Collaboration for Environmental Evidence

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Systematic Review No. 75

WORKING TITLE:

Have wet meadow restoration projects in the Southwestern U.S. been effective in restoring hydrology, geomorphology, soils, and plant species composition to conditions comparable to wet meadows with minimal human-induced disturbance?

Review Protocol

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Cover Sheet

Title	**Working title: Have wet meadow restoration projects in the Southwestern U.S. been effective in restoring hydrology, geomorphology, soils, and plant species composition to conditions comparable to wet meadows with minimal human-induced disturbance?**
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1. BACKGROUND

High elevation streamside or spring-fed meadows occur in numerous locations throughout the American Southwest. They are often referred to as riparian meadows, montane (or high-elevation) riparian meadows, sedge meadows, or simply as “wet meadows,” which is the term we will use for this review. In the same high-elevation regions of the Southwest, wet meadows can occasionally be found in isolated depressions, such as along the fringes of ponds and lakes with no outlets.

Where wet meadows have not been excessively altered, sedges (*Carex* spp.), rushes (*Juncus* spp.), and spikerush (*Eleocharis* spp.) are common species (Patton and Judd 1970, Hendrickson and Minckley 1984, Muldavin et al. 2000). Willow (*Salix*) and alder (*Alnus*) species often occur in or adjacent to these meadows (Long 2000, 2002, Maschinski 2001, Medina and Steed 2002). High-elevation wet meadows frequently occur along a gradient that includes aquatic vegetation at the lower end and mesic meadows, dry meadows, and ponderosa pine (*Pinus ponderosa*) or mixed conifer forest at the upper end. These vegetation gradients are closely associated with differences in flooding, depth to water table, and soil characteristics (Judd 1972, Castelli et al. 2000, Dwire et al. 2006).

The extent of wet meadows in the American Southwest is unknown, but it is clear that they are relatively rare. Less than 1% of the landscape in the region is characterized as wetland (Dahl 1990), and wet meadows are just one of several wetland types that occur. The only estimate of the extent of wet meadows in the region that has been located to date is by Patton and Judd (1970), who reported that approximately 17,700 ha of wet meadows occur on national forests in Arizona and New Mexico; they also noted that many more wet meadows occur in areas adjacent to the national forests, such as on the Fort Apache Indian Reservation in eastern Arizona.

While relatively rare, wet meadows are believed to be of disproportionate value because of their use by wildlife and the range of other ecosystem services they provide. Elk and other ungulates, for example, have been shown to make extensive use of wet meadows as foraging sites (Patton and Judd 1972, Dodd et al. 2007). The high population of voles in some wet meadows is an important food source for Mexican spotted owls, a threatened species, where their home ranges encompass wet meadows (D. Fleishman, US Forest Service, personal communication). It is also likely that wet meadows perform many of the same ecosystem functions associated with other wetland types, such as water quality improvement, reduction of flood peaks, and carbon sequestration. In addition to their ecological values, wet meadows are known to be of significant cultural importance to some Native American tribes (Long 2002).

Despite their apparent value, wet meadows are one of the most heavily altered types of ecosystems in the American Southwest. Among other things, they have been used extensively for grazing livestock, have become the site of many small dams and stock tanks, have had roads built through them, and have experienced other types of hydrologic alterations, most notably the lowering of their water tables due to stream downcutting, surface water diversions, or groundwater withdrawal (Neary and Medina 1996, Gage and Cooper 2008). It is also possible that the extirpation of beaver in the Southwest led to profound changes in wet meadow environments by reducing flooding and potentially facilitating some of the stream downcutting that occurred in so many riparian areas (Parker et al. 1985, Weber 2005).

Because of their relative rarity and the important hydrologic and ecological functions they are believed to perform, there is currently a significant degree of interest in the restoration of wet meadows. Several restoration projects have been recently completed or are underway in the region (Long 2000, Medina and Long 2002, 2004, Anderson et al. 2003, Steed and DeWald 2003, Long et al. 2004, Mullen et al. 2006, Natural Channel Design, Inc. 2007), sometimes at considerable expense and with minimal monitoring. Before many new projects are initiated, it is important to review what has been done to date, as well as related hydrological and ecological research that has been published and that may help inform future restoration efforts.

2. OBJECTIVE OF THE REVIEW

2.1 Primary question

Have wet meadow restoration projects in the Southwestern U.S. been effective in restoring hydrology, geomorphology, soils, and plant species composition to conditions comparable to wet meadows with minimal human-induced disturbance?

2.2 Secondary question *(if sufficient data are available)*

Have wetland-dependent wildlife species increased in diversity and/or abundance following wet meadow restoration?

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
  - Biological Sciences
  - BioOne
  - Environmental Science and Pollution Management
  - Forest Science Database (Ovid)
  - JSTOR
  - Plant Science
  - ProQuest: Dissertations and Theses Full Text
  - Science Direct
  - Wilson OmniFile
- Additional sources of information will include at a minimum:
  - ISI Web of Science
  - Google Scholar and at least one non-academic search engine

- Government and university websites and libraries (e.g., USDA Forest Service's TreeSearch, Ecological Restoration Institute and School of Forestry electronic libraries, state game and fish agency websites and libraries)
- Unpublished reports (e.g., project monitoring reports) will be sought directly from individuals and organizations responsible for restoration projects.

Search terms will include wet meadow or riparian meadow or montane meadow in combination with the following: restoration, hydrology, sedimentation, diversity, grazing, erosion, channel, wildlife, *Carex*, and *Juncus.*

3.2 Study inclusion criteria

- **Relevant subject(s):**
  Herbaceous and mixed herbaceous/scrub-shrub dominated riparian ecosystems that are clearly wetlands (e.g., dominated by obligate or facultative wetland species in genera such as *Carex*, *Juncus*, *Salix*, and *Alnus*); meadows adjacent to these wetlands that are more typically characterized as mesic and that are often have a diverse flora characterized by facultative or facultative wetland species, including a greater number of grass and forb species than typically found in "true" wet meadows.
- **Types of intervention: (Note: these categories overlap somewhat)**
  Hydrologic restoration techniques (e.g., check dams, artificial riffle formations)
  Geomorphological and/or soil restoration techniques (e.g., channel relocation, site recontouring, topsoil placement or removal)
  Vegetation restoration techniques (e.g., seeding, planting, herbivore exclusion)
  Modifications of adjacent areas (e.g., thinning or prescribed burning of adjacent forests to increase water yields, reductions in groundwater withdrawals)
- **Types of comparator:**
  Replicated randomized experiments with controls (expected to be rare or nonexistent)
  Projects that use reference ecosystems as comparators
  Before-after control-impact (BACI) studies
- **Types of outcome:**
  Hydrologic outcomes such as changes in water table levels and flooding depth, duration and/or timing.
  Geomorphological and soil outcomes such as channel stability, presence/movement of nick points, and development of redoximorphic soil properties.
  Vegetation outcomes such as species composition, percent cover and biomass, survival of planted material, and presence or absence of invasive species.

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

3.3 Potential effect modifiers and reasons for heterogeneity:

The American Southwest is a vast region and considerable heterogeneity exists due to differences in elevation, topography, soils, natural disturbances, and land use history. There has also been considerable variation in the type and intensity of restoration treatments. All of these factors have the potential to modify the effects of restoration on hydrologic, geomorphologic, soil, and vegetation response variables.

3.4 Study quality assessment

Studies will be evaluated based on the types of methods used. While considerable caution will be exercised with strictly observational studies, unpublished reports, and work that does not involve randomized experiments and rigorous peer review, it is recognized that some work of these types may still be of high quality. A key factor that will be used to determine whether studies will be included in this review will therefore be where they fit in Pullin's and Knight's (2003) hierarchy of quality of evidence. Evidence in Categories I through II-3 (see Table 1) will be included. Evidence that falls into Categories III and IV will be treated with a high degree of caution, but may still be used if all authors agree and if appropriate qualifiers (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) are included. Typically, if any Category IV evidence is reported it will be more for the purpose of indicating areas of potentially valuable future research than for drawing definitive conclusions about treatment effects. To assist in this process, all studies considered for inclusion in this review that include treatment effects will be placed into one of the categories in Table 1 and agreed upon by the authors. Also, all authors will be familiar with the guidelines for assessing quality of evidence outlined in Pullin and Stewart (2006) and will use those guidelines as appropriate (e.g., possibly contacting authors of some papers to request additional data).

Table 1. Hierarchy of quality of evidence, 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 without 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

Two 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. All potentially useful publications will be reviewed by all reviewers. Material determined to be of use will then be stored in a location accessible to the whole review team and summarized in a master spreadsheet by one of the primary reviewers (Karissa Ramstead).

If a sufficient amount of quantitative data on the effects of specific restoration treatments can be extracted, a meta-analysis will be conducted, possibly employing *MetaWin* Version 2.0© software. 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 vegetation (species diversity, cover, biomass), hydrology (esp. water table changes) and soil characteristics (organic matter content, redoximorphic characteristics, redox potential, bulk density). Some of the other variables listed above in the "Types of Outcomes" subsection may also be considered as possible effects to be considered in a meta-analysis.

3.6 Data synthesis and presentation

All publications will be read by the reviewers and results will be discussed by all, but one reviewer (James Allen) 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, soils, and vegetation to restoration treatments.

4. POTENTIAL CONFLICTS OF INTEREST AND SOURCES OF SUPPORT

This review is funded by the Northern Arizona University Ecological Restoration Institute, with additional support from the NAU School of Forestry. 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 or the School of Forestry.

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