



Biodiversity knowledge synthesis: an introduction to meta-analyses and systematic reviews

Why do we need systematic review
and evidence maps?

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Chercheur CIRAD- Hortsys

Seeing the forest for the trees



Systematic reviews are the remote-sensing tools of ecology.
They allow us to step back & see a broader, albeit less
detailed overview of how a system operates.
(Hillebrand & Cardinale 2010)

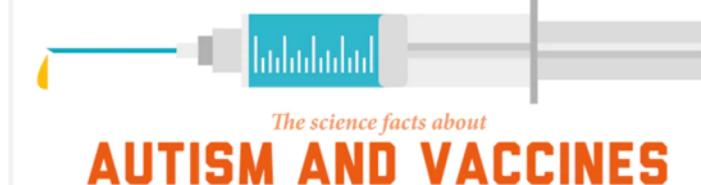
Focus...



Step back!



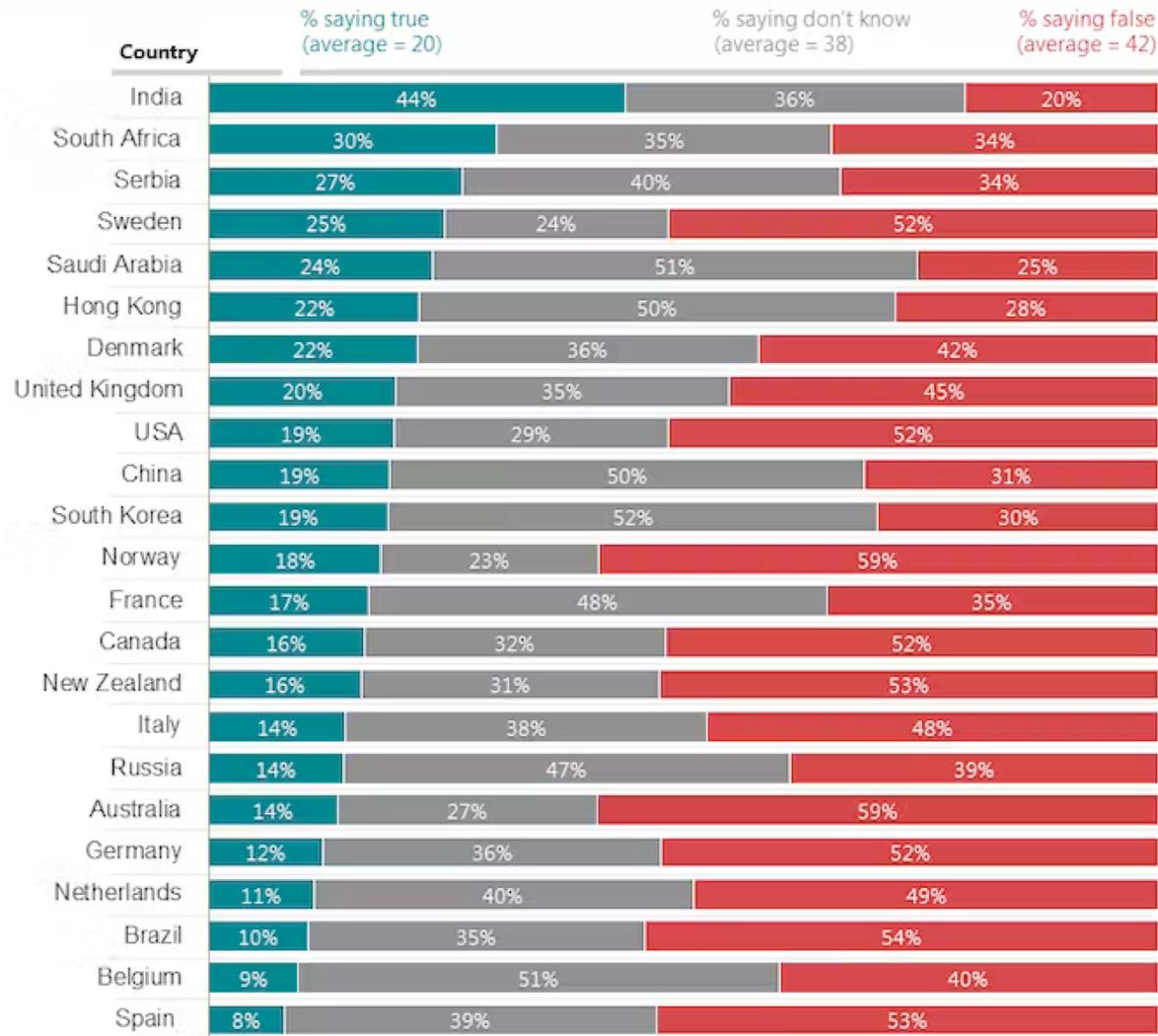
Depicts 106,000 aluminum cans, the number used in the US
every 30s



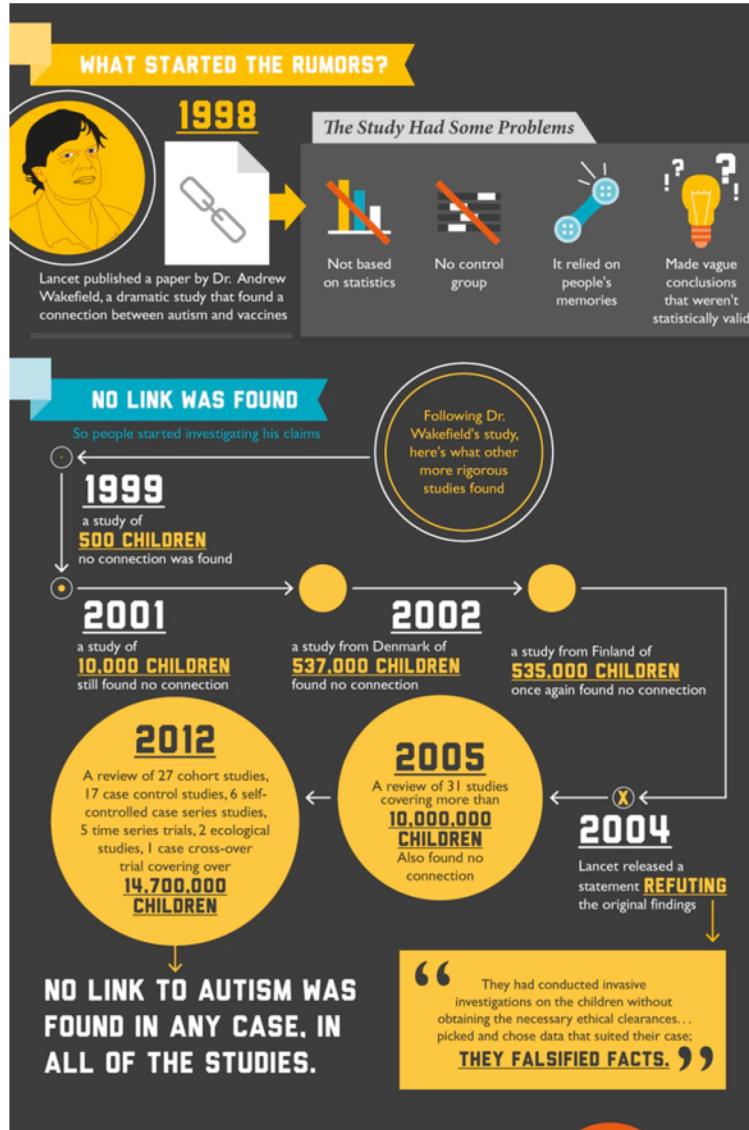
Do you think the following statement is true or false?

« Some vaccines cause autism in healthy children. »

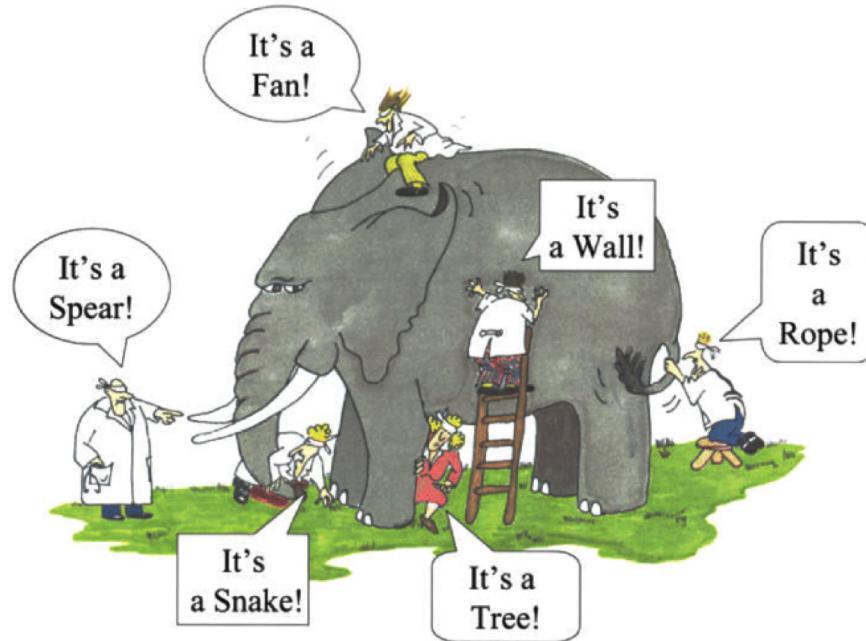
Misinformation



Misinformation



Contradictory evidence



Contradictory evidence

Consulter
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ACTUALITÉS

ÉCONOMIE

VIDÉOS

DÉBATS

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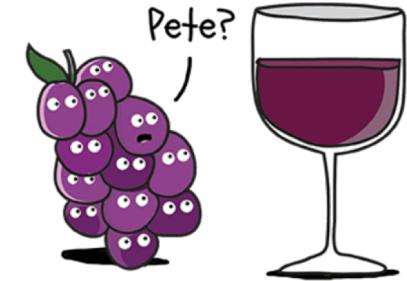
Se connecter

DÉBATS



Deux verres de vin rouge n'augmentent pas les risques de cancer

Mieux vaut boire raisonnablement que s'abstenir en mangeant mal, estiment David Servan-Schreiber, Richard Béliveau et Michel de Lorgeril.



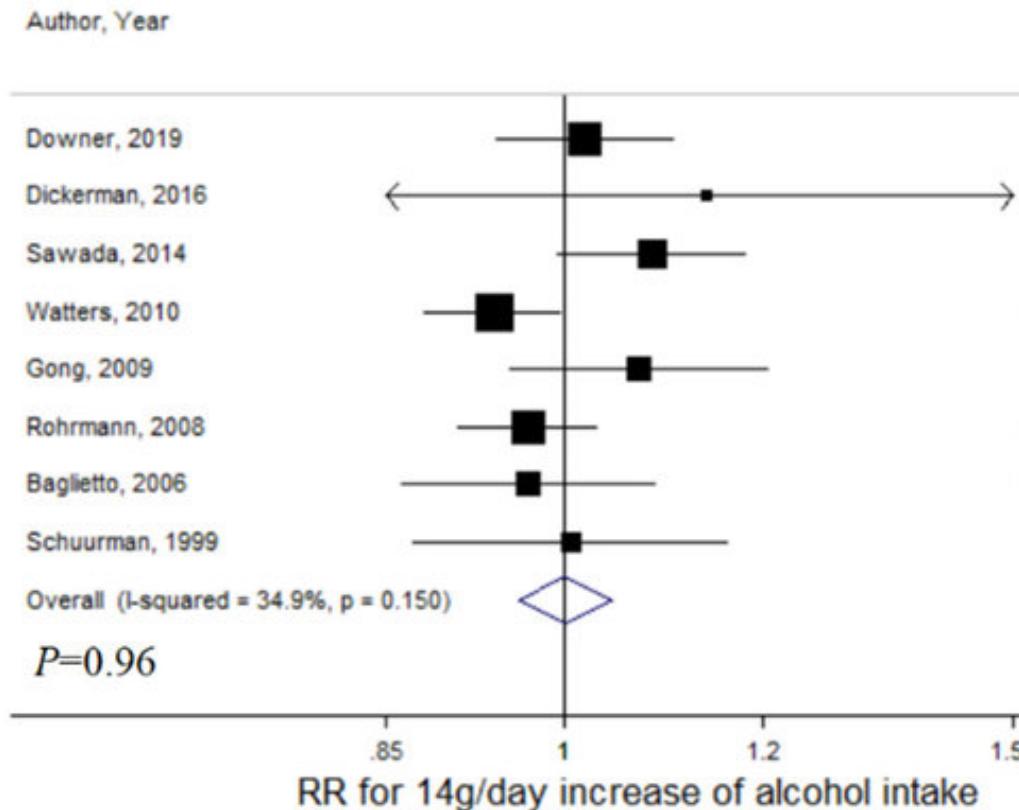
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santé

Médecine | Santé Publique | Bien-être | Famille | Sex

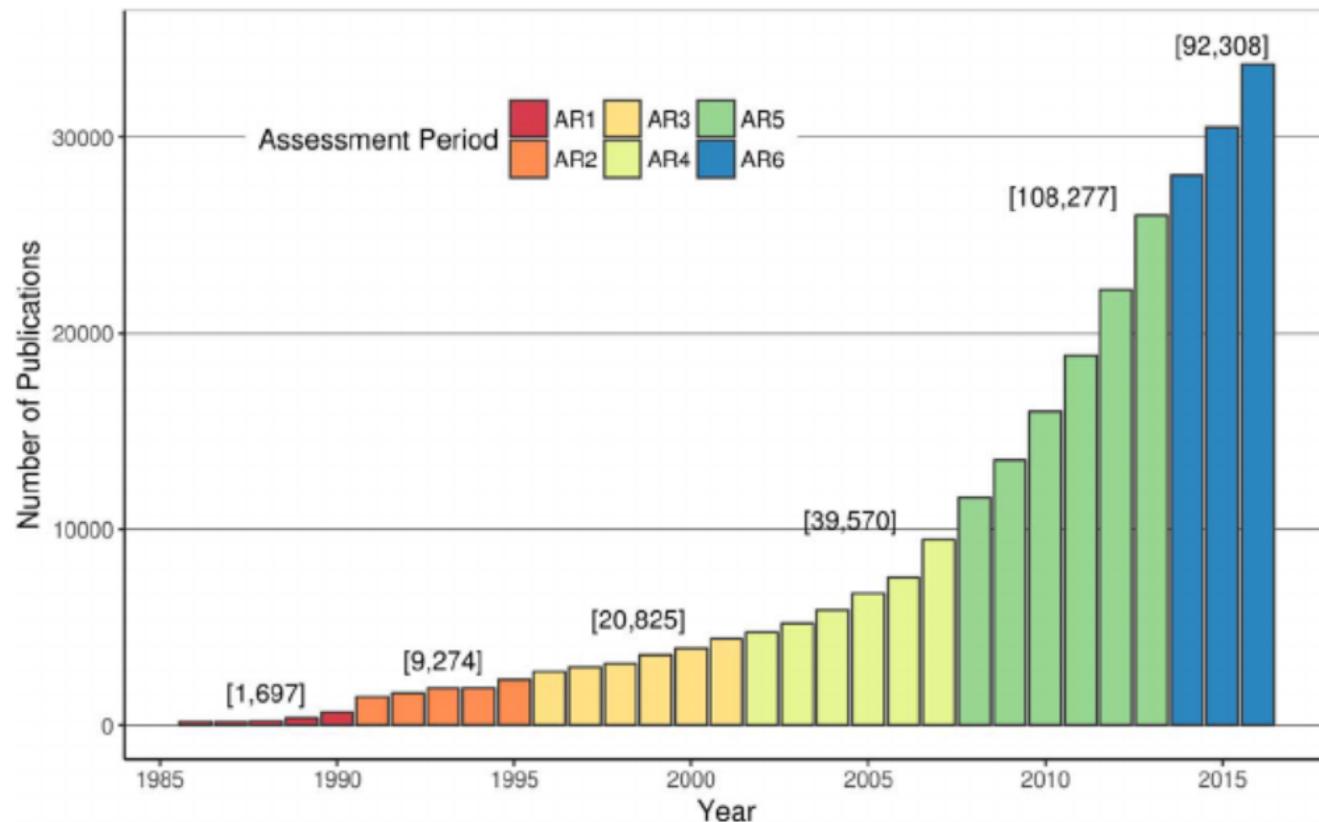
Actualités Santé > Santé publique

Un verre de vin quotidien suffit à augmenter le risque de certains cancers

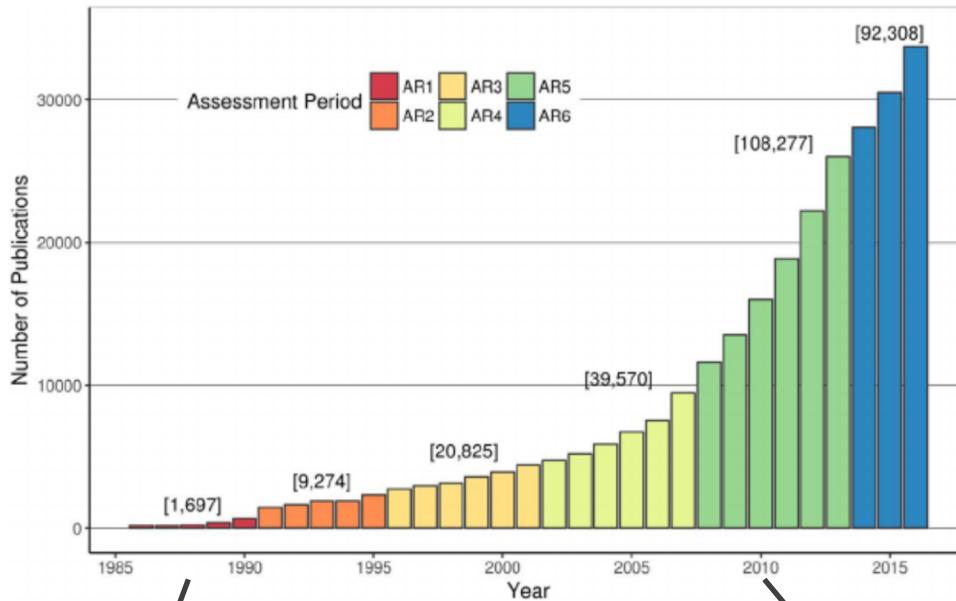
Contradictory evidence



A plethora of scientific articles



A plethora of scientific articles



~63% of the published literature cited in the 1st assessment report

~23% of the published literature cited in the 5th assessment report

A real need for reliable evidence

to objectify knowledge, accurately estimate phenomena and their effects, and sometimes even answer questions that have not been asked by individual studies.

Example of meta-analyses in Ecology

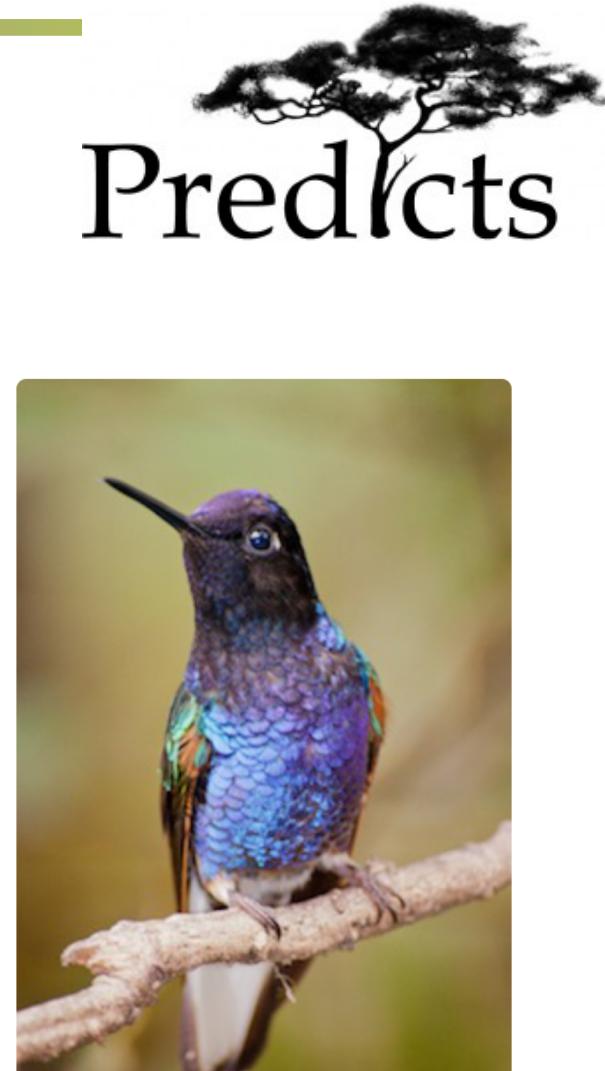
The PREDICTS project

PREDICTS - Projecting Responses of Ecological Diversity In Changing Terrestrial Systems - is a collaborative project aiming to use a meta-analytic approach to investigate how local biodiversity typically responds to human pressures such as land-use change, pollution, invasive species and infrastructure, and ultimately improve our ability to predict future biodiversity changes.

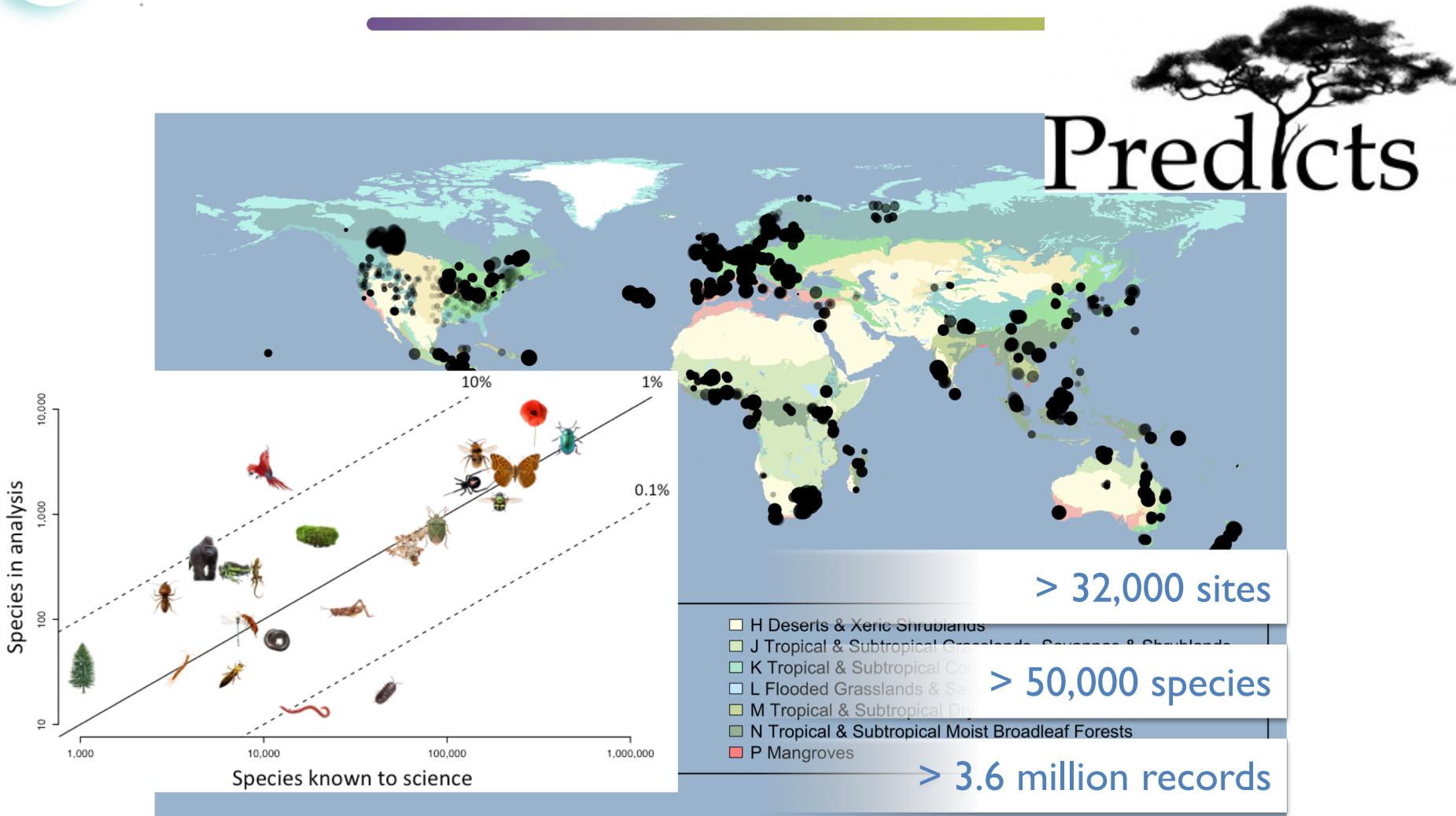
Human activities are causing major changes in biological communities worldwide, and these changes can harm biodiversity and ecosystem function. Ecosystem function is important in supporting plant and animal communities, as well as ensuring the long-term survival of human populations. Understanding how human pressures influence global biodiversity at a local scale can help us make predictions of future changes, and can inform conservation policy at national and global levels.

Read more about [conservation and global biodiversity declines](#).

We need more data!



Example of meta-analyses in Ecology



Hudson *et al.* (2014), *Ecology and Evolution*

Example of meta-analyses in Ecology

Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment

Tim Newbold,^{1,2*} Lawrence N. Hudson,³ Andrew P. Arnell,¹ Sara Contu,³ Adriana De Palma,^{3,4} Simon Ferrier,⁵ Samantha L. L. Hill,^{1,3} Andrew J. Hoskins,⁵ Igor Lysenko,⁴ Helen R. P. Phillips,^{3,4} Victoria J. Burton,³ Charlotte W. T. Chng,³ Susan Emerson,³ Di Gao,³ Gwilym Pask-Hale,³ Jon Hutton,^{1,6} Martin Jung,^{7,8} Katia Sanchez-Ortiz,³ Benno I. Simmons,^{3,4} Sarah Whitmee,² Hanbin Zhang,³ Jörn P. W. Scharlemann,^{1,8} Andy Purvis^{3,4}

Land use and related pressures have reduced local terrestrial biodiversity, but it is unclear how the magnitude of change relates to the recently proposed planetary boundary ("safe limit"). We estimate that land use and related pressures have already reduced local biodiversity intactness—the average proportion of natural biodiversity remaining in local ecosystems—beyond its recently proposed planetary boundary across 58.1% of the world's land surface, where 71.4% of the human population live. Biodiversity intactness within most biomes (especially grassland biomes), most biodiversity hotspots, and even some wilderness areas is inferred to be beyond the boundary. Such widespread transgression of safe limits suggests that biodiversity loss, if unchecked, will undermine efforts toward long-term sustainable development.

and use and related pressures have been the main drivers of terrestrial biodiversity change (1) and are increasing (2). Biodiversity has already experienced widespread large net losses (3), potentially compromising its contribution to resilient provision of ecosystem functions and services, such as biomass production and pollination, that underpin human well-being (4–7). Species-

removal experiments suggest that loss of ecosystem function accelerates with ongoing species loss (5), implying that there may be thresholds beyond which human intervention is needed to ensure adequate local ecosystem function (8, 9). The loss of 20% of species—which affects ecosystem productivity as strongly as other direct drivers (5)—is one possible threshold, but it is unclear by which

sciencemag.org SCIENCE

Newbold *et al.* (2016), *Science*

16



ARTICLE

doi:10.1038/nature14324

Global effects of land use on local terrestrial biodiversity

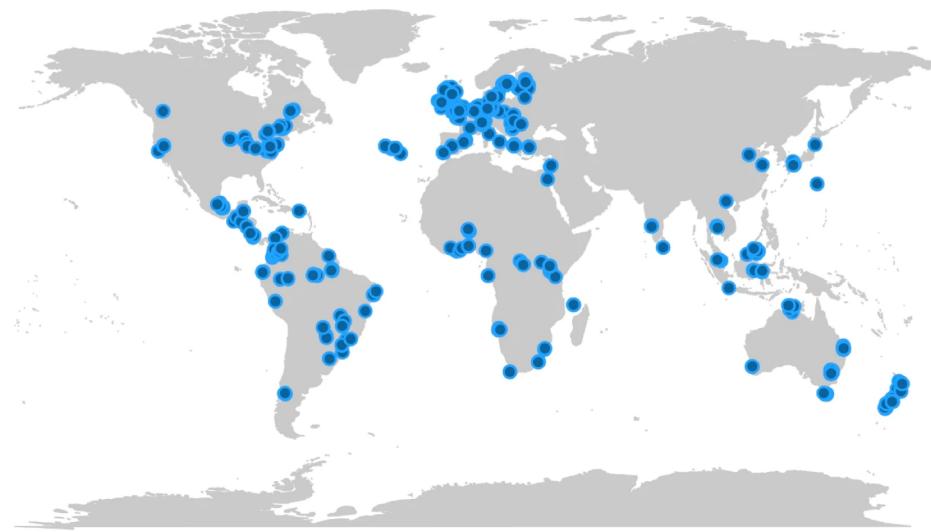
Tim Newbold^{1,2*}, Lawrence N. Hudson^{3*}, Samantha L. L. Hill^{1,3}, Sara Contu³, Igor Lysenko⁴, Rebecca A. Senior^{1†}, Luca Börger⁵, Dominic J. Bennett^{4†}, Argyrios Chioines^{3,4}, Ben Collen⁶, Julie Day^{4†}, Adriana De Palma^{3,4}, Sandra Diaz⁷, Susy Echeverria-Londono⁸, Melanie J. Edgar³, Anat Feldman⁸, Morgan Garon⁴, Michelle L. K. Harrison⁴, Tamera Alhusseini⁴, Daniel J. Ingram^{4†}, Yuval Itescu⁸, Jens Kattge^{9,10}, Victoria Kemp⁴, Lucinda Kirkpatrick^{4†}, Michael Kleverl¹¹, David Laginha Pinto Correia³, Callum D. Martin⁴, Shai Meir⁸, Maria Novosolov⁸, Yuan Pan⁴, Helen R. P. Phillips^{3,4}, Drew W. Purves², Alexandra Robinson⁴, Jake Simpson⁴, Sean L. Tuck¹², Evan Weilher¹³, Hannah J. White^{4†}, Robert M. Ewers⁴, Georgina M. Mace⁶, Jörn P. W. Scharlemann^{1,14} & Andy Purvis^{3,4}

Human activities, especially conversion and degradation of habitats, are causing global biodiversity declines. How local ecological assemblages are responding is less clear—a concern given their importance for many ecosystem functions and services. We analysed a terrestrial assemblage database of unprecedented geographic and taxonomic coverage to quantify local biodiversity responses to land use and related changes. Here we show that in the worst-affected habitats, these pressures reduce within-sample species richness by an average of 76.5%, total abundance by 39.5% and rarefaction-based richness by 40.3%. We estimate that, globally, these pressures have already slightly reduced average within-sample richness (by 13.6%), total abundance (10.7%) and rarefaction-based richness (8.1%), with changes showing marked spatial variation. Rapid further losses are predicted under a business-as-usual land-use scenario; within-sample richness is projected to fall by a further 3.4% globally by 2100, with losses concentrated in biodiverse but economically poor countries. Strong mitigation can deliver much more positive biodiversity changes (up to a 1.9% average increase) that are less strongly related to countries' socioeconomic status.

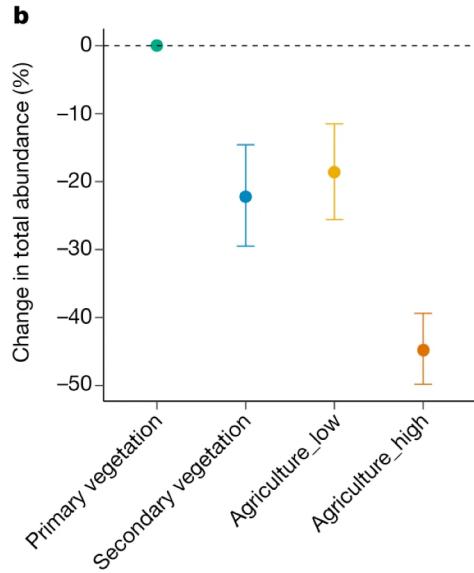
Newbold *et al.* (2015), *Nature*

Example of meta-analyses in Ecology

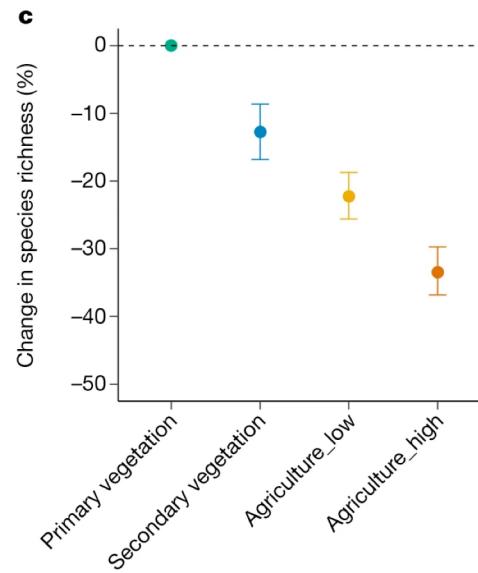
a



b



c



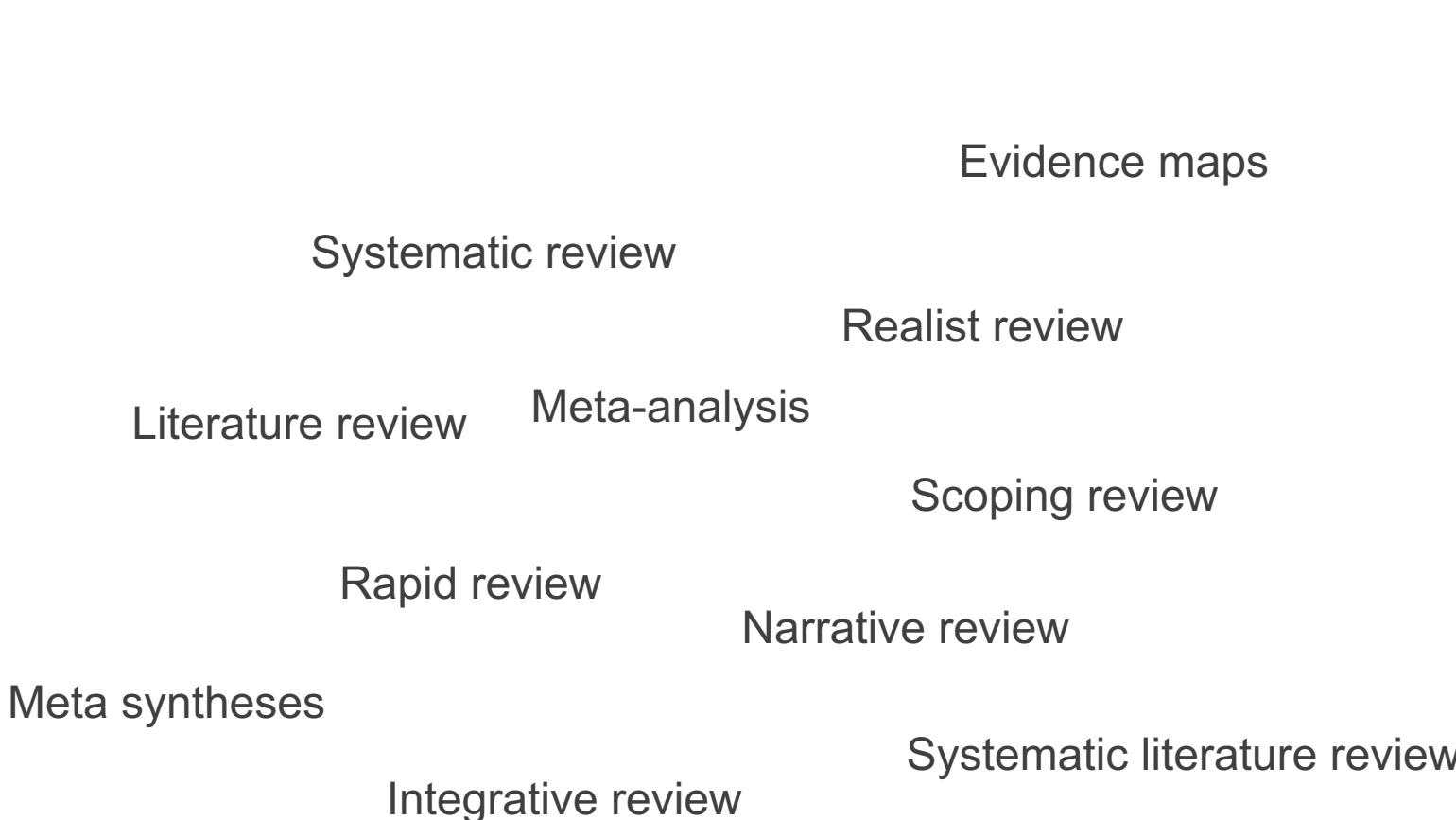
Predicts



Outwhaite *et al.* (2022), *Nature*

A review is?

an overview or summary of existing research



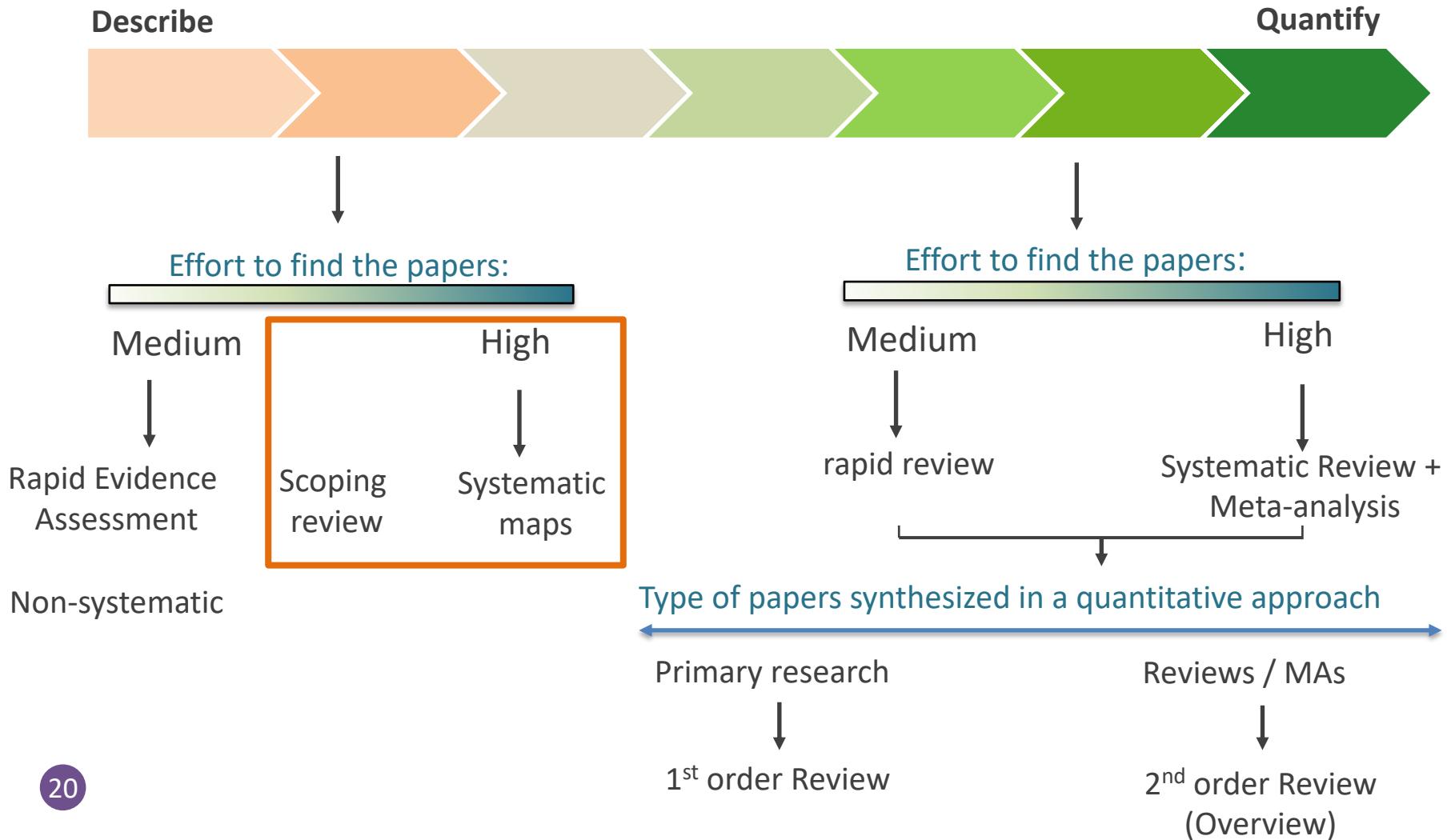
What types of reviews exist ?

- Rapid Evidence Assessment (REA)
- Scoping Review (SR)
- Non-systematic reviews (NSR)
- **Systematique Review (SR)**
- **Systematic maps (SM)**
- **Meta-analysis (MA)**

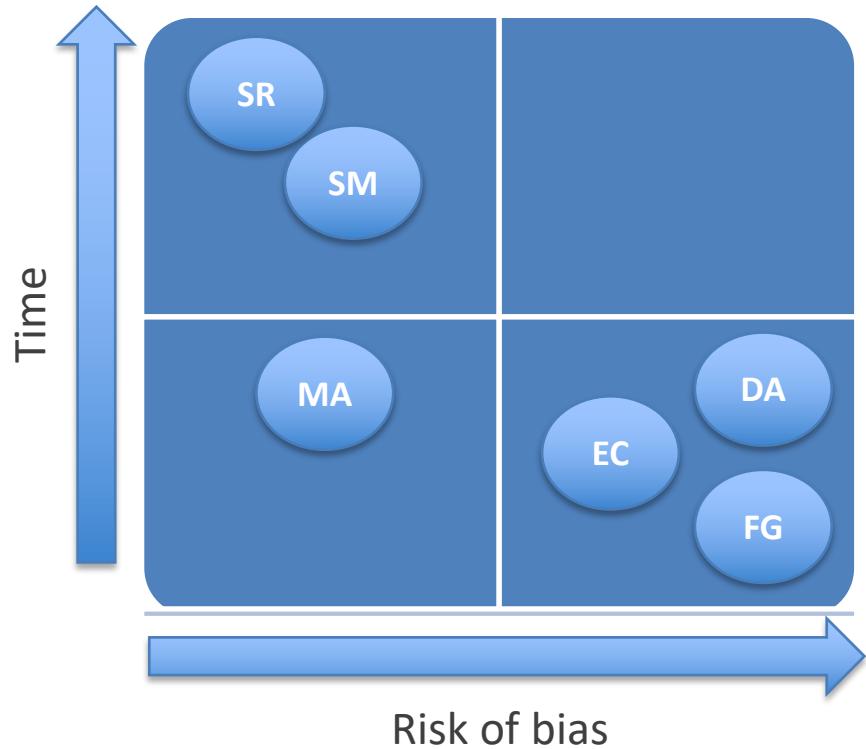


- Expert consultation (EC)
- Multiple Expert Consultation with Formal Methods (Delphi)
- Focus Groups (FG)
- Discourse Analysis (DA)

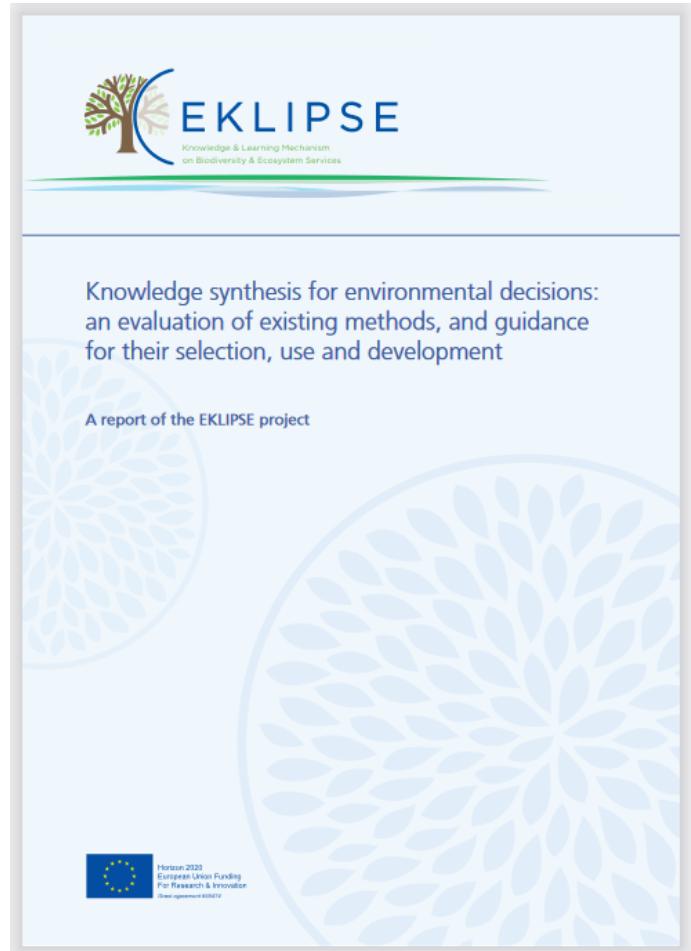
What types of reviews exist ?



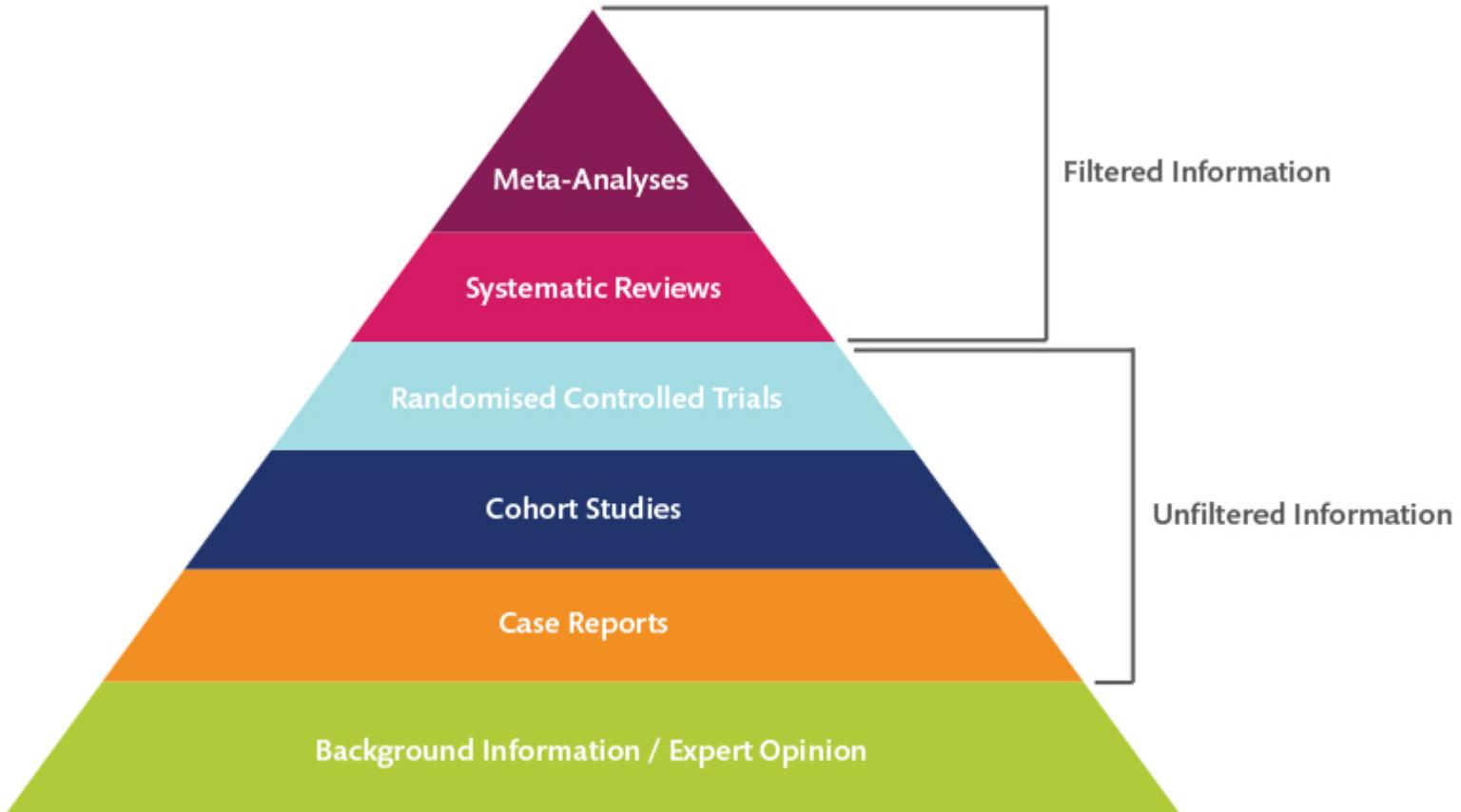
What types of reviews exist ?



Source: Dicks et al, 2018: https://www.eklipse-mechanism.eu/apps/Eklipse_data/website/EKLIPSE_D3-1_On-lineReport_NewInset4Print_012019_HL3.pdf



Levels of evidence pyramid



Systematic (evidence) map

- **Purpose:** they provide an overview or “landscape of knowledge” on a given issue.
 - Broader issues than a journal.
 - Mapping / cataloguing all existing research.
- The map stops before the evaluation of publications (no critical appraisal):
 - it does not evaluate the results of primary studies.
- **They aim to highlight:**
 - Knowledge “gaps” = prioritization for research ?
 - Knowledge “clusters”

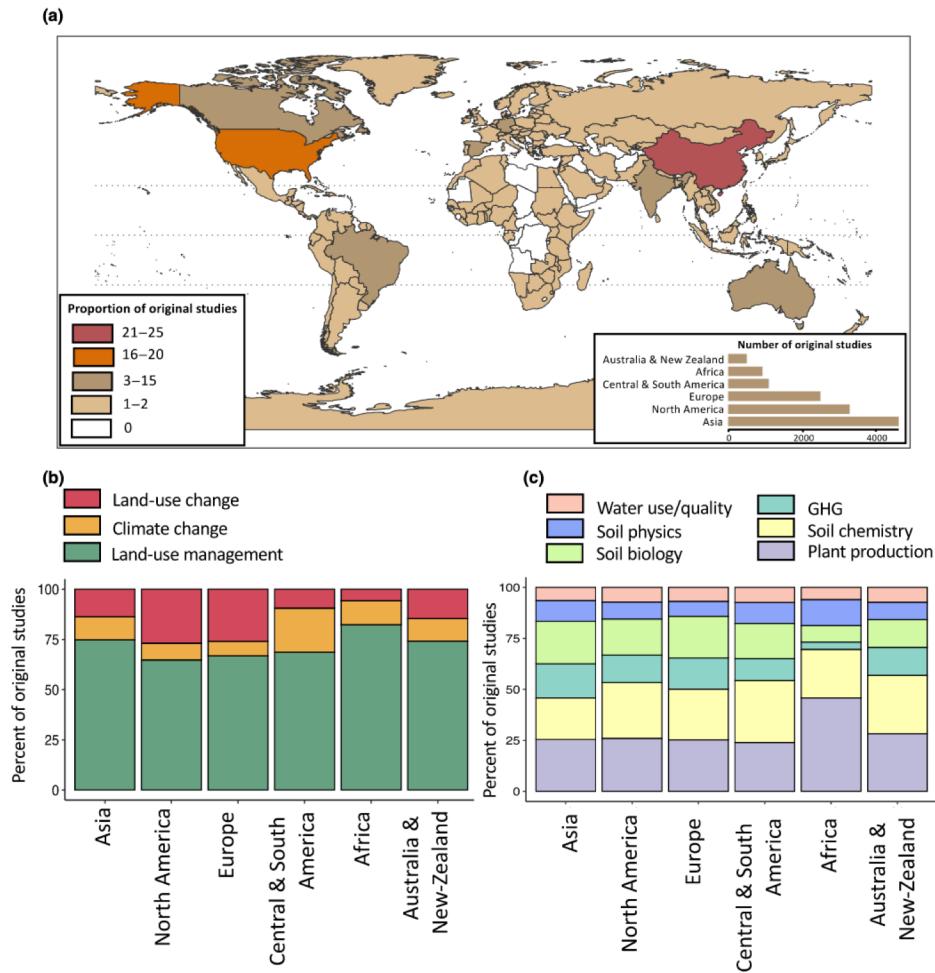


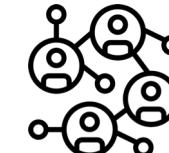
FIGURE 3 (a) Locations of the original studies ($n = 13,270$) included in the meta-analyses. (b) Proportion of original studies per geographic zone and per driver of soil organic carbon (SOC) change. (c) Proportion of original studies per geographic zone and per not-SOC related outcome. Some meta-analyses did not provide the list of their original studies, and are thus not accounted for in this figure [Colour figure can be viewed at wileyonlinelibrary.com]

Strengths of evidence maps

I. Visual representation of the knowledge accumulated/gaps
(i.e. no need to read hundreds of primary studies!)



2. Typology/categorization of the research
(often term and definition varies a lot to represent a same phenomena/practice)



3. Offer a foundation for further, more focused research synthesis
(a first step for a new meta-analysis)



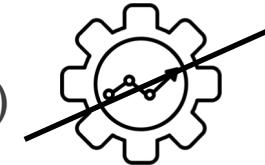
4. Political/scientific agenda for future research



Weakness of evidence maps

I. Only descriptive – no analyses

(i.e. do not inform on the effectiveness of the tested interventions)

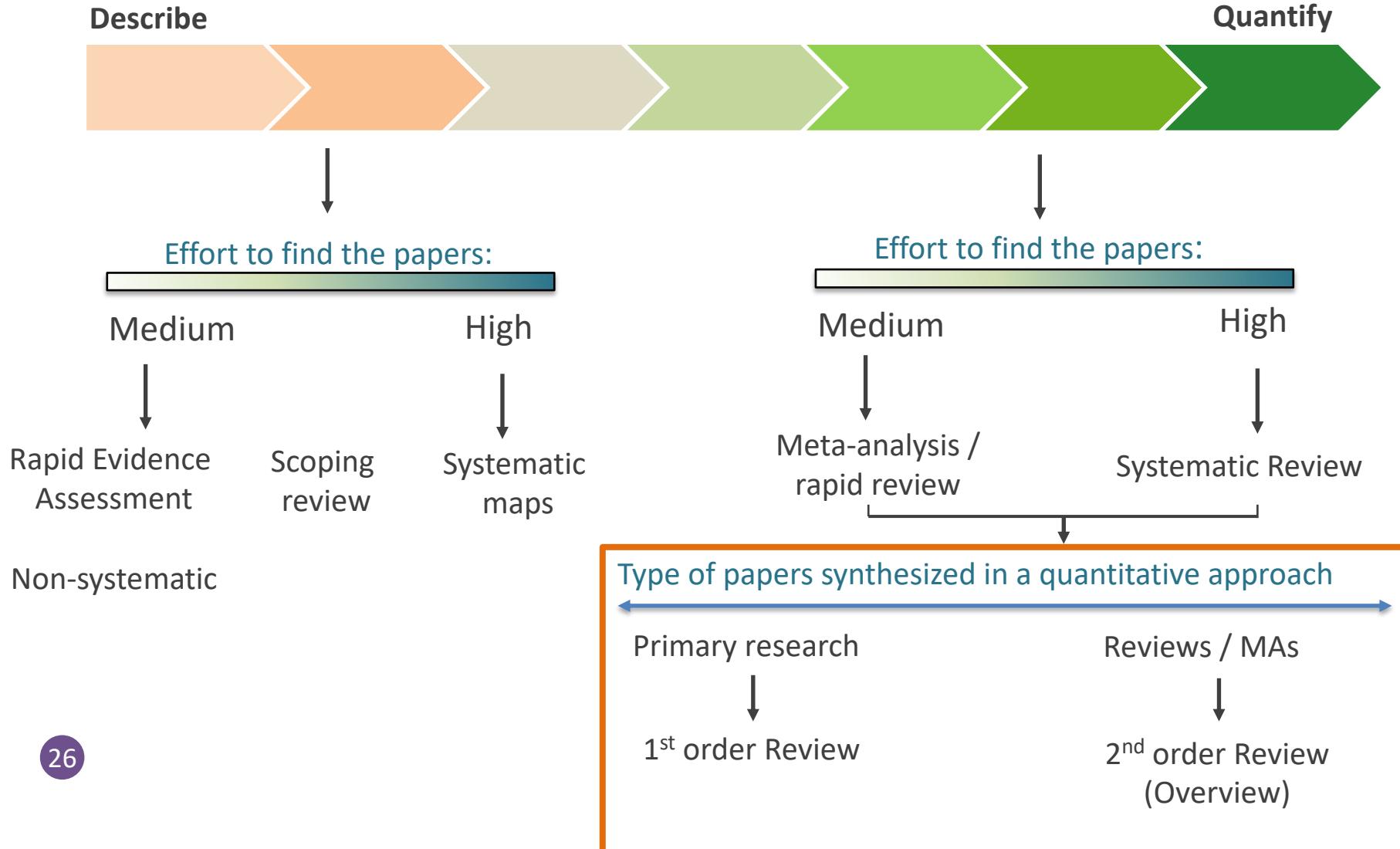


2. The results could also be presented in meta-analyses

(beware of redundancies!)



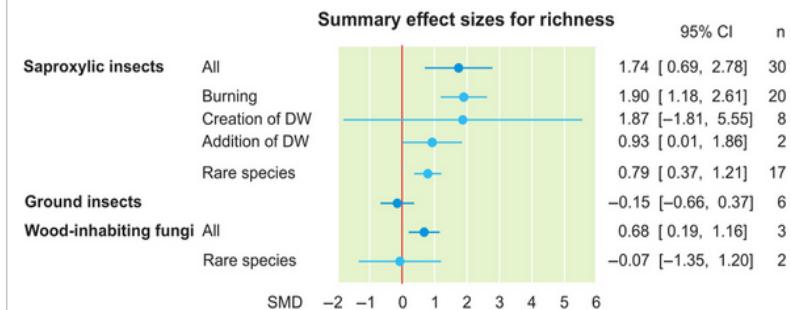
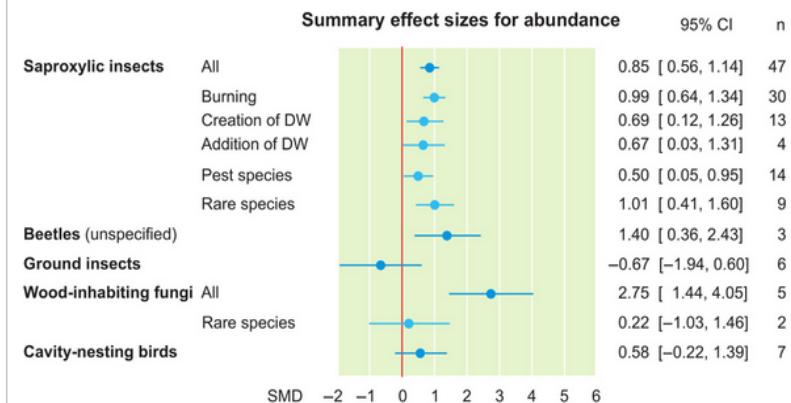
What are the differences ?



Systematic Review (with meta-analysis)

- **Purpose:** they answer a specific question.
- **Founding assumption:** publication of an article does not guarantee "perfection".
- Critical appraisal: assessing the level of bias in articles
- Universal criteria for robustness of an experiment:
 - Relevant comparator
 - Replication of the experiment
 - Choice of study sites
- Categorization into low, medium and high bias
- Exclusion of high bias articles

Impacts of dead wood manipulation on the biodiversity of temperate and boreal forests. A systematic review



e.g. "the creation of dead wood" in forest increases the richness and abundance of certain taxa

Strengths of meta-analyses

1. See the forest for the trees

(i.e. see effects and relationships that might not be visible in individual studies)



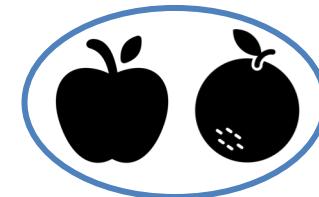
2. Synthesize knowledge on controversial issues

(find average effect while trying to minimize bias)



3. Can compare apples and oranges (to some degree)

(meta-analysis is specifically designed to deal with heterogeneity)



4. Identify knowledge gaps

(very important role of meta-analysis!)



5. Examine reasons for variation (to some degree)



Weakness of meta-analyses

1. See the tree for the forest

(i.e. apply results to individuals)



2. Cannot overcome bias

(e.g. partial synthesis, publication bias, subjective methods choices)



3. Comparing apples and oranges

(combining things that should not be combined)



4. Not representative

(Study population = scientific studies, **≠ population of interest**)



5. Not able to examine causality



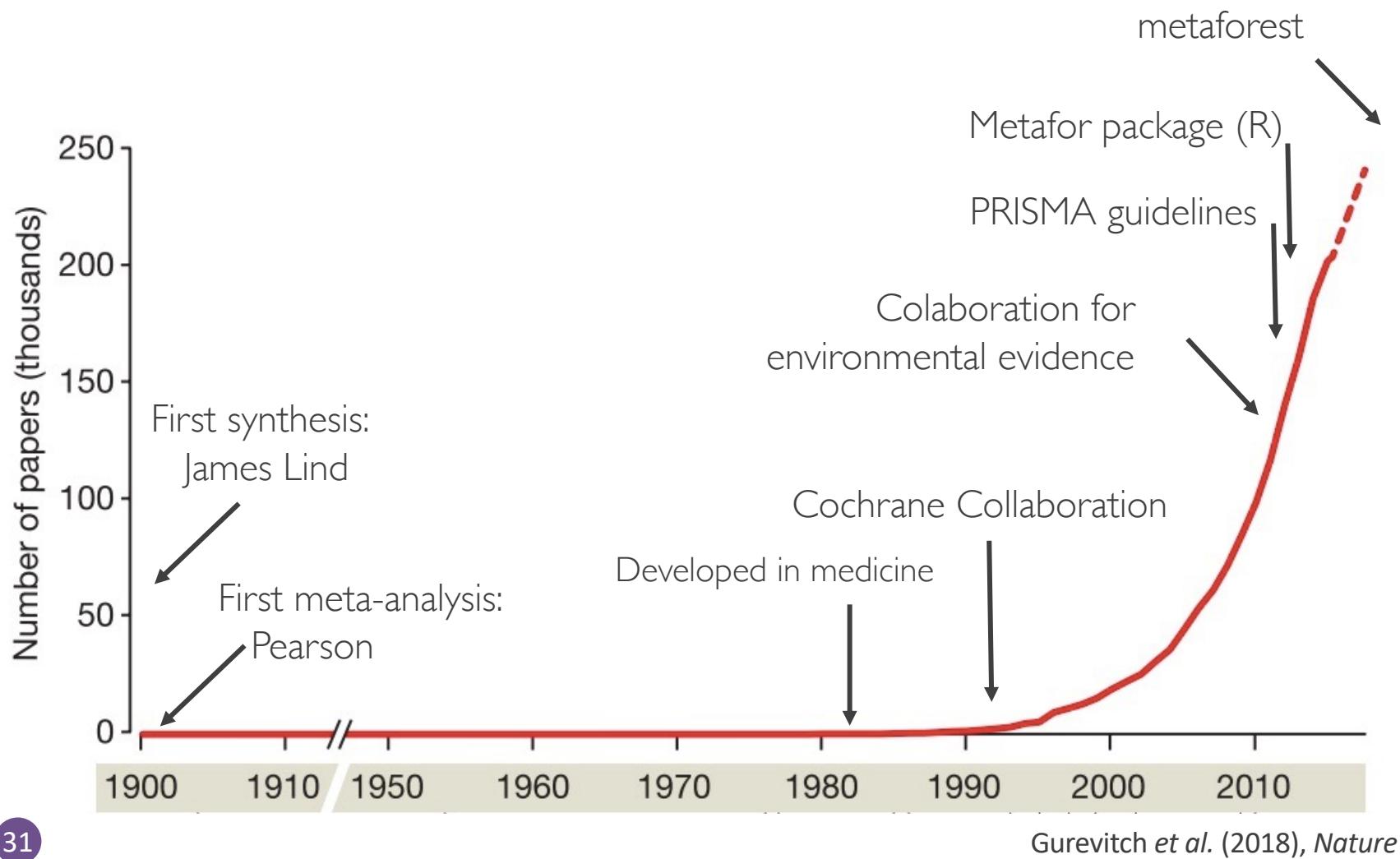
Differences between a Review and a Map, selon la CEE

Table 2.5. Key aspects of Systematic Reviews and Systematic Maps

	Systematic Review	Systematic Map
Protocol	Mandatory	Mandatory
Systematic searching	Mandatory	Mandatory
Systematic study selection	Mandatory	Mandatory
Critical appraisal of study validity	Mandatory, to ensure robustness of the review answer – directly influences the data synthesis and interpretation steps	Optional (possible if study validity indicators can be captured using the coding method, but unlikely in practice) – does not influence mapping process itself
Data coding and extraction	Mandatory, Meta-data coded and outcome measures (e.g. effect sizes) extracted.	Mandatory, metadata only coded. No extraction of outcome measures (e.g. effect sizes).
Data synthesis approach	Aggregative, seeking an unbiased answer with known precision; could involve meta-analysis	Exploratory; may include coding and group analysis
Typical output	A quantitative or qualitative answer with an indication of uncertainty and any threats to validity. May include estimate of variance caused by external factors.	A description of the evidence base, showing the distribution and abundance of evidence across different elements of the question. A relational database may be provided.

Source : guidelines de la CEE (Pullin et al. 2018)

Research synthesis are trendy...

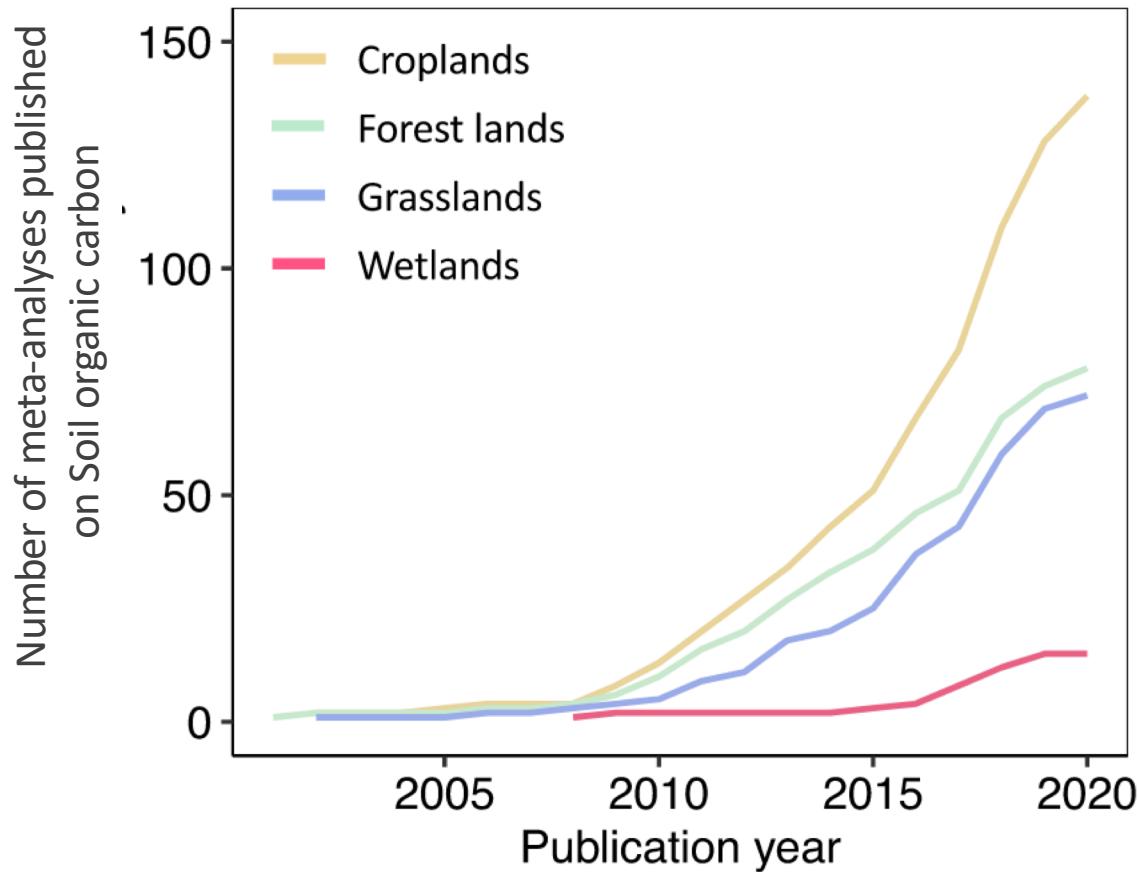


New trends in systematic reviews

A strong methodological development in recent years:

- Metaforest (random forest adapted to meta-analyses)
- Distributional random forest (model several Y variable simultaneously)
- Bayesian statistics
- clarification of the factors explaining the values observed for each individual
- Cumulative meta-analyses and living reviews
- Automation of various steps of the meta-analyses
- webplatform to present and difuse the results
- ...

An increrase in the number .. But what about the quality?



BUT

« Too many meta-analyses and systematic reviews are of **low quality** »

« Education in high-quality research-synthesis methods »

The different steps to perform a systematic review



La revue systématique : 4 collaborations internationales

- Method originating in the medical field (Cochrane) intended to objectify decision-making (medical treatments).
- Now the approach is fully developed in the field of ecology (Collaboration for Environmental Evidence) and in the social sciences (Campbell collaboration).



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ZEBRAFISH

EBTC is conducting a systematic review to determine how well the Zebrafish - Zebrafish Embryotoxicity Test (ZET) can predict human toxicity. The ZET is a commercial guideline toxicity test using rats and rabbits with the same endpoints.

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EBTC was founded in 2011 at Johns Hopkins Bloomberg School of Public Health with the vision to make evidence-based methodologies the standard that is used to ensure public health, a healthy environment and a sustainable future.



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June 2017: Handbook Editors' Update

The Handbook editorial team is currently updating Handbook versions 5.0, 5.1 and 5.2 for a planned release of Version 6 in 2018. This is a major update. Senior Scientific Editors Julian Higgins and James Thomas have reorganized some material to include recent developments. There are also several new chapters including writing a protocol, equity and specific populations, complex interventions, network meta-analysis, and synthesizing findings using non-statistical methods. Please note following the introduction of the Methodological Expectations for Cochrane Intervention Review (MECIR) standards, we set out to produce a minor Handbook update, version 5.2 to include these standards. Due to limited editorial capacity, we only produced a limited number of chapters. These chapters are 1, 8, 9, 10, 11, 12, and 21 and are available as pdf versions for Cochrane members. These chapters only include minor edits to improve clarity, some limited new material and updating. There are currently no substantive changes to methods in these chapters, we expect to include these in Version 6. For more details see the [What's new?](#) page.

[Click here to browse Handbook version 5.1 online](#)

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There are three stages in the production of a Campbell review: (1) title registration, (2) protocol, and (3) review. You will find a Word template for each of these three stages, with a 'Campbell template instructions' document in our online library.

The editorial process for your review will be managed by one Campbell's Coordinating Groups.

General guidance can be found in Campbell's [Policies and Guidelines](#) and [Expectations and guidance](#) for systematic review authors. See the bottom of this page for a [list of links](#) to the resources needed.

1. Title registration

The first step is to complete the title registration form (TRF). Please read the document ['Campbell template instructions'](#) before filling in the form.

The proposed title for your systematic review should clearly state the scope of the review. This scope should be determined in consultation with key stakeholders including intended end users. Guidance on formulating the review title may be found in the [Cochrane Handbook](#), which is the basis for the suggested title format you will find in the TRF template.

An additional resource to assist at the title stage is [The Equity Checklist](#).

The completed TRF should be sent directly to the Managing Editor of the Coordinating Group with which the review

Guidelines and standards: a need for rigour, objectivity and transparency

Collaboration for Environmental Evidence

How We Work
Guidelines for Authors

Guidelines and Standards for Evidence Synthesis in Environmental Management
VERSION 5.0
2018

Please note that these guidelines will be periodically updated and each update recorded (see [Updates and Corrections](#)). Major updates will be announced through social media.

[Read the guidelines online here](#)

Please cite as:

Collaboration for Environmental Evidence. 2018. *Guidelines and Standards for Evidence synthesis in Environmental Management*. Version 5.0. www.environmentalevidence.org/information-for-authors [date of access].

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Thanks to the editorial team for this version of the CEE Guidelines and Standards (in alphabetical order): Geoff Frampton, Barbara Liverell, Gillian Petrokofsky and Andrew Pullin

We thank all authors contributing to this version of the CEE Guidelines and Standards and the papers on which some sections were based (in alphabetical order): Helen Bayliss, Alison Bethel,

Find Out More

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In France, The FRB is the representing scientific structure for the CEE network.