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4 **Collaboration for Environmental Evidence**  
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9 **Systematic Review No. 87**  
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11 **WORKING TITLE:** Have springs restoration projects in the  
12 southwestern United States been effective in restoring hydrology,  
13 geomorphology, and invertebrates and plant species composition  
14 comparable to natural springs with minimal anthropogenic disturbance?  
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19 **Draft Review Protocol**  
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## Cover Sheet

Title	Working title: Have springs restoration projects in the South-western U.S. been effective in restoring hydrology, geomorphology, soils, and invertebrate and plant species composition comparable to natural springs with minimal anthropogenic disturbance?
Systematic review	Nº 87
Reviewer(s)	Abe Springer, Christina Davis, & Larry Stevens
Date draft protocol published on website	15 <sup>th</sup> January 2010
Date final protocol published on website	
Date of most recent amendment	
Date of most recent SUBSTANTIVE amendment	
Details of most recent changes	
Contact address	School of Earth Sciences and Environmental Sustainability Northern Arizona University P.O. Box 4099 Flagstaff, AZ 86011 U.S.A. Abe.springer@nau.edu
Sources of support	Northern Arizona University's Ecological Restoration Institute
Conflicts of interest	

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44 **1. BACKGROUND**

45 Springs are places where groundwater is exposed at the earth's surface, often flowing  
46 naturally from bedrock or soil onto the land surface or into a body of surface water.  
47 There may be  $10^5$ - $10^6$  springs in the United States, occupying a total area of 500-1000  
48  $\text{km}^2$  (less than 0.01 % of the nation's land area). Springs, particularly those in arid  
49 regions, are vastly more complex, diverse, and productive than those in adjacent  
50 uplands; however, at a national and continental scale, springs are among our most  
51 threatened ecosystems, with estimates of ecological impairment in the West  
52 exceeding 90 % (Stevens and Meretsky 2008). Although Odum's (1957) studies of  
53 Silver Springs in Florida laid the groundwork for much of the science of ecosystem  
54 ecology, his study remains one of the few comprehensive examples of springs  
55 ecosystem function. Springs are important, largely non-renewable ecological and  
56 cultural resources, but a lack of scientific study and conservation has limited the  
57 knowledge available to translate to appropriate springs restoration theory and  
58 methods.

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60 **2. OBJECTIVE OF THE REVIEW**

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62 **2.1 Primary question**

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Have springs restoration projects in the southwestern United States been effective in restoring hydrology, geomorphology, and plant and invertebrates species composition comparable to conditions of natural springs with minimal anthropogenic disturbances?

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68 **3. METHODS**

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70 **3.1 Search strategy**

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- Electronic databases available through Northern Arizona University's Cline Library will be a primary source, including at a minimum:

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- Academic Search Premier
- Environmental Science and Pollution Management
- Forest Science Database (Ovid)
- JSTOR
- ProQuest: Dissertations and Theses Full Text
- Science Direct
- Wilson OmniFile
- GeoRef (CAS Illumina)
- GeoScienceWorld GSW
- SpringerLink

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- Additional sources of information will include at a minimum:
  - ISI Web of Science
  - Google Scholar
  - Government and university websites and libraries (e.g., USDA Forest Service's TreeSearch, Ecological Restoration Institute and School of Forestry electronic

- 90 libraries, Arizona Water Protection fund archives, state  
91 game and fish agency websites and libraries)  
92 • Unpublished reports (e.g., project monitoring reports,  
93 interviews, and agency report) will be sought directly  
94 from individuals and organizations responsible for  
95 restoration projects.  
96 • Search terms to include all combinations of the following:  
97 • Springs, natural springs, riparian springs, watersheds,  
98 catchments AND  
99 • Restoration, prescribed burns, natural fire, wildfire,  
100 management, hydrology, geomorphology, conservation,  
101 fencing, diversion, stabilization.  
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### 103 3.2 Study inclusion criteria

- 104 • **Relevant subject(s):**  
105 Natural occurrences where aquifers meet the ground surface  
106 through seepage or fractures, classified as natural springs, in the  
107 southwestern United States including:  
108 • Riparian environments sourced from springs  
109 • Lakes/pools sourced from springs  
110 • Catchments  
111 • Watersheds  
112 • **Types of intervention:**  
113 Hydrologic restoration techniques including:  
114 • Check dams  
115 • Weirs  
116 • Weather stations  
117 • Watershed gauges  
118 Geomorphological and/or soil restoration techniques including:  
119 • Channel relocation  
120 • Site re-contouring  
121 • Topsoil placement or removal  
122 Vegetation restoration techniques including:  
123 • Seeding  
124 • Planting  
125 • Herbivore exclusion  
126 Historic fish distribution restoration including:  
127 • Eradication of non-native fish species  
128 • Re-introduction of native fish species  
129 Modifications of adjacent areas including:  
130 • Thinning or prescribed burning of adjacent forests to  
131 increase water yields  
132 • Reduction in groundwater withdrawals  
133 • Fencing enclosures to reduce access  
134 • Natural or anthropogenic induced erosion  
135 • **Types of comparator:**  
136 • Experiments with controls (no intervention) and  
137 treatments (restoration)



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### 3.4 Study quality assessment:

Studies will be evaluated based on the types of methods used and outcomes, if any, achieved. It is recognized that some works, which have not been published or subjected to diligent peer review, may be of high quality; however, careful consideration will be exercised when reviewing these sources, and Pullin’s and Knight’s (2003) hierarchy of evidence quality will be used to determine whether studies will be included (see Table 1). Evidence from Categories I through II-3 will be included, while evidence that falls under Categories III and IV will be considered with caution. If all authors agree, and if appropriate qualifiers are included from Categories III and IV (e.g., an explanation of why a particular set of evidence falls into Category IV and why we still think it is appropriate to mention), studies may still be included. If any Category IV evidence is reported, it will be for the purpose of indicating where future research can be beneficial, and not for definitive interpretations about treatments. To assist in the consideration process, all studies will be assigned to one of the categories in Table 1. In addition, authors will be familiar with and use Pullin’s and Stewart’s (2006) guidelines for assessing evidence quality (e.g., possibly contacting authors of some papers to request additional data).

Table 1. Hierarchy of evidence quality, as modified by Pullin and Knight (2003).

Category	Quality of Evidence
I	Strong evidence obtained from at least one properly designed; randomized controlled trial of appropriate size.
II-1	Evidence from well designed controlled trials with randomization.
II-2	Evidence from a comparison of differences between sites with and without (controls) a desired species or community.
II-3	Evidence obtained from multiple time series or from dramatic results in uncontrolled experiments.
III	Opinions of respected authorities based on qualitative field evidence, descriptive studies or reports of expert committees.
IV	Evidence inadequate owing to problems of methodology (e.g. sample size, length or comprehensiveness of monitoring) or conflicts of evidence.

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### 3.5 Data extraction strategy

Three primary reviewers will conduct the initial database and library searches and identify publications of potential value based primarily on an assessment of titles and abstracts. One reviewer will then review all potentially useful publications and papers, and eliminate irrelevant articles based on abstracts. Material determined to be of use will then be summarized in a master spreadsheet by one of the primary reviewers (Christina Davis). Reviewers will then check references of remaining papers to find additional material.

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If a sufficient amount of quantitative data on the effects of specific restoration treatments can be extracted, a meta-analysis will be conducted. However, the amount of good quality data on effect sizes is believed to be quite limited, which in turn may limit the use of formal meta-analysis methods. We will be looking for papers that describe quantitative effects on springs hydrology (esp. flow changes) and riparian environment changes (presence, or lack there-of, of vegetation and invertebrates). Some of the other variables, such as types of outcomes, may also be subject to meta-analysis.

### **3.6 Data synthesis and presentation**

The reviewers will read all publications and discuss the results, but two reviewers (Abe Springer and Larry Stevens) will take the primary responsibility for synthesizing and presenting the results. The results of this review will be organized around the components listed in the primary question, which involve the responses of hydrology, geomorphology, vegetation, and invertebrates to restoration treatments.

## **4. POTENTIAL CONFLICTS OF INTEREST AND SOURCES OF SUPPORT**

The Ecological Restoration Institute is providing funding for this review, along with additional support from Northern Arizona University's School of Earth Sciences and Environmental Sustainability (SESES) and the Museum of Northern Arizona (MNA). Although there is no known conflict of interest, independent reviews will be sought both through the CEE and directly from scientists not affiliated with the Ecological Restoration Institute, the SESES, and the MNA.

## **5. REFERENCES**

- Odum, H.T. 1957. Trophic structure and productivity of Silver Springs, Florida, *Ecological Monographs* 27:55-112.
- Pullin, A.S. and T.M. Knight. 2003. Support for decision making in conservation practice: An evidence-based approach. *Journal for Nature Conservation* 11: 83-90.
- Pullin, A.S. and G.B. Stewart. 2006. Guidelines for systematic review in conservation and environmental management. *Conservation Biology*, 20(6): 1647-1656.
- Stevens, L.E. and V.J. Meretsky. 2008. *Aridland Springs in North America: Ecology and Conservation*. University of Arizona Press, Tucson.