



## Collaboration for Environmental Evidence

### Systematic Review No. 83

**WORKING TITLE: *Does fertilisation and irrigation reduce biodiversity in alpine grasslands?***

### Draft Review Protocol

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## Cover Sheet

Title	<b>Working title:</b> <i>Does fertilisation and/or irrigation reduce biodiversity in subalpine and alpine grasslands?</i>
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## 1. Background

Semi-natural, sub-alpine grasslands in Europe were traditionally established below the tree line and maintained as treeless grasslands through extensive grazing and / or mowing for hay production. Traditionally (i.e. extensively) managed sub-alpine grasslands support impressive biodiversity at multiple scales (Baur et al. 1996). However over the last 50 years patterns of land-use in have changed in two ways: (1) the abandonment of less accessible areas and (2) the intensification of practices in more favourable areas. Abandonment, and hence cessation of traditional disturbance regimes, usually results in encroachment by lower-diversity forests (e.g. Albert et al. 2008). Intensification on the other hand involves the application of liquid fertilizer (manuring) and / or aerial irrigation. Sub-alpine and alpine plant growth is characteristically nitrogen limited (Bowman et al. 1993, Kohler et al. 2001), so fertilisation can increase productivity, but usually by means of increasing the dominance a few productive plant species (usually graminoids) at the expense of forb and legume species (Marini et al. 2007, Niu et al. 2008). Such alterations of plant community composition and structure are likely to impact grassland biodiversity more broadly. Declines in diversity associated with intensification have already been reported for a range of taxonomic groups (Boschi and Baur 2008, Marini et al. 2008).

In addition to direct nutrient additions associated with intensification, deposition of atmospheric nitrogen is also increasing in many terrestrial ecosystems (Galloway et al. 2003) and concern has been raised over the effects of N deposition on species rich alpine grasslands in Europe (Bassin et al. 2007) and North America (Burns 2004). While alpine grasslands occur above the tree line and are less frequently utilised by farmers, many are N-limited ecosystems and insights from experiments exploring nitrogen enrichment effects on diversity are relevant to management of sub-alpine grasslands.

Experimental studies that investigate the direct effects of nutrient addition or irrigation on ecosystem properties are undertaken at small spatial scales within an ecosystem. While these studies yield important information, the generality of results is often limited. Observational studies on the other hand explore effects at larger scales and aim to determine the relative influence of intensification after accounting for other sources of variation. The results are applicable at broader scales but the uncertainty surrounding fertiliser or irrigation effects is larger than in experimental studies and it may not be possible to completely isolate these from the effects of covariates. The drawbacks of both of these approaches highlight the value of synthesising research in a meta-analytical framework.

This systematic review aims to evaluate all relevant and available evidence on the effects of fertilisation and / or irrigation on the diversity of alpine and sub-alpine grasslands in Europe and North America.

## 2. Objective of the Review

### 2.1 Primary question

Does fertilisation and / or irrigation decrease biodiversity in sub-alpine and alpine grasslands in Europe and North America?

Table 1. Elements of the systematic review question

Subject	Intervention	Comparators	Outcomes
Alpine and subalpine grasslands in Europe and North America	Fertilisation and / or irrigation	Control plots or reference sites that have not been fertilised or irrigated	Species diversity or richness

### 2.2 Secondary question (*if applicable*)

Do particular functional groups consistently increase or decrease in response to fertilisation and / or irrigation in sub-alpine and alpine grasslands?

Do different taxonomic groups respond differently to fertilisation and / or irrigation in sub-alpine and alpine grasslands?

If fertilisation and / or irrigation does reduce biodiversity, are the effects reversible?

## 3. Methods

### 3.1 Search strategy

The following databases will be searched for relevant documents: ISI Web of Knowledge, Science Direct, Scirus, Directory of open access journals, Scopus, Scientific Electronic Library Online, JSTOR, Agricola, CAB Abstracts and Index to Theses Online. The first 100 pdf or word documents from a Google Scholar search will also be included. Hits from each search will form the first cut of the overall search, in addition to relevant citations no more than one step away from original hits to capture relevant grey literature. Titles and abstracts from each search will be stored in a single Endnote database and duplicates removed. Searches in German and French will also be conducted on databases that include non-English publications.

The following search string will be used in English:

**Subject:**

(semi-natural OR alpine OR subalpine OR montane OR alps OR carpathian OR “rocky mountains” OR pyrenees)

AND

(grassland OR meadow OR fen OR tundra)

AND

**Intervention:**

(fertilis\* OR fertiliz\* OR nitrogen OR ammonium OR nitrate OR manur\* OR irrigat\* OR intensification OR eutrophication)

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AND

**Outcome:**

(diversity OR richness OR composition OR abundance OR assemblag\* OR "functional type" OR "functional group" or guild)

This search string was developed through a scoping exercise using ISI Web of Knowledge, following CEBC recommendations (CEBC 2009). It returned 809 records and is considered a conservative (i.e. sensitive) starting point, but is small enough list refine given available time and resources. In relation to the subject search terms, subalpine meadows are often referred to as “semi-natural” grasslands without mention of the climatic zone. We recognise that semi-natural grasslands occur at low altitudes as well but included the term in this general sense as a conservative measure. The geographical descriptors (“alps”, “pyrenees”, carpathian” or “rocky mountains”) were required because some relevant studies did not use the terms semi-natural, alpine, subalpine or montane in the title, abstract or keywords. These geographical terms capture the dominant alpine and subalpine regions in Europe and North America with the exception of Scandinavia. The inclusion of “Scandinavian mountains” did not increase the number of hits. All articles known by us to be relevant from Norway and Sweden were captured by the above search string. “Fen” was included because it is often used to describe wet alpine or subalpine meadows. Alpine “tundra” is commonly used to describe alpine grasslands in North America.

The intervention terms are also quite general. “Nitrogen”, “ammonium” and “nitrate” captured many irrelevant ecosystem studies, but were included to ensure adequate sensitivity. The outcome terms should refine the search somewhat. They were developed to capture all studies that report changes in diversity or composition of any taxonomic group. “Functional group”, “functional type” and “guild” were also included to capture studies relevant to a secondary question.

### 3.2 Study inclusion criteria

Firstly, titles from the first cut database will be assessed for obviously spurious results. Then, the remaining titles and abstracts will be manually scanned to assess relevance. References will be retained if they refer to the following in the title or abstract:

1. Sub-alpine or alpine grasslands (or other acceptable terms from the search string);  
AND
2. Fertilization (or other acceptable terms from the search string);  
OR
3. Irrigation;  
OR
4. land use intensification;  
OR
5. Nitrogen deposition  
AND

6. Some mention of ecosystem or community properties (e.g. not just a selection of species from an alpine habitat)

No specific mention of species richness or diversity is required at this stage. Studies that compare relevant interventions (e.g. fertilization) across multiple ecosystems should also be retained even if no mention is made of sub-alpine or alpine grasslands in the title or abstract. A conservative approach will be taken so that references are retained if doubt remains after applying the above selection criteria. The criteria will allow for the inclusion of both experimental and observational studies.

A random subset of the database will be scanned by a second reviewer using the same inclusion criteria. Inclusion consistency will be assessed using kappa statistics. If  $\kappa > 0.6$ , the selection criteria will be redefined to increase agreement.

- **Relevant subject(s):**  
Natural or semi-natural grasslands in the sub-alpine and alpine climatic zones in Europe and North America. Generally treeless, dominated by graminoid and forb species.
- **Types of intervention:**  
One or both of the following: (1) addition of nitrogen fertilizer (alone or in combination with other nutrients), (2) aerial irrigation with sprinklers. Includes experimental and observational studies.
- **Types of comparator:**  
Control plots that did not receive treatment (experimental studies) or suitable reference areas that have not been fertilised or irrigated (observational studies).
- **Types of outcome:**  
Richness or diversity of at least one taxonomic group. Also changes in composition or relative abundance of functional groups.
- **Types of study:**  
Scientific journal articles, book chapters, PhD theses, MSc theses, technical reports and any other types of document that fulfil the study quality requirements (see below).

### 3.3 Potential effect modifiers and reasons for heterogeneity:

Fertilization and irrigation of sub-alpine and alpine grasslands has been studied to assess the direct effects of agricultural intensification on various ecosystem characteristics (e.g. vascular plant richness) or functions (e.g. soil microbial activity, biomass production). Experimental application of fertilizers has also been used to explore the potential effects of increased atmospheric nitrogen deposition. Therefore effect modifiers will include the type, rate, frequency and duration of fertilizer application and / or irrigation.

Additional sources of heterogeneity will include baseline phytosociological differences and variation in geological parent material, soil characteristics, climate, topography and other important environmental factors. Additional management

factors (in addition to the interventions) may also be important, e.g. grazing and mowing history.

### **3.4 Study quality assessment**

Studies will be assessed using the classification system of Pullin and Knight (2003). Only studies in category II-2 and above will be considered for inclusion. This will allow for both experimental and observational studies to be included, but will exclude studies that provide only qualitative evidence.

### **3.5 Data extraction strategy**

Richness ignores the relative abundance of species, but is often quoted in combination with other diversity measures such as Simpson and Shannon indices. All richness and diversity responses will be extracted where multiple measures are provided. Data from each reference will be entered into spreadsheets including all potentially relevant information for comparisons (see sources of heterogeneity). Where insufficient data are provided for extraction, an attempt will be made to contact the corresponding author to obtain the required data.

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

Both qualitative and quantitative syntheses will be undertaken. The qualitative part will be a simple vote counting exercise reporting the number of studies reporting increases, decreases or no change. This qualitative assessment will incorporate findings from observational as well as experimental studies. Only experimental studies will be included in the quantitative analysis because reported effect sizes from observational studies are often conditional on the effects of covariates included to explain intersite variation. The type of diversity responses and the manner in which results are presented will determine the approach to a large extent. Results presented in relevant publications obtained during a preliminary literature search indicate that richness is likely to be the most commonly presented response. If a common measure can be extracted for control and treatment plots with associated sample sizes and standard deviations, then a response ratio approach will be used (Hedges et al. 1999). If such data can not be obtained for enough studies then correlation coefficients (transformed with Fisher's r-to-z transformation) will be calculated from summary statistics and used for effect sizes instead. Mixed-effects meta-regression will be used to quantify overall effect sizes. This will allow suitable environmental covariates to be incorporated, weighting of coefficient estimates using study specific inverse variances and the inclusion of random effects to account for inter-study variation not explained by the covariates. The Metafor package in R (Viechtbauer 2009) will be used for all meta-regression analyses.

The completed review will be submitted for peer-review to the CEE website. Once accepted as a final review, a succinct and clearly communicated summary of findings will be distributed to public administrators and Agricultural unions. We plan to submit the review for publication in a peer-reviewed ecological journal.

## **4. Potential Conflicts of Interest and Sources of Support**

None declared.

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