Collaboration for Environmental Evidence

Systematic Review No. 87

WORKING TITLE: Have arid land springs restoration projects been effective in restoring hydrology, geomorphology, and invertebrates and plant species composition comparable to natural springs with minimal anthropogenic disturbance?

Review Protocol

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Cover Sheet

Title	Working title: Have arid land springs restoration projects in been effective in restoring hydrology, geomorphology, soils, and invertebrate and plant species composition comparable to natural springs with minimal anthropogenic disturbance?
Systematic review	**N°·** *87*
Reviewer(s)	Abe Springer, Christina Davis, & Larry Stevens
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Date of most recent amendment	*22 June 2010*
Date of most recent SUBSTANTIVE amendment	**-**
Details of most recent changes	1. Widened scope from south western U.S. to arid land regions; 2. Added more background detail; 3. Addressed other comments from 1st peer review.
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Conflicts of interest	-

1. BACKGROUND

Springs are places where groundwater is exposed at the earth's surface, often flowing naturally from bedrock or soil onto the land surface or into a body of surface water. There may be 10^5-10^6 springs in the United States, occupying a total area of 500-1000 km^2 (less than 0.01 % of the nation's land area). Springs, particularly those in arid regions, are vastly more complex, diverse, and productive than those in adjacent uplands; however, at a national and continental scale, springs are among our most threatened ecosystems, with estimates of ecological impairment in the West exceeding 90% (Stevens and Meretsky 2008). Although Odum's (1957) studies of Silver Springs in Florida laid the groundwork for much of the science of ecosystem ecology, his study remains one of the few comprehensive examples of springs ecosystem function. Springs are important resources because they are largely non-renewable ecological and cultural resources which provide habitats for a diverse variety of aquatic, wetland, plant and mammal species, many which are endangered or endemic (Anderson et al., 2003; Springer and Stevens, 2009).

While there have been some arid land springs ecosystem restoration efforts (e.g., Anderson et al., 2003; Anderson et al., 2004; Otis Bay, 2006), few have been continually monitored to evaluate their successes. There also still lacks baseline knowledge of many springs ecosystems conditions to determine restoration potential. This lack of knowledge may be a result of the expense of long-term monitoring, or the lack of funding to continue monitoring springs ecosystems after restoration has been completed. In addition, development and adherence to one springs inventory and monitoring protocol has been a challenge for scientists. This is in part because of the many different jurisdictions under which researchers and land managers operate, along with the lack of cross-jurisdictional coordination. Lack of scientific study and conservation has limited the knowledge available to translate to appropriate springs restoration theory and methods. Knowledge of the location, quantity, and quality of a resource is the start toward effective riparian area conservation and restoration in semi-arid and arid regions (Thompson et al., 2002). If more information about springs ecosystems were available, then there may be compelling evidence to promote a greater effort to restore and monitor these ecosystems.

This review aimhopes to resolve deficiencies in the state of knowledge of arid land springs ecosystems restoration and monitoring, thus moving toward a more consistent way of monitoring springs ecosystems. If these issues are left unresolved, it could be detrimental to the future of springs ecosystems and ultimately water resources in arid regions. This review will also be beneficial for the future improvement of restoration and monitoring projects by summarizing the state of knowledge of past restoration monitoring efforts, thus limiting the amount unknown attributes of arid land springs. It will also provide information to help springs ecosystems managers to better prioritize management or restoration actions with generally limited and precious financial resources.

2. OBJECTIVE OF THE REVIEW

2.1 Primary question

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?

3. METHODS

3.1 Search strategy

- Electronic databases available through Northern Arizona University's Cline Library will be a primary source, including at a minimum:
    - 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
- 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 libraries, Arizona Water Protection fund archives, state game and fish agency websites and libraries)
    - Unpublished reports (e.g., project monitoring reports, interviews, and agency report) will be sought directly from individuals and organizations responsible for restoration projects.
- Search terms to include all combinations of the following:
    - Springs, natural springs, riparian springs, watersheds, catchments AND
    - Restoration, prescribed burns, natural fire, wildfire, management, hydrology, geomorphology, conservation, fencing, diversion, stabilization.

3.2 Study inclusion criteria

- **Relevant subject(s):**
  Natural occurrences where aquifers meet the ground surface through seepage or fractures, classified as natural springs, in arid lands:
    - Riparian environments sourced from springs
    - Lakes/pools sourced from springs
    - Catchments
    - Watersheds

- **Types of intervention:**
  Hydrologic restoration techniques:
    - Check dams
    - Weirs
    - Weather stations
    - Watershed gauges

  Geomorphological and/or soil restoration techniques:
    - Channel relocation
    - Site re-contouring
    - Topsoil placement or removal

  Vegetation restoration techniques:
    - Seeding
    - Planting
    - Herbivore exclusion
    - Excavation of non-native species, such as Tamarisk and Russian Olive

  Historic fish distribution restoration:
    - Eradication of non-native fish species, including crayfish
    - Re-introduction of native fish species

  Modifications of adjacent areas:
    - Thinning or prescribed burning of adjacent forests to increase water yields
    - Reduction in groundwater withdrawals
    - Fencing enclosures to reduce access
    - Natural or anthropogenic induced erosion
- **Types of comparator:**
    - Experiments with controls (no intervention) and treatments (restoration)
    - Before-after control-impact (BACI) studies
    - Predictive (modelling) studies
- **Types of outcome:**
  Hydrologic outcomes such as changes:
    - Water table level
    - Flow from springs
    - Duration and/or timing of flow
    - Natural or anthropogenic induced erosion

  Geomorphological and soil outcomes such as:
    - Channel presence and/or stability
    - Rockfall & slope processes
    - Integrity and restoration of soils

  Vegetation outcomes such as:
    - Species composition
    - Percent cover and architectural structure, biomass
    - Survival of planted material

  Invertebrate outcomes such as:
    - Species composition
    - Presence percentages

Vertebrate populations

- Native fish, herpetofaunal, avifaunal, mammalian population and habitat use

- **Types of study:**
Primary, peer-reviewed studies will be considered the most dependable; however, it is expected that much of the available information will be from unpublished sources such as theses and dissertations, monitoring reports, observational studies, and other types of grey literature.

3.3 Potential effect modifiers and reasons for heterogeneity:

Among arid land regions, heterogeneity exists between elevation, topography, disturbances, and land use history. Extensive heterogeneity exists between springs sites from the type of species present to species abundance and where the springs emerge. Springs species richness varies by geomorphic setting (sloping bedrock surfaces and backwalls generally supported fewer plant species than channel terraces and colluvial slopes), and by elevation. The manner in which springs are restored also varies considerably due to the disturbance level or management goals.

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 based on 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.

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 summarized in a master spreadsheet (Table 2) by one of the primary reviewers (Christina Davis). Reviewers will then check references of remaining papers to find additional material.

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.

Table 2. Data to be extracted from literature for analysis:

Data to be recorded from literature:
Author(s)
Publication year
Project name
Project objective
Restoration treatments (methods)
Focused site measurements
Baseline comparisons
Pre-intervention disturbances (yes/no):
- Roads w/in 100 m?
- Agriculture?
- Grazing?
- Channel alterations?
- Culverts, dams, or water boxes?
- Recreation?
Interventions (i.e. Restoration recommendations/actions)
Replication or previous restoration actions/recommendations
Year restoration complete
Year monitoring/follow up complete
Duration of monitoring
Number of times monitored
Intra-treatment variations
- Negative changes
- Positive changes
Project objectives met (yes/no)?
Successful measurements
Quality assurance measures
Criteria met for successful restorations?*
Post-restoration actions/assessments

*Successful restoration determined based on The SER International Primer on Ecological Restoration (2004).

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 and Table 2, 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

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