Evidence in Conservation Teaching Initiative

Systematic Review and Meta-analysis

By Jérôme Pellet
2020

https://www.britishecologicalsociety.org/applied-ecology-resources/about-aer/additional-resources/evidence-in-conservation-teaching/

What this lecture is about

The need for research synthesis

Types of research synthesis

Systematic review: the steps

Systematic review: an example

Vote counting

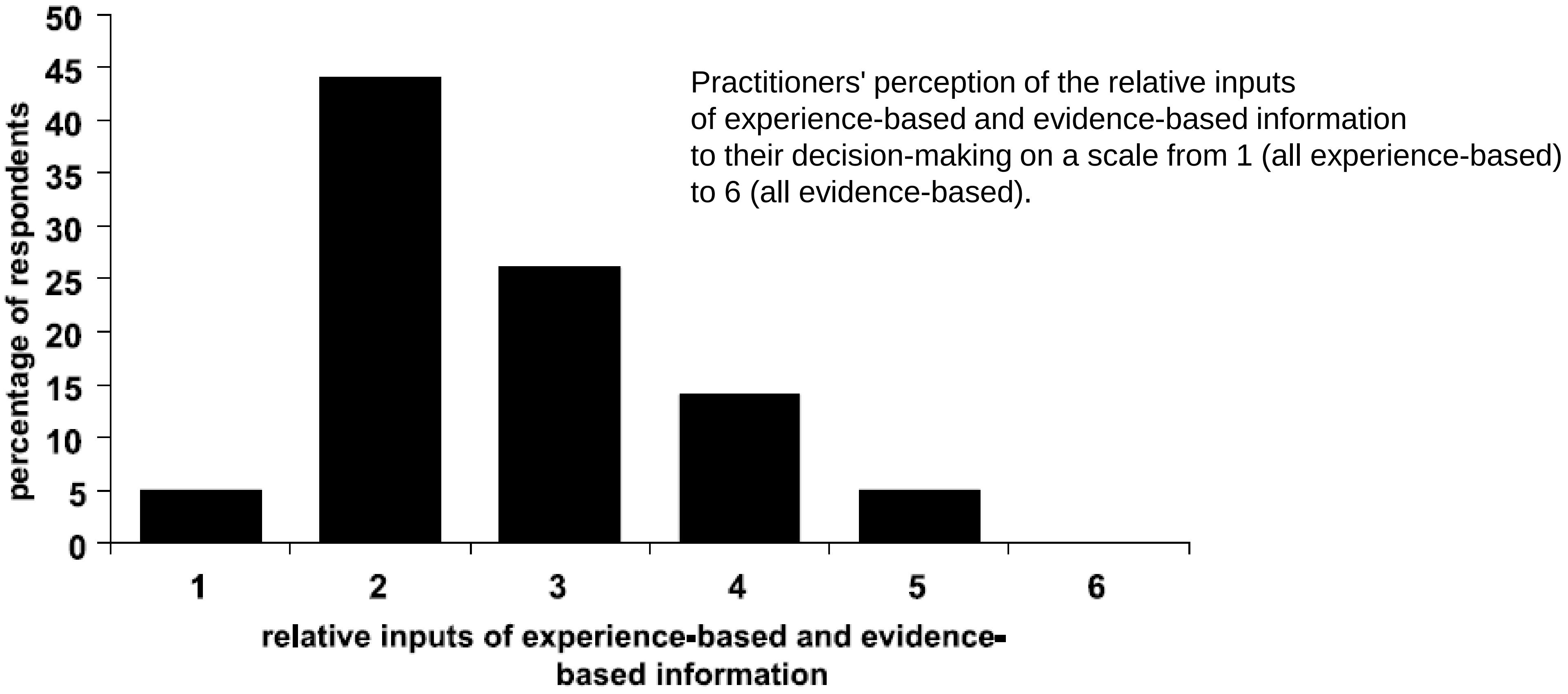
Meta-analysis

The need for research synthesis

- >12‘000 articles are published annually in the field of ecology (ISI Citation Report)
- Reading 2 articles per day,
  you would fall 17 years behind in one year!
- But you could also read 34 papers per day (including week-ends of course!)
- Have you read the latest issues:
  - Nature, Science
  - Biological Conservation, Conservation Biology
  - Journal of Applied Ecology
  - TREE, etc?

Experience vs. evidence-based conservation?

- Epistemological revolution in conservation
- Need for evidence-based conservation



Pullin et al. 2004. Conservation Biology

The conservation context

- Practitioners have even less time to devote to articles
- Decision-makers need to know which actions do or do not work
- In the absence of accessible evidence, they will inevitably rely on subjective methods combined with personal experience
- Current decision-making processes may lack objective scientific rationale or evaluation of effectiveness
- Conserving biodiversity involves making practical (and sometimes quick) decisions from a range of options
- We need research syntheses to help!

Research syntheses

1. Summarize data from multiple sources on a single ecological subject
2. Provide an evidence-based foundation for conservation
3. Highlight research needs
4. Disseminate results to practitioners

Research synthesis types

- Qualitative synthesis (reviews):
  - Narrative reviews
  - Systematic reviews (rigorous and transparent methodology) – [SR]
- Quantitative synthesis (reviews):
  - Vote counting
  - Meta-analyses (statistically founded) – [MA]

Traditional vs. systematic reviews

Feature	Traditional review	Systematic review
Question	Often broad in scope	Focused question
Sources & search	Not usually specified, potentially biased	Comprehensive sources & explicit search strategy
Selection	Rarely specified, potentially biased	Criterion-based selection, uniformly applied
Appraisal	Variable	Rigorous critical appraisal, uniformly applied
Synthesis	Often a qualitative summary	Quantitative summary* when appropriate
Inferences	Sometimes evidence-based	Evidence-based
*A quantitative summary that includes a statistical synthesis s a meta-analysis		

Systematic review

- Systematic review is a tool that provides empirical answers to scientific research questions using existing available evidence
- Key features
  - Systematically locate data
  - Critically appraise methodology
  - Synthesise evidence
- Follow a strict methodological and statistical protocol
  - more comprehensive
  - minimising the chance of bias
  - improves transparency, repeatability and reliability

Systematic review stages

The all-seeing eye

1. Question formulation
2. Literature search
3. Literature filtering
4. Data extraction
5. Data synthesis
6. Management recommendations and research gap identification

→Evidence-based conservation biology

1. Question formulation

“Does intervention x on subject y produce outcome z?”

Subject	Unit of study (e.g., ecosystem, habitat, species) that should be defined in terms of the subject(s) on whom the intervention will be applied
Intervention	Proposed management regime, policy, or action
Outcome	All relevant objectives of the proposed management intervention that can be measured reliably with particular consideration given to the most important management outcome and to any outcome critical to whether the proposed intervention has greater benefits or disadvantages than any other alternatives (i.e., the outcome desired)

2. Literature search protocol

- Choose keywords strings and search across multiple search engines
- Evaluate scientific soundness
- Select and document (for repeatability) rigorous inclusion criteria
- Type of collection:
  - all previous research on the subject (both published and unpublished)
  - all published research on the subject
  - a representative sample of research on the subject

Databases

- Databases differ by coverage of data sources (journals, books, proceedings, dissertations)
- Coverage of some journals differ between databases
- Databases differ by coverage of disciplines (ecology, environment, medicine, agriculture, taxonomy, etc.)
- Databases differ by coverage of languages (i.e. papers in national languages are often omitted)

Common search gaps

- Any source published
  in languages other than English
- National journals (not covered by ISI)
- Collections of papers
- Abstracts and conference proceedings
- Low circulation reports and dissertations
- Unpublished data
- …

Literature search

- Reflect the subject, intervention and outcome
- Consider synonyms, alternative spellings and abbreviations (e.g., colonise and colonize)
- Foreign language translations
- Combinations and permutations
  - Trade off between effort and return
  - Sensitivity vs. specificity
- Search generic and specific information sources

3. Literature filtering

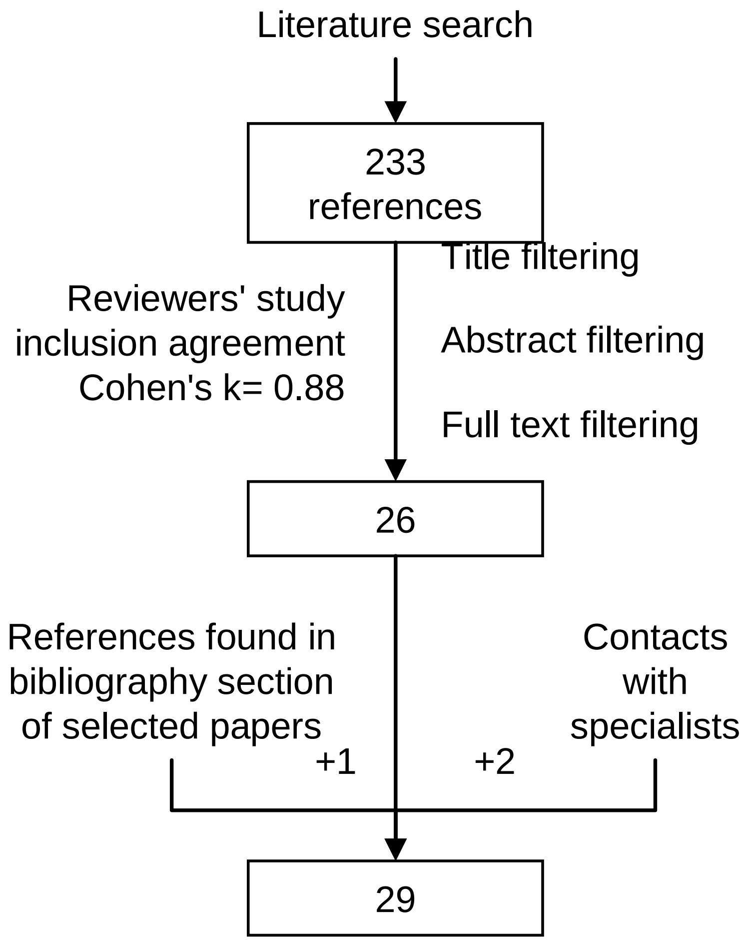
Based on <u>inclusion criteria:</u>

- right subject?
- right intervention?
- measure and outcome?

3 levels of filtering:

- Title filtering
- Abstract filtering
- Full text filtering

→ Validated by two people through a kappa statistic



Cohen's kappa statistics

= an index which compares the agreement against that which might be expected by chance.

		Reviewer A		
		Exclude	Include	Total
Reviewer B	Exclude	10 (34.5%)	7 (24.1%)	17 (58.6%)
	Include	0 (0.0%)	12 (41.4%)	12 (41.4%)
Total		10 (34.5%)	19 (65.5%)	29

Kappa = (Observed agreement - Chance agreement)/(1 - Chance agreement)
Observed agreement = (10 + 12)/29 = 0.76
Chance agreement = 0.586 * 0.345 + 0.655 * 0.414 = 0.474
Kappa = (0.76 - 0.474)/(1 - 0.474) = 0.54

4. Data extraction

- Standardised recording of primary information presented in the studies
- Strike a balance
  - Too few data to do informative formal analysis
  - Too many data that the process is very time consuming
- Extract information on:
  - Subject
  - Intervention
  - Outcome
  - Sources of heterogeneity

Assessing methodology

- Question elements
  - population, intervention, and outcome defined
- Searches for unpublished “grey” literature
- Assessment of each studies quality/validity
  - experimental designs, sampling accuracy, appropriate timescales, baseline survey, scale, pseudo-replication
- Data synthesis
  - Descriptive qualitative synthesis, quantitative synthesis, meta-analysis, investigation of sources of heterogeneity
- …

Assessing methodology

Outcome (based on ratified common standards monitoring) in terms of yes/no/neutral answer to the question 'does burning degrade blanket bog?'

Quality of evidence	Yes (does degrade)	Equivocal	No (does not degrade)
Randomised controlled trials	2	3	
Site comparisons	1	2	3
Total	3	5	3

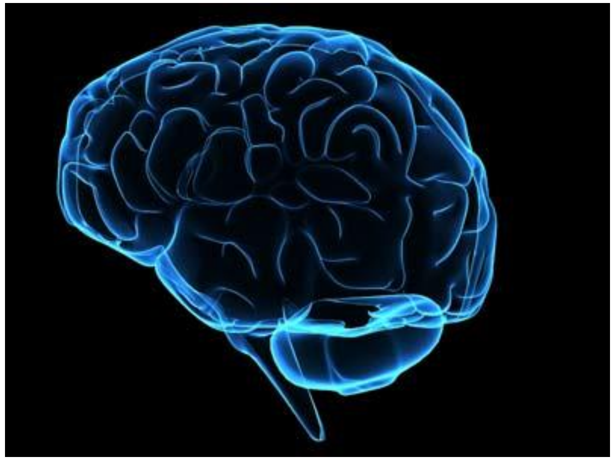
Data sets are separated according to quality of methodology.

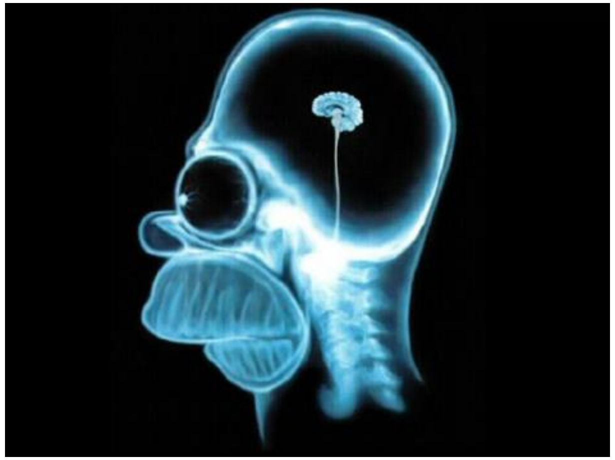
5. Data synthesis

- Synthesize results in a table

  or in a graph if possible
- Identify general patterns!
- Identify research gaps!
- Report results to the scientific

  and the practitioner community





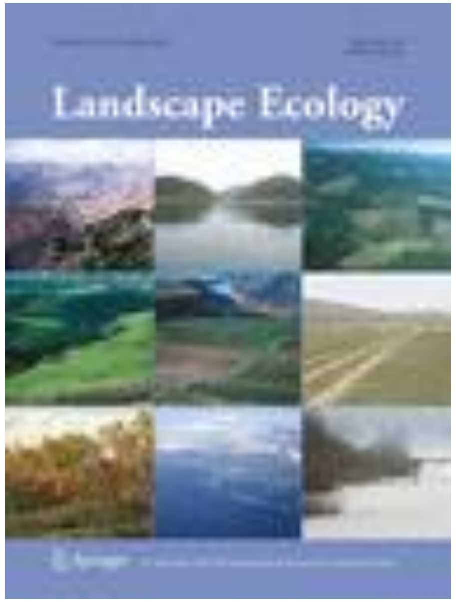
A systematic review example

Landscape Ecol (2007) 22:333–351
DOI 10.1007/s10980-006-9064-4

REVIEW

Are hedgerows effective corridors between fragments of woodland habitat? An evidence-based approach

Zoe G. Davies · Andrew S. Pullin



Context and goal

- 20 years of debate on:
  - Woodland fragmentation
  - Habitat connectivity
  - Hedgerow ecology
- Goal: evaluate the effectiveness of habitat corridors in promoting population viability of target species and biodiversity within fragments of remnant habitat
  - Do hedgerows mitigate woodland habitat fragmentation?
  - Do hedgerows increase the population viability of target species occupying otherwise isolated fragments of woodland habitat?

Question formulation

- Subject: mammal, bird, invertebrate
or amphibian populations or assemblages
- Intervention: a hedgerow, or hedgerow network, connecting two or more fragmented woodland habitat
- Outcome: change in population density for a target species or change in species richness within assemblages

Literature search

- Hedgerow* AND corridor*
- Hedgerow* AND movement*
- Hedgerow* AND dispersal
- Hedgerow* AND colonisation
- Hedgerow* AND colonization
- Hedgerow* AND connectivity
- Hedgerow* AND population*
- Hedgerow* AND communit*
- …?

Hedgerow corridors

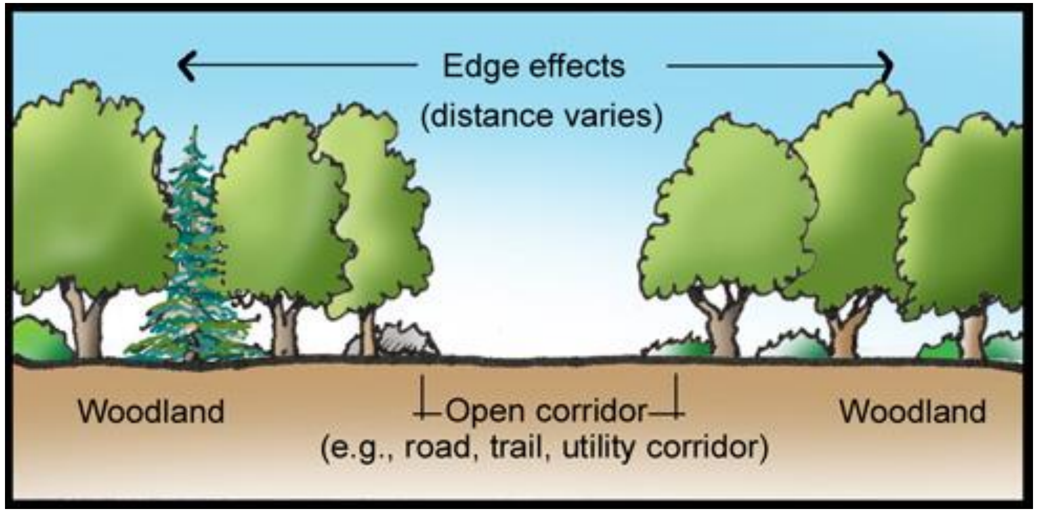
Systematic review stage	No. studies
Studies captured using search terms in electronic databases (including duplicates)	7455
Studies captured using search terms in electronic databases (excluding duplicates)	2537
Studies remaining after title filter	747
Studies remaining after abstract filter	204
Studies remaining after full text filter	51

Hedgerow corridors

Taxon	No. studies accepted for full text evaluation	No. studies rejected at full text evaluation	No. studies accepted into the systematic review
Mammals	18	3	15
Birds	8	3	5
Invertebrates	14	7	7
Amphibians	2	2	0

General synthesis

- Insufficient evidence to definitively evaluate their effectiveness
- Anecdotal evidence of local population effects, indicating that species were using hedgerows as movement conduits



Reasons for heterogeneity

- Physical structure of the hedgerow
- Vegetation composition of the hedgerow
- Nature of the non-habitat matrix
- Life history stage of the target species (e.g., dispersing juveniles)

Specific results: mammals

- Rodents
- Species presence and abundance were positively related to:
  - Hedgerow density within the surrounding landscape
  - Number of hedgerow connections into the study wood
- Movement was positively related to:
  - Increased levels of vegetation cover
  - Hedgerow structural complexity
  - Hedgerow presence was shown to increase the dispersal rates of individuals between woods

Specific results: birds

- Species presence, population density, species richness and assemblage composition were positively related to:
  - No. of hedgerows connected to study wood
  - Hedgerow structural complexity
  - Hedgerow density within the surrounding landscape

Specific results: invertebrates

- Carabid beetles
- Species abundance and presence were positively related to:
  - Vegetation cover and hedgerow structural complexity
  - Hedgerow length
- Movement of individuals was inhibited by gaps in the hedgerow and improved with increasing vegetation cover

Caveats

- Large numbers of confounding variables (heterogeneity)
- Hard to find suitable analogous controls in close proximity within a study area
- Temporal experimentation might necessitate activities that are detrimental or inappropriate for the conservation of species

Collaboration for Environmental Evidence

Collaboration for Environmental Evidence

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Welcome

The Collaboration for Environmental Evidence is a partnership between scientists and managers working towards a sustainable global environment and the conservation of biodiversity. The collaboration seeks to synthesise evidence on issues of greatest concern to environmental policy and practice.

CEE is formally registered as a charity and its Objects are:

The protection of the environment and conservation of biodiversity through preparation, maintenance promotion and dissemination of systematic reviews of the effects and impacts of environment management interventions, for the public benefit.

Syntheses take the form of systematic reviews providing rigorous and transparent methodology to assess the impacts of human activity and effectiveness of policy and management interventions. This website contains a small but fast growing Library of Environmental Evidence in the form of systematic reviews.

News Headlines

New! Sense about Science, the science education charity, have released the preliminary findings of their international survey of scientists on the peer review process. For details on their findings, please visit their website.

Note! Draft reviews and review protocols are now handled by the CEE. Please visit our 'draft reviews' section to find out more about draft documents currently available for consultation.

Research synthesis types

- Qualitative synthesis (reviews):
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Vote-counting

- Studies are either
  - Significant in one direction
  - Significant in the other
  - Not significant
- Sum of counts in all category → synthesis
- It does not incorporate sample size
- Low power for small effect sizes

Vote-counting

Overview of the <u>occurrences</u> according to the relationship between demographic change and biodiversity showing the categories of demographic change addressed. The numbers indicate the occurrences in all studies.

Demographic change influences biodiversity

	Positive	Negative	Context dependent	No effect	Unclear
Population density	8	58	8	5	1
Population increase	1	41	12	1	0
Population decrease	1	3	5	2	0
Gender	1	1	1	0	0
Age	0	3	1	0	0
Migration	1	7	5	1	0
Socio-Economy	6	29	12	0	0

Biodiversity influences demographic change

	Positive	Negative	Context dependent	No effect	Unclear
Population density	2	0	0	1	0
Population increase	1	0	0	1	0
Population decrease	0	0	0	0	0
Gender	1	0	0	0	0
Age	0	0	0	0	0
Migration	0	1	0	0	0
Socio-Economy	0	1	0	0	0

Both

	Positive	Negative	Context dependent	No effect	Unclear
Population density	0	0	1	0	0
Population increase	0	0	1	0	0
Population decrease	0	0	0	0	0
Gender	0	0	0	0	0
Age	0	0	0	0	0
Migration	0	0	2	0	0
Socio-Economy	0	0	2	0	0

Unspecified

	Positive	Negative	Context dependent	No effect	Unclear
Population density	10	0	2	0	6
Population increase	0	0	0	0	1
Population decrease	0	0	0	0	0
Gender	0	0	0	0	0
Age	0	0	0	0	0
Migration	0	0	0	0	0
Socio-Economy	1	0	0	0	1

Number of occurrences

0   6-15

1-5   > 15

Mering et al. 2019. Ambio

Why perform a meta-analysis?

- MA synthesizes a question addressed across multiple studies
- MA is a quantitative method that goes beyond the vote-count that gives a “yes” or “no” answer
- It takes into accounts study sample sizes (power)
- It is another basis for evidence-based conservation

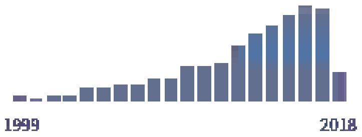
History of meta-analyis

- 1904: First medical quantitative synthesis
- 1976: First time "meta-analysis" is used
- 1970's and 1980's: Wide use of meta-analysis in medicine and psychology
- 1991: First ecological meta-analysis in *Ibis*
- 1995 and 2001: 2 seminal papers
  - Arnqvist and Wooster 1995. *TREE*
  - Gurevitch et al. 2001. *Advances in Ecological Research*

Hot topic?

Total Publications

980



h-index

105

Average citations per item

43,53

Sum of Times Cited

42 658

Without self citations

41 622

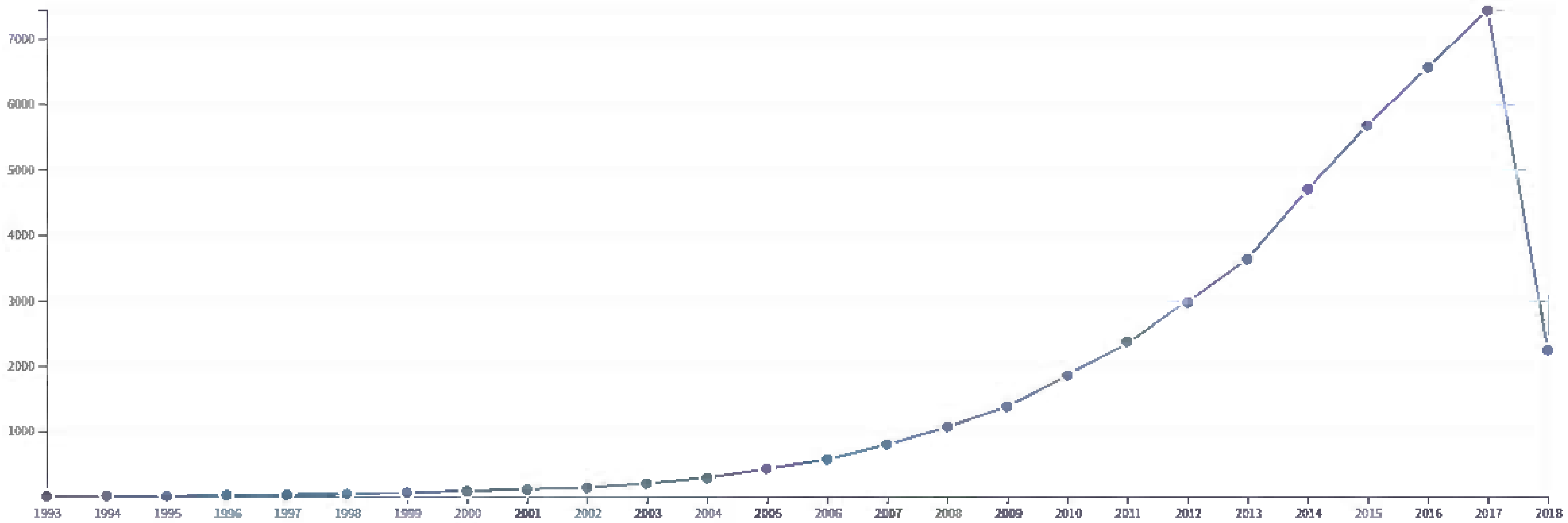
Citing articles

35 959

Without self citations

35 522

Sum of Times Cited per Year



The 7 steps of the MA procedure (similar to SR)

1. Formulate a question
2. Search for relevant studies
3. Standardize the results of each study (effect size) into a “common currency”
4. Weight the effect size by the sample size
5. Average effect size across all studies and test if this average effect size differs significantly from zero
6. Look for publication biases and heterogeneity

Effect size
= the common currency

- The effect size makes meta-analysis possible
  - it is the “dependent variable”
  - it standardizes findings across studies such that they can be directly compared
- Any standardized index can be an “effect size” (e.g., standardized mean difference, correlation coefficient, odds-ratio) as long as it meets the following
  - is comparable across studies
  - represents the magnitude and direction of the relationship of interest
  - is independent of sample size

3. Standardize the results of each study into a "common currency"

- Metrics of effect size
  - Hedge's d
  - Response ratio
  - Odds ratio
  - Correlation coefficient
- To be retrieved from the text, tables or figures or directly from the authors
- These data should be available from all papers (think about it when you write and review)

Choosing the “common currency”

Data	Effect size
Comparison of two groups in terms of continuous response variable (means, sample sizes and measures of variance)	Hedge’s *d* Response ratio (RR)
Comparison of two groups in terms of categorical response variable (2×2 contingency table)	Odds ratio (OR)
Relationship between two continuous variables	Correlation coefficient

Hedge's *d*

= Standardized difference between means in experiment (*Xe*) and control (*Xc*), divided by pooled standard deviation (*s*) and adjusted for sample size by correction term (*J*)

- Interpretation is subjective
  - d< 0.2 - small effect
  - d~ 0.5 – moderate effect
  - d> 0.8 – large effect
- Differences in *d* may reflect either differences in the magnitude of the effect or differences in variance among studies
- Some data (most commonly SD or sample sizes) are often lacking

$$d = \frac{(\bar{X}e - \bar{X}c)}{s} J$$

Response ratio

- Easily interpretable
- Results of primary studies are often presented in the form of response ratios
- Effect sizes are not affected by different variance in control and experimental groups

$$\ln R = \ln\left(\frac{\bar{X}e}{\bar{X}c}\right) = \ln(\bar{X}e) - \ln(\bar{X}c)$$

Odds ratio (OR)

- For categorical responses

	Treatment	Control
Response	A	B
No response	C	D

$$OR = A/C : B/D = AD/BC$$

= the odds of a response in the treatment group
relative to the odds of a response in the control group

Pearson's correlation coefficient

- Easy to interpret (varies from –1 to +1)
- Cohen's "rules-of-thumb":
  - $| r |$ = 0.10 = small
  - $| r |$ = 0.25 = medium
  - $| r |$ = 0.40 = large
- Mean $| r |$ in ecology = 0.19 (95% CI 0.14-0.25) Møller & Jennions 2002 Oecologia
- r can be derived from Z, t, F, of χ^2 values

4. Weight the effect by sample size

- The larger studies are given more weight than smaller studies
- Given the same sample size, more weight will be given to studies with smaller variance
- Effect sizes are usually weighed by the inverse of the sampling variance ($w=1/\upsilon$)
- Weighting
  - increases the precision of the combined estimates and increases the power of tests
  - makes certain statistics to have simpler sampling distributions

6. Test if the average effect size differs significantly from zero

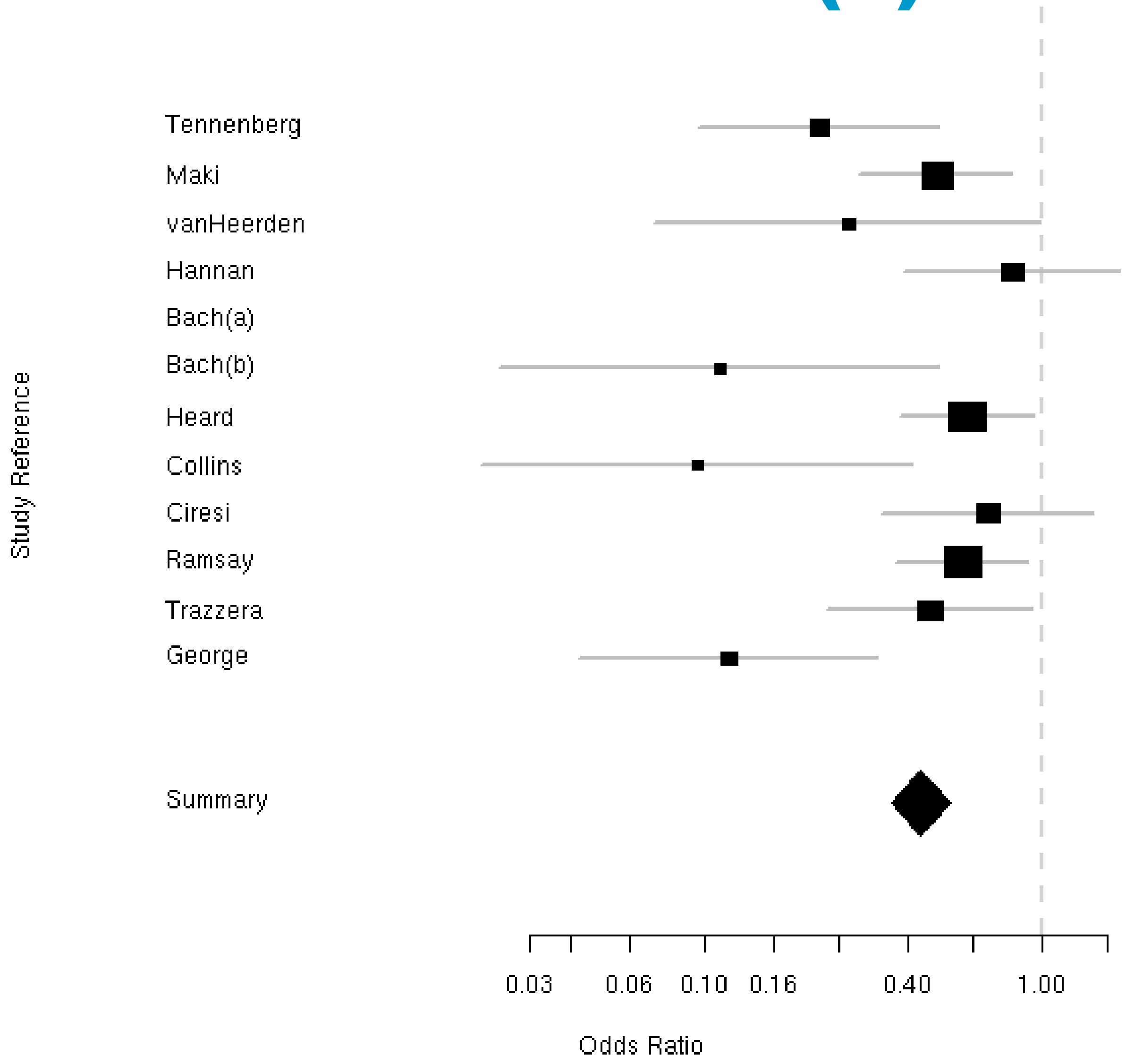
1. Forest plots (visual inspection)

2. Cumulative effect size and 95% CI

3. Test for heterogeneity (*Q*)

Package ‘metafor’

Forest plot and cumulative effect size (E)



$$\bar{E} = \frac{\sum w_i E_i}{\sum w_i}$$

Look for heterogeneity

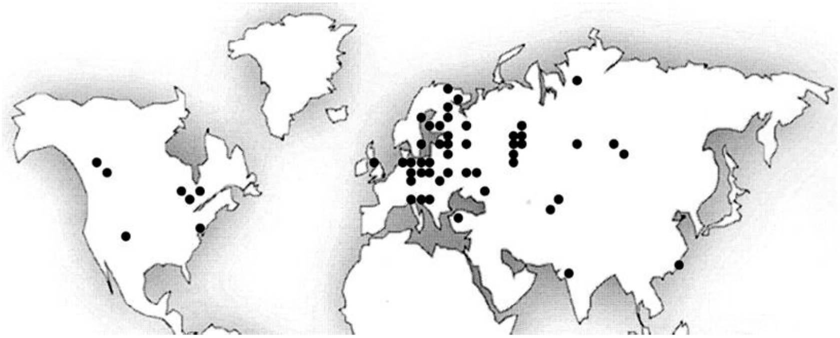
- Heterogeneity analysis first asks the question: "Is the observed variance in effect sizes significantly different from that expected by sampling error alone?"

$$\bar{Q} = \sum w_i (E_i - \bar{E})^2$$

- Chi-square distributed
- If the value of *Q* is higher than the critical, then we proceed to examine whether study characteristics are associated with effect sizes

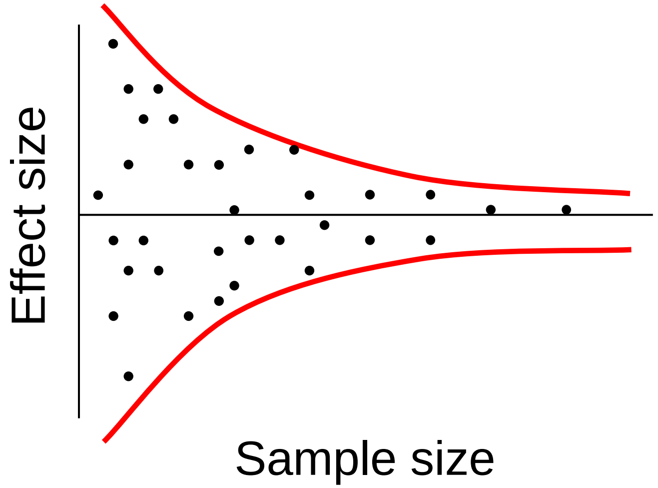
7. Look for publication biases

- Research bias: the tendency to perform experiments on organisms or under conditions in which one has a reasonable expectation of detecting statistically significant effects
- Publication bias: influence of research findings on the probability of a study being published
- Dissemination bias: dependence of accessibility of research findings on the direction or strength of these findings



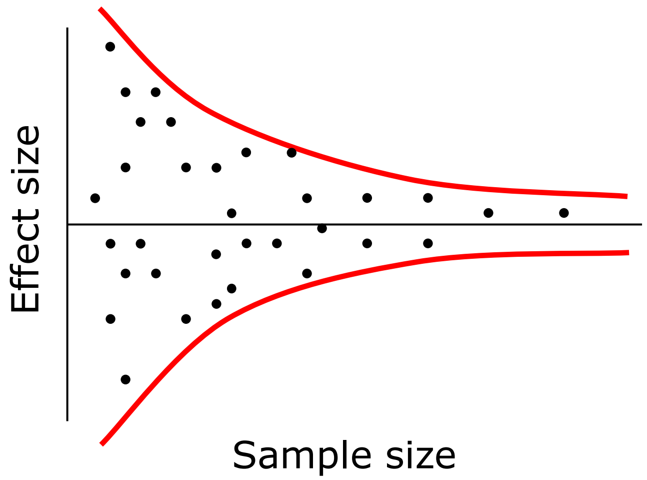
Funnel plots

- Funnel plots are skewed and asymmetrical in the presence of publication bias and other biases
- Critical examination of systematic reviews for publication and related biases should be considered a routine procedure

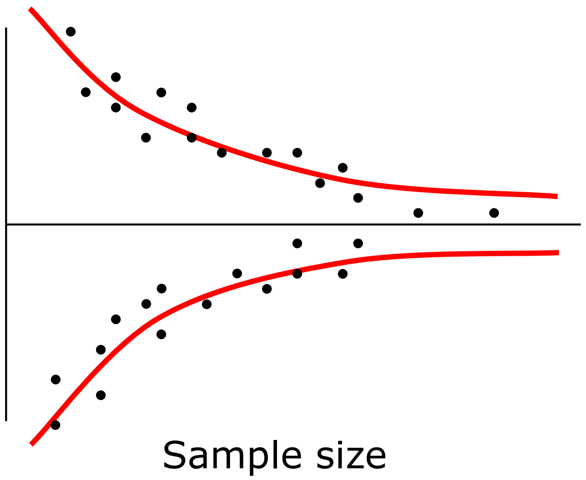


Visual inspection of funnel plots

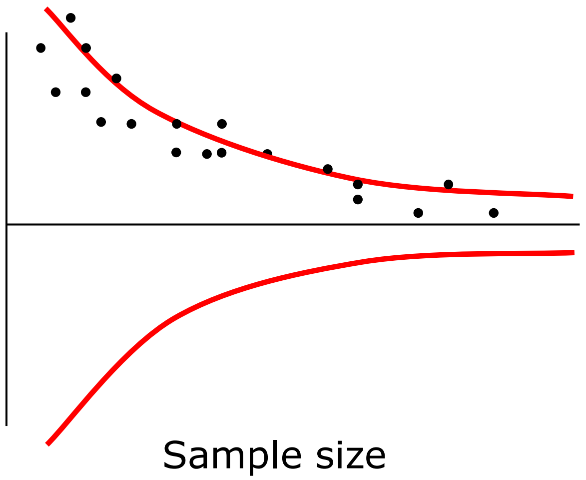
No bias



Only significant results reported



Only positive results reported



Criticism of meta-analysis

- Mix dissimilar studies
  ("apples and oranges")
- Incorporate “bad” studies
  (“garbage in - garbage out”)
- Summarize a paper by a single value
- Risk publication bias
- Non-independence among papers
  (splitters and lumpers)
- Correlational nature of evidences

When to perform a MA?

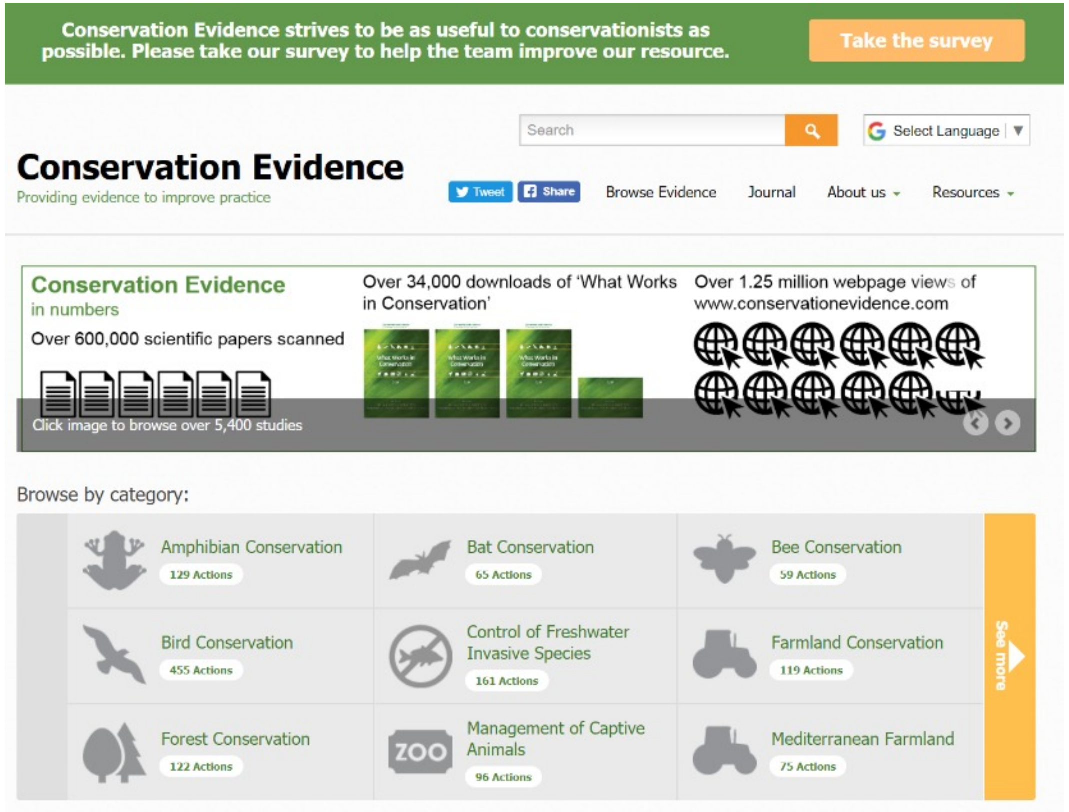
1. There is a moderate to large amount of empirical work available
2. The results are variable across studies
3. The expected magnitude of the effect is relatively weak
4. The sample sizes of individual studies are limited for some reason

CEE

Collaboration for Environmental Evidence

THE COCHRANE COLLABORATION®

- Similar to the well established
- But see also the…
- We need research syntheses!



"*Science is built up with facts, as a house is with stones.*
But a collection of facts is no more a science
than a heap of stones is a house"

Jules Henri Poincaré

Exercise

UNIVERSITÄT BERN

Ecology & Evolution
Conservation biology

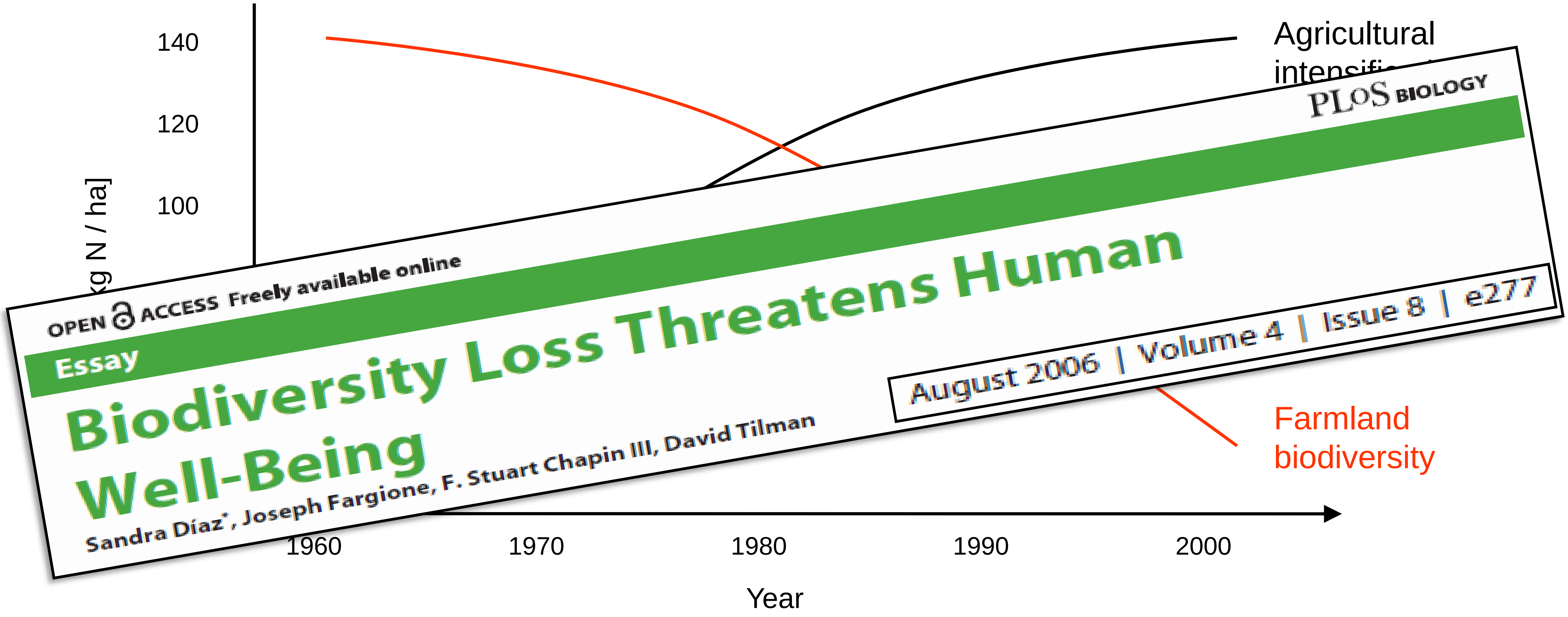
Does delaying the first mowing date benefit biodiversity in meadowland?

Systematic review published in *Environmental Evidence*

Dr Jean-Yves Humbert
Dr Jérôme Pellet
Pierrick Buri
Prof. Raphaël Arlettaz

ECCB2012, Glasgow, 29.08.2012

Research context - background



Adapated from Robinson & Sutherland 2002 *J App Ecol*

Research context - AES

- EU, agri-environment schemes (AES)

- CH, ecological compensation areas (ECA), since 1993

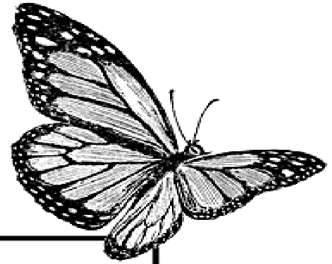
- Evaluation studies have shown only a moderate effect of AES on biodiversity, especially on field invertebrates (e.g. Kleijn et al. 2006 *Ecol Lett;* Aviron et al. 2009 *Front Ecol Environ*)

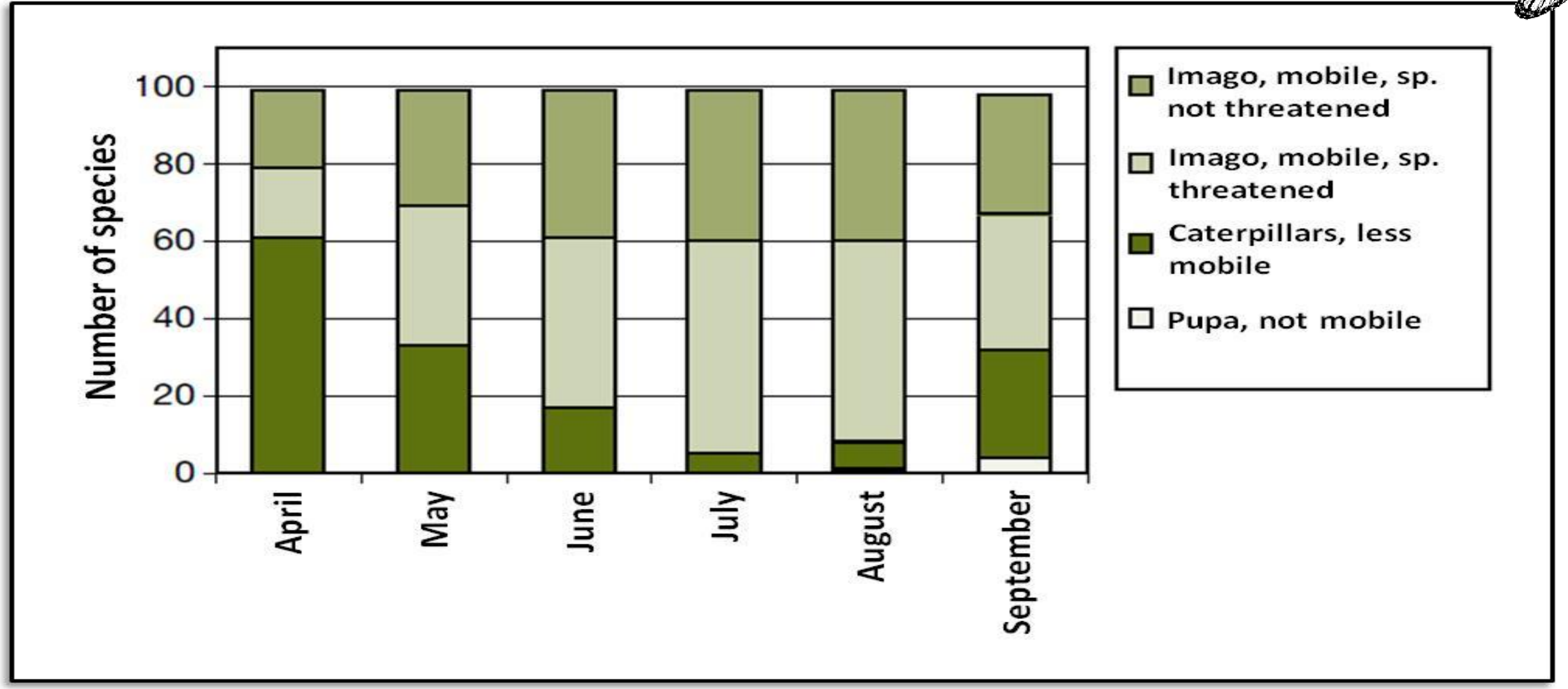
Why this moderate success?

- …
- Landscape fragmentation and lack of source populations (e.g. Tscharntke and Brandl 2004 *Annu Rev Entomo*; Knop et al. 2008 *Restor Ecol*)
- Reduction in spatial and temporal farmland heterogeneity (Benton et al. 2003 *TREE*; Cole et al. 2010 *Agric Ecosyst Environ*)
- Meadow harvesting process (Humbert et al. 2009 & 2010 *Agric Ecosyst Environ*; 2010 *J Appl Entomol*)
- Inappropriate harvesting time (Humbert et al. 2012 *Environ Evid*)

CH lowlands
Subsidized extensively managed hay meadows (AES)
Not to be mown before June 15

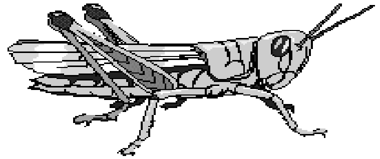
Phenology of butterflies

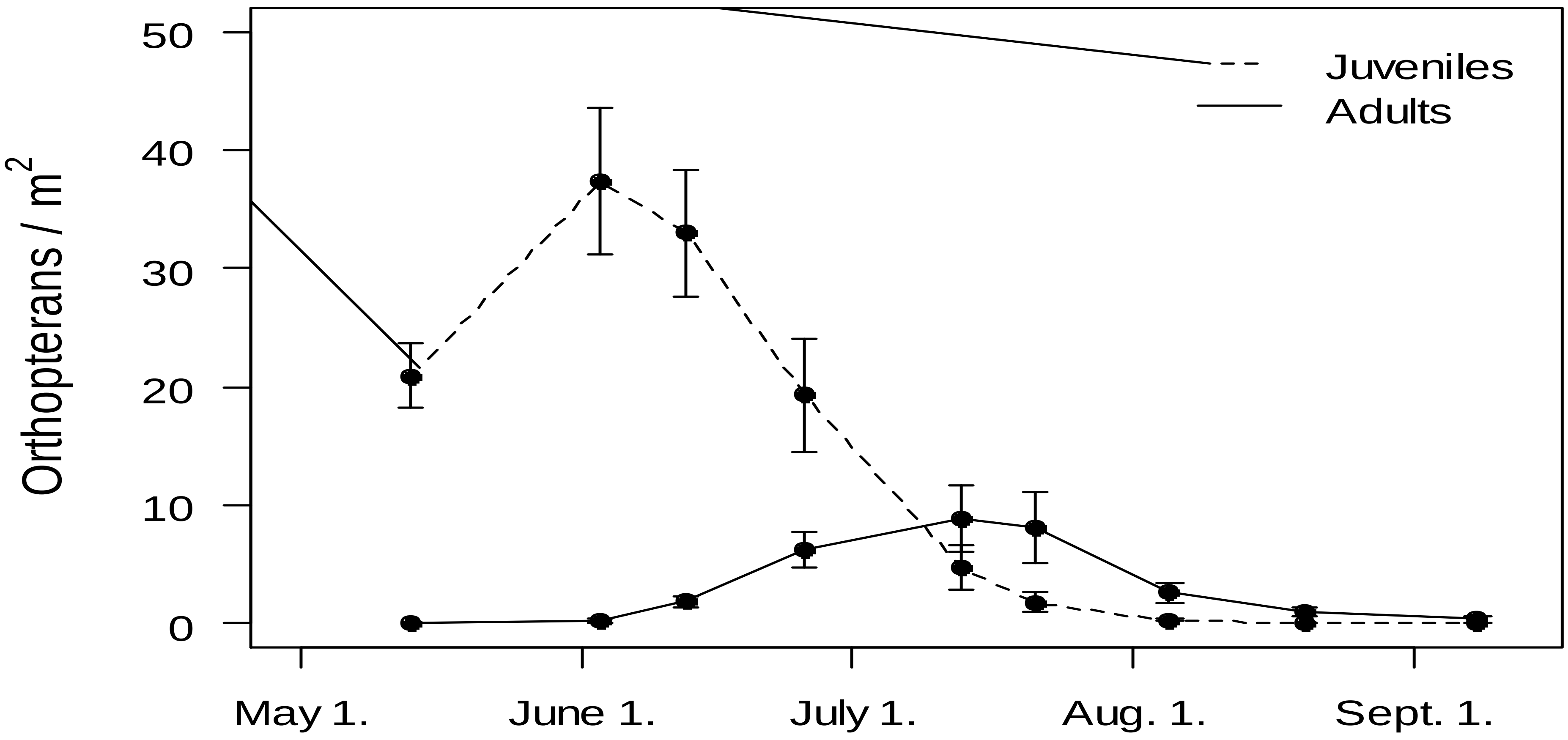




Walter et al. 2007 *AGRARForschung*

Phenology of orthopterans





Dominant species: *Chorthippus montanus, Mecostethus parapleurus, Stethophyma grossum, Metrioptera roeselii*

Humbert 2010 *PhD Thesis*

Phenology of plants

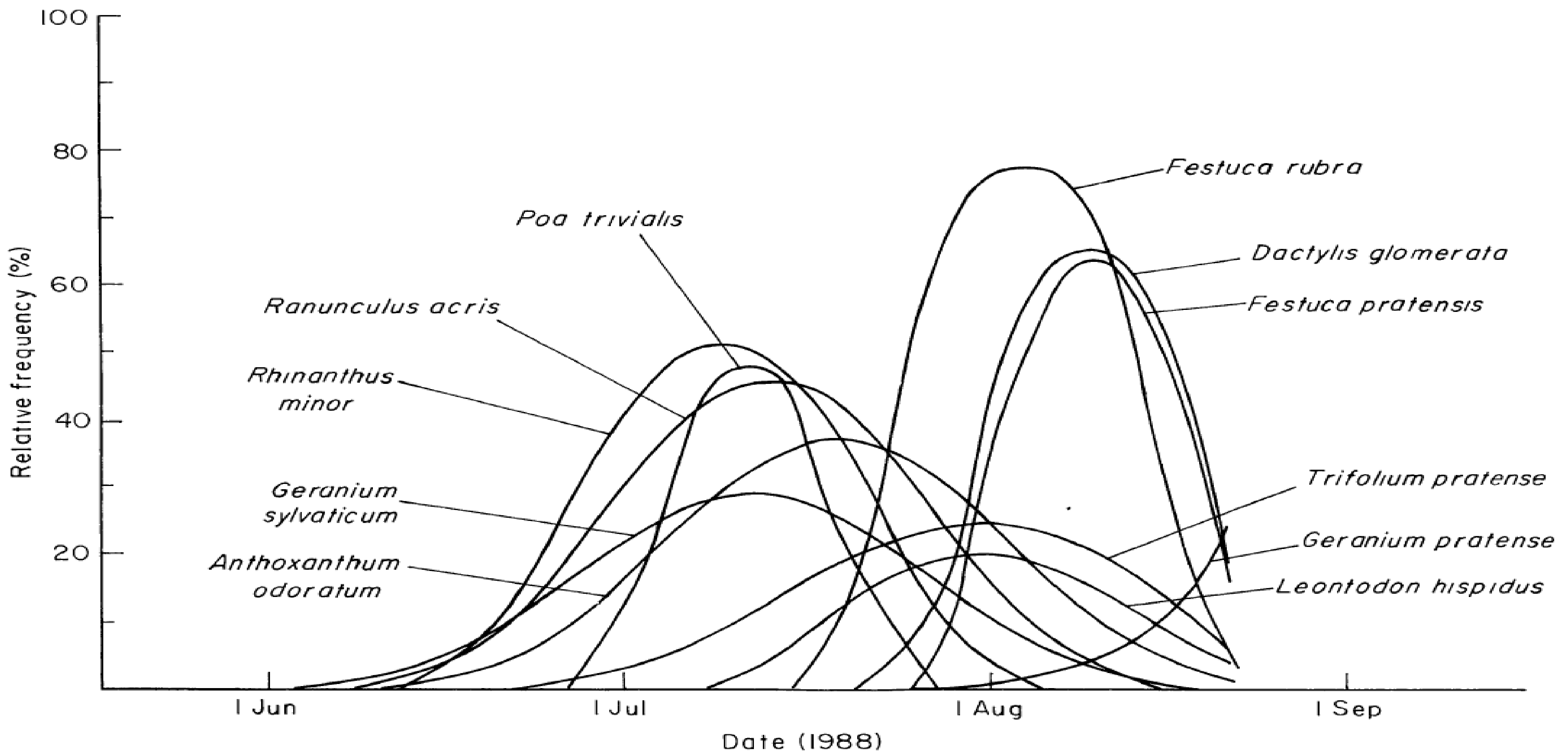
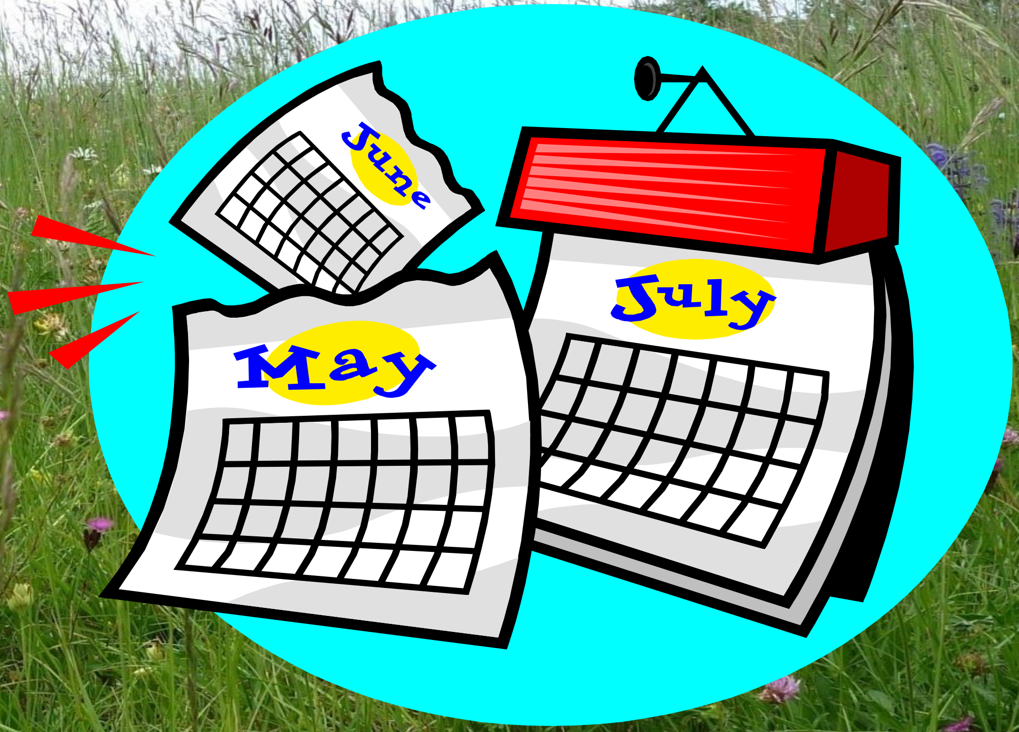


FIG. 7. The development of ripe seed in eleven species.

Smith and Jones 1991 *J Appl Ecol*

What can we do...



Delay mowing?

Systematic review on the influence of delaying the first mowing date on biodiversity Humbert et al. 2012 *Environ Evid*

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Does delaying the first mowing date increase biodiversity in European farmland meadows?

What is the aim of the review?

The objective of this review is to systematically collate and synthesise available evidence to estimate the biodiversity benefits of a delayed mowing date on European farmland meadows.

Who's in the review team?

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  Institute of Ecology and Evolution, University of Bern

At what stage is the review?

The review protocol has now been finalised and the review is underway. Please check this page again soon for further progress updates.

Comments?

If you would like to comment on any aspect of this review, please email us. Your feedback is appreciated.

Document Links

- Protocol

http://www.environmentalevidence.org/

Flow diagram

Literature research

↓

367 articles

Reviewers' study inclusion agreement Cohen's k= 0.81

Title filtering (96 excluded)

Abstract filtering (221 excluded)

Full text filtering (23 excluded)

↓

27 articles

Not independent or unsuitable data for a meta-analysis (12 excluded)

↓

15 articles

Additional records from contacts with experts or found in bibliography section of selected papers

+9

↓

24 articles

↓

55 data points

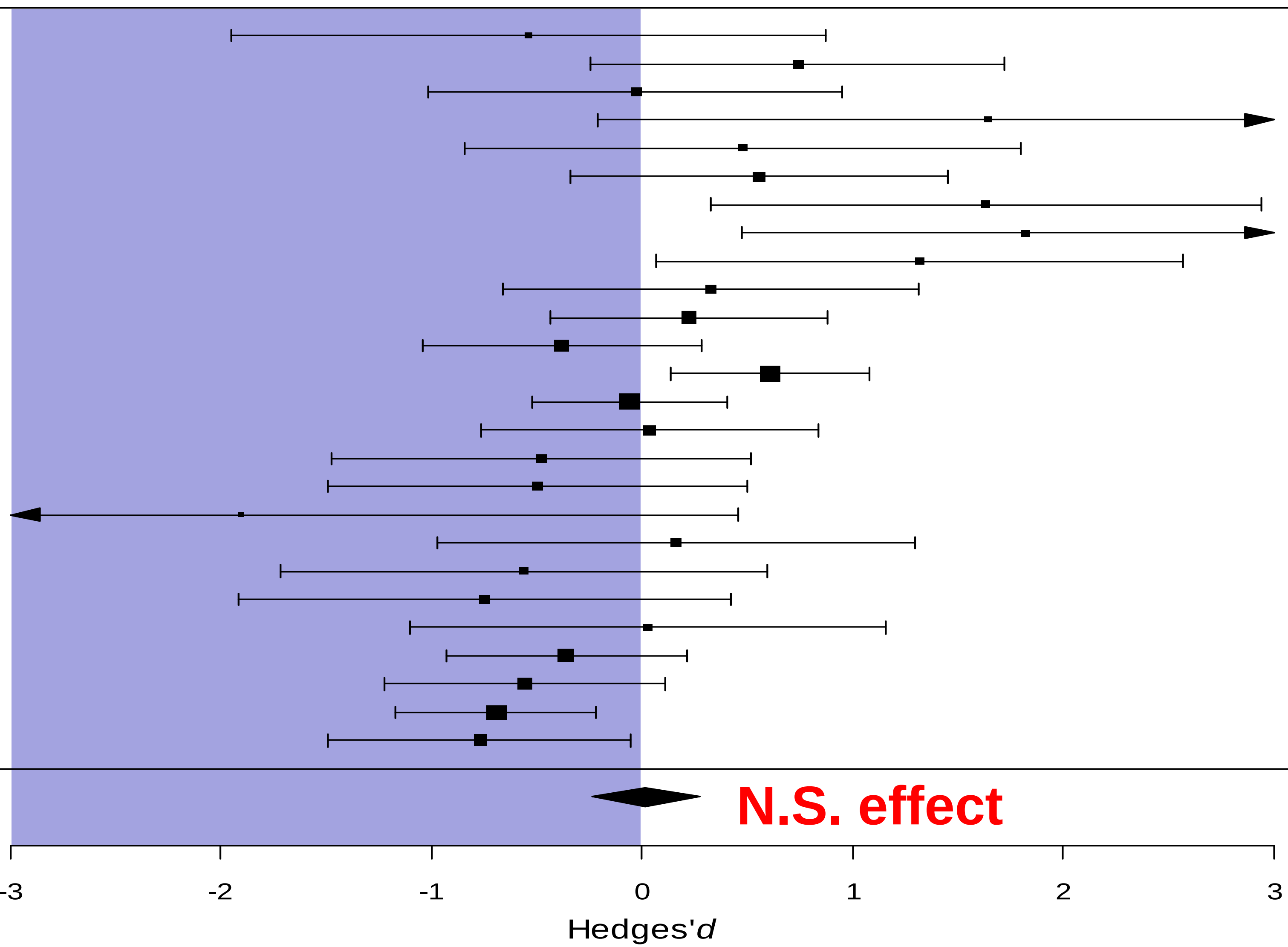
Study inclusion criteria

- **Relevant subjects:** semi-natural grasslands that are mown annually.
- **Types of intervention:** first mowing date delayed (treatment).
- **Types of comparator:** comparison with similar meadows or plots that are first mown on an earlier date (control). **Treatment and control plots had to be similar in all management aspects, except the date of the first cut, and must be located in the same habitat type.**
- **Types of outcome:** species richness and/or abundance.

Results. Plant species richness (N = 26)

All cut delaying situations considered

Source, early cut-delayed cut	Std. mean difference [95% CI]
Beltman et al. 2003, May-July	-0.54 [-1.95 , 0.87]
Bissels et al. 2004, June-Sept	0.74 [-0.25 , 1.72]
Bobbink and W. 1991, exp.1 June-Aug	-0.03 [-1.01 , 0.95]
Fenner and P. 1998, June-Aug	1.64 [-0.21 , 3.49]
Hegland et al. 2001, lateJune-lateJuly	0.48 [-0.84 , 1.80]
Hellström et al. 2006, June-Aug	0.56 [-0.34 , 1.45]
Kirkham and T. 1995, May-July	1.63 [0.33 , 2.94]
Kirkham and T. 1995, May-Aug	1.82 [0.47 , 3.16]
Kirkham and T. 1995, May-Sept	1.32 [0.07 , 2.57]
Parr and W. 1988, June-July	0.33 [-0.66 , 1.32]
Smith et al. 1996b, June-July	0.22 [-0.43 , 0.88]
Smith et al. 1996b, June-Sept	-0.38 [-1.04 , 0.28]
Smith et al. 2000, June-July	0.61 [0.13 , 1.08]
Smith et al. 2000, June-Sept	-0.06 [-0.52 , 0.40]
Woodcock et al. 2007, May-July	0.04 [-0.76 , 0.84]
Bobbink and W. 1991, exp.1 June-Nov	-0.48 [-1.48 , 0.51]
Bobbink and W. 1991, exp.1 Aug-Nov	-0.50 [-1.49 , 0.50]
Bobbink and W. 1991, exp.2 Aug-Nov	-1.90 [-4.26 , 0.46]
Kirkham and T. 1995, July-Aug	0.16 [-0.97 , 1.29]
Kirkham and T. 1995, July-Sept	-0.56 [-1.71 , 0.59]
Kirkham and T. 1995, Aug-Sept	-0.75 [-1.92 , 0.42]
Köhler et al. 2005, July-Oct	0.03 [-1.10 , 1.16]
Marriott et al. 2003, June-Oct	-0.36 [-0.93 , 0.21]
Smith et al. 1996b, July-Sept	-0.56 [-1.22 , 0.11]
Smith et al. 2000, July-Sept	-0.69 [-1.17 , -0.22]
Cop et al. 2009, earlyJune-lateJune	-0.77 [-1.49 , -0.05]
Summary	0.02 [-0.24 , 0.27]



Results. Plant species richness (N = 15)

Only spring to summer delayed cuts considered

Source, early cut-delayed cut	Std. mean difference [95% CI]
Beltman et al. 2003, May-July	-0.54 [-1.95 , 0.87]
Bissels et al. 2004, June-Sept	0.74 [-0.25 , 1.72]
Bobbink and W. 1991, exp.1 June-Aug	-0.03 [-1.01 , 0.95]
Fenner and P. 1998, June-Aug	1.64 [-0.21 , 3.49]
Hegland et al. 2001, lateJune-lateJuly	0.48 [-0.84 , 1.80]
Hellström et al. 2006, June-Aug	0.56 [-0.34 , 1.45]
Kirkham and T. 1995, May-July	1.63 [0.33 , 2.94]
Kirkham and T. 1995, May-Aug	1.82 [0.47 , 3.16]
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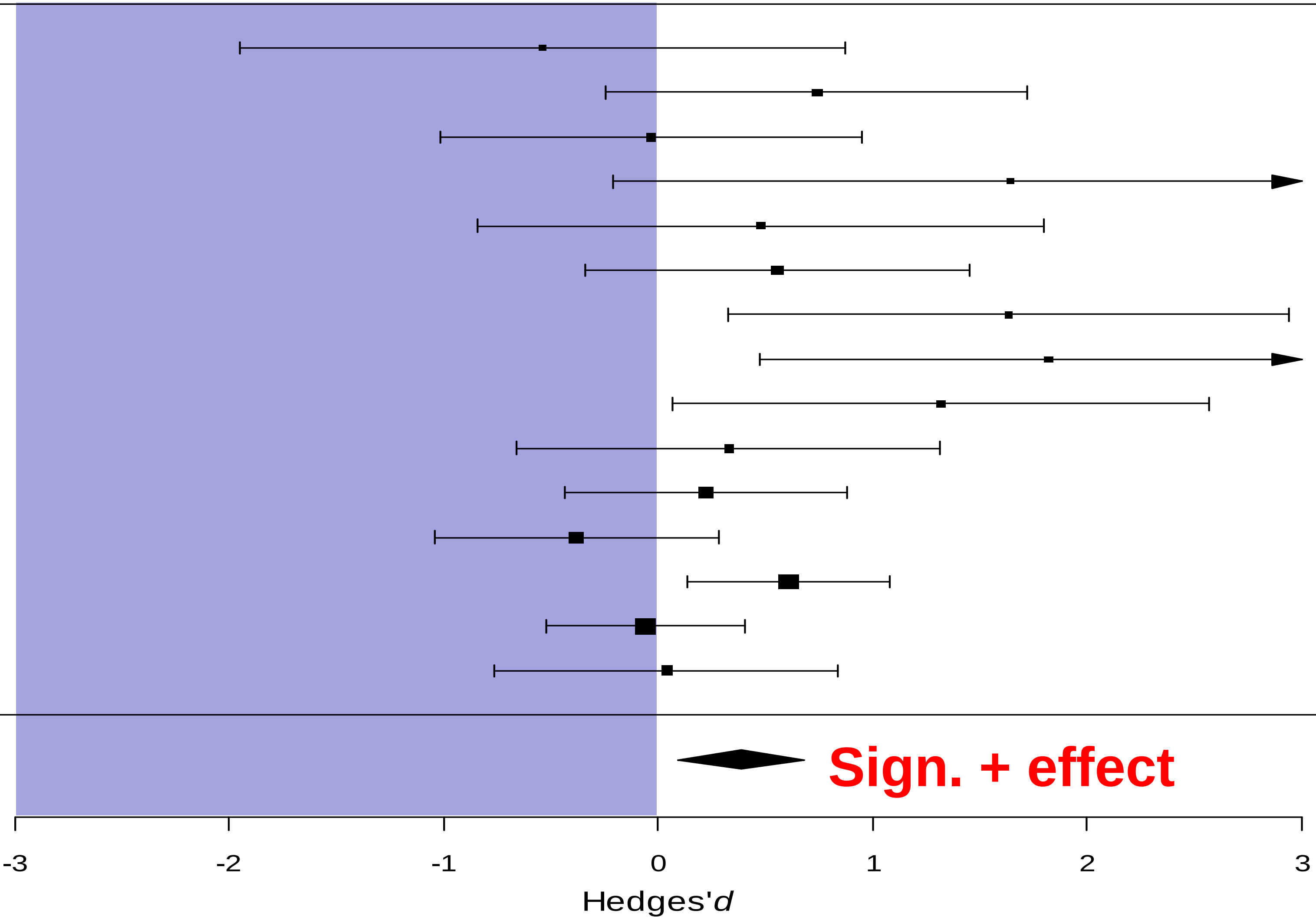
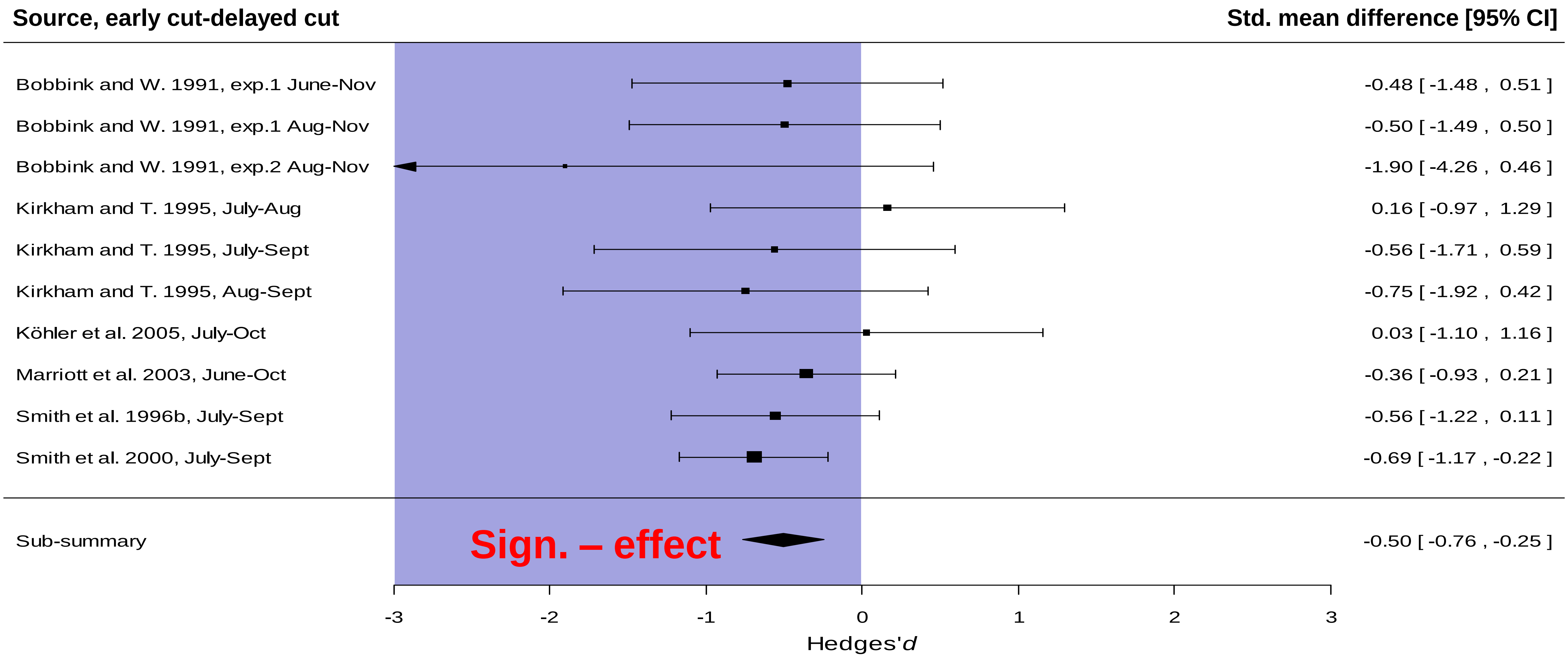
Smith et al. 1996b, June-July	0.22 [-0.43 , 0.88]
Smith et al. 1996b, June-Sept	-0.38 [-1.04 , 0.28]
Smith et al. 2000, June-July	0.61 [0.13 , 1.08]
Smith et al. 2000, June-Sept	-0.06 [-0.52 , 0.40]
Woodcock et al. 2007, May-July	0.04 [-0.76 , 0.84]
Sub-summary	0.39 [0.09 , 0.68]



Results. Plant species richness (N = 10)

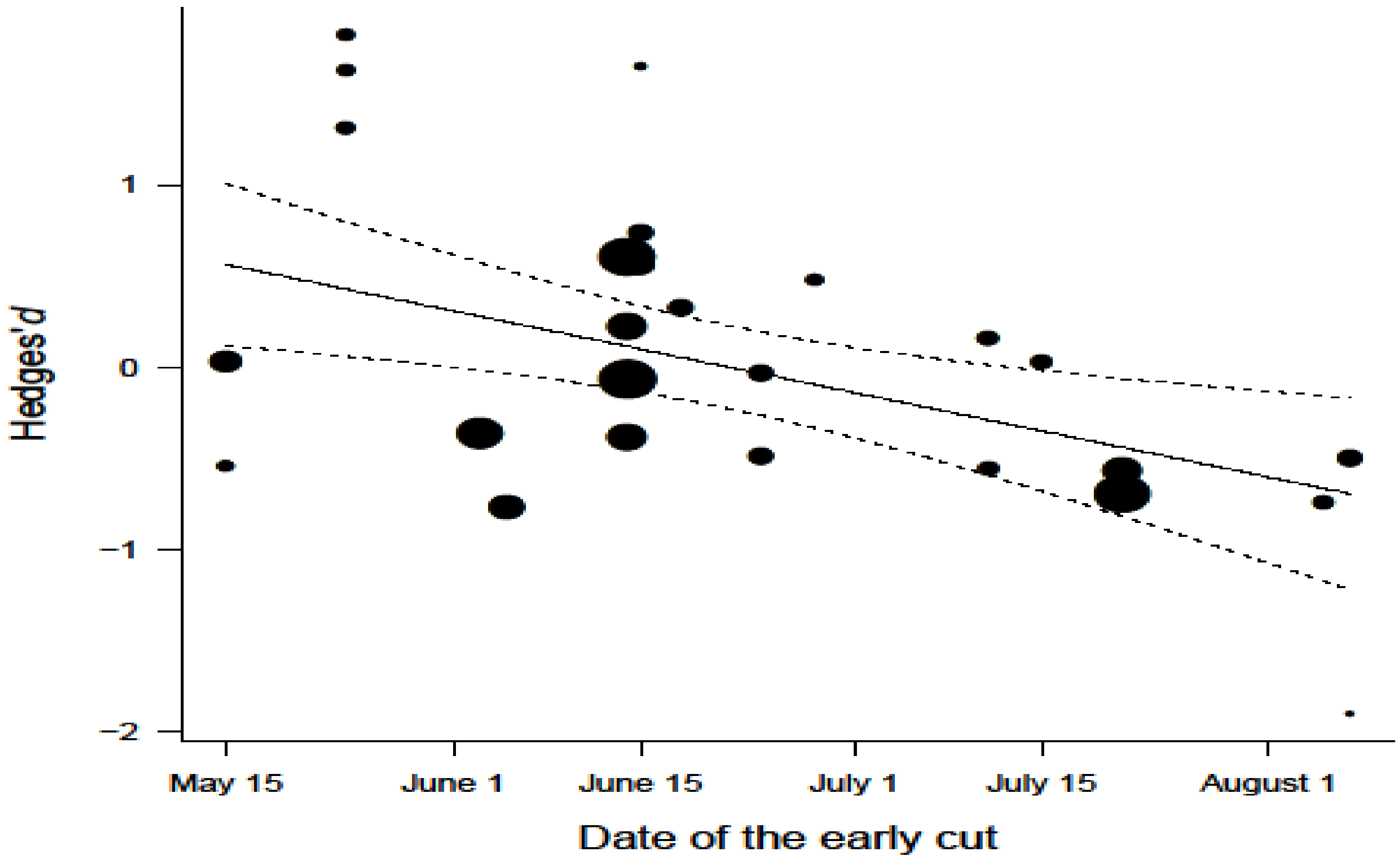
All other cut delaying situations



Significant negative effect

Results. Plant species richness (N = 26)

Hedges'*d *as a function of the date of the early cut



Results. Plant species richness (N = 26)

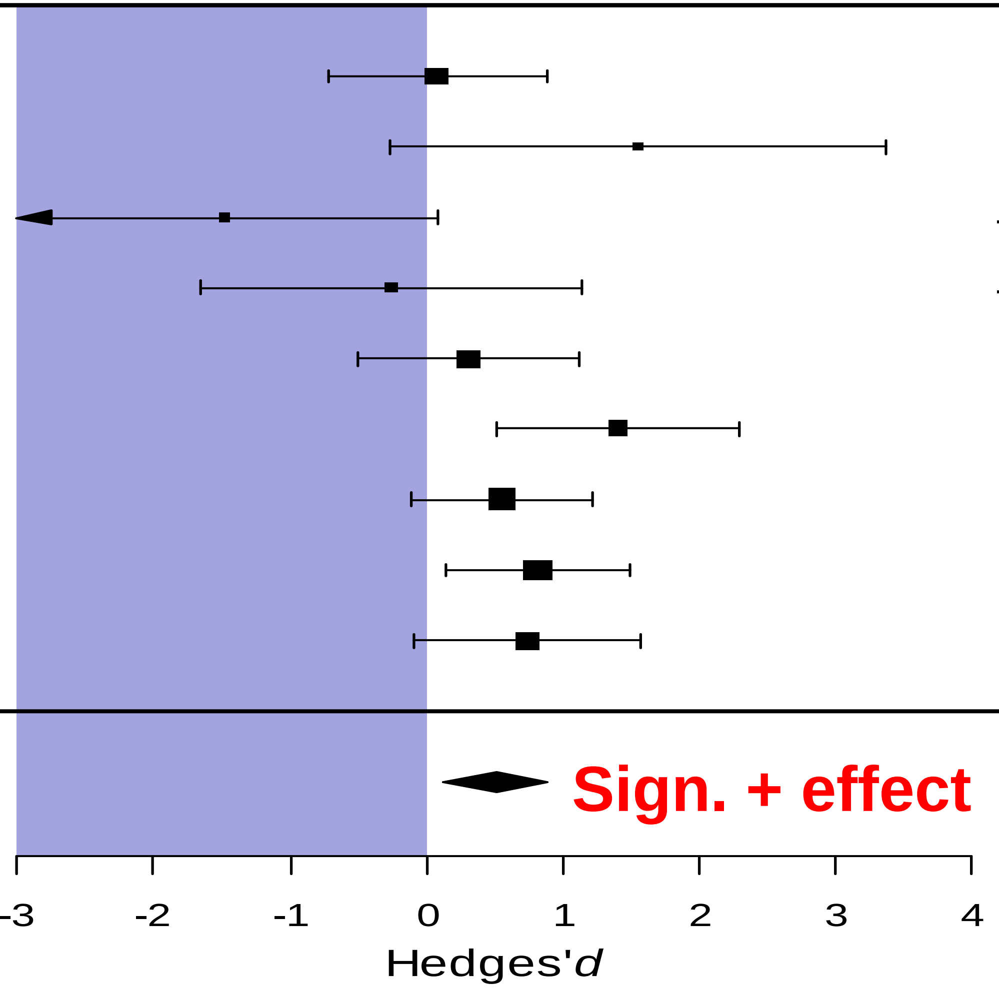
Hedges'd as a function of:

- Date of the **delayed cut**
- **Time lapse** [in days] between the early and the delayed cuts
- **Study duration** [in years]
- **Plot size** of the vegetation relevé

no statistically significant influence

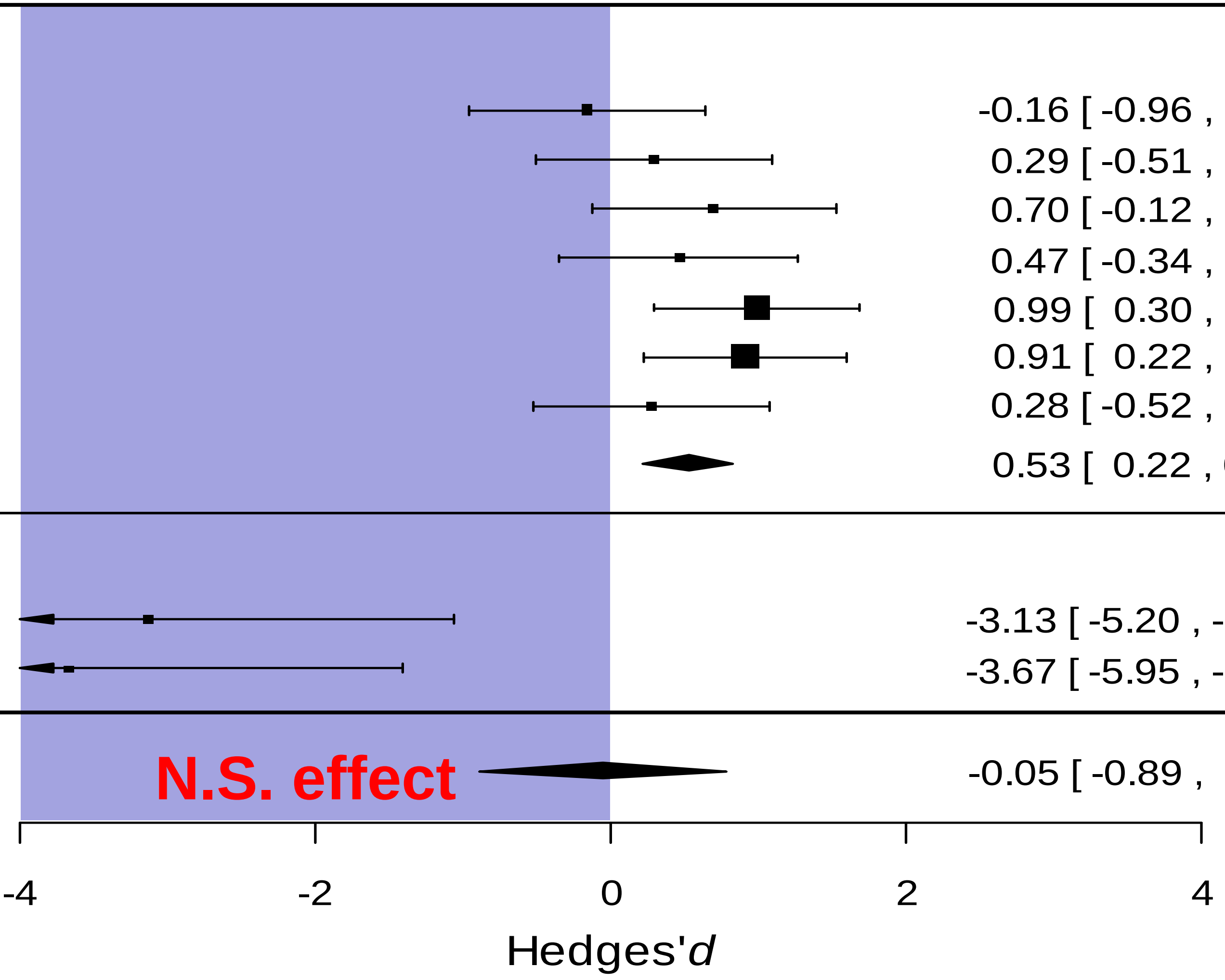
Results. Invertebrate species richness (N = 9)

Source, early cut-delayed cut		Std. mean difference [95% CI]
Blake et al. 2011, May-July	Auchenorrhyncha	0.08 [-0.72 , 0.88]
Fenner and P. 1998, June-Aug	Invertebrates	1.55 [-0.28 , 3.37]
Morris 1979, May-July	Heteroptera	-1.49 [-3.05 , 0.08]
Morris 1981a, May-July	Auchenorrhyncha	-0.26 [-1.65 , 1.13]
Potts et al. 2009, May-July	Bumblebees	0.31 [-0.49 , 1.12]
Potts et al. 2009, May-July	Butterflies	1.41 [0.51 , 2.30]
Valtonen et al. 2006, July-Aug	Butterflies	0.55 [-0.11 , 1.22]
Valtonen et al. 2006, July-Aug	Diurnal.moths	0.82 [0.14 , 1.50]
Woodcock et al. 2007, May-July	Beetles	0.74 [-0.08 , 1.57]
Summary		0.51 [0.13 , 0.89]



Results. Invertebrate abundance (N = 9)

Source, early cut-delayed cut		Std. mean difference [95% CI]
a) Without studies of Morris		
Blake et al. 2011, May-July	Auchenorrhyncha	-0.16 [-0.96 , 0.64]
Potts et al. 2009, May-July	Bumblebees	0.29 [-0.51 , 1.10]
Potts et al. 2009, May-July	Butterflies	0.70 [-0.12 , 1.53]
Potts et al. 2009, May-July	Butterfly.larvae	0.47 [-0.34 , 1.28]
Valtonen et al. 2006, July-Aug	Butterflies	0.99 [0.30 , 1.68]
Valtonen et al. 2006, July-Aug	Diurnal.moths	0.91 [0.22 , 1.60]
Woodcock et al. 2007, May-July	Beetles	0.28 [-0.52 , 1.09]
Sub-summary		0.53 [0.22 , 0.84]
b) Studies of Morris		
Morris 1979, May-July	Heteroptera	-3.13 [-5.20 , -1.06]
Morris 1981a, May-July	Auchenorhyncha	-3.67 [-5.95 , -1.40]
Summary		-0.05 [-0.89 , 0.78]



Conclusions and recommendations as regards delaying the first mowing date 1/2

- **Plant sp. richness:**
  - From spring to summer → effect +
  - From spring to fall, or from early summer to late summer, or from summer to fall → effect −
- **Invertebrate sp. richness:** → clear overall significant effect +
- **Invertebrate abundance:** → no overall influence, but … +

Conclusions and recommendations as regards delaying the first mowing date 2/2

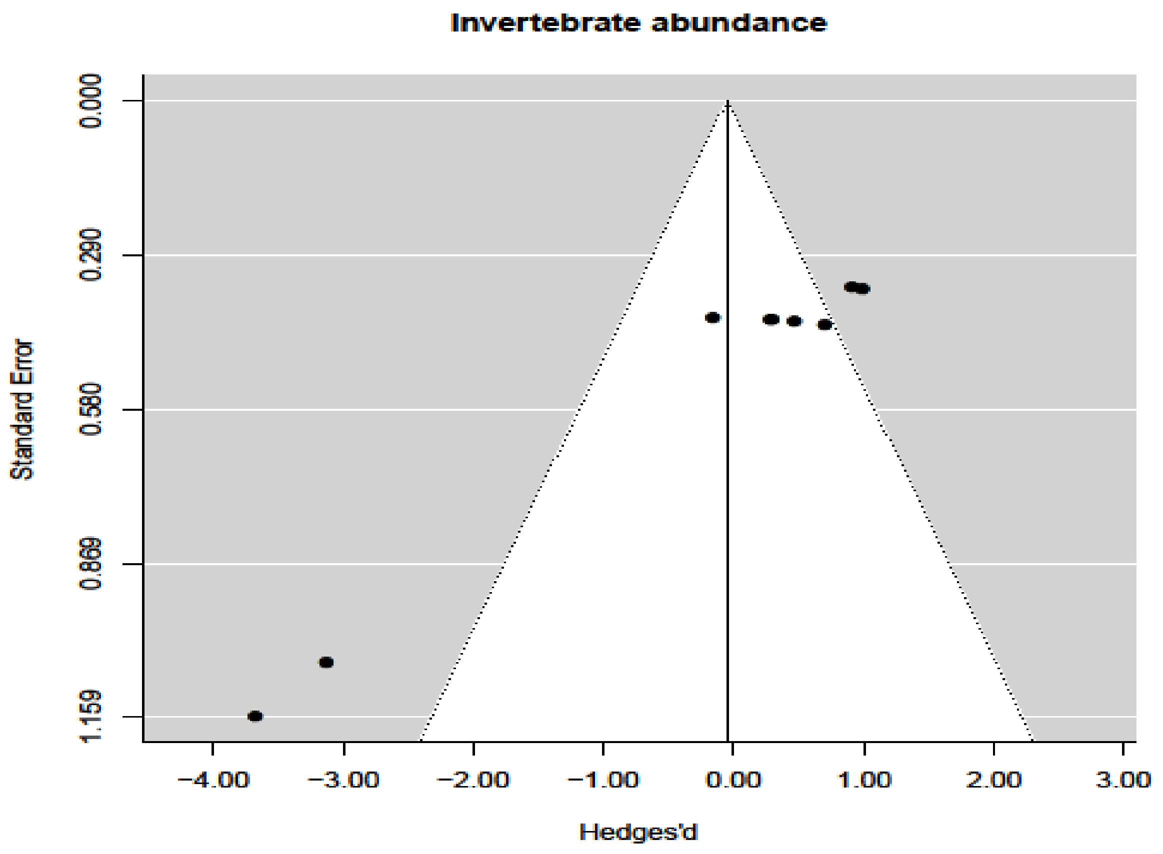
- We evidenced a high **between-study heterogeneity**, emphasizing that factors other than mowing date might play an important role.
- But these factors could not be investigated due to a too small sample size or strong bias. Theses factors deserve further investigations. Especially:
  - Meadow types (wet, meso, dry)
  - Specific invertebrate taxa
- Further long-term study are needed.

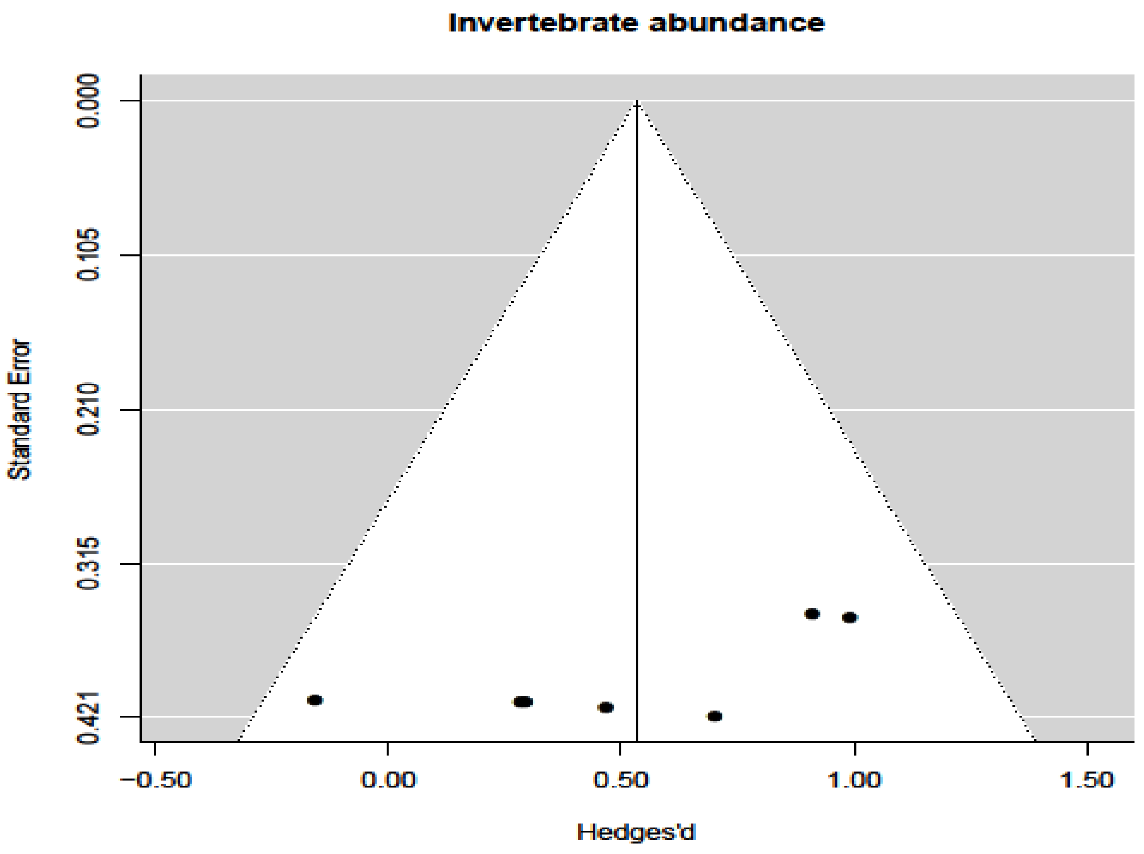
Acknowledgements

- **Co-authors, Judith Wunderlin** and my **colleagues** from Unibe
- **Swiss National Science Foundation**, the **Federal Office for the Environment** & the agricultural offices and/or environmental offices of the following cantons **AG**, **BE**, **BL**, **FR**, **NE**, **VD**, **VS**
- **Authors** of the compiled papers who provided additional info on their data

Thanks for your attention

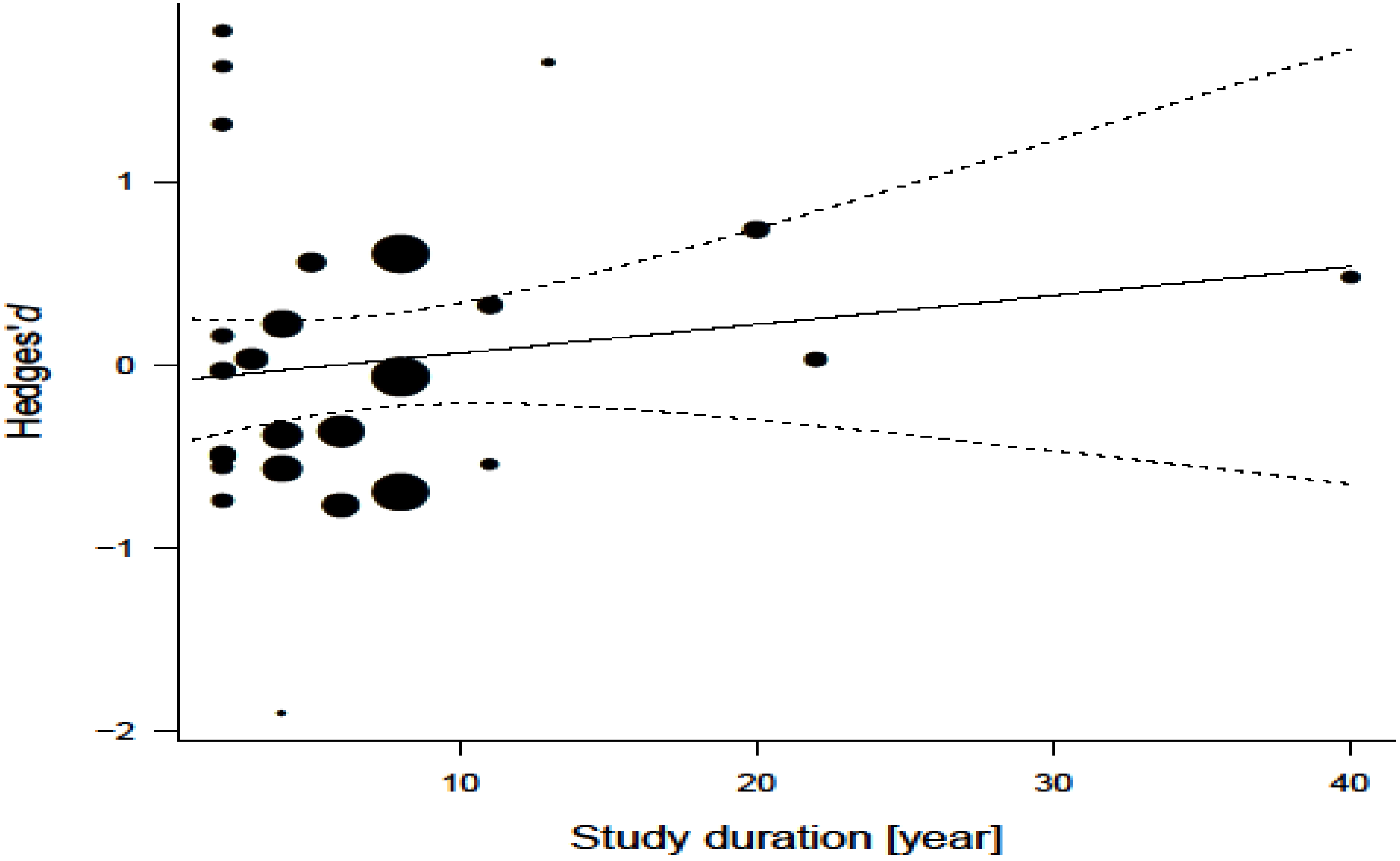
Funnel plots for invertebrate abundance





Results. Plant species richness (N = 26)

Hedges'd as a function of the study duration

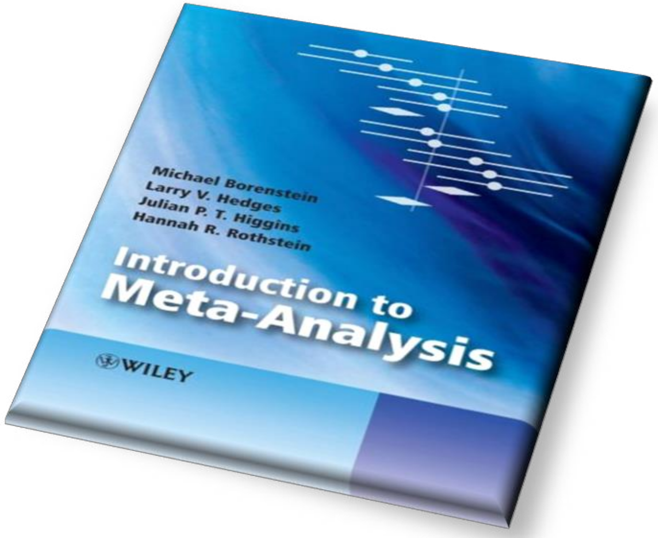


Hedges' *d* was used as effect size

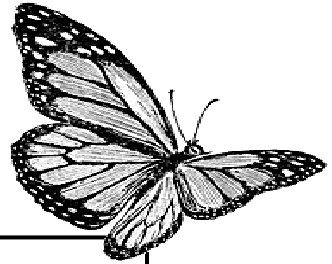
$$d = \frac{(X^{\mathrm{T}} - X^{\mathrm{C}})}{S} J$$

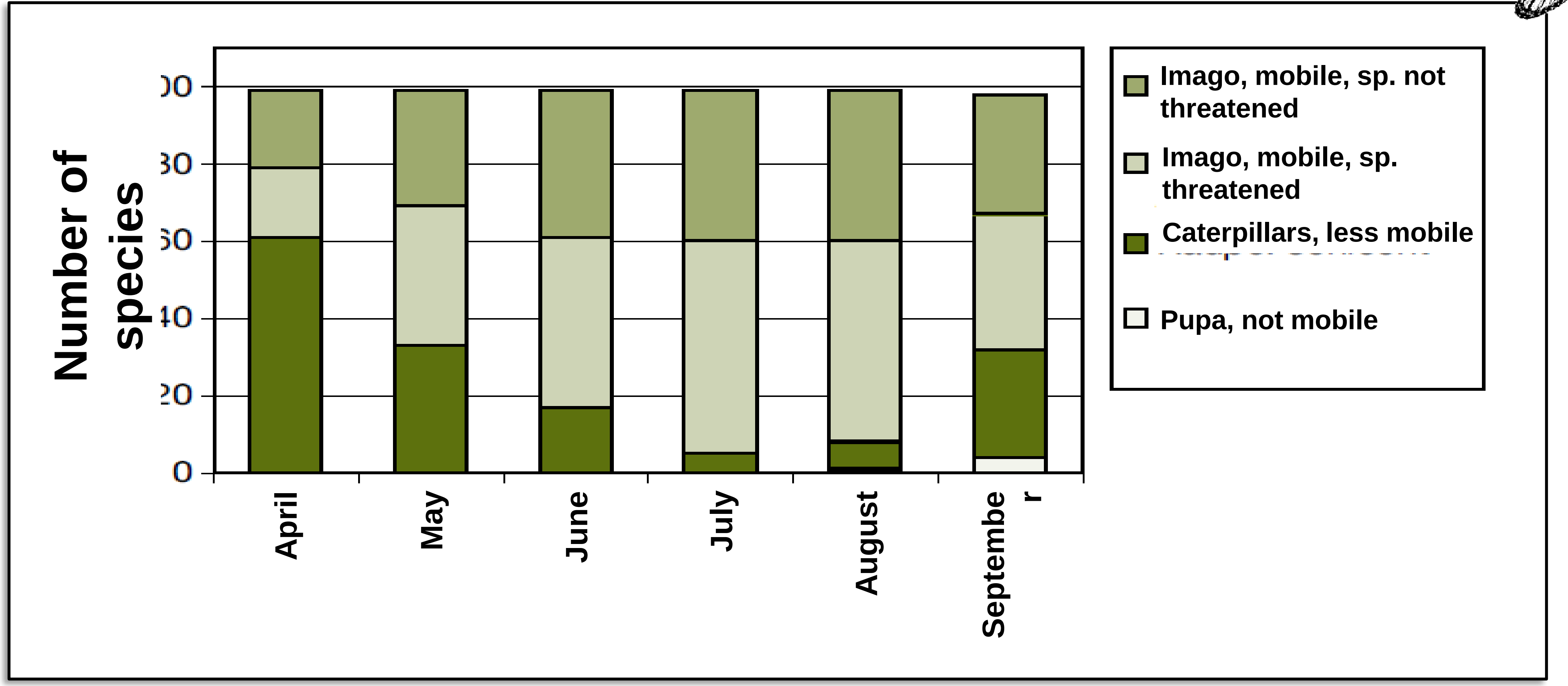
= Standardized difference between means in treatment (X^T) and control (X^C), divided by pooled standard deviation (S) and adjusted for sample size by correction term (J)

- Interpretation is subjective
  - $d = 0$ → no effect
  - $d < 0.2$ → small effect
  - $d \sim 0.5$ → moderate effect
  - $d > 0.8$ → large effect



Phenology of butterflies





Walter et al. 2007 *AGRARForschung*

Questions about Humbert et al. 2012 :

1) Is it as narrative review, a SR, a MA or a mix?
2) What are the subject, intervention, outcome and comparator?
3) What is the sampling unit?
4) What is the overall effect of delaying the first mowing date on plant species richness? (What is the effect size? And interpret it)

Exercises:

1) Run the code and try to interpret the output of the “summary(R.model.0)” in light of the related forest plot (Fig. 2 in the paper).
2) Run the model on plant species richness with only spring vs summer cuts:
   a. With Hedges'd as effect size (Fig. 2b in the paper).
   b. With the response ratio (lr) as effect size.
   c. Are results consistent?
3) In R, create/plot figure 3b of the paper.
   a. What is the slope (value)?
   b. Is it statistically significant?
   c. What is the 95% confidence interval of it?

Final question:

The SR concluded that [Overall, there was also strong between-study heterogeneity, pointing to other major confounding factors, the elucidation of which requires further field experiments …]

Potentially, what could be these sources of heterogeneity?

Data

SR_exercise_data.txt

R code

SR_exercise_R_code.txt

Associated papers

Humbert et al 2012 SR on delaying mowing.pdf

VIECHTBAUER-2010 Conducting Meta-Analyses in R with the metafor.pdf