Versailles, 2016

How to synthetize knowledge?

David Makowski
INRA

How to synthetize knowledge?

- Expert-based approach
- Modelling
- Narrative review
- Systematic review
- Meta-analysis

Research synthesis

Systematic review

« The application of strategies that limit bias in the assembly, critical appraisal, and synthesis of all relevant studies on a specific topic »

Chalmers et al., 2002

Meta-analysis

« The analysis of analyses »

« The statistical synthesis of the data from separate but similar, i.e. comparable studies, leading to a quantitative summary of the pooled results.

« The statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings »

« Statistical methods for combining the magnitudes of the outcomes (effect sizes) across different data sets addressing the same research question »

« Systematic review + statistical analysis »

Dictionary of epidemiology, 2001; Chalmers et al., 2002; Glass, 1976; Koricheva et al., 2013

Historical examples

James Lind (Scottish naval surgeon, 18th century)

As it is no easy matter to root out prejudices . . . it became requisite to exhibit a full and impartial view of what had hitherto been published on the scurvy, and that in a chronological order, by which the sources of these mistakes may be detected. Indeed, before the subject could be set in a clear and proper light, it was necessary to remove a great deal of rubbish. (p. x).

From Chalmers et al., 2002

Karl Pearson, 1904, about the effect of a vaccine against typhoid

Inoculation Against Enteric Fever

Correlation Between Immunity and Inoculation			
I.	Hospital staffs	+0.373	±0.021
II.	Ladysmith garrison	+0.445	±0.017
III.	Methuen's column	+0.191	±0.026
IV.	Single regiments	+0.021	±0.033
V.	Army in India	+0.100	±0.013
	Mean value	+0.226	
Correlation Between Mortality and Inoculation			
VI.	Hospital staffs	+0.307	±0.128
VII.	Ladysmith garrison	–0.010	±0.081
VIII.	Methuen's column	+0.300	±0.093
IX.	Single regiments	+0.119	±0.022
X.	Various military hospitals	+0.194	±0.022
XI.	Army in India	+0.248	±0.050
	Mean value	+0.226	

Yates, 1941, UK, on crop fertilisation

« as the war began and it became clear that phosphate and potash fertilizers were going to be extremely scarce, Yates with E. M. Crowther, the head of the Chemistry Department at Rothampsted, brought together and analyzed all the published experiments on fertilizer responses that they could lay their hands on (Yates&Crowther, 1941). . . . An example of its findings is the statement that the application of 1 cwt/acre of sulphate of ammonia at a cost of £4m would be expected to yield an extra crop to the value of £11m. As a result of this study, fertilizer rationing in the UK was placed on a rational basis and some of the survival of wartime Britain can be set to its credit ». Healy, 1995.

Criticisms

« An exercice of mega-silliness »

« Abandonment of scholarship »

« The problems of pooling, drowning, and floating »

« Meta-research: The art of getting it wrong»

→ Controversy about reaching generalizations from data, and the nature of scientific evidence

Why Most Published Research Findings Are False

PLoS Medicine, 2005

John P. A. Ioannidis

However, there are several approaches to improve the post-study probability.

Better powered evidence, e.g., large studies or low-bias meta-analyses, may help, as it comes closer to the

The Cochrane Collaboration
Trusted evidence. Informed decisions. Better health.

Oral herbal therapies for treating osteoarthritis Updated

Cameron M, Chrubasik S **Published Online:** 22 May 2014

Insufficient evidence to confirm an association between hormonal contraception and HIV acquisition New

Hofmeyr G, Singata M, Sneden J **Published Online:** 20 May 2014

"*The Cochrane Collaboration is an enterprise that rivals the Human Genome Project in its potential implications for modern medicine.*"

- The Lancet

Thousands meta-analyses are published every year in medical sciences.

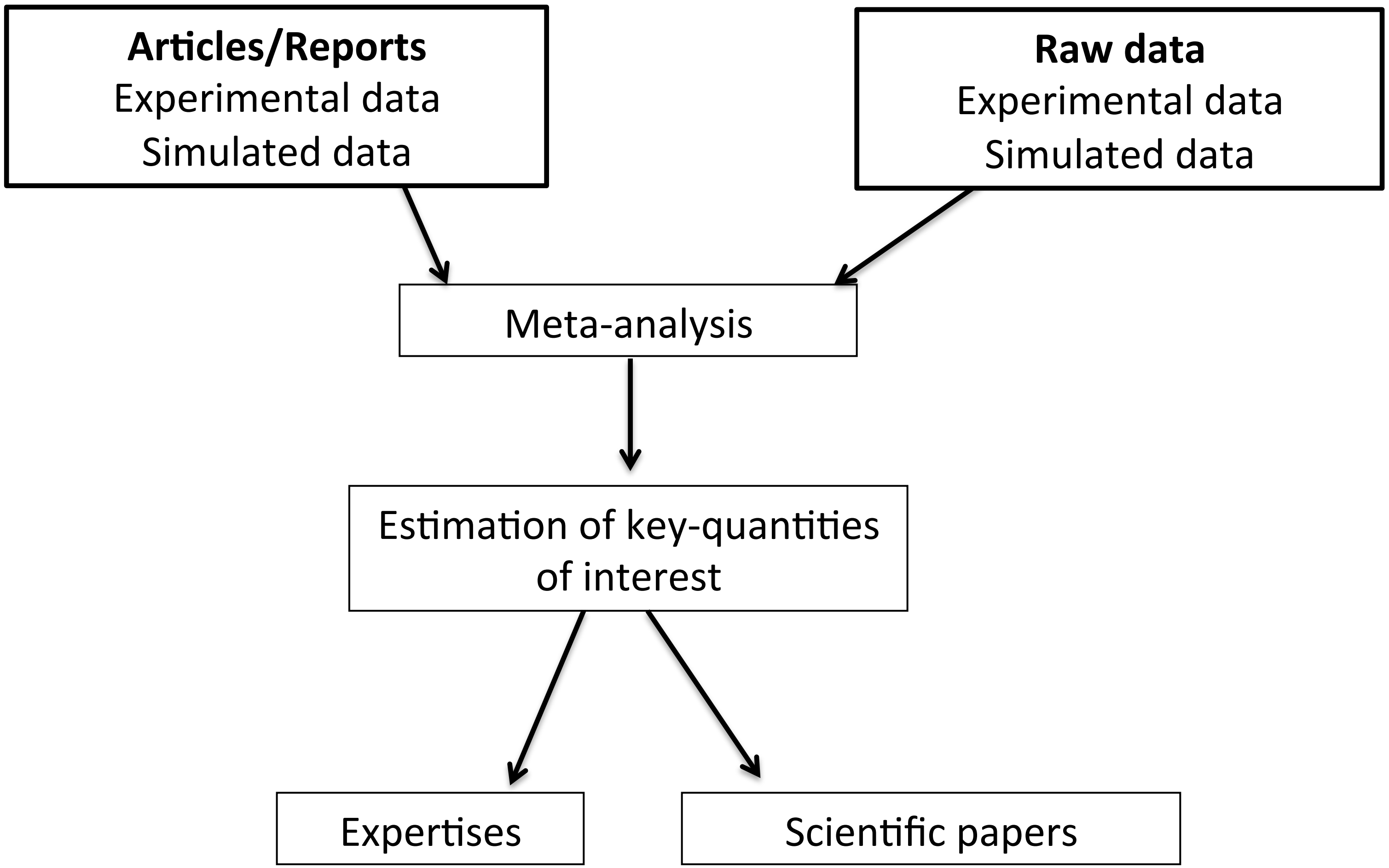
Hundreds meta-analyses are published every year in social sciences.

Evidence-based approach in environmental and agricultural science?

Meta-analysis could help environmental and agricultural scientists to weight evidences

The two main objectives of reseach synthesis

- Reduction of bias (to become more objective)
- Reduction of imprecision (to become more precise)



Articles/Reports
Experimental data
Simulated data
Raw data
Experimental data
Simulated data
Meta-analysis
Estimation of key-quantities of interest
Expertises
Scientific papers

Objective

- Estimation of effect sizes of treatments
- Analysis of the relationship between variables

Objective

- Estimation of effect sizes of treatments
- Analysis of the relationship between variables

Example 1

Effect size = Yield ratio

= Corn yield after cover crop / Corn yield after bare soil

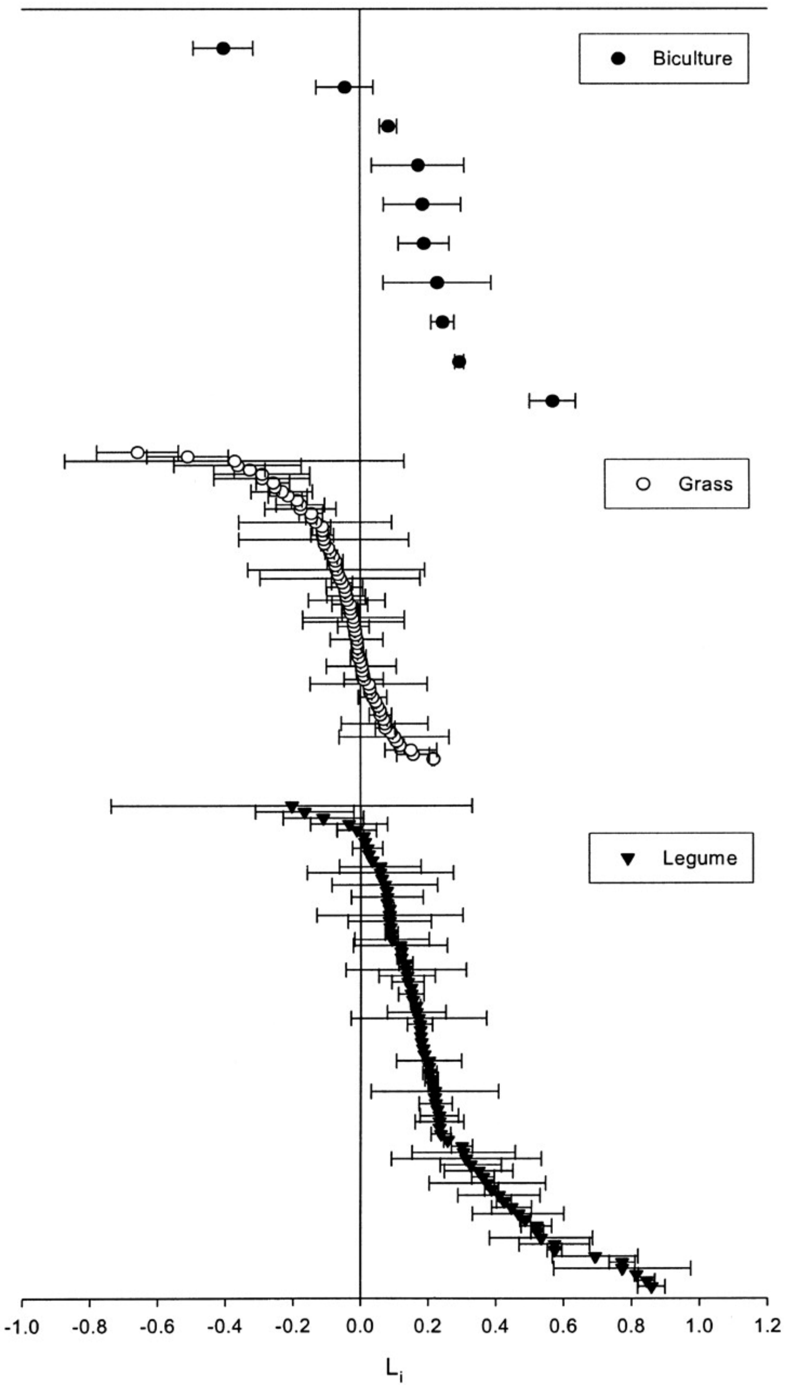
Effet des cultures intermédiaires sur le rendement

Table A1. Reference, year, location of the study, and winter cover crop (WCC) used for each study included in the meta-analysis database.

Publication	Year	Location	WCC†
Bowen et al.	1991	IN	G, L
Clark et al.	1994	Coastal Plain and Piedemont, MD	G, L, B
Clark et al.	1997	Coastal Plain and Piedemont, MD	G, L, B
Corak et al.	1991	Lexington, KY	L
Decker et al.	1994	Coastal Plain and Piedemont, MD	G, L
Drury et al.	2003	Ontario, Canada	L
Eckert	1988	Wooster, OH	G
Ewing et al.	1991	Saratoga and Rocky Mount, NC	L
Fleming et al.	1981	GA	L
Frye et al.	1985	Lexington, KY	G, L
Hivley and Cox	2001	NY	G, L
Holderbaum et al.	1990a	Salisbury, MD	L
Holderbaum et al.	1990b	Salisbury, MD	L
Johnson et al.	1998	Ames, IA	G
Jones et al.	1998	Hickory Corners, MI	G, B
Kuo and Jellum	2000	Puyallup, WA	G, L
Kuo and Jellum	2002	Puyallup, WA	G, L, B
Mitchell and Teel	1977	Georgetown, DE	G, L, B
Moschler et al.	1967	VA	G, L, B
Mt. Pleasant and Scott	1991	Aurora, NY	G, L
Ott and Hargrove	1989	GA	G, L
Power et al.	1991	Lincoln, NE	L
Raimbault et al.	1990	Ontario, Canada	G
Roberts et al.	1998	Milan, TN	G, L
Sainju and Singh	2001	Fort Valley, GA	L
Sarrantonio et al.	1988	Aurora, NY	L
Scott et al.	1987	Aurora, NY	G, L, B
Sullivan et al.	1991	Blacksburg, VA	G, L
Tollenaar et al.	1992	Ontario, Canada	G
Tollenaar et al.	1993	Ontario, Canada	G
Torbert et al.	1996	AL	G, L
Utomo et al.	1990	Lexington, KY	G, L
Varco et al.	1989	Lexington, KY	L
Vaughan and Evanylo	1999	Whitethorne and Orange, VA	G, L, B
Vyn et al.	1999	Ontario, Canada	G, L
Vyn et al.	2000	Ontario, Canada	G, L
Wagger	1989	McLeansville, NC	G, L

† G: grass winter cover crop, L: legume winter cover crop, B: biculture winter cover crops.

Meta-analysis de données issues de 37 articles
(Miguez & Bollero 2005)



Effect of cover crop on corn yield

(Miguez & Bollero 2005)

Logarithm of yield ratio

$$Li = \log\left(\frac{\text{Yield after cover crop}}{\text{Yield w/o cover crop}}\right)$$

pour biculture(10 observations),
grass (68 observations),
legume (82 observations)

Horizontal bar = variance

Example 2

Effect size = Yield ratio

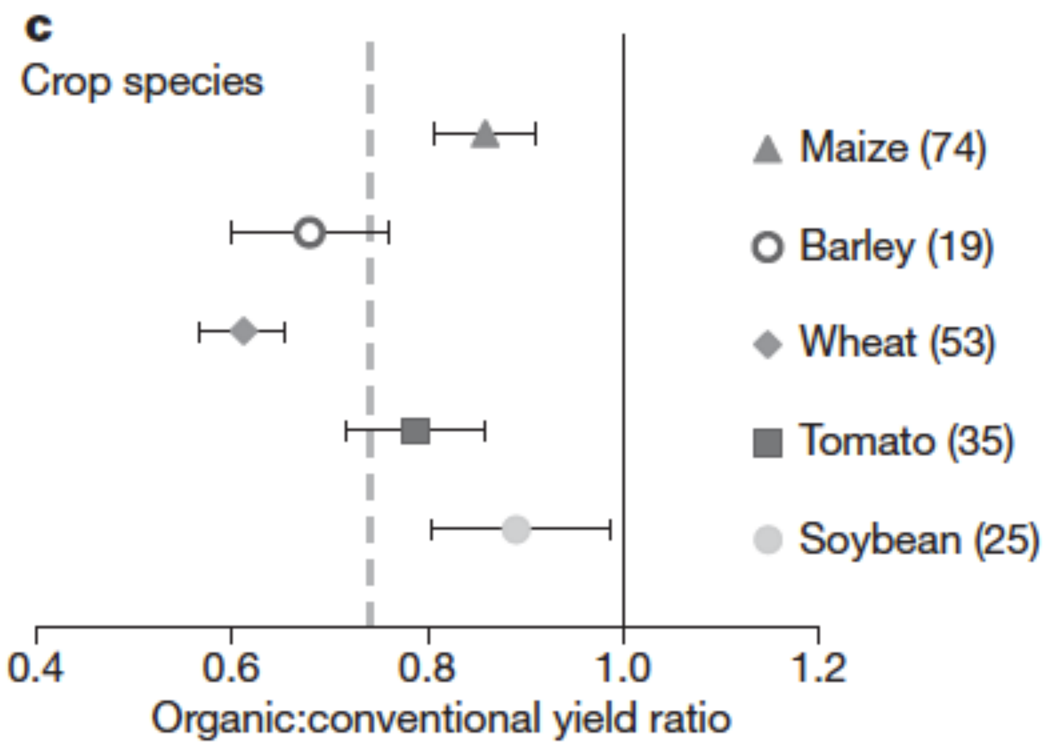
= Yield of organic crop / Yield of conventional crop

LETTER

doi:10.1038/nature11069

Comparing the yields of organic and conventional agriculture

Verena Seufert[1], Navin Ramankutty[1] & Jonathan A. Foley[2]



Nature, 2012

NATURE | LETTER

日本語要約

Comparing the yields of organic and conventional agriculture

Verena Seufert, Navin Ramankutty & Jonathan A. Foley

Affiliations | Contributions | Corresponding author

Nature **485**, 229–232 (10 May 2012) | doi:10.1038/nature11069

Received 06 November 2011 | Accepted 09 March 2012 | Published online 25 April 2012

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agricult

Verena Seufer

Affiliations | C

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PDF files

1. Supplementary Information (759K)

   This file contains Supplementary Figures 1-10, Supplementary Tables 1-14, a Supplementary Discussion and Supplementary References.

Excel files

1. Supplementary Data 1 (379K)

   This file contains data used in the meta-analysis. The data table shows the raw yield data, yield effect sizes and study information with categorical variables.

2. Supplementary Data 2 (231K)

   This file contains data that could not be used in the meta-analysis. The data table shows, in the spreadsheet 'exclusion6', study information and yield data of studies that were excluded because they did not meet selection criteria 6 (i.e. no information on an error term and sample size was available). In the spreadsheet 'exclusion1-5' information on studies that were excluded because they did not meet the basic selection criteria 1-5 (see methods) and the reason for exclusion is shown.

Example 3

Effect size = Bird abundance ratio

= Abundance in organic farm / Abundance in conventional farm

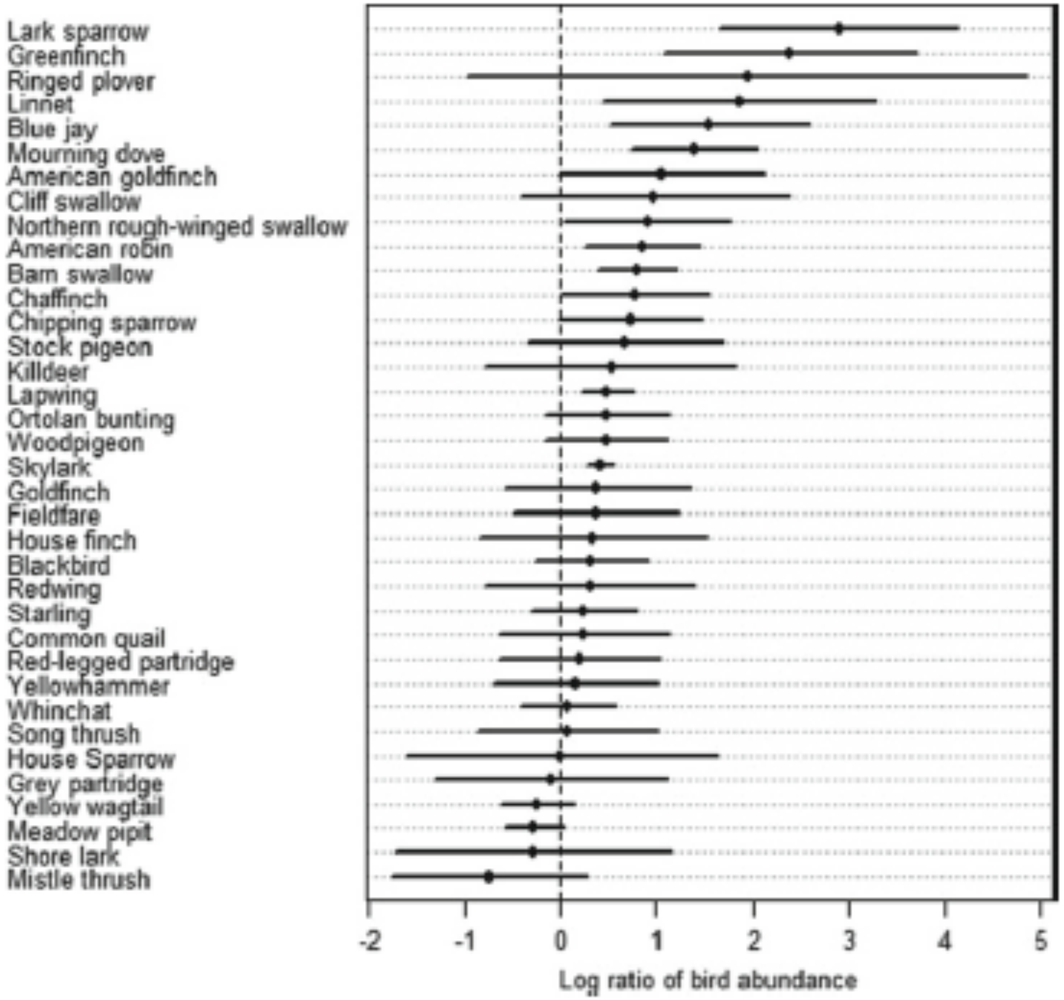


Fig. 2 Difference between organic and conventional farming for the different bird species used in the meta-analysis. The difference between the two farming systems was assessed using the Log ratio of species abundance between the organic system and conventional system. It was considered as significant if the 95 % CIs of the ratios did not overlap with zero. The error bars correspond to the 95 % confidence intervals. The log ratios were computed for a total of 36 species. Log ratios confidence intervals of 10 out of 36 species do not overlap zero, showing a significant positive effect of organic system on abundance

Wilcox et al., 2014

Example 4

Effect size = Yield ratio

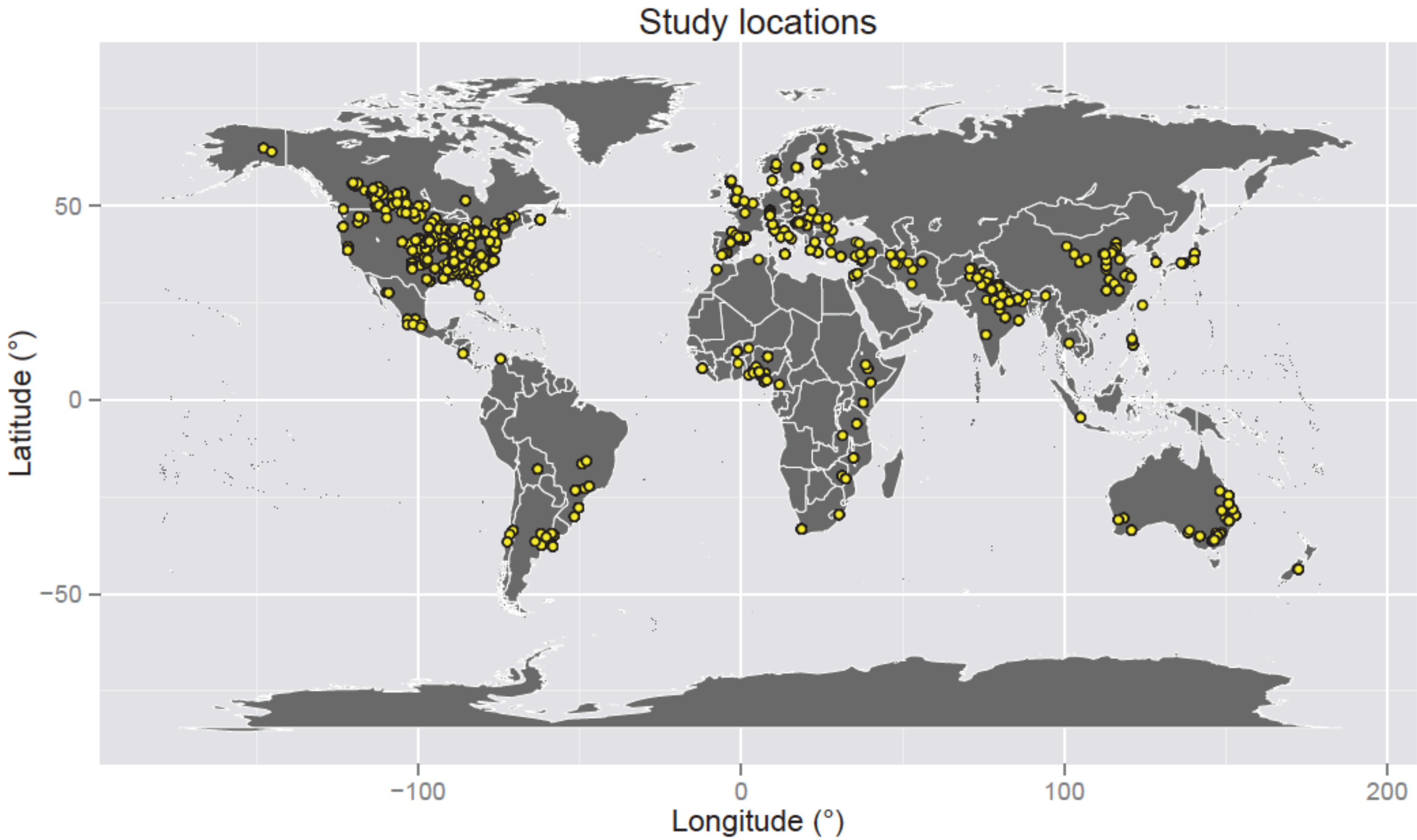
= Yield in no till system / Yield in conventional tillage system

LETTER

doi:10.1038/nature13809

Productivity limits and potentials of the principles of conservation agriculture

Cameron M. Pittelkow[1]*†, Xinqiang Liang[2]*, Bruce A. Linquist[1], Kees Jan van Groenigen[3], Juhwan Lee[4], Mark E. Lundy[1], Natasja van Gestel[3], Johan Six[4], Rodney T. Venterea[5,6] & Chris van Kessel[1]



Extended Data Figure 1 | The location of studies containing yield comparisons between no-till and conventional tillage systems used in the meta-analysis.

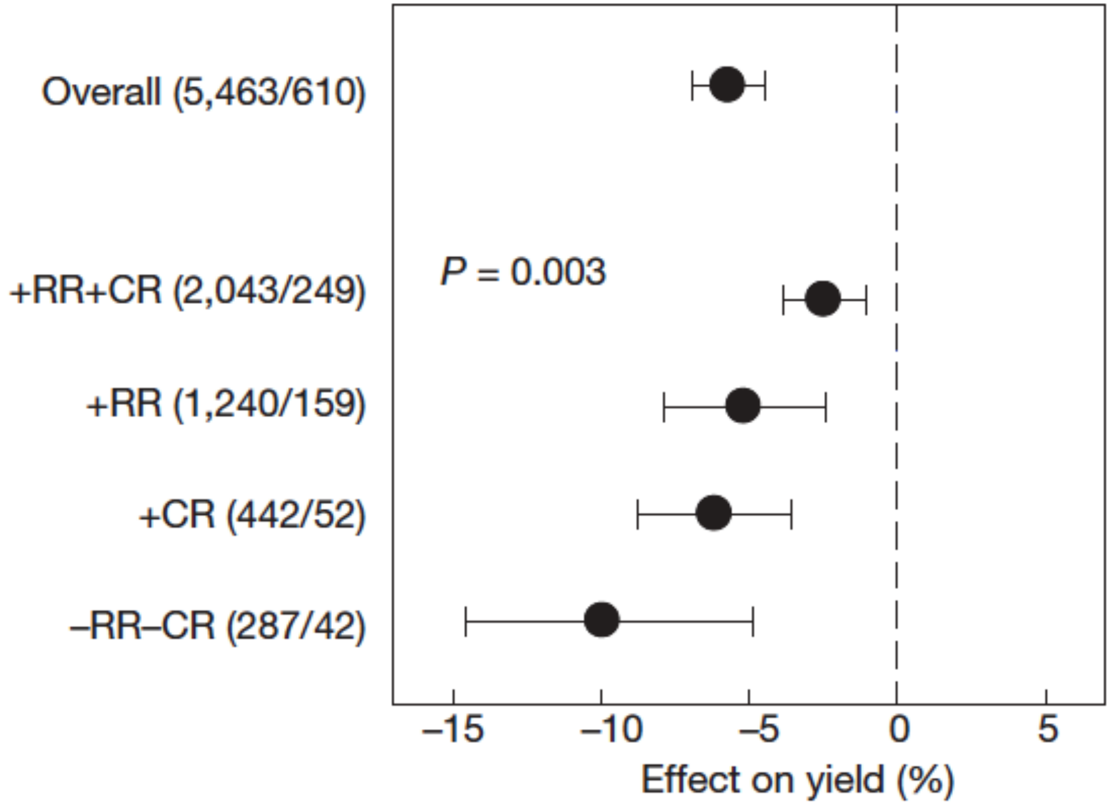


Figure 1 | Comparison of yield in no-till versus conventional tillage systems in relation to the other two principles of conservation agriculture. Results are shown for the entire data set (overall) and for subcategories of studies which indicated the presence or absence of residue retention and crop rotation for both no-till and conventional tillage systems: +RR+CR (residue retention + crop rotation), +RR (residue retention), +CR (crop rotation), or –RR–CR (without residue retention or crop rotation). The number of observations and total number of studies included in each category are displayed in parentheses. Error bars represent 95% confidence intervals. Significant differences between categories are indicated by *P* values based on randomization tests.

Example 5

Effect size = Farmers' profit ratio

= Profit with GMO crop / Profit without GMO

OPEN ACCESS Freely available online

PLOS ONE

A Meta-Analysis of the Impacts of Genetically Modified Crops

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Abstract

Background: Despite the rapid adoption of genetically modified (GM) crops by farmers in many countries, controversies about this technology continue. Uncertainty about GM crop impacts is one reason for widespread public suspicion.

Objective: We carry out a meta-analysis of the agronomic and economic impacts of GM crops to consolidate the evidence.

Data Sources: Original studies for inclusion were identified through keyword searches in ISI Web of Knowledge, Google Scholar, EconLit, and AgEcon Search.

Study Eligibility Criteria: Studies were included when they build on primary data from farm surveys or field trials anywhere in the world, and when they report impacts of GM soybean, maize, or cotton on crop yields, pesticide use, and/or farmer profits. In total, 147 original studies were included.

Synthesis Methods: Analysis of mean impacts and meta-regressions to examine factors that influence outcomes.

Results: On average, GM technology adoption has reduced chemical pesticide use by 37%, increased crop yields by 22%, and increased farmer profits by 68%. Yield gains and pesticide reductions are larger for insect-resistant crops than for herbicide-tolerant crops. Yield and profit gains are higher in developing countries than in developed countries.

Limitations: Several of the original studies did not report sample sizes and measures of variance.

Conclusion: The meta-analysis reveals robust evidence of GM crop benefits for farmers in developed and developing countries. Such evidence may help to gradually increase public trust in this technology.

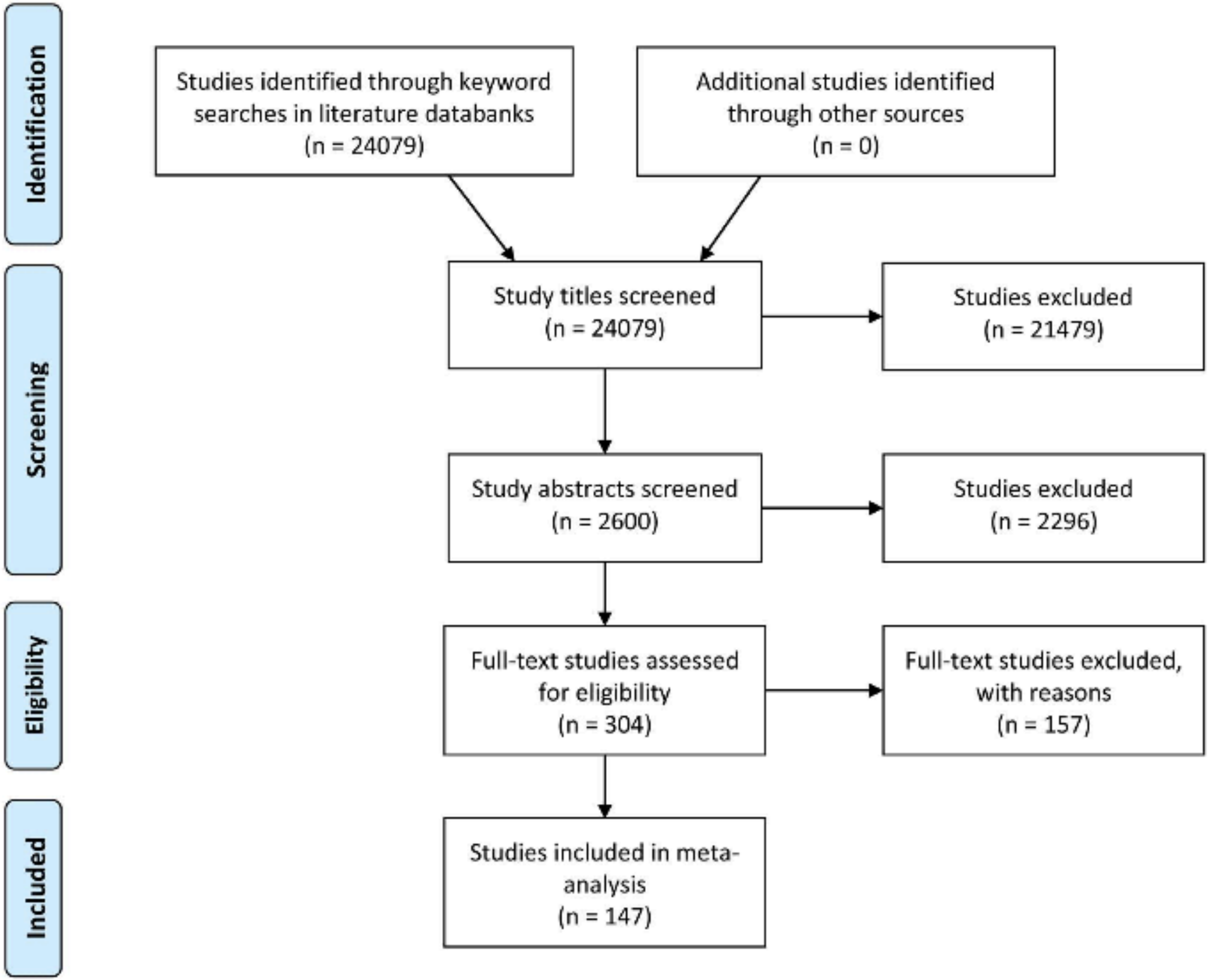


Figure 1. Selection of studies for inclusion in the meta-analysis.
doi:10.1371/journal.pone.0111629.g001

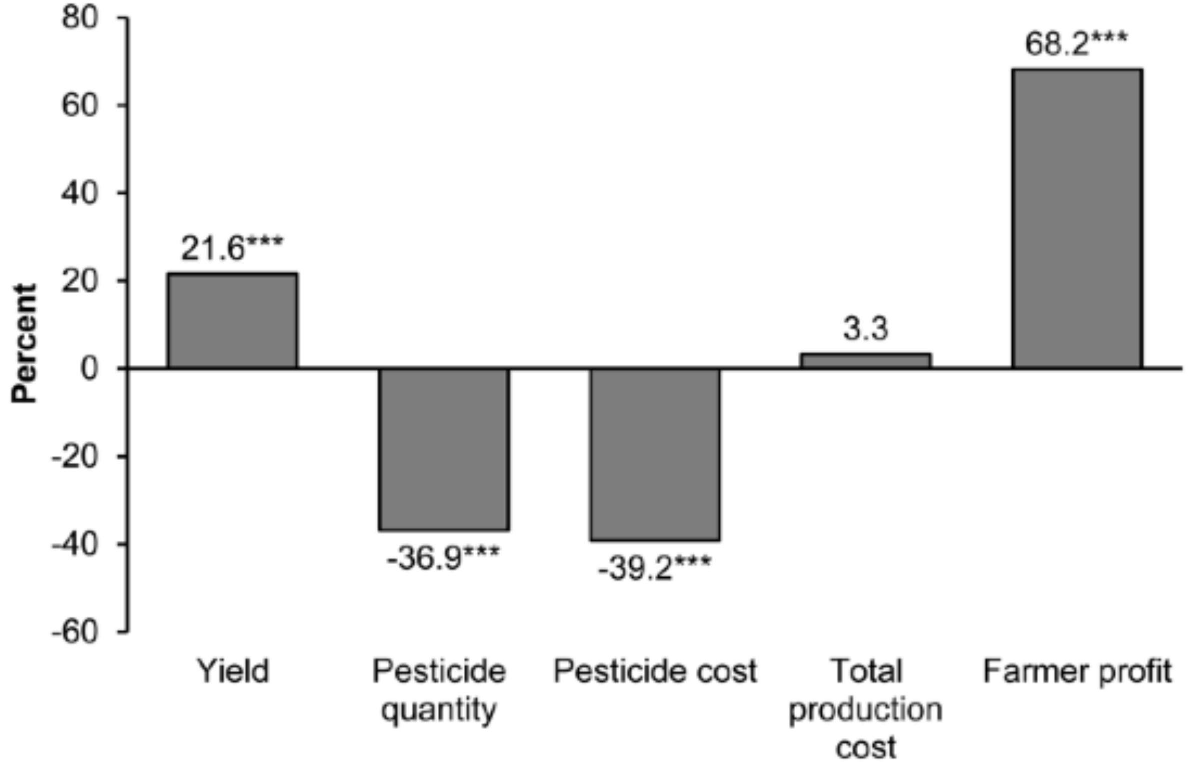


Figure 2. Impacts of GM crop adoption. Average percentage differences between GM and non-GM crops are shown. Results refer to all GM crops, including herbicide-tolerant and insect-resistant traits. The number of observations varies by outcome variable; yield: 451; pesticide quantity: 121; pesticide cost: 193; total production cost: 115; farmer profit: 136. *** indicates statistical significance at the 1% level.
doi:10.1371/journal.pone.0111629.g002

Objective

- Estimation of effect sizes of treatments
- Analysis of the relationship between variables

Example 6

N_2O emission = *f*(N fertilizer dose)

IPCC – Tier 1 method

$$Y = EF.X$$

Y	N_2O emissions in kg N_2O-N ha^{-1} $year^{-1}$
X	amount of synthetic and organic N applied in kg N ha^{-1} $year^{-1}$
EF	emission factor (amount of N_2O emitted per unit of applied N in kg N_2O-N/kg N)

- In 1999, EF was fixed at 1.25% (Bouwman, 1996)
- In 2006, EF decreased at 1% (Stehfest & Bouwman, 2006)

Effect N fertilizer dose on N_2O emission (Bouwman et al. 1996)

Emission =1 + 0.0125 Dose

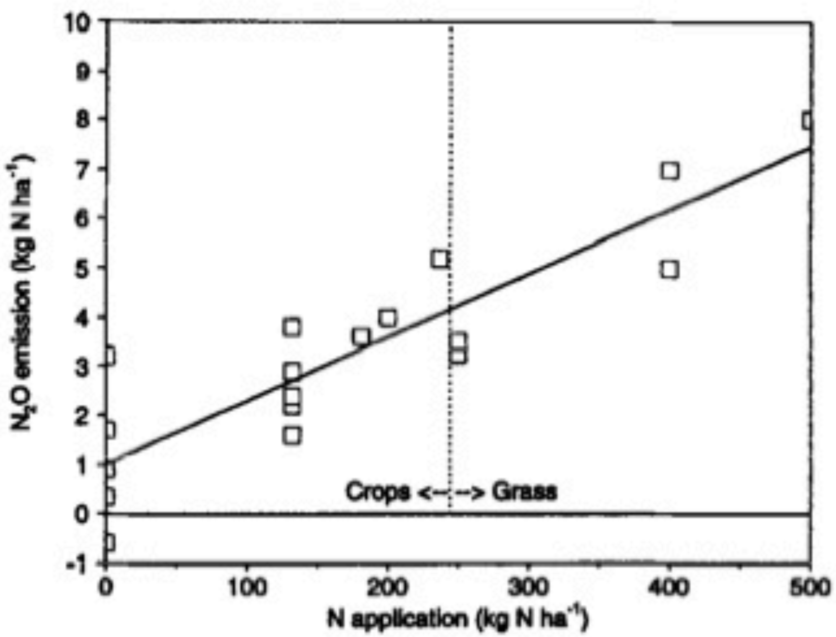


TABLE 4.17
UPDATED DEFAULT EMISSION FACTORS TO ESTIMATE DIRECT N_2O EMISSIONS FROM AG

Emission Factor	IPCC Default Value (EF_1 in kg N_2O-N/kg N) (EF_2 in kg N_2O-N/ha-yr)
EF_1 for F_{SN}	1.25%
EF_1 for F_{SN} when applied to fields already receiving organic fertiliser/animal manure (applied or grazing)	1.25%
EF_1 for F_{AM}	1.25%
EF_1 for F_{BN}	1.25%
EF_1 for F_{CR}	1.25%
EF_2 for Mid-Latitude Organic Soils	5
EF_2 for Tropical Organic Soils	10

Source: *IPCC Guidelines*, Klemedtsson *et al.* (1999), Clayton *et al.* (1997).

GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 16, NO. 4, 1058, doi:10.1029/2001GB001811, 2002

Emissions of N_2O and NO from fertilized fields: Summary of available measurement data

A. F. Bouwman and L. J. M. Boumans
National Institute for Public Health and the Environment, Bilthoven, Netherlands

N. H. Batjes
International Soil Reference and Information Centre (ISRIC), Wageningen, Netherlands

Received 17 October 2001; revised 27 February 2002; accepted 27 February 2002; published 18 October 2002.

[1] Information from 846 N_2O emission measurements in agricultural fields and 99 measurements for NO emissions was summarized to assess the influence of various factors regulating emissions from mineral soils. The data indicate that there is a strong increase of both N_2O and NO emissions accompanying N application rates, and soils with high
restri
(thou
favor
NO,
Rega
effec
emissions than less intensive measurements (2–3 per week). The available data can be used to develop simple models based on the major regulating factors which describe the spatial variability of emissions of N_2O and NO with less uncertainty than emission factor approaches based on country N inputs, as currently used in national emission inventories.

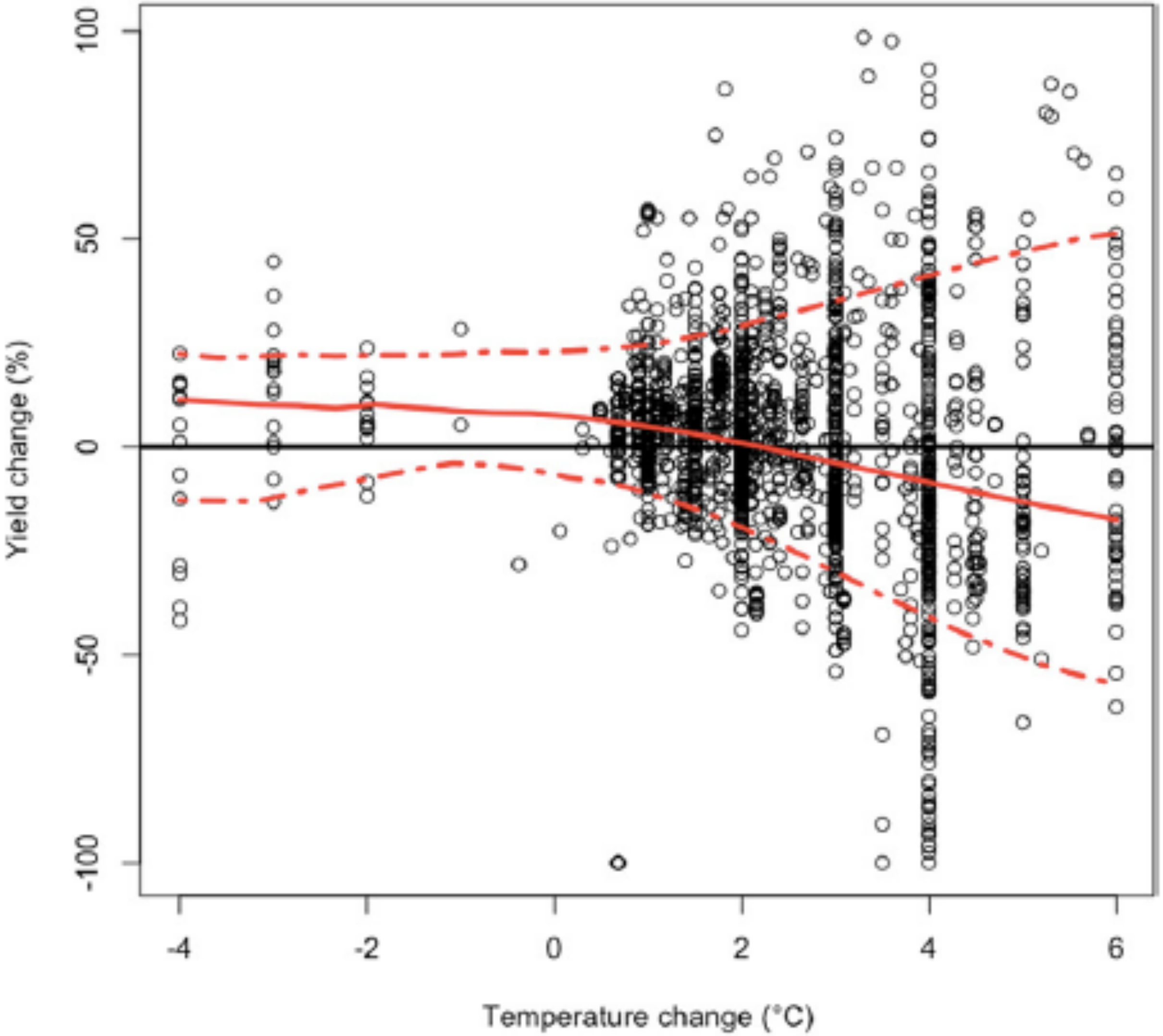
INDEX TERMS: 0315 Atmospheric Composition and Structure: Biosphere/atmosphere

Dataset

> Download the N_2O and NO emission data set (XLS, 1,5MB)

Example 7

Yield change = f(climate change)



Wilcox and Makowski (2014)

Main steps of a meta-analysis

- Definition of the objective
- Systematic review
- Data selection and extraction
- Statistical analysis
- Assessment of risk of publication bias and sensitivity analysis
- Presentation of results and of associated uncertainties

Main steps

- **Definition of the objective**
  - **Definition of the quantity of interest (response variable, ratio etc.)**
  - **Definition of explanatory variables**
  - **Population**
- Systematic review
- Data selection and extraction
- Statistical analysis
- Assessment of risk of publication bias and sensitivity analysis
- Presentation of results and of associated uncertainties

Value in the experimental treatment

$$R = \frac{X_E}{X_C}$$

Value in the control treatment

Yield in organic system

$$R = \frac{X_E}{X_C}$$

Yield in conventional system

$$R = \frac{X_E}{X_C}$$

X_E: Yield of a crop grown after a cover crop

X_C: Yield of crop grown directly after another crop

$$R = \frac{X_E}{X_C}$$

Number of insects in a GM crop

Number of insects in a non-GM crop

Bird abundance in organic farms

$$R = \frac{X_E}{X_C}$$

Bird abundance in conventional farms

Response variable

$$Y = f(X)$$

Explanatory variable(s)

N_2O emission

$$Y = \alpha_0 + \alpha_1 X$$

Nitrogen fertilizer dose

N_2O emission

$$Y = \exp(\alpha_0 + \alpha_1 X)$$

Nitrogen fertilizer dose

N_2O emission

Soil organic content

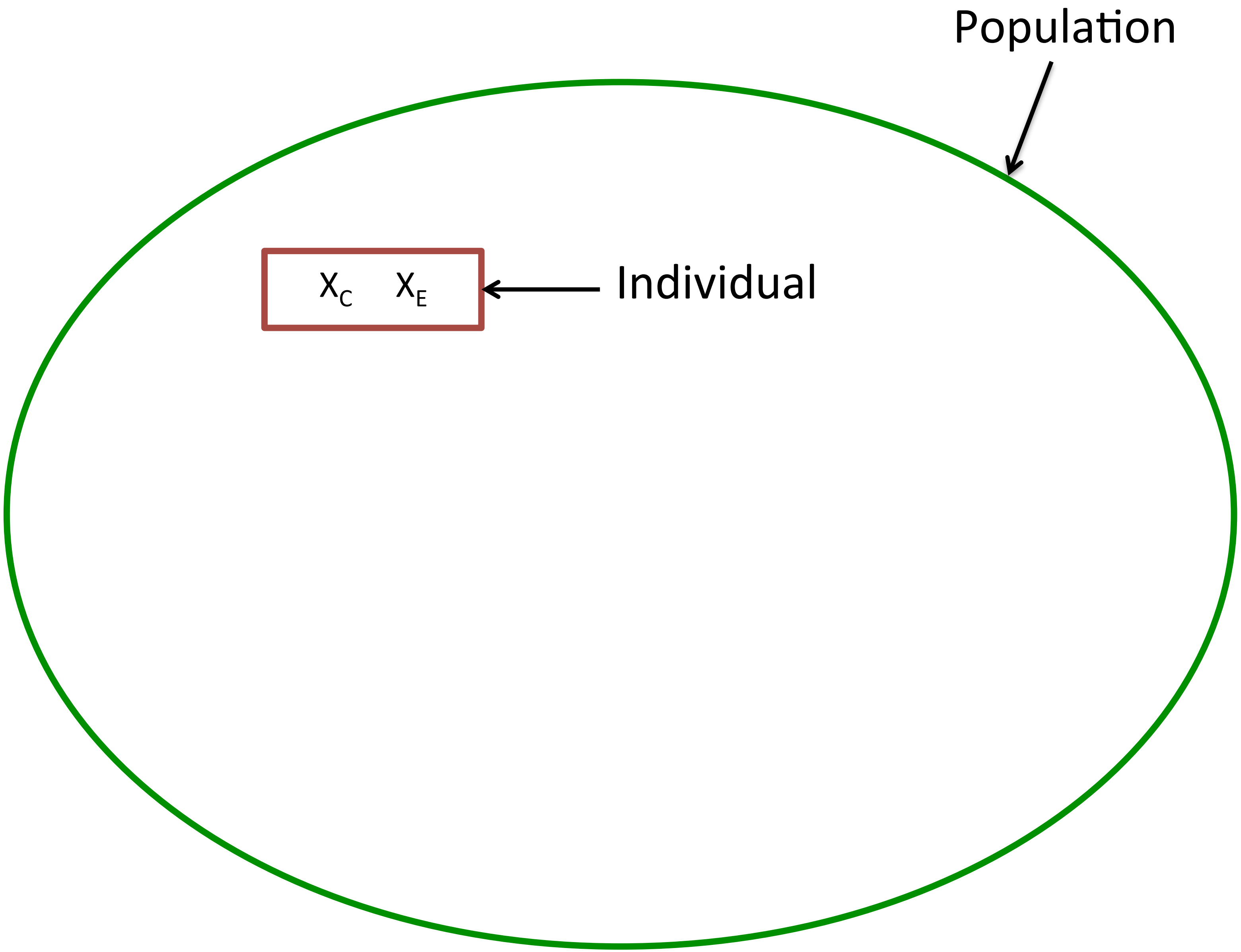
$$Y = \exp(\alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \ldots)$$

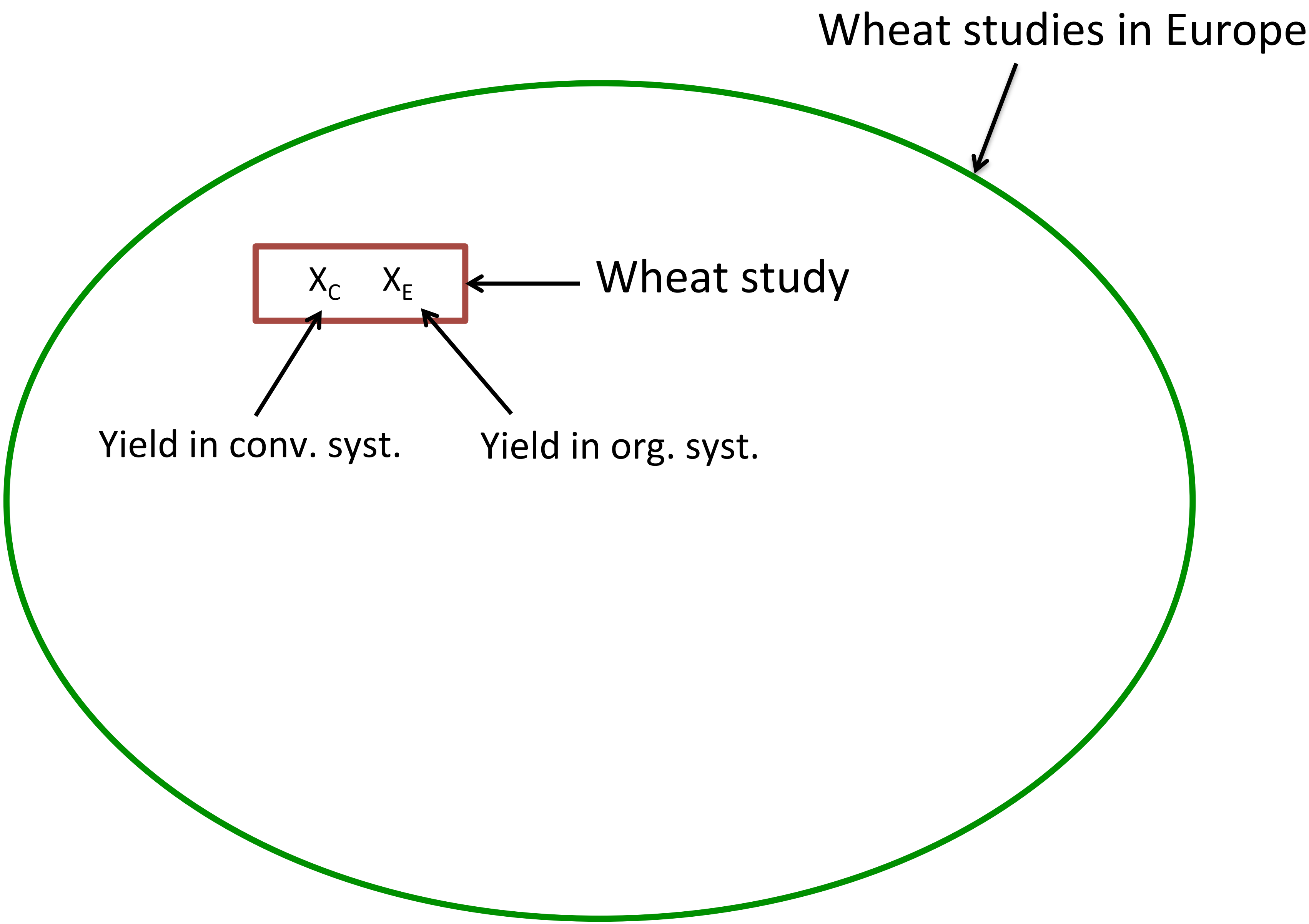
Nitrogen fertilizer dose

Proportion of diseased plants

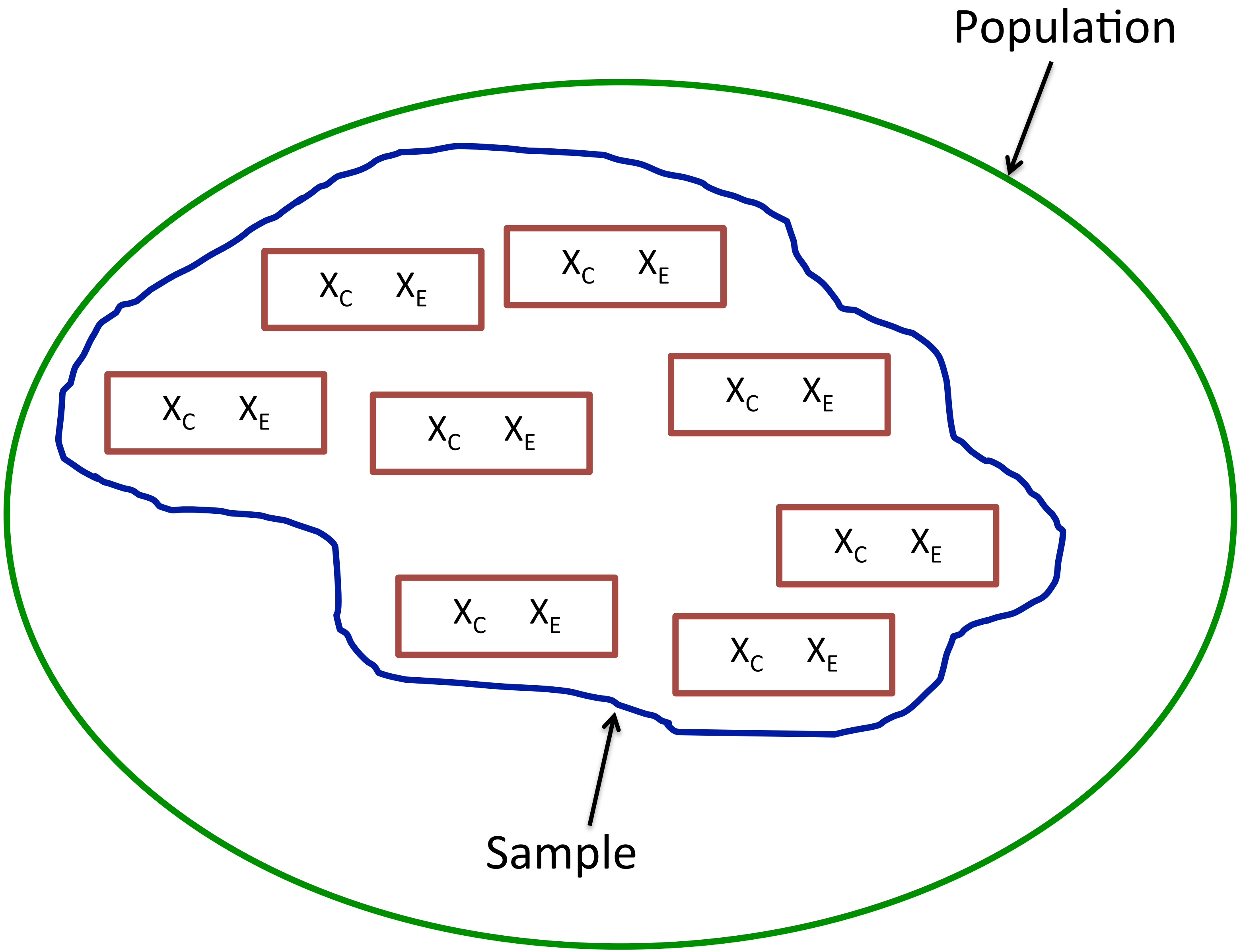
Dose of fungicide

$$\log \frac{Y}{1-Y} = \alpha_0 + \alpha_1 X$$


Population
X_C X_E
Individual



Wheat studies in Europe
X_C X_E
Wheat study
Yield in conv. syst.
Yield in org. syst.


Population
X_C X_E
X_C X_E
X_C X_E
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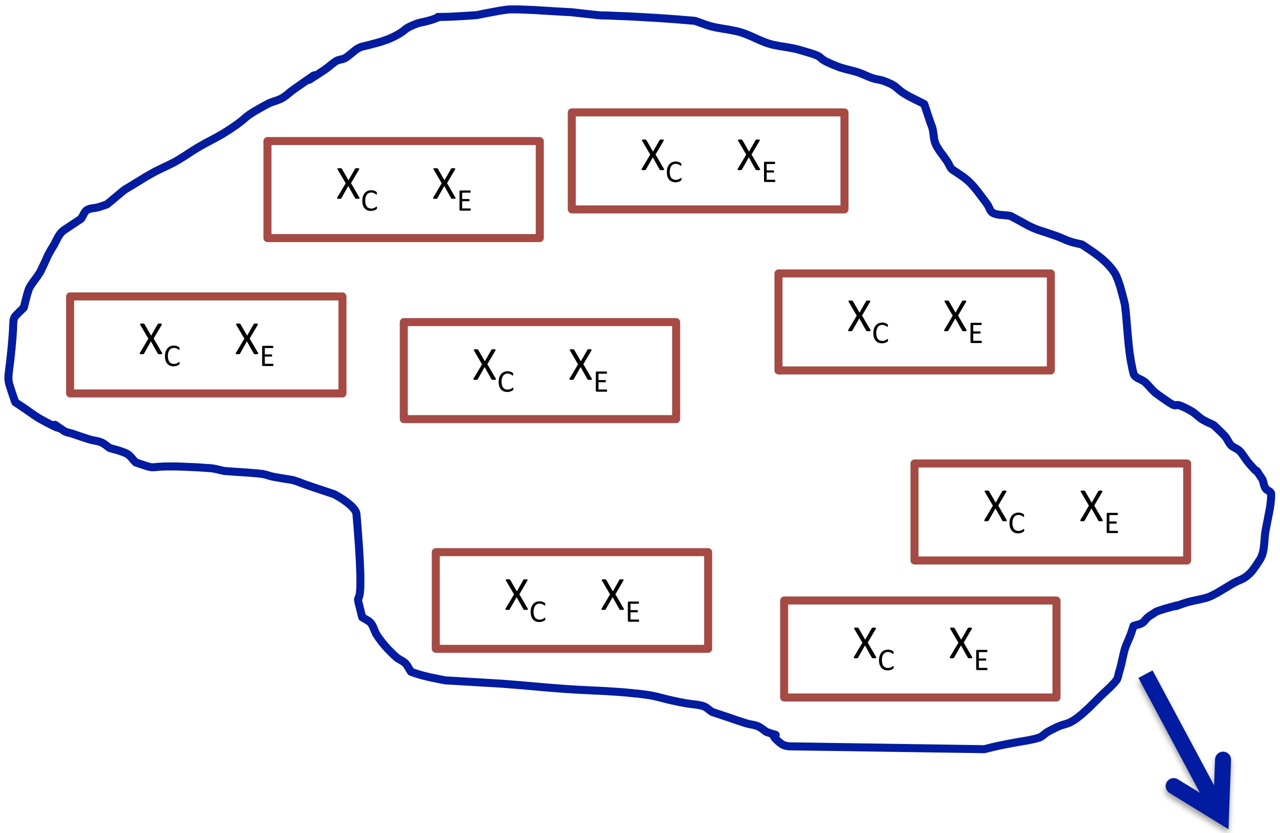
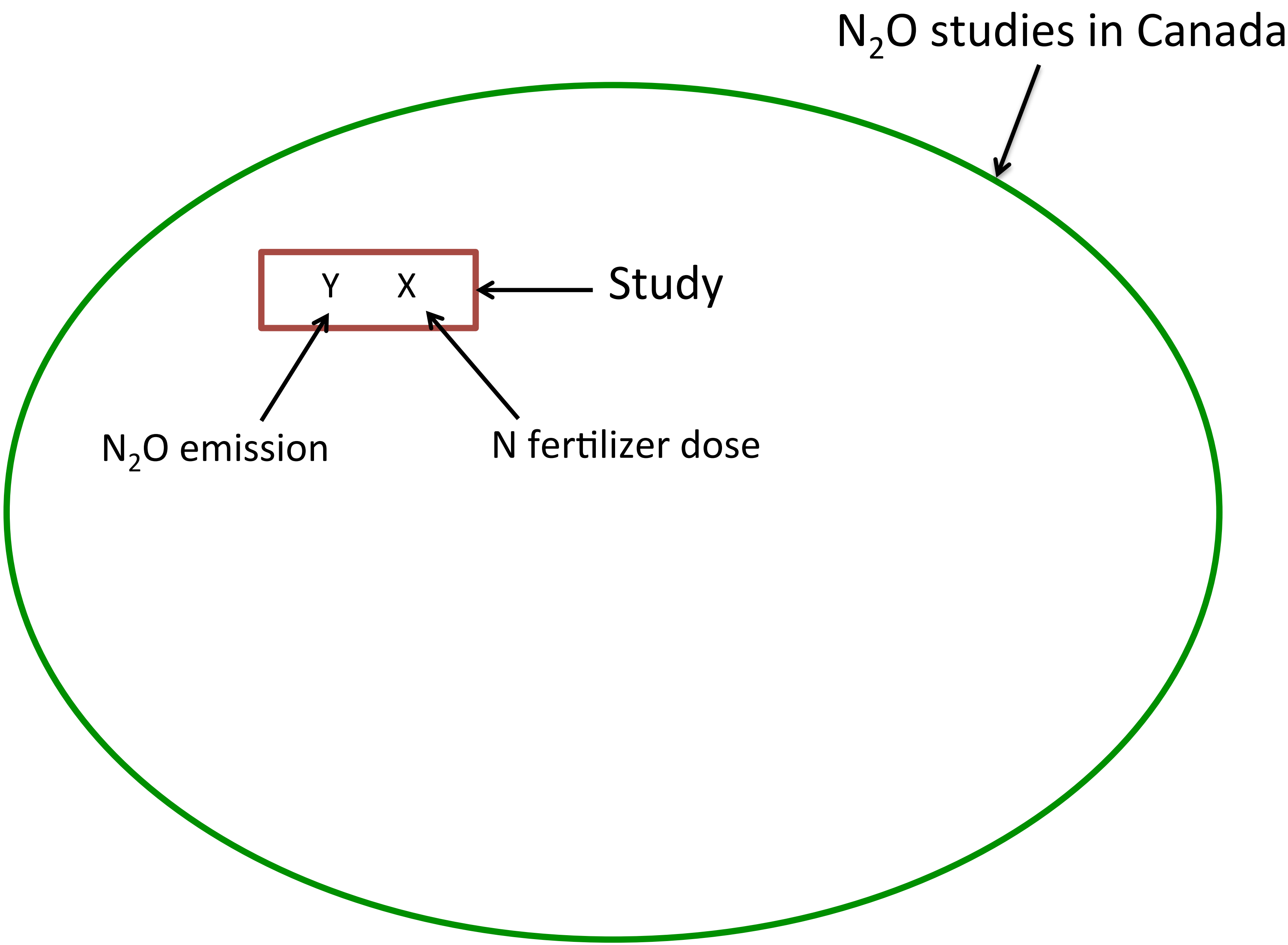
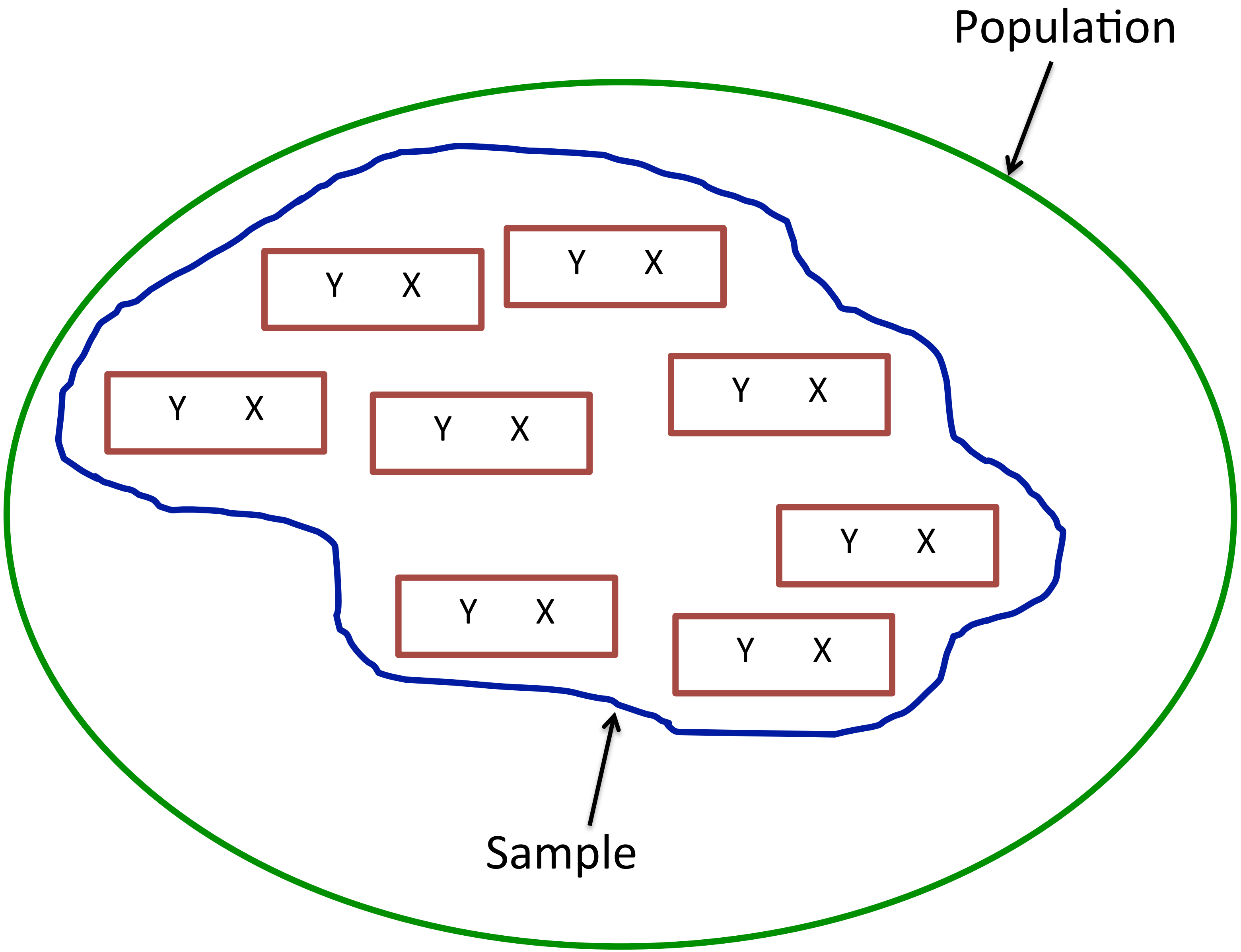
X_C X_E
X_C X_E
X_C X_E
Sample

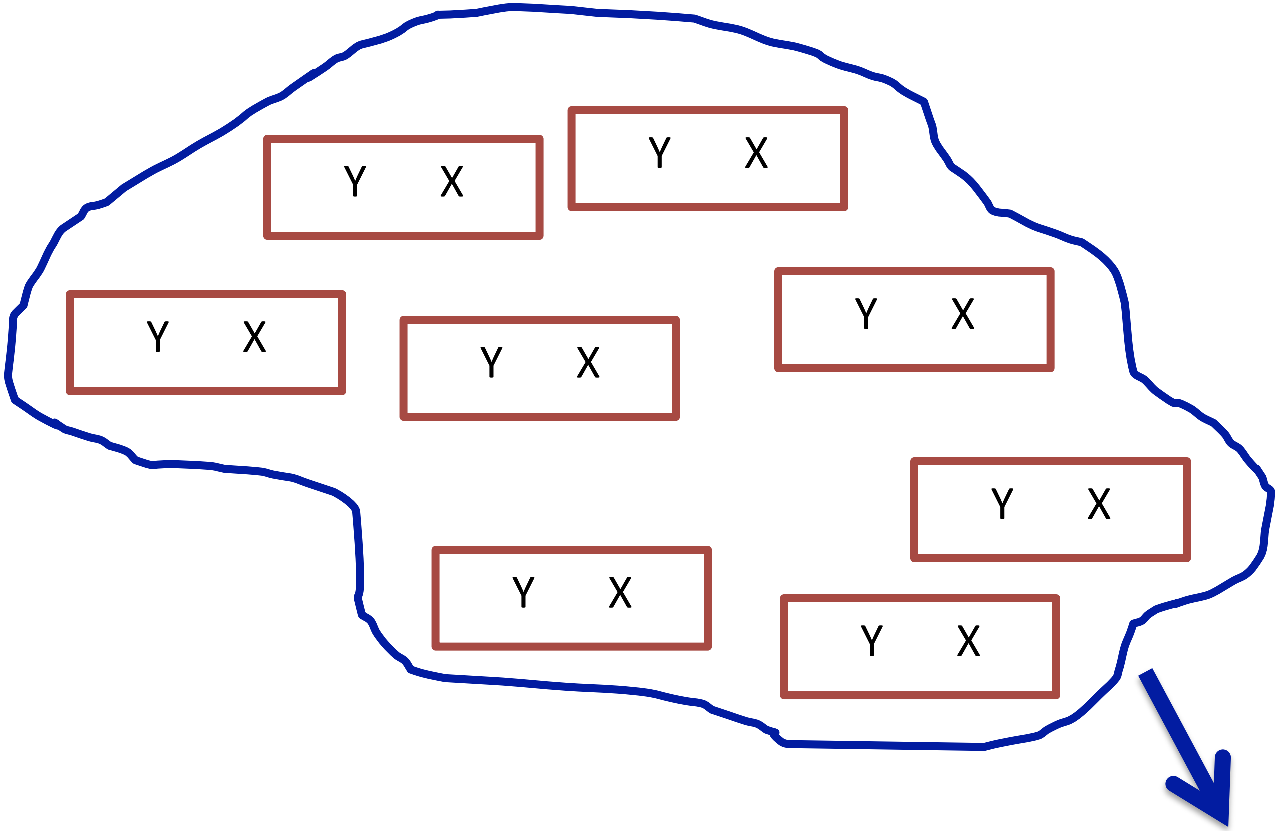


Estimation of $E\left(\frac{X_E}{X_C}\right)$



N_2O studies in Canada
Y
X
Study
N_2O emission
N fertilizer dose


Population
Y X
Y X
Y X
Y X
Y X
Y X
Y X
Y X
Sample



Estimation of $Y = \alpha_0 + \alpha_1 X$

PICO method (Counsell, 1997)

Population, Intervention, Comparator, Outcome

P.I.C.O. Model for Clinical Questions

P	Patient, Population, or Problem	How would I describe a group of patients similar to mine?
I	Intervention, Prognostic Factor, or Exposure	Which main intervention, prognostic factor, or exposure am I considering?
C	Comparison or Intervention (if appropriate)	What is the main alternative to compare with the intervention?
O	Outcome you would like to measure or achieve	What can I hope to accomplish, measure, improve, or affect?

Main steps

- Definition of the objective
- **Systematic review**
  - **Definition of a litterature search equation**
  - **Paper listing**
  - **Addition of unpublished studies**
- Data selection and extraction
- Statistical analysis
- Assessment of risk of publication bias and sensitivity analysis
- Presentation of results and of associated uncertainties

Main steps

- Definition of the objective
- Systematic review
- **Data selection and extraction**
  - **Definition of selection criteria**
  - **Selection of relevant studies**
  - **Data extraction**
- Statistical analysis
- Assessment of risk of publication bias and sensitivity analysis
- Presentation of results and of associated uncertainties

A meta-analysis of the predicted effects of climate change on wheat yields using simulation studies

Julia Wilcox[a,b], David Makowski[a,*]

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[b] INRA, UREP, n 5, Chemin de Beaulieu, 63100 Clermont-Ferrand, France

2. Materials and methods

2.1. Literature review

We performed a literature search to compile peer-reviewed journal articles describing the response of wheat to climate change simulated using computer models. The following keywords were used to search the literature: yield, nitrogen use efficiency, water use efficiency, disease, grain, climate change, global warming, wheat, *Triticum aestivum*, and model. We found 639 articles using these keywords in ISI Web of Science in May 2012. For inclusion into the meta-analysis, the articles had to meet the following criteria: (1) The article needed to contain at least one response variable from the following list: wheat yield, grain number, grain weight, grain protein, disease, water use efficiency, nitrogen use efficiency, or growing period. (2) The articles needed to study the effect of at least one climate variable, including CO_2 concentration, temperature change, or precipitation change. (3) The study had to compare the effects of current and future climate on the response variable using modeling techniques. Although we attempted to extract data from the literature that used many different response variables, we only found sufficient data on wheat yields. Using the above criteria, 90 articles were found with yield data suitable for the meta-analysis.

2. Materials and methods

Search

2.1. Literature review

We performed a literature search to compile peer-reviewed journal articles describing the response of wheat to climate change simulated using computer models. The following keywords were used to search the literature: yield, nitrogen use efficiency, water use efficiency, disease, grain, climate change, global warming, wheat, *Triticum aestivum*, and model. We found 639 articles using these keywords in ISI Web of Science in May 2012. For inclusion into the meta-analysis, the articles had to meet the following criteria: (1) The article needed to contain at least one response variable from the following list: wheat yield, grain number, grain weight, grain protein, disease, water use efficiency, nitrogen use efficiency, or growing period. (2) The articles needed to study the effect of at least one climate variable, including CO_2 concentration, temperature change, or precipitation change. (3) The study had to compare the effects of current and future climate on the response variable using modeling techniques. Although we attempted to extract data from the literature that used many different response variables, we only found sufficient data on wheat yields. Using the above criteria, 90 articles were found with yield data suitable for the meta-analysis.

Search equation

ISI Web of Knowledge: Web of Science

TS=((yield OR ((water OR nitrogen) AND use AND efficiency) OR disease OR grain)
AND ((climat* AND change) OR (global AND warming))
AND ((triticum AND aestivum) OR wheat)
AND model*)

639 references found in Web of Science on 22/05/2012

2. Materials and methods

2.1. Literature review

We performed a literature search to compile peer-reviewed journal articles describing the response of wheat to climate change simulated using computer models. The following keywords were used to search the literature: yield, nitrogen use efficiency, water use efficiency, disease, grain, climate change, global warming, wheat, *Triticum aestivum*, and model. We found 639 articles using these keywords in ISI Web of Science in May 2012. For inclusion into the meta-analysis, the articles had to meet the following criteria: (1) The article needed to contain at least one response variable from the following list: wheat yield, grain number, grain weight, grain protein, disease, water use efficiency, nitrogen use efficiency, or growing period. (2) The articles needed to study the effect of at least one climate variable, including CO_2 concentration, temperature change, or precipitation change. (3) The study had to compare the effects of current and future climate on the response variable using modeling techniques. Although we attempted to extract data from the literature that used many different response variables, we only found sufficient data on wheat yields. Using the above criteria, 90 articles were found with yield data suitable for the meta-analysis.

Selection

Criteria for selecting articles using the text

- 154 articles classified as useful
- 19 articles did not have the full text available
- 135 articles to read
- 45 articles did not meet the data criteria
- 90 articles with useful data

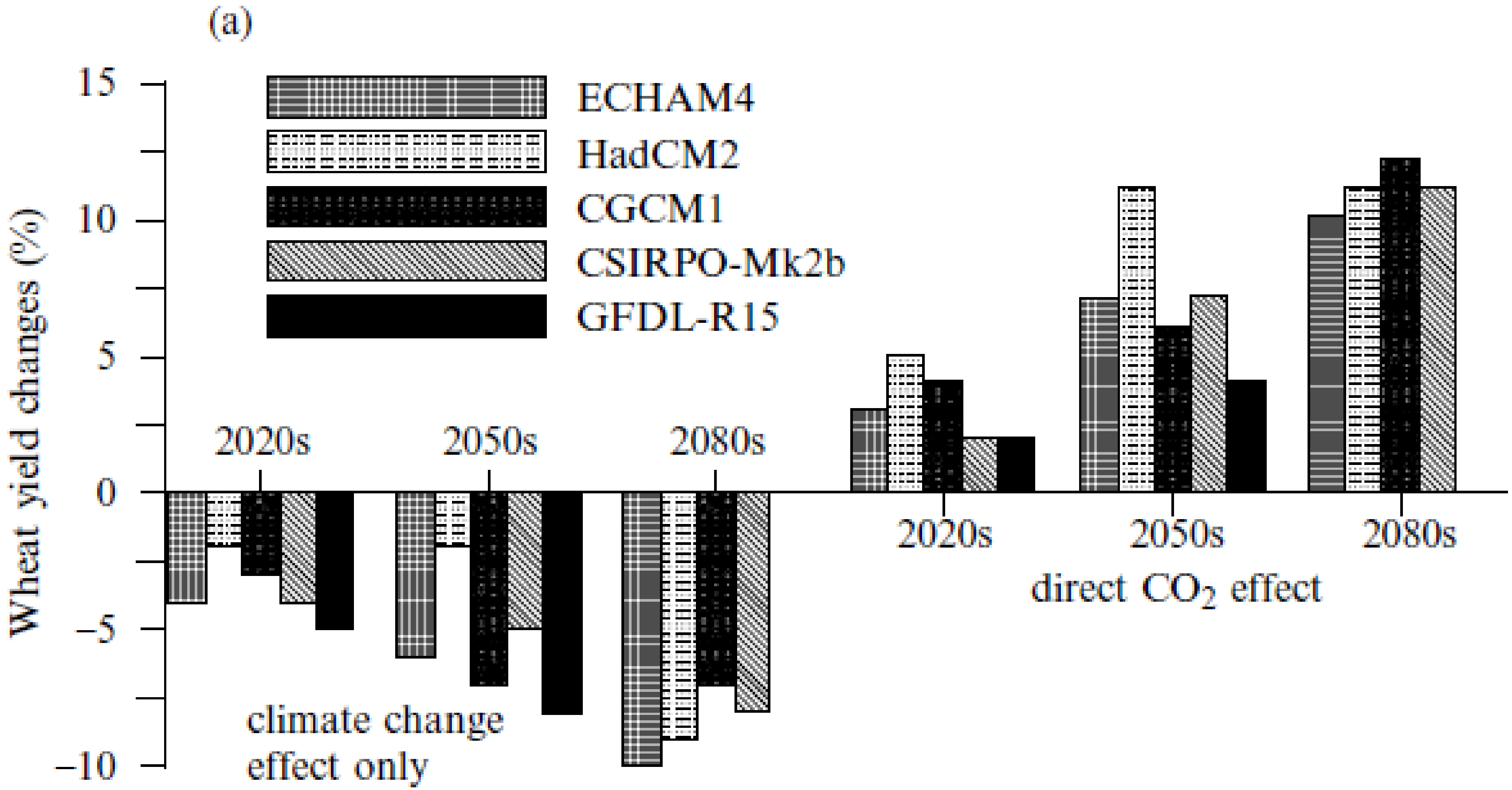
Data Example 1

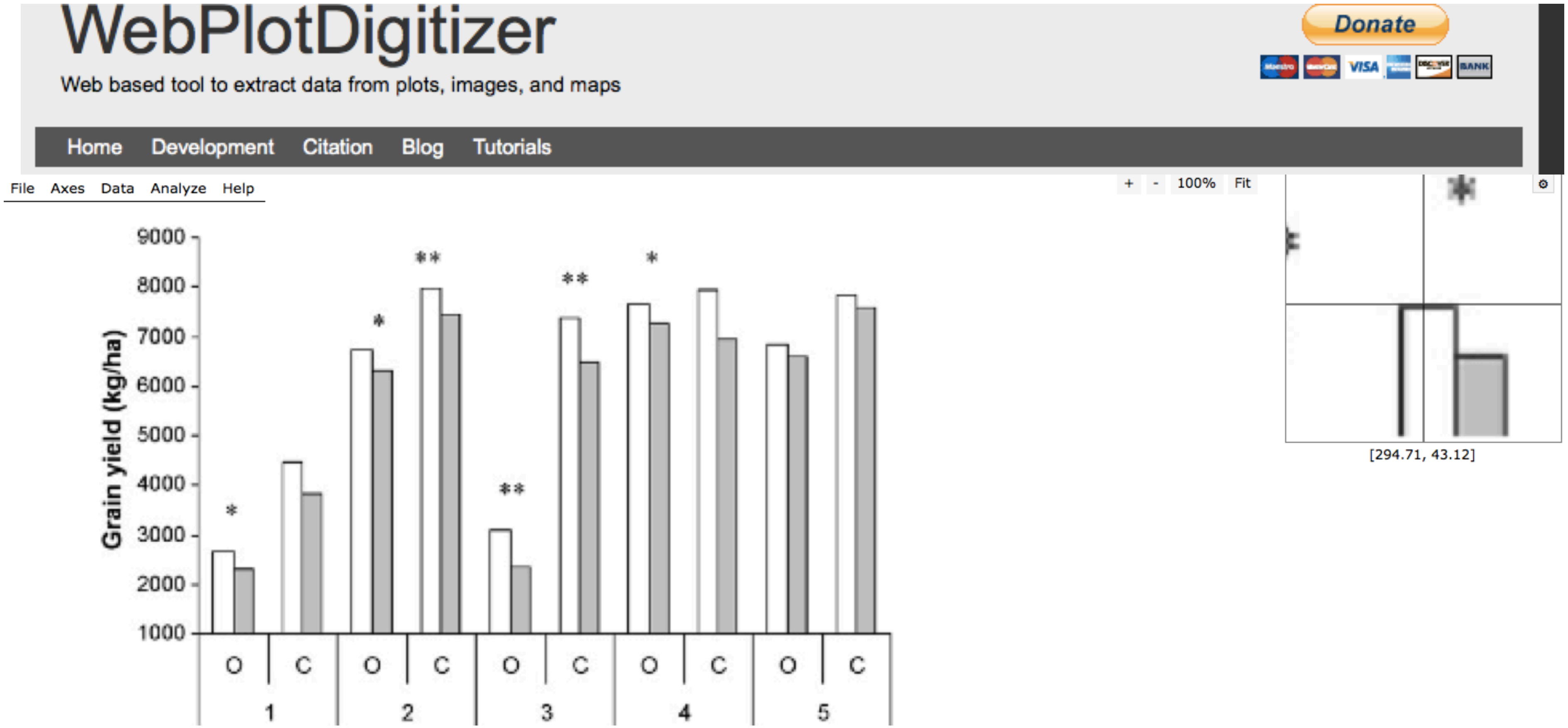
Table 4. Percent change in yield and consumptive water use of wheat and maize under climate change scenarios in the first season.

Variety	Climate Scenario	Wheat				Maize			
		Yield	PR	CU	PI	Yield	PR	CU	PI
		t ha^{-1}	%	mm	%	t ha^{-1}	%	mm	%
V1	Current	5.91	NP	379.80	NP	5.70	NP	542.82	NP
	A2	3.20	46	398.94	5	2.61	54	605.75	12
	B2	3.61	39	402.81	6	3.35	41	651.13	20
V2	Current	5.82	NP	361.88	NP	5.42	NP	530.42	NP
	A2	3.22	45	386.31	7	2.55	53	597.9	13
	B2	3.63	38	387.71	7	3.27	40	625.94	18
V3	Current	5.51	NP	355.64	NP	NP	NP	NP	NP
	A2	2.90	47	375.65	6	NP	NP	NP	NP
	B2	3.32	40	375.8	6	NP	NP	NP	NP

V1: wheat var. Sids 1 or maize hybrid TWC310; V2: wheat var. Sakha 93 or maize hybrid TWC324; V3: wheat var. Giza 168; PR%: percent reduction between measured and predicted yield; NP: not applicable; CU: consumptive water use; PI%: percent increase between measured and predicted consumptive water use; A2 and B2: two climate change scenarios.

Data Example 2




WebPlotDigitizer
Web based tool to extract data from plots, images, and maps
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Tutorials
File
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Analyze
Help
+
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Fit
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7000
6000
5000
4000
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2000
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Database structure

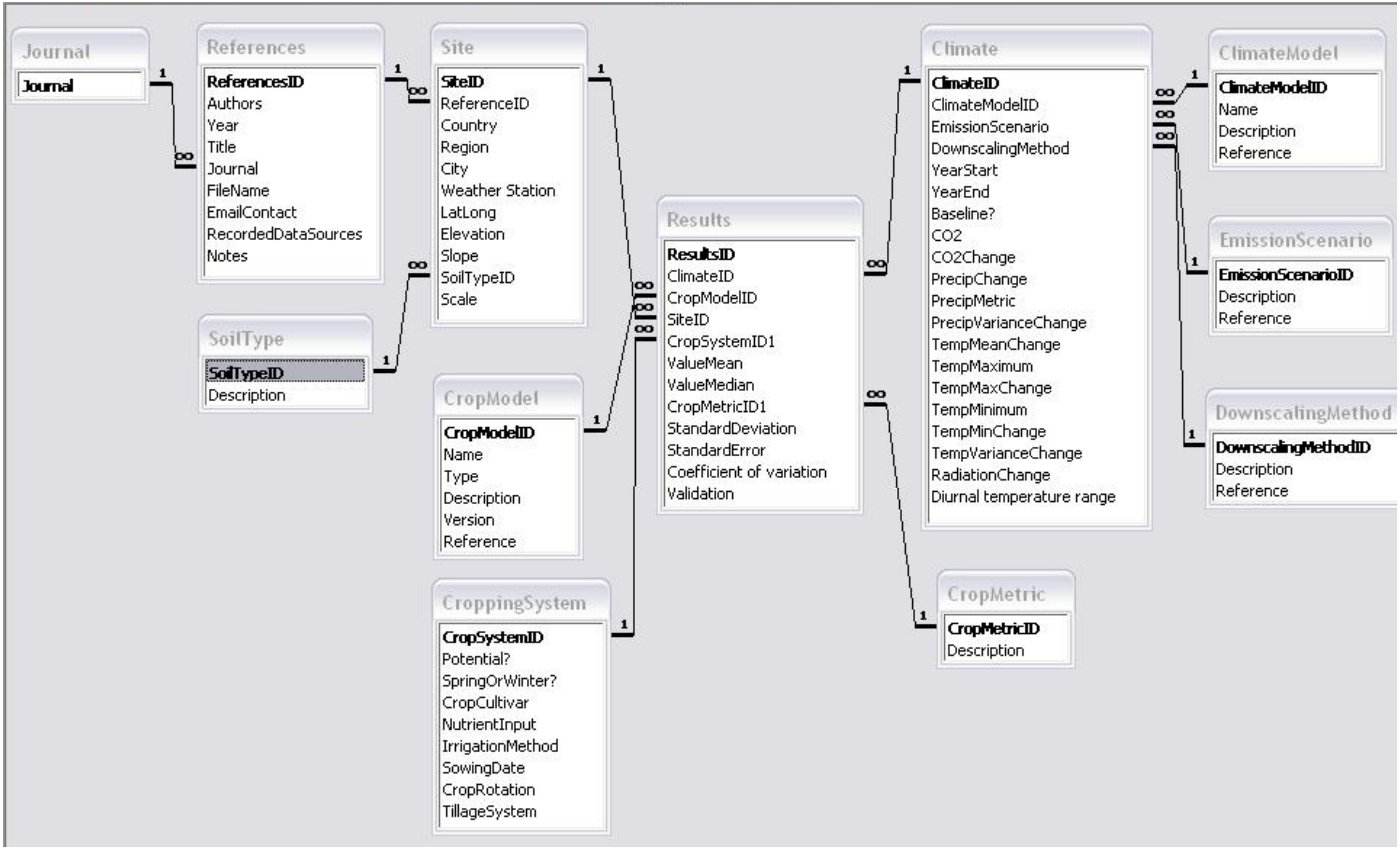

Table 1.

The number of data and articles available for each climatic variable.

Climate variable	Number of data	Number of articles
Change in temperature (°C)	2220	57
Change in precipitation (%)	1462	36
CO_2 level (ppm)	2932	66
All three variables	1084	28

Effect of climate change on wheat yield (%)

	Minimum	Mean	Maximum	Nb of data
Egypt	−51.00	−25.91	8.00	42
Israel	−57.50	−19.87	17.20	24
Bangladesh	−73.00	−15.90	56.00	30
Spain	−100.00	−15.13	33.87	119
Switzerland	−29.39	−13.44	3.05	4
Turkey	−31.86	−8.40	35.56	64
Russia	−8.28	−8.28	−8.28	1
Denmark	−25.74	−7.23	17.34	40
Japan	−6.49	−6.49	−6.49	1
Chile	−19.60	−3.24	6.75	7
Australia	−100.00	−2.85	90.76	758
Canada	−48.10	−2.13	45.92	99
Argentina	−23.50	−1.12	18.32	14
Pakistan	−37.97	3.90	48.11	91
USA	−97.62	4.58	155.78	997
Italy	−57.14	5.15	69.84	22
Hungary	−2.63	6.34	15.30	2
UK	−100.00	6.78	63.72	384
Austria	−26.77	8.25	71.75	40
Germany	−21.66	9.63	61.40	35
CzechRepublic	−25.37	10.68	26.26	42
Poland	3.48	12.83	22.17	2
France	−21.35	12.94	73.08	83
India	−66.28	14.85	58.12	92

Appendix A. Supplementary data

The following are the supplementary data to this article:

Help with XLS files

Options

Download file (1496 K)

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日本語要約

Comparing the yields of organic and conventional agriculture

Verena Seufert, Navin Ramankutty & Jonathan A. Foley

Affiliations | Contributions | Corresponding author

Nature **485**, 229–232 (10 May 2012) | doi:10.1038/nature11069
Received 06 November 2011 | Accepted 09 March 2012 | Published online 25 April 2012

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PDF files

1. Supplementary Information (759K)

   This file contains Supplementary Figures 1-10, Supplementary Tables 1-14, a Supplementary Discussion and Supplementary References.

Excel files

1. Supplementary Data 1 (379K)

   This file contains data used in the meta-analysis. The data table shows the raw yield data, yield effect sizes and study information with categorical variables.

2. Supplementary Data 2 (231K)

   This file contains data that could not be used in the meta-analysis. The data table shows, in the spreadsheet 'exclusion6', study information and yield data of studies that were excluded because they did not meet selection criteria 6 (i.e. no information on an error term and sample size was available). In the spreadsheet 'exclusion1-5' information on studies that were excluded because they did not meet the basic selection criteria 1-5 (see methods) and the reason for exclusion is shown.

Datasets

Dataset and Program available for meta-analysis in agronomy.

ID	Title	Key-words	Dataset
PD15	Carbon sequestration in agricultural soils via cultivation of cover crops – A meta-analysis	Soil carbon sequestration, Agricultural management, Cover crops, Catch crops, Green manure, Land use, Carbon response function	see Appendix A online paper
CR15	Financial competitiveness of organic agriculture on a global scale	sustainable agriculture, food security, organic premiums, meta-analysis, economic	see methods section online paper
L15	Ranking yields of energy crops: a meta-analysis using direct and indirect	Meta-analysis, Lignocellulosic crops, Energy crops, Biomass	Dataset


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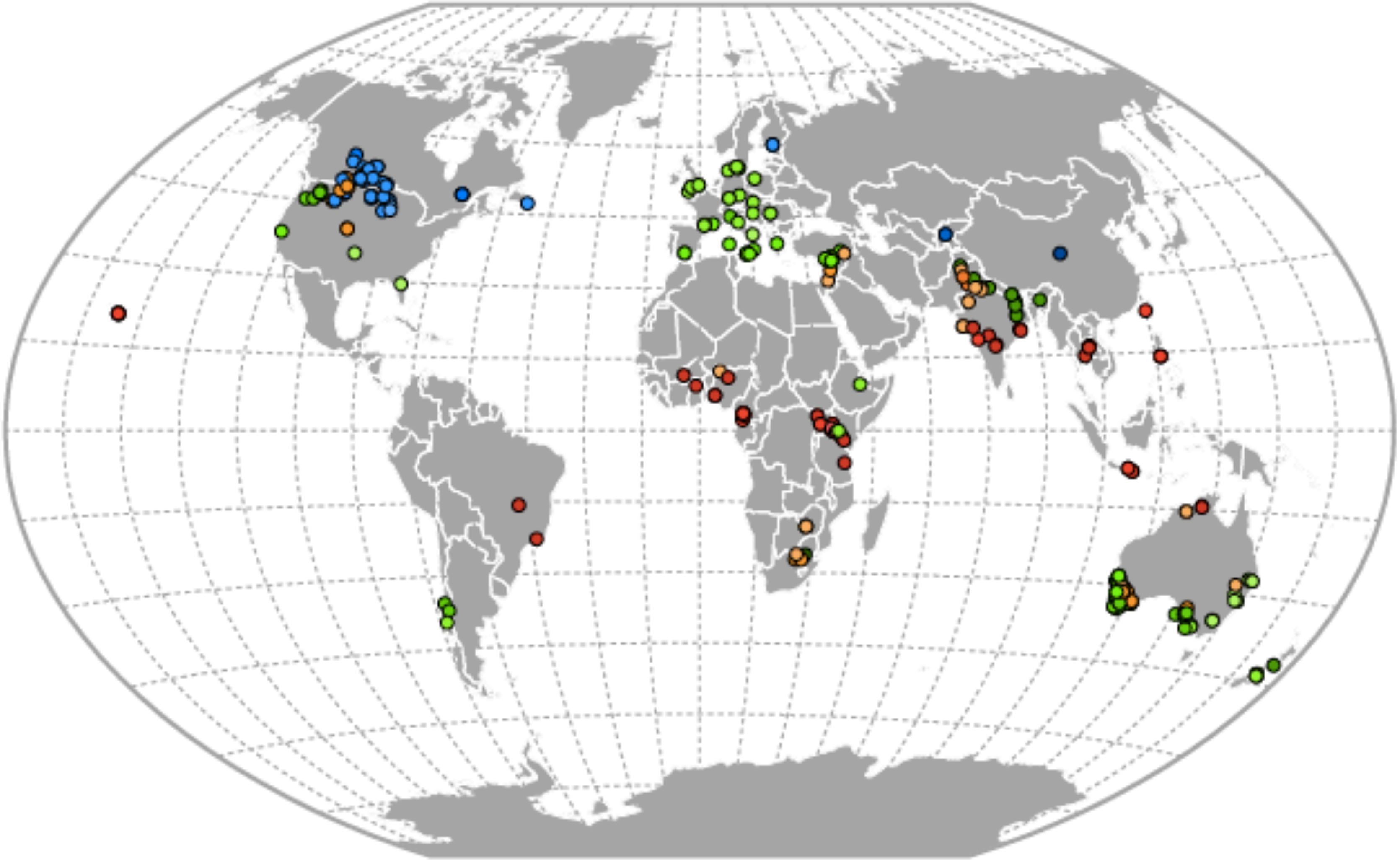
A global experimental dataset for assessing grain legume production

Charles Cernay[1], Elise Pelzer[1] & David Makowski[1]

Affiliations

[1]UMR Agronomie, INRA, AgroParisTech, Université Paris-Saclay, 78850 Thiverval-Grignon, France



Data Citations

1. Cernay, C., Pelzer, E. & Makowski, D. *Dryad Digital Repository* http://dx.doi.org/10.5061/dryad.mf42f (2016).

2. Cernay, C., Pelzer, E. & Makowski, D. *Dryad Digital Repository* http://dx.doi.org/10.5061/dryad.mf42f (2016).

3. Cernay, C., Pelzer, E. & Makowski, D. *Dryad Digital Repository* http://dx.doi.org/10.5061/dryad.mf42f (2016).

4. Cernay, C., Pelzer, E. & Makowski, D. *Dryad Digital Repository* http://dx.doi.org/10.5061/dryad.mf42f (2016).

5. Cernay, C., Pelzer, E. & Makowski, D. *Dryad Digital Repository* http://dx.doi.org/10.5061/dryad.mf42f (2016).

6. Cernay, C., Pelzer, E. & Makowski, D. *Dryad Digital Repository* http://dx.doi.org/10.5061/dryad.mf42f (2016).

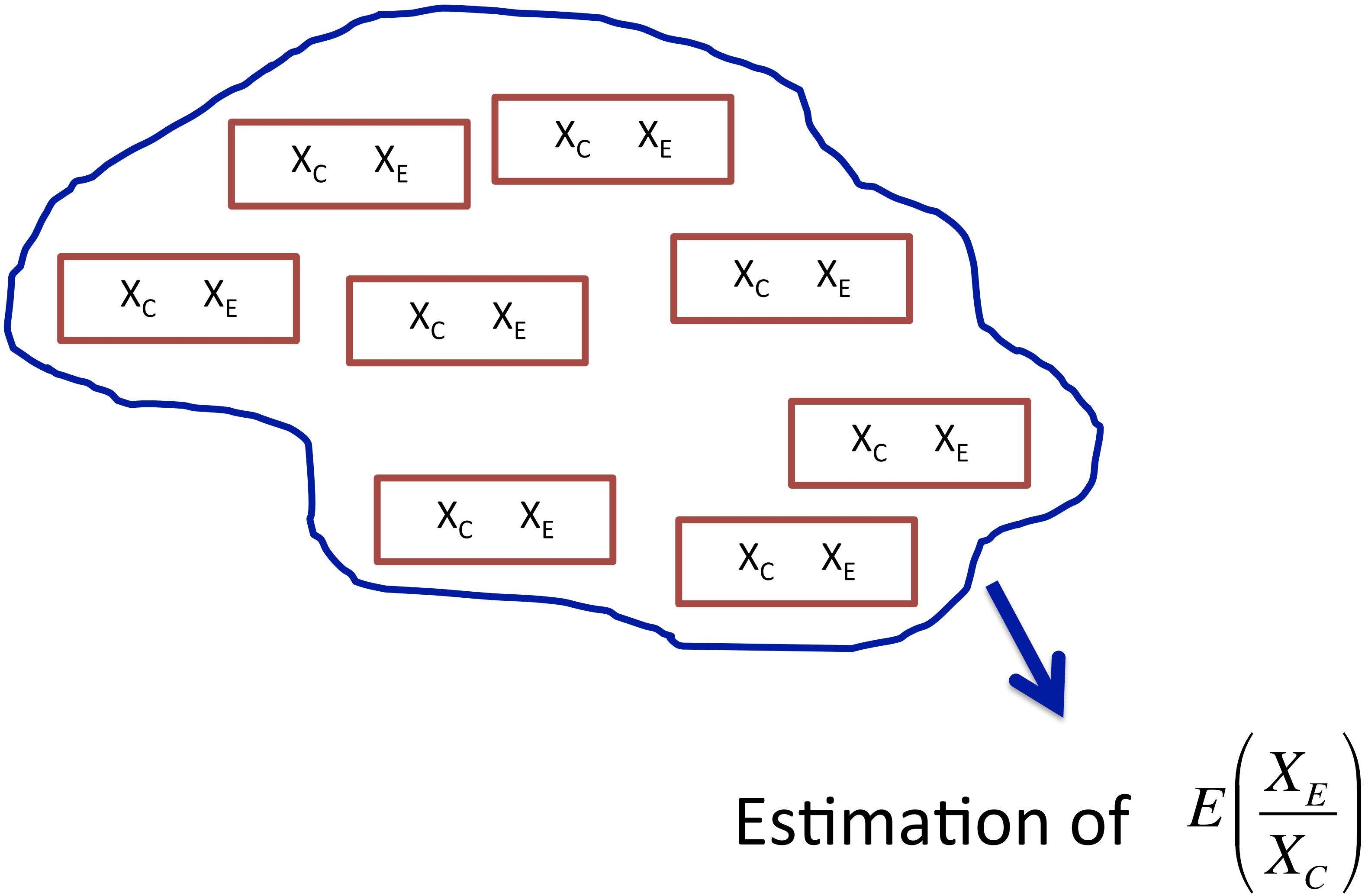
7. Cernay, C., Pelzer, E. & Makowski, D. *Dryad Digital Repository* http://dx.doi.org/10.5061/dryad.mf42f (2016).

8. Cernay, C., Pelzer, E. & Makowski, D. *Dryad Digital Repository* http://dx.doi.org/10.5061/dryad.mf42f (2016).

9. Cernay, C., Pelzer, E. & Makowski, D. *Dryad Digital Repository* http://dx.doi.org/10.5061/dryad.mf42f (2016).

Main steps

- Definition of the objective
- Systematic review
- Data selection and extraction
- **Statistical analysis**
  - **Definition of a statistical model**
  - **Estimation**
  - **Uncertainty analysis**
- Assessment of risk of publication bias and sensitivity analysis
- Presentation of results and of associated uncertainties



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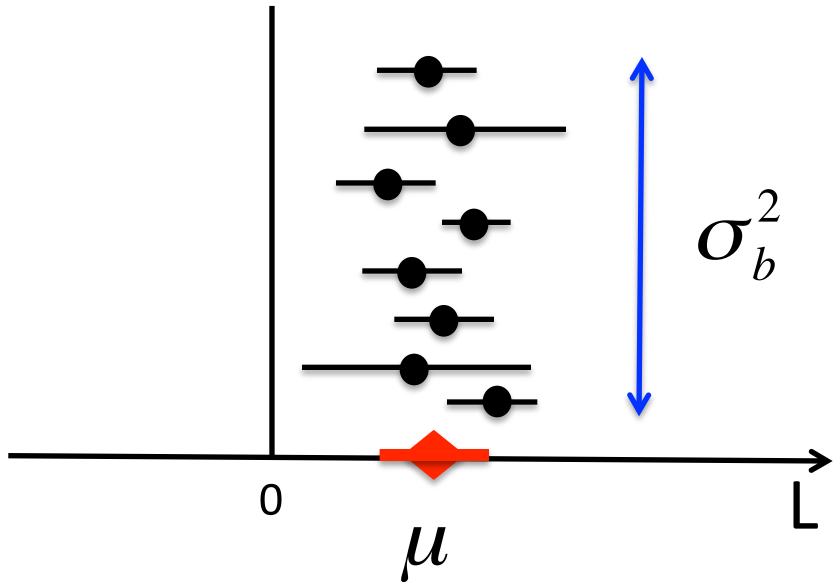
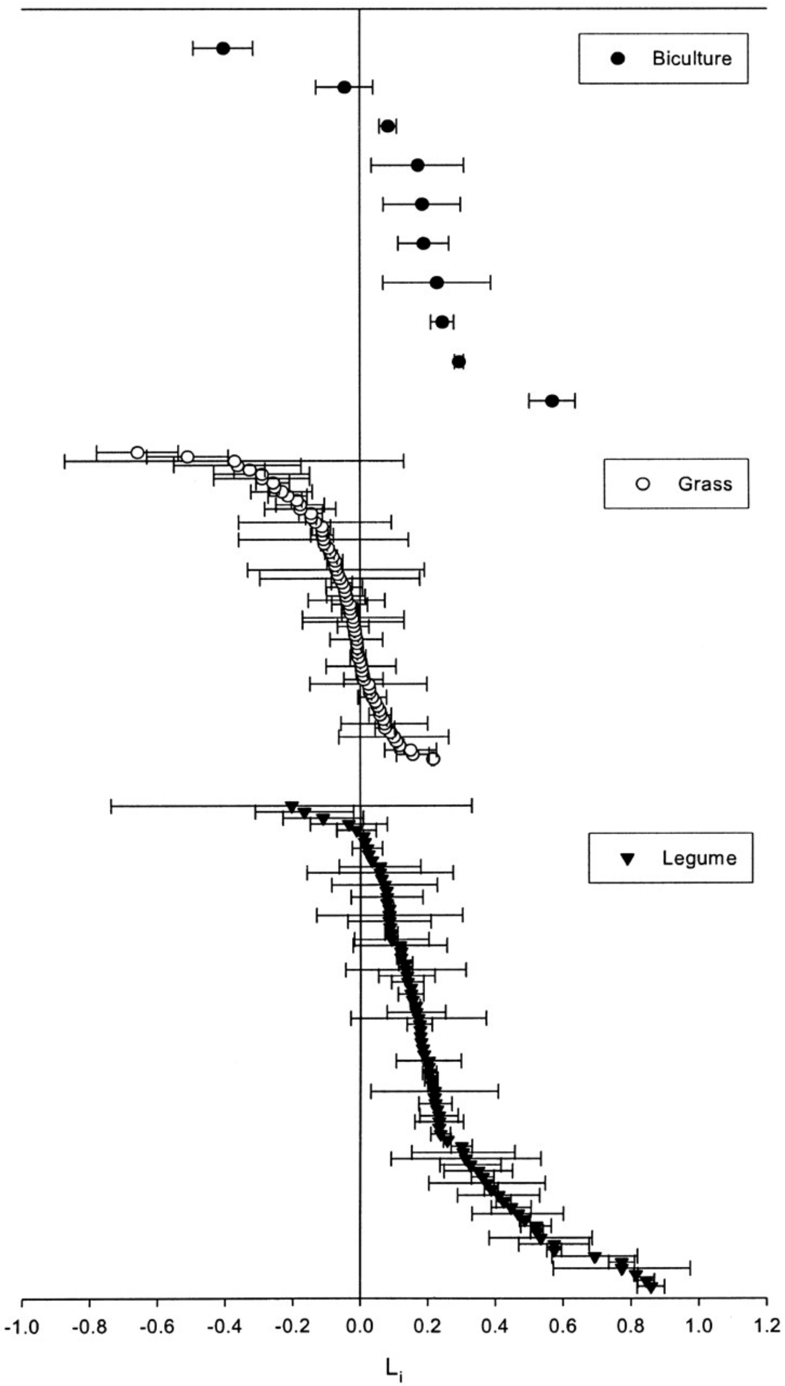
Estimation of $E\left(\frac{X_E}{X_C}\right)$

Random-effect model





Effect of cover crop on corn yield

(Miguez & Bollero 2005)

Logarithm of yield ratio

$$Li = \log\left(\frac{\text{Yield after cover crop}}{\text{Yield w/o cover crop}}\right)$$

pour biculture(10 observations),
grass (68 observations),
legume (82 observations)

Horizontal bar = variance

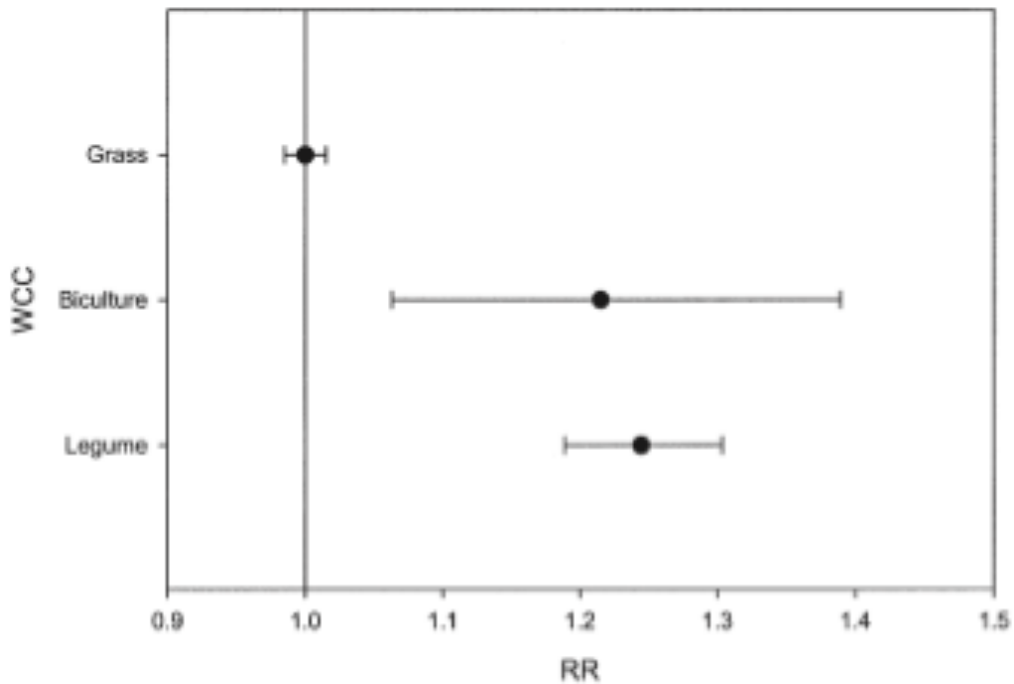
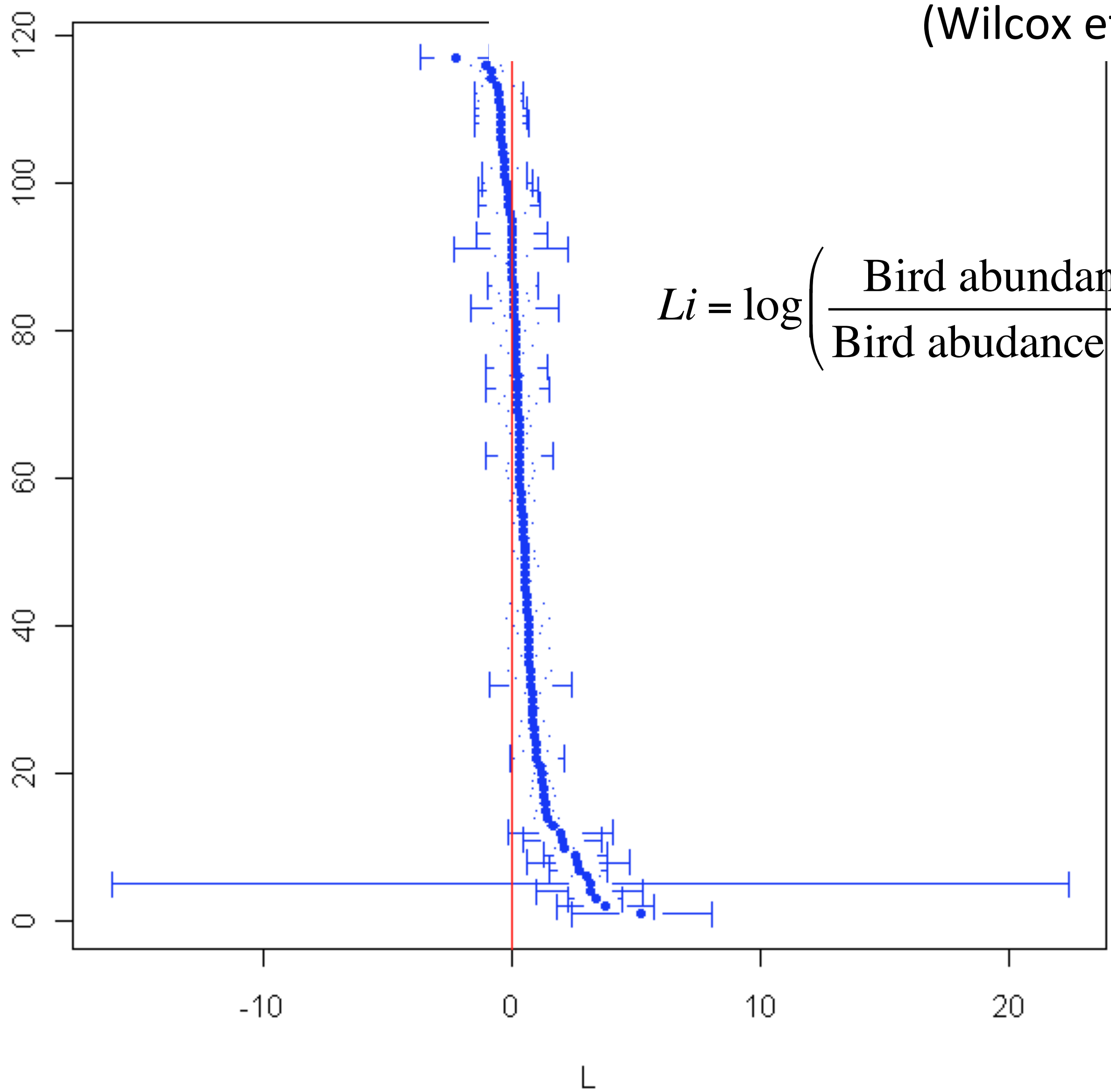


Fig. 3. Mean response ratio [yield of corn following winter cover crops/yield of corn following no cover (RR)] and 95% confidence interval (horizontal bars) for the three levels of winter cover crop (WCC).

Main steps

- Definition of the objective
- Systematic review
- Data selection and extraction
- Statistical analysis
- **Assessment of risk of publication bias and sensivity analysis**
  - **Funnel plot**
  - **Sensitivity analysis to dataset characteristics/statistical methods**
- Presentation of results and of associated uncertainties

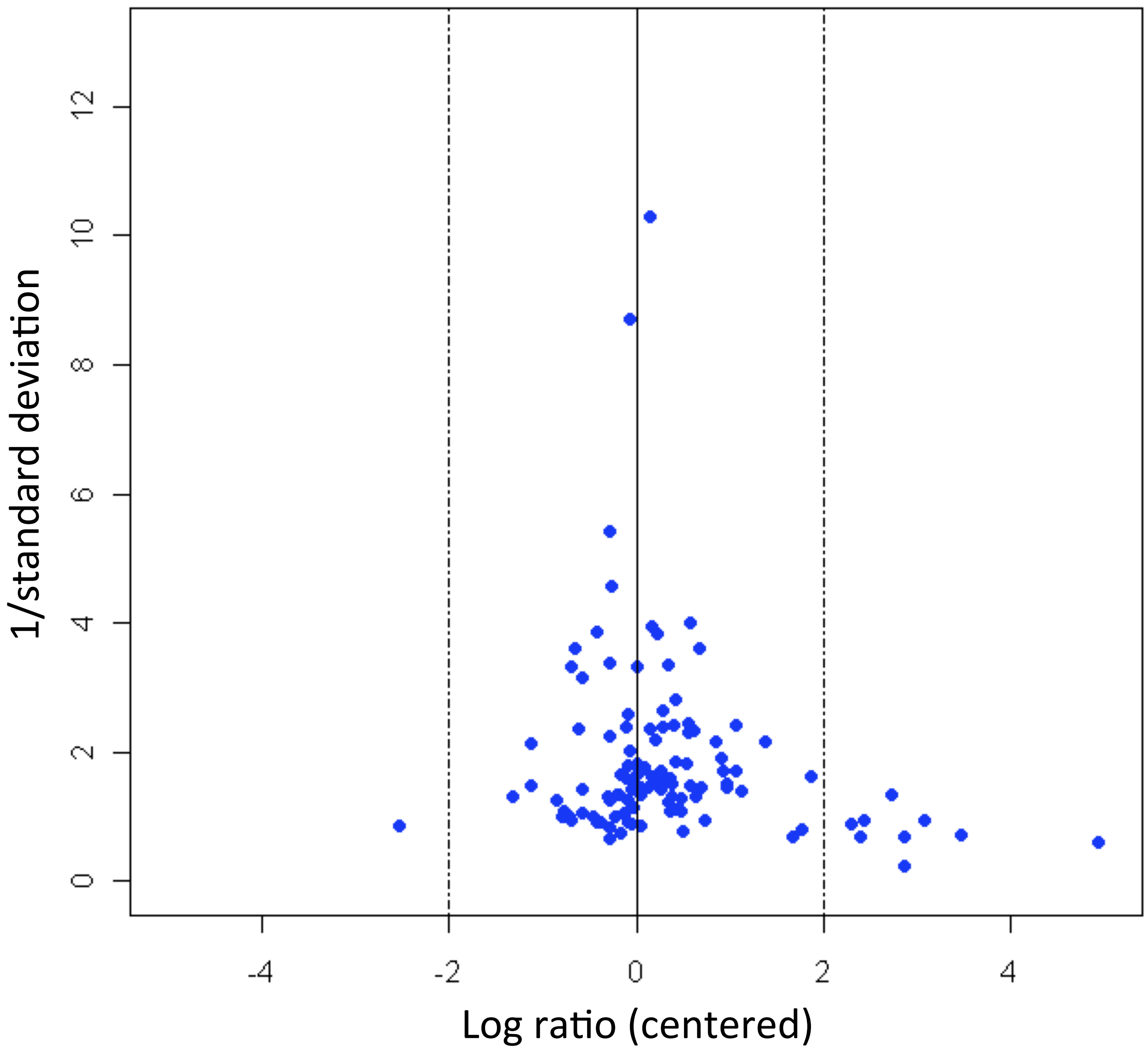
Effect or organic farming on bird population
(Wilcox et al., 2014)



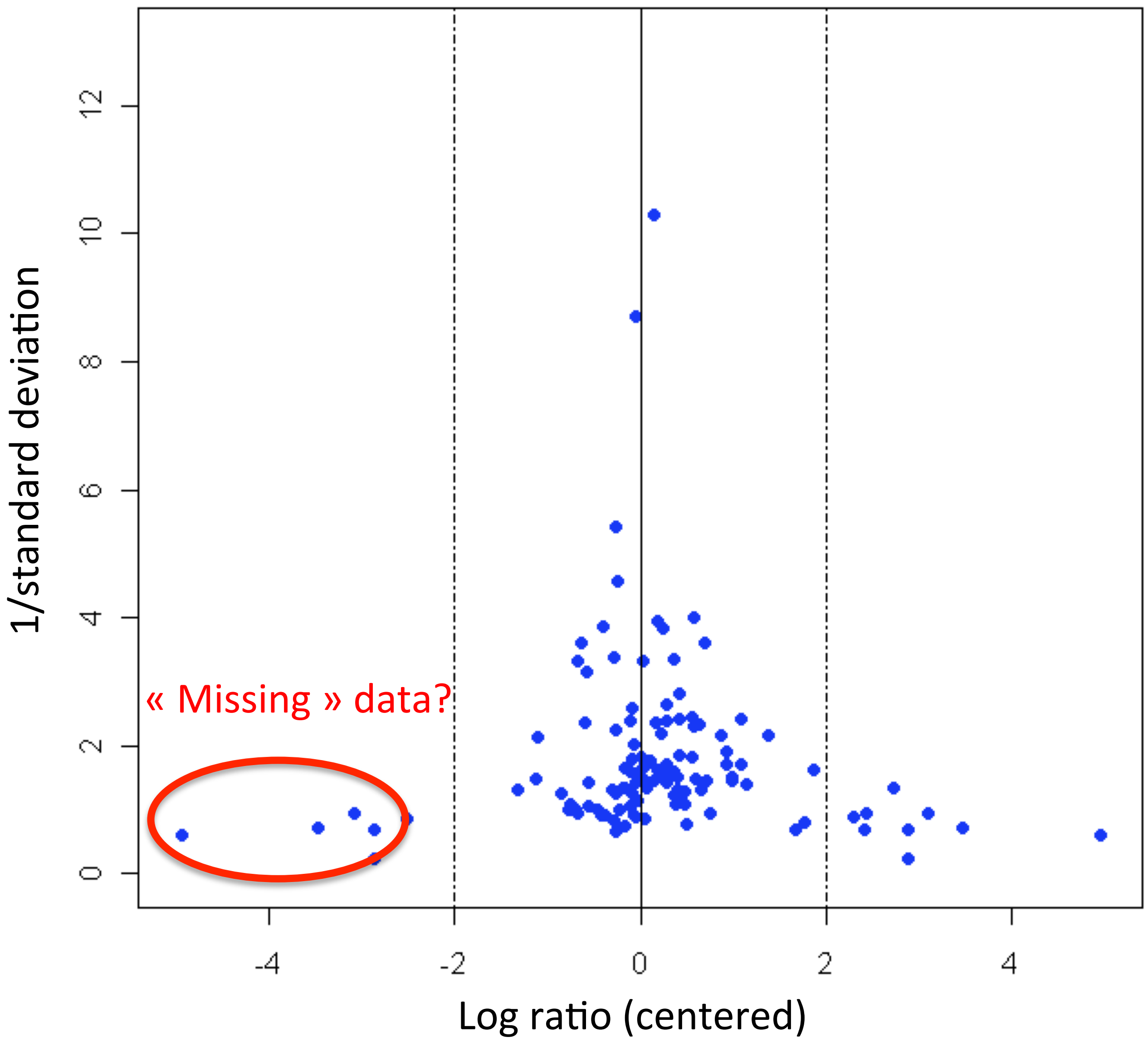
$$Li = \log\left(\frac{\text{Bird abundance in organic farming area}}{\text{Bird abudance in non-organic farming area}}\right)$$

Weighted average →+33% of bird in organic area

Publication bias?



Publication bias?

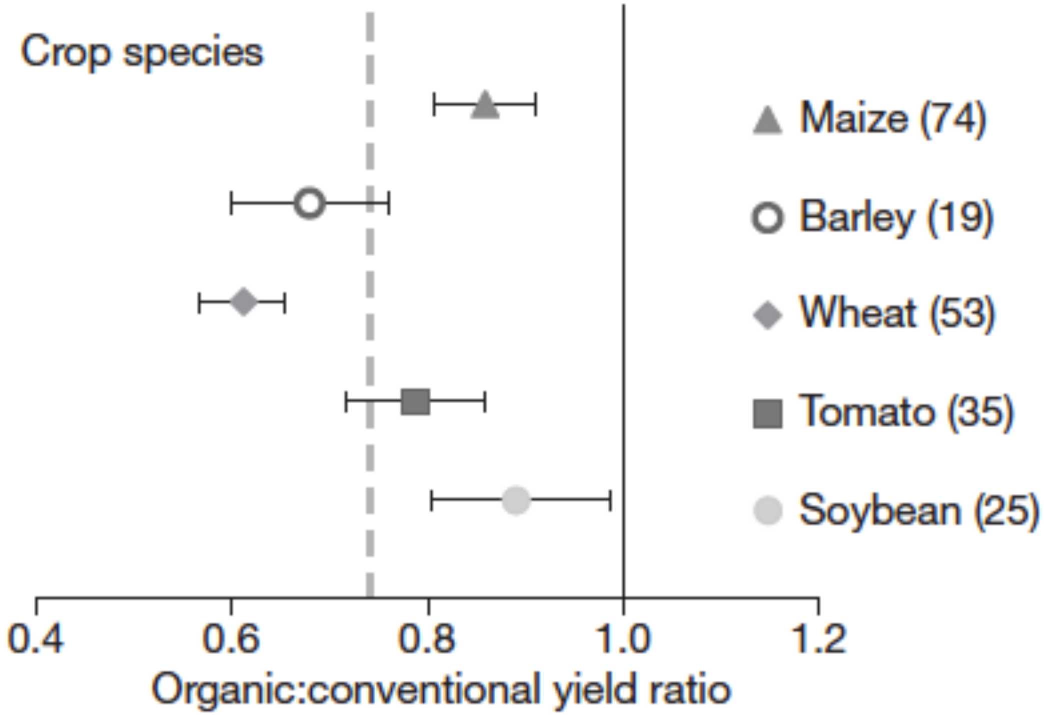


Main steps

- Definition of the objective
- Systematic review
- Data selection and extraction
- Statistical analysis
- Assessment of risk of publication bias and sensitivity analysis
- **Presentation of results and of associated uncertainties**
  - **Forest plot**
  - **Tables etc.**

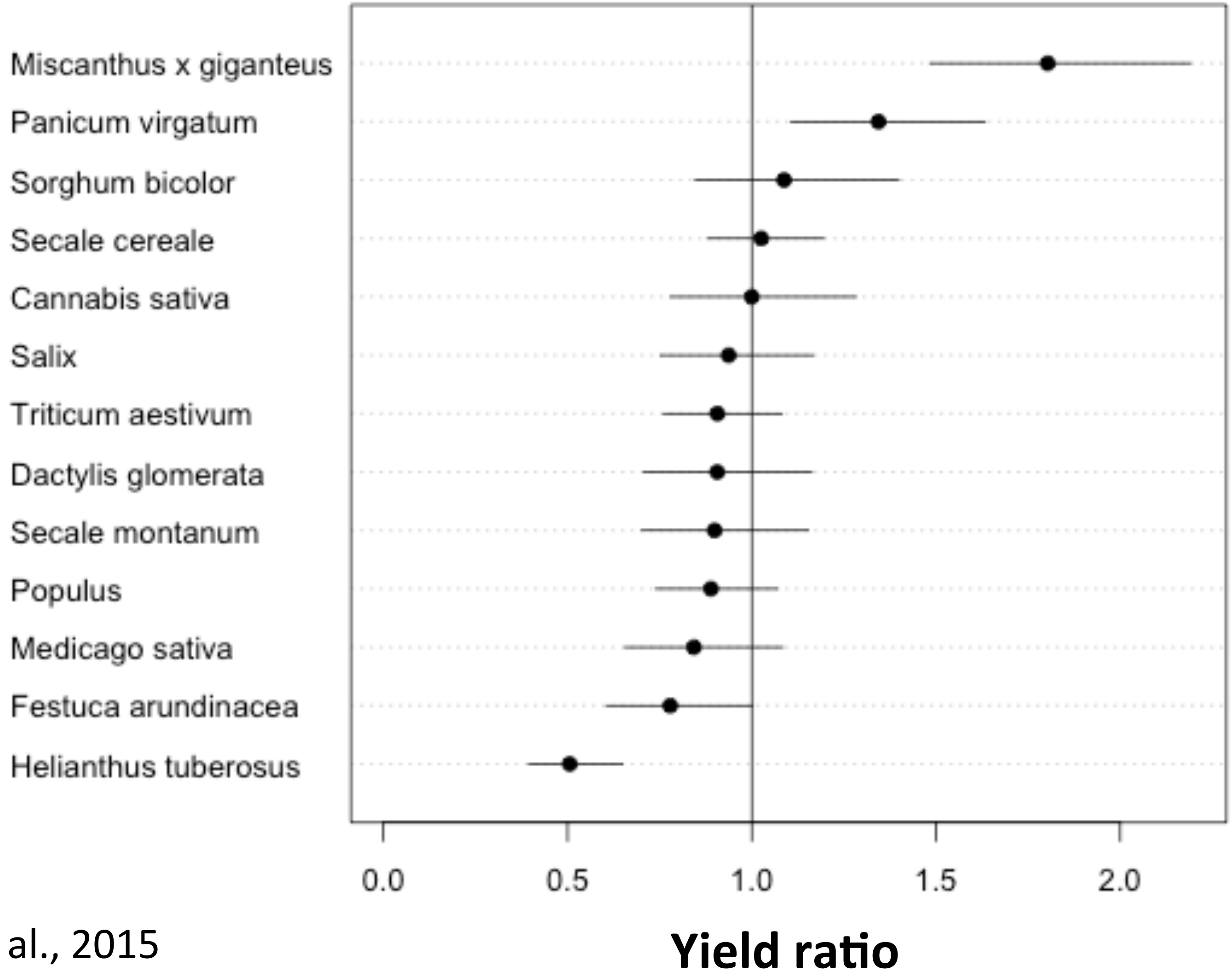
Comparing the yields of organic and conventional agriculture

Verena Seufert[1], Navin Ramankutty[1] & Jonathan A. Foley[2]



Nature, 2012

Yield ratio of crop species compared to *Triticosecale* (Ratio=Yield species *X* / Yield triticosecale)



Laurent et al., 2015

« Evidence-based analysis »

- Meta-analysis = systematic review + statistical analysis of data
- More objective than qualitative review
- Quantitative analysis of a given topic
- Include an analysis of uncertainty
- Useful for identifying knowledge gaps
- Cumulative approach