally focused on specific resources, such as flow, rare species populations, cultural or economic resources, and climate change influences. The Level 2 springs inventory and information management approaches recommended above are generally sufficient for whole-ecosystem monitoring, but monitoring schedule and monitoring special resources will be based on specific information needs and resource development or response timing. Determination of the range of natural variation in flow requires at least seasonal monitoring for a decade or more; however, research also may be useful for determining flow variability, including dendrochronology of nearby trees, springs soil trenching, the presence of springsnails (Hydrobiidae) or other obligate springs aquatic species, as well as experimental flow reduction and other lines of evidence.

RESTORATION/REHABILITATION

Although many springs have been severely altered by human actions, springs often can be restored to high levels of functionality if aquifer functionality and groundwater quality remain natural (e.g., Cooper and MacDonald 2000; Burke et al. in press). The BLM and Grand Canyon Wildlands Council rehabilitated Pakoon Springs on Parashant National Monument in northwestern Arizona. Removal of tons of rusting ostrich ranch equipment and structures, as well as a l2.5 m-long alligator, was followed by backfilling excavated ponds and redevelopment of natural channels and patterns of flow. Restoration actions since 2008 have created lush springs riparian vegetation, extraordinary bird and wildlife habitat, and the longest flowing springfed stream on this large national monument. Similar success was reported by Patterson and Cooper (2007) for fens in the Sierra Nevada Range in California, and elsewhere (Stacey et al. 2011).

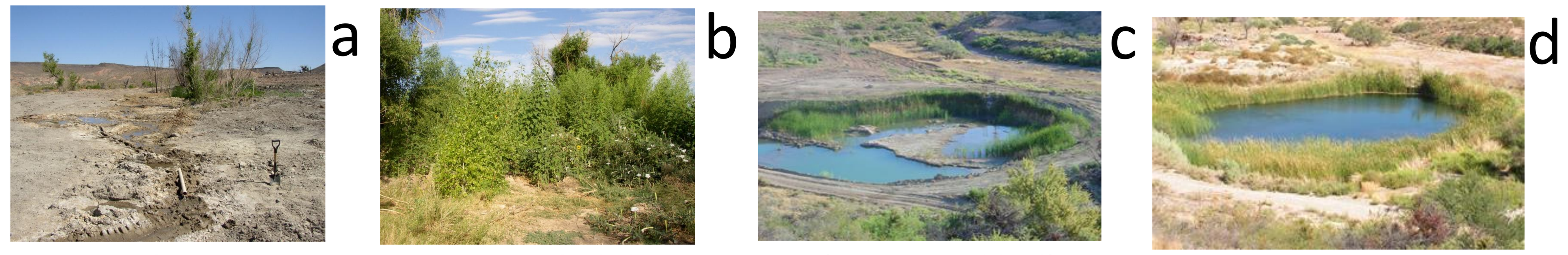


Fig. 6: Pakoon Springs ecosystem rehabilitation in a,c) 2004 and b,d) 2011.

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