



Collaboration for Environmental Evidence

Systematic Review No. 71

**WORKING TITLE: WHAT ARE THE EFFECTS OF CLIMATE
CHANGE ON THE ENVIRONMENTAL IMPACTS OF INVASIVE
SPECIES?**

Draft Review Protocol

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Cover Sheet

Title	Working title: What are the effects of climate change on the environmental impacts of invasive species?
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Note on terminology: There is much terminology used to describe invasive species and meanings often vary. For the purposes of this review, we will use the following definition of an invasive species:

Invasive species: A species present in a geographic area or habitat outside of its natural range as a direct or indirect result of human activity, causing or likely to cause economic or environmental harm or harm to human health.

1. Background

Invasive species are of global importance as one of the greatest threats to biodiversity (Sutherland *et al.*, 2006). The cost of invasive species damage has been estimated at \$1.4 trillion (1 400 000 000 000 USD) or almost 5% of the world economy each year (Pimental *et al.*, 2001). It is believed that invasive species will interact synergistically with other pressures such as land use change, contributing to a greater human-caused global change (Vitousek *et al.*, 1996; 1997).

The problems caused by invasive species are expected to be exacerbated by climate change (Pyke *et al.*, 2008), potentially impacting on the survival of other species (Thomas *et al.*, 2004). The facilitation of invasive species by climate change has been identified as one of the top 25 novel threats facing UK biodiversity (Sutherland *et al.*, 2008) and features in the top 100 ecological questions of high policy relevance for the UK (Sutherland *et al.*, 2006). Climate change is likely to influence species distributions (Dukes and Mooney, 1999) and impact on all aspects of the invasion pathway (Hellmann *et al.*, 2008). It is expected that climate change will favour invasive species (Dukes and Mooney, 1999). Although a number of papers discuss the potential impacts of climate change on invasive species (e.g. Dukes and Mooney, 1999; Hellmann *et al.*, 2008; Pyke *et al.*, 2008), there appear to be few studies demonstrating an impact (Brook, 2008). This systematic review seeks to collate all available research evidence demonstrating the responses of invasive species to climate change to establish the evidence base on this topic.

2. Objective of the Review

This scoping review seeks to collate and categorise all available data demonstrating an impact of climate change on invasive species and their environmental impacts. Subsequent syntheses, where possible, will be developed using a series of amendments to the protocol or through development of subsequent clustered protocols.

2.1 Primary question

What are the effects of climate change on the environmental impacts of invasive species?

Table 1. Definitions of components of the systematic review questions

Subject	Interventions	Comparators	Outcomes
Invasive species: a species present in a geographic area/habitat outside of its natural range as a direct or indirect result of human activity, causing or likely to cause economic or environmental harm or harm to human health.	Change in climate e.g. increase in temperature, atmospheric carbon dioxide, nitrogen deposition, sea level	None required	Any reported e.g. change in range, size, survival, behaviour (including overwintering), diet etc.

3. Methods

3.1 Search strategy

Multiple sources of information will be searched to capture a comprehensive and unbiased sample of the literature. General scientific resources will be searched, as will subject specific resources and websites. Additionally, the internet will be searched.

3.1.1 *Databases and repositories of scientific literature*

A number of databases of scientific literature will be searched. References will be exported into EndNoteX2. Numbers of results for each search will be recorded.

- ISI Web of Knowledge
- Science Direct
- CAB Abstracts
- ECODISC
- Wiley InterScience
- Index to Theses
- Australasian Digital Theses Program
- conservationevidence.com
- ConserveOnline.org

3.1.2 *Specialist sources*

The following journals will be hand searched for all relevant materials:

- Global Change Biology
- Biological Invasions
- Aquatic Invasions

The following databases and project or organisation websites about invasive species will be searched. The first 50 hits from each will be recorded and examined for relevant data. Where no search function exists, publication lists will be checked.

- ALARM
- ALTER -Net
- DAISIE
- Global Invasive Species Database
- Global Invasive Species Information Network
- IUCN SSC Invasive Species Specialist Group
- Knowledge Network for Biocomplexity
- National Invasive Species Information Centre (USA)
- Non-Native Species Secretariat (NNSS) (United Kingdom)
- National Biological Information Infrastructure (USA)

Additionally, searches will be made of the following organisations' websites or publication catalogues and the first 50 hits checked:

- Environment Agency - UK
- Joint Nature Conservation Committee - UK
- Natural England - UK
- Department of the Environment, Water, Heritage and the Arts - Australia
- Ministry for the Environment – New Zealand

- Land Care Research
- European Environment Agency
- Science.gov – USA
- Hawaii Invasive Species Partnerships - USA

3.1.3 Internet searches

The internet will be searched using the search engines and gateways below. The first 50 hits for each search will be recorded and examined for relevant data.

- Google (www.google.com)
- Google Scholar (scholar.google.com)
- Scirus (www.scirus.com)
- Thomson Scientific WebPlus (http://scientific.thomsonwebplus.com/)

3.1.4 Additional sources of evidence

Additional sources utilised during this review include:

- Email lists such as Aliens-L IUCN ISG listserv and BES-INVASIVE
- References of review articles and included studies (reference chaining)
- Personal contact with subject experts
- Networks of stakeholders with an interest in invasive species

3.1.5 Search terms

Database searches will include the following English language search terms in combination:

Table 2: Search terms to be used in the systematic review

Invasive species combine with OR	AND	Climate change combine with OR
invasive species		global change
non-native		climate change
alien		global warming
non-indigenous		carbon dioxide or CO ₂
exotic		nitrogen
inva*		Greenhouse gas*
pest		methane
weed*		temperature
introdu*		range expansion
feral		sea level
		drought
		heat wave
		fire
		storm
		cyclone OR hurricane
		weather event
		humidity

Specialist sources and the internet will be searched where possible using the following terms:

“invasive species” AND “climate change”

3.2 Study inclusion criteria

All documents captured by the search will be assessed for relevance at title. Where relevance is unclear studies will be assessed at title and abstract against the study inclusion criteria. Any for which relevance can not be determined by abstract will be included for assessment at full text alongside relevant studies. A subset of studies (10% or 300, whichever ever is smaller) will be relevance assessed by a second independent reviewer and kappa analysis used to determine agreement. Studies meeting the general inclusion criteria below will be evaluated to determine the nature of the evidence and allocated to a category. The study inclusion criteria are:

- Relevant Subjects:** Invasive species (any reported)
- Types of intervention:** Climate change (any reported) e.g.
- Temperature change
 - Carbon dioxide increase
 - Nitrogen deposition
 - Severe weather events e.g. flooding
- Types of comparator:** None required
- Types of outcome:** Any reported e.g.
- Survival
 - Change in range
 - Change in size
 - Change in growth rate
 - Change in community composition
 - Change in diet
 - Change in behaviour
 - Change in overwintering etc
- Types of study:** Any initially

3.3 Potential effect modifiers and reasons for heterogeneity

The following reasons for heterogeneity and potential effect modifiers will be recorded where available:

About the invasive species:

- Species
- Biological classification (plant, invertebrate, vertebrate etc)
- Terrestrial/marine/freshwater
- Invasive aggressiveness (if known)
- Generalist/specialist
- Dispersal method and distance/range
- Similarity of species to comparators (where applicable)

About the climatic variable:

- Climatic variable value e.g. temperature, atmospheric CO₂ concentration

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- Other environmental conditions e.g. precipitation, humidity, day length

About the invaded ecosystem:

- Habitat type
- Geographic location
- Climate type (temperate, tropical etc)
- State of host ecosystem e.g. degraded, highly invaded, pristine, fragmented
- Extreme climatic events recorded
- Other factors impacting on habitat e.g. pollution events, development

3.4 Study categorisation and quality assessment

All articles meeting the general inclusion criteria will be assessed and categorised based on the type of information they contain. Internal and external validity of studies will then be assessed using a set of *a priori* criteria.

Categorisation of accepted studies will follow a key similar to this:

Does the study match the inclusion criteria?

No – **reject**

Yes – accept

Study contains quantitative data?

No – qualitative - does the study contain specific examples?

No – **theory paper** (read and check refs)

Yes – Is the information anecdotal?

Yes – **anecdotal evidence** *

No – **descriptive or case study** *

Yes – Does the study have comparators?

Yes – **Meta-analysis I** - Random effects model using Hedges D

No – Can the data be used in other statistical analysis?

Yes – **Meta-analysis II**

No – treat as **descriptive or case study** *

* For case studies, descriptive papers and studies where more data may be available, attempts will be made to access the additional data.

Studies meeting the relevance criteria will be assessed for validity, reliability and applicability. Study quality assessment will take into account the following internal and external validity factors where relevant (developed from critical appraisal guidance for healthcare from www.phru.nhs.uk).

1. Clear aim or question
2. Experimental design/methods
3. Sample size, scale and selection
4. Biases
5. Method and accuracy of measurement
6. Confounding factors
7. Timescale and replication
8. Results and how presented
9. Precision of results

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10. Applicability of results (biological/ecological relevance)

3.5 Data extraction strategy

All documents accepted into the review will have relevance and study quality assessed and recorded before data extraction takes place. It is expected that included studies containing data will be either controlled experiments or case studies. Data extraction will aim to extract empirical data available for meta-analysis. Where data is available for meta-analysis, data will be preferentially extracted as:

- 1) Before-after-control-intervention (BACI) data
- 2) Control/Intervention data
- 3) Before/After data
- 4) Other data

For each study containing data, study characteristics and reasons for heterogeneity will be recorded (where known).

For studies containing other sources of information, details recorded for study inclusion criteria will be used (subject/intervention/outcome) as well as any additional information available.

3.6 Data synthesis and presentation

Data synthesis methods will be determined by data available. Initially, included documents will be grouped according to type of information presented e.g. review article, study. Statistical analysis of data will be undertaken if sufficient studies are obtained (Table 3). If insufficient studies are obtained to allow meta-analysis, qualitative analysis of evidence may be undertaken.

Table 3: Possible analysis methods and data types

Data type	Analysis method
Complex data with comparators	Random effects model using Hedges D
Binary data	Risk ratio
Other data	Z transform
Qualitative only	Factor analysis/ Bayesian Belief Network
Mixture	Bayesian Belief Network

A number of studies (e.g. Smith *et al*, 2000) have looked at responses of weeds or grasslands to elevated CO₂ – some of these contain invasive grasses and may be suitable for meta-analysis. In addition, Ziska and George (2004) contain references of studies examining rising CO₂ levels on noxious weeds which may yield data for meta-analysis.

4. Potential Conflicts of Interest and Sources of Support

There are no conflicts of interest to report. This systematic review is funded by Harper Adams University College as part of a PhD studentship.

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