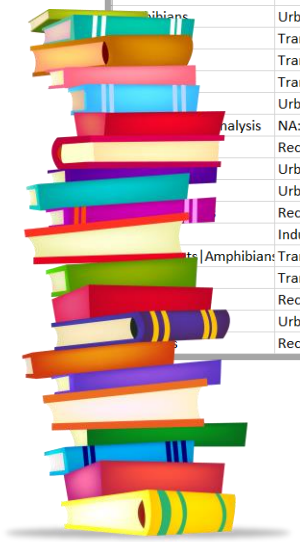
Biodiversity knowledge synthesis: an introduction to meta-analyses and systematic reviews

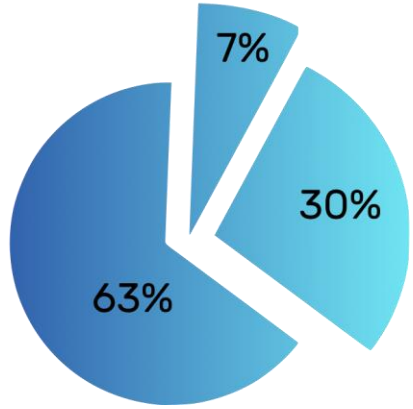
Metadata visualisation

Léa Terray & Romain Sordello
Cellule Cartes et Revues systématiques, PatriNat

Objective

population	exposition	outcome	study_context	study_design	research_lab_location	study_location
NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis
Birds	Urban	Communication	In-situ	Observational	USA	USA
NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis
NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis
Birds	Industrial	Behaviour	In-situ	Experimental	POL	POL
NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis
Birds	Transportation	Behaviour	In-situ	Experimental	CHN	CHN
Mammals	Transportation	Behaviour	Modeling	NA	CAN	NA
[illegible]	Urban|Transportation	Communication	In-situ	Observational	ARG	ARG
[illegible]	Transportation	Reproduction	In-situ	Experimental	USA	USA
[illegible]	Transportation	Communication	In-situ	Experimental	COL	COL
[illegible]	Transportation	Ecosystem	In-situ	Observational	CHN	CHN
[illegible]	Urban	Space use	In-situ	Observational	USA	USA
[illegible]nalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis
[illegible]	Recreational	Behaviour	In-situ	Observational	GBR	GBR
[illegible]	Urban	Communication	In-situ	Observational	MEX	MEX
[illegible]	Urban	Ecosystem	In-situ	Observational	CHN	CHN
[illegible]	Recreational	Behaviour	Ex-situ	Observational	GBR	IRL(zoo)
[illegible]	Industrial	Space use	In-situ	Observational	CAN	CAN
[illegible]ts|Amphibians	Transportation|Urban|R	Ecosystem	In-situ	Observational	CHN	CHN
[illegible]	Transportation	Communication	In-situ	Observational	USA	USA
[illegible]	Recreational	Behaviour	In-situ	Observational	AUS	AUS
[illegible]	Urban	Reproduction	In-situ	Observational	CHN	CHN
[illegible]	Recreational	Behaviour	Ex-situ	Observational	AUS	AUS(zoo)





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Birds	Urban	Communication	In-situ	Observational	USA	USA
NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis
NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis
Birds	Industrial	Behaviour	In-situ	Experimental	POL	POL
NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis
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[illegible]nalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis	NA:review-metanalysis
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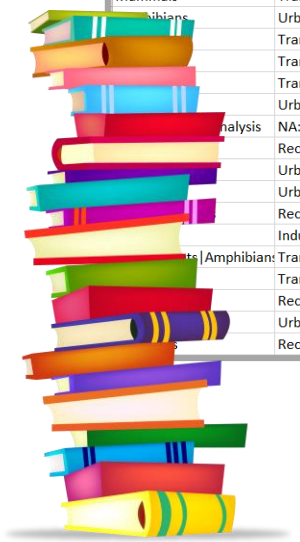
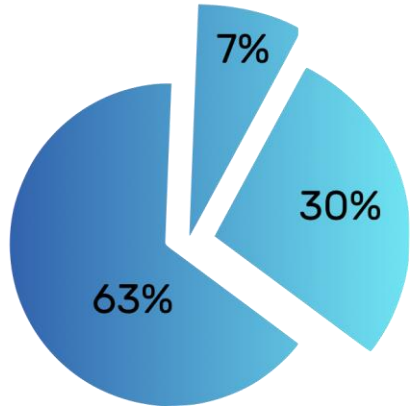




All the features mentioned in the systematic overview protocol must be represented

EEJ guidelines

Mapping the **quantity** of studies relevant to the question

Present here a figure or a database, showing **how the relevant literature is organized** (categories, coding...) according to transparent, replicable criteria.

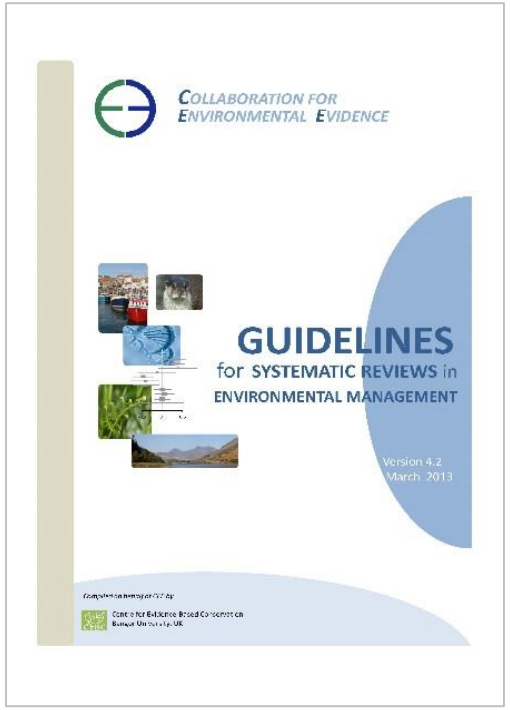
Mapping the **quality** of studies relevant to the question

The map should provide some preliminary **estimate of the quality of the available evidence**. This may involve providing a **description of the design of each study**.

The visualizations presented should make it easier to navigate through the collected literature and **identify avenues for future systematic reviews**.

Must be identified and described:
Knowledge gaps, unrepresented or underrepresented subtopics that warrant further primary research.
Knowledge clusters, well-represented subtopics that are amenable to full synthesis via systematic review.

Collaboration for Environmental Evidence



Which data should be represented?

Key data

- Bibliometric data: chronological distribution of publications, locality of studies, documents types, documents contents
- Population
- Exposition
- Outcomes

Data related to study design

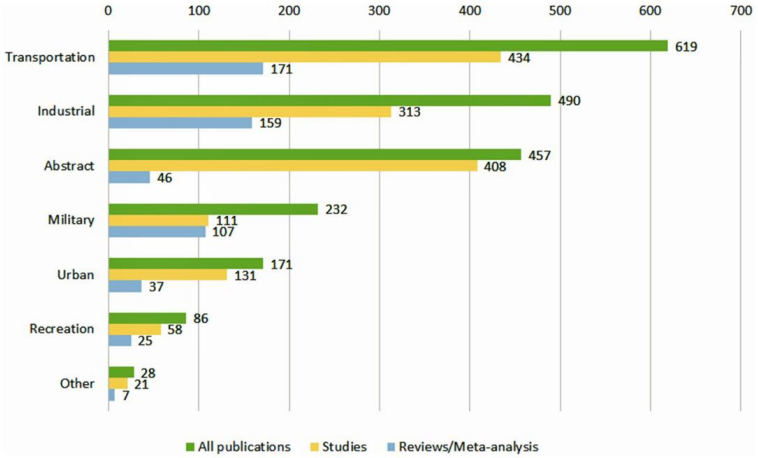
- observational/experimental
- types of experimental protocols
- *in situ/ex situ*

etc

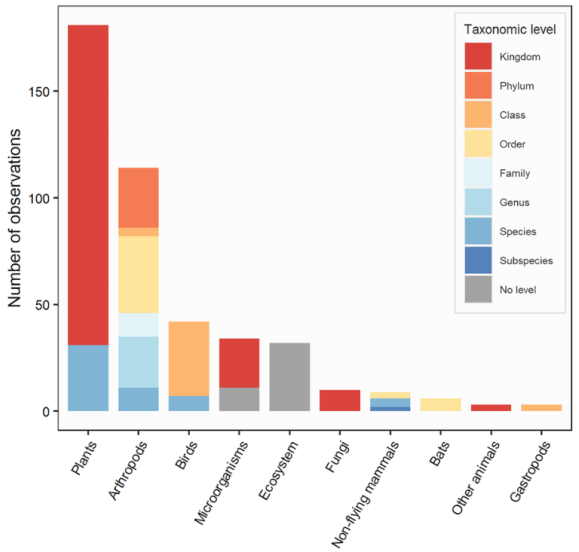
Key data highlighting strong results

Endless possibilities

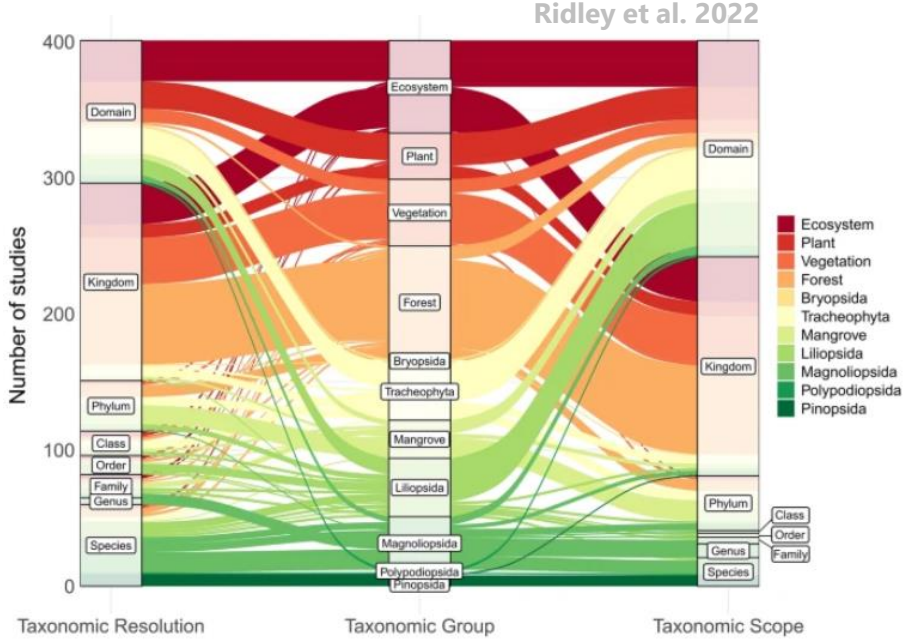
Sordello et al. 2020

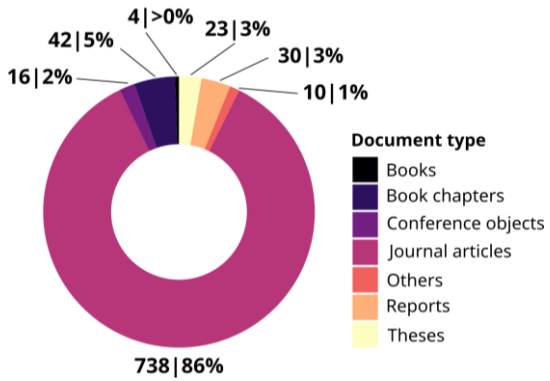


Lafitte et al. 2023



Ridley et al. 2022





Terray et al. *in prep*

	Abstract	*Industrial*	*Transportation*	*Military*	*Urban*	*Recreation*	*Other*
Mammals	181	145	145	73	12	27	11
Fishes	86	104	97	14	2	11	5
Birds	74	60	142	25	109	20	3
Amphibians	23	4	31	0	5	2	0
Insects	19	2	10	0	2	2	1
Crustaceans	9	18	8	1	0	0	2
Mollusks	9	9	6	1	0	0	0
Other invertebrates	2	3	5	0	0	0	0
Reptiles	1	7	7	3	0	1	0
Other vertebrates	1	1	2	0	0	2	0
Arachnids	1	1	1	0	1	0	0

Sordello et al. 2020

Endless possibilities

To sort out the possibilities, you need to :

Choose the right data to represent

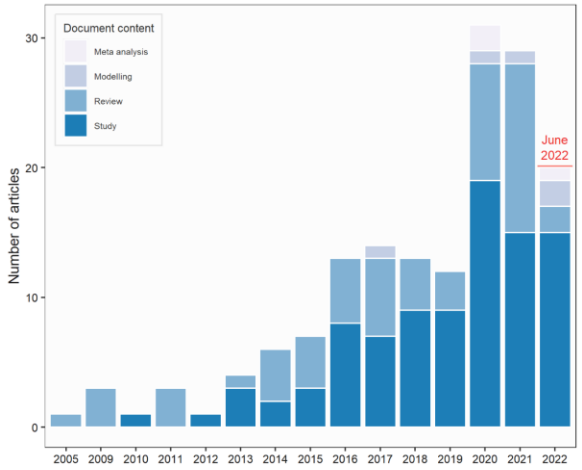
The data chosen must be the most relevant, and present both an overview of the corpus and the data that responds specifically to the question(s) on the map.

Choose the right visualisations

The visualisations chosen must be the most appropriate for representing the data selected

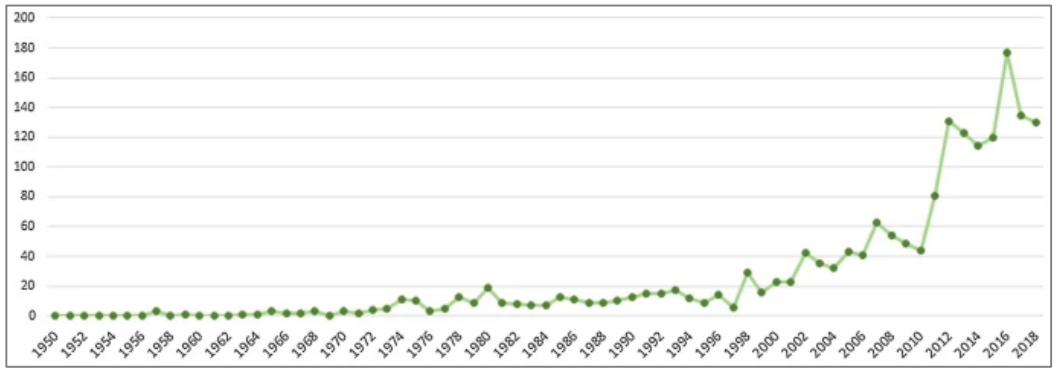
Bibliometric data

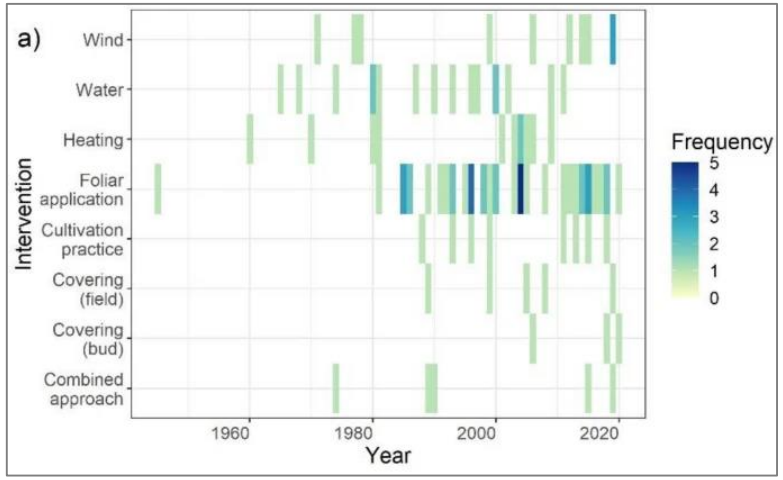
Chronological distribution of studies



Lafitte et al. 2023

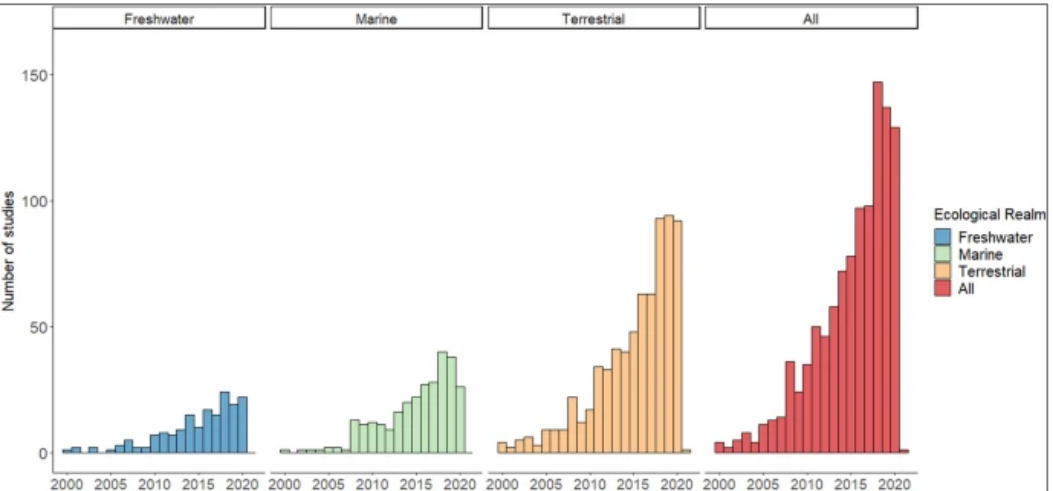
Sordello et al. 2020



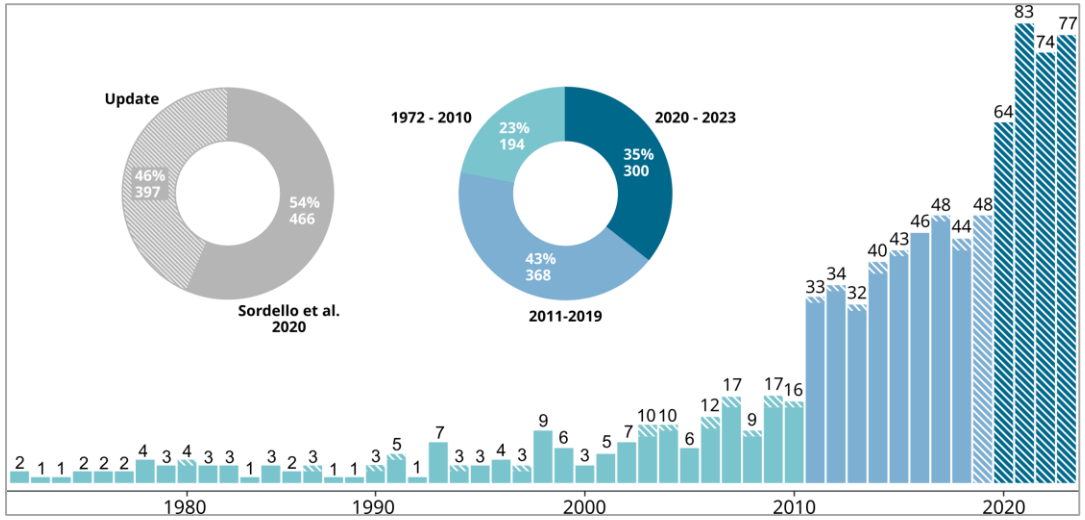


Drepper et al. 2020

Ridley et al. 2022

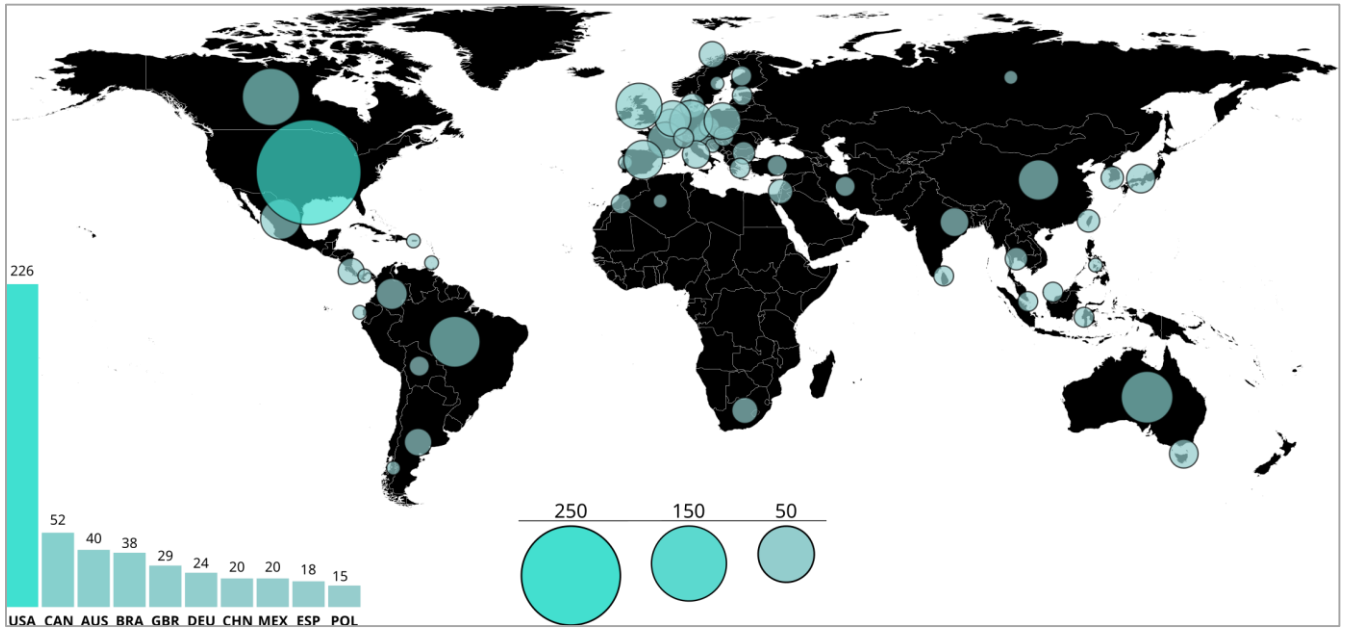


Terray et al. *in prep*

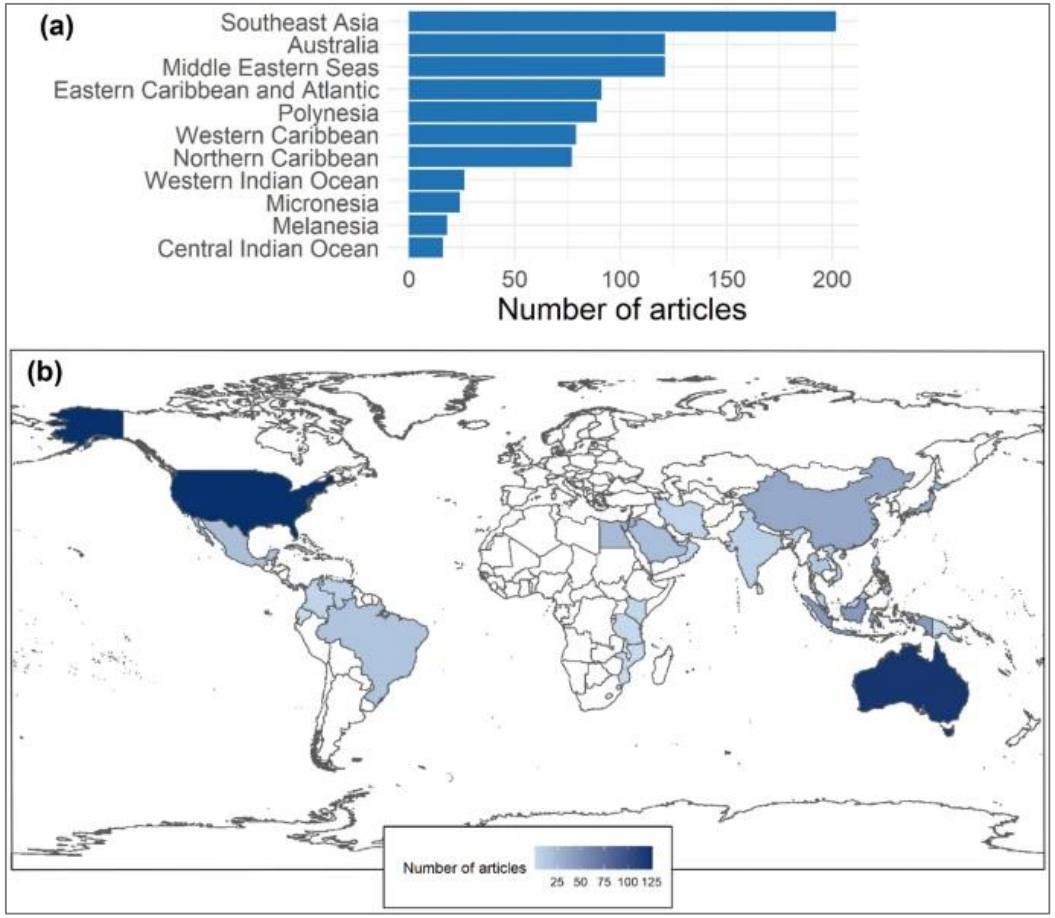


Bibliometric data

Spatial distribution of studies



Terray et al. *in prep*

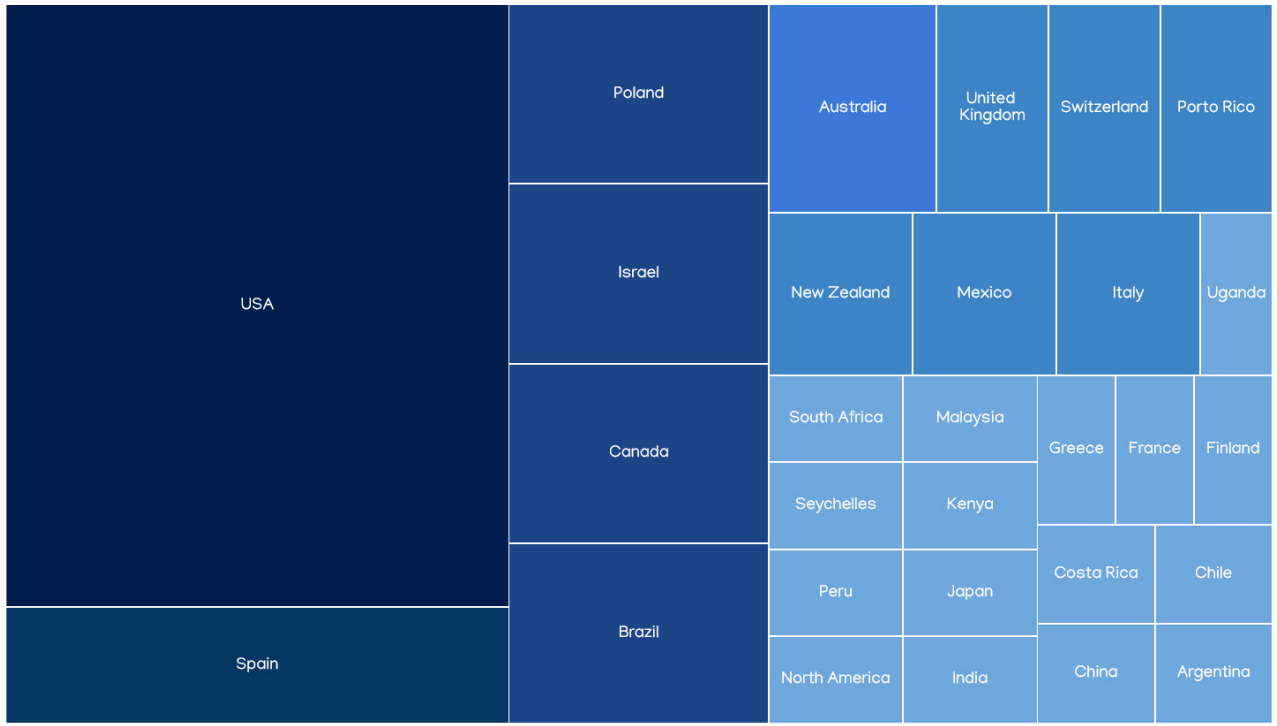


Ouédraogo et al. 2021

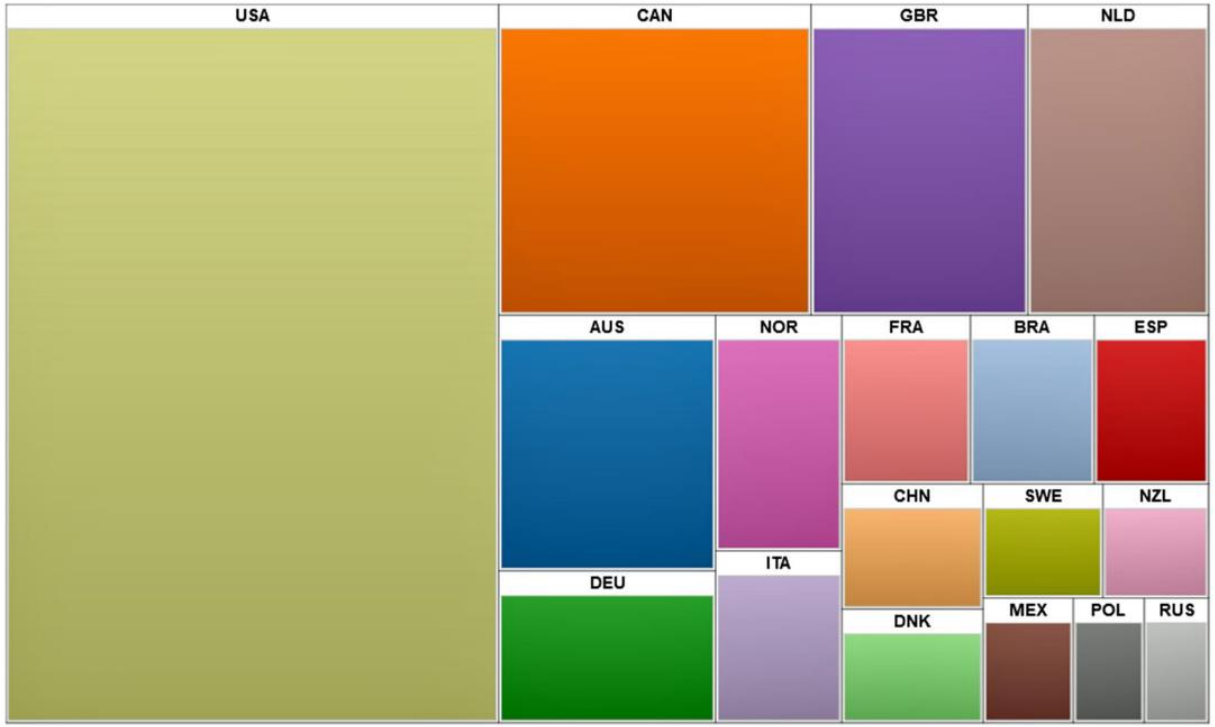
Bibliometric data

Spatial distribution of studies

TreeMap, online tool: https://online.visual-paradigm.com/



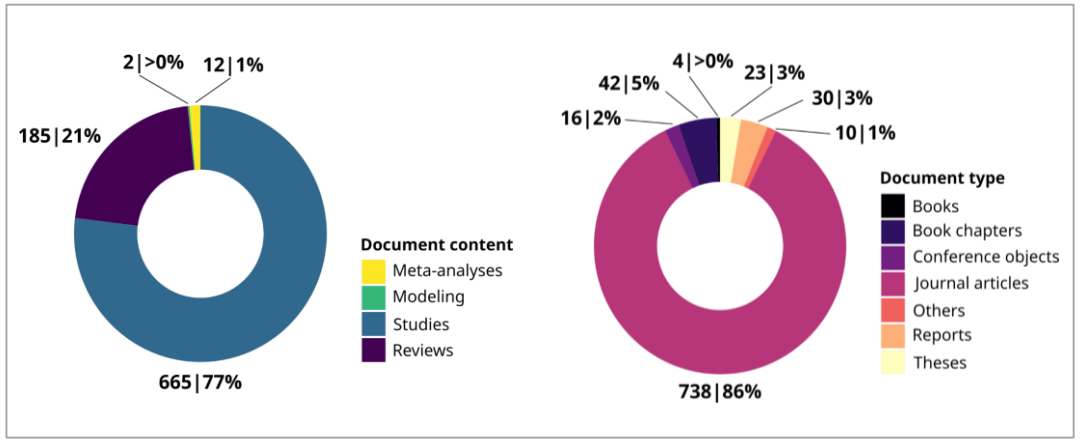
Sordello et al. 2023



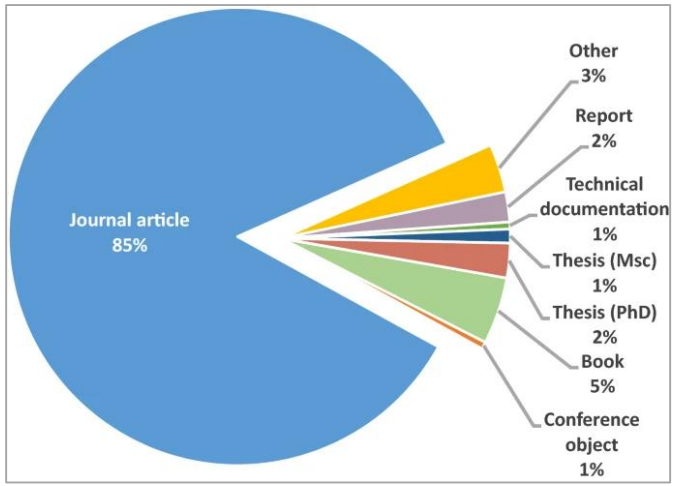
Sordello et al. 2020

Bibliometric data

Documents types and contents

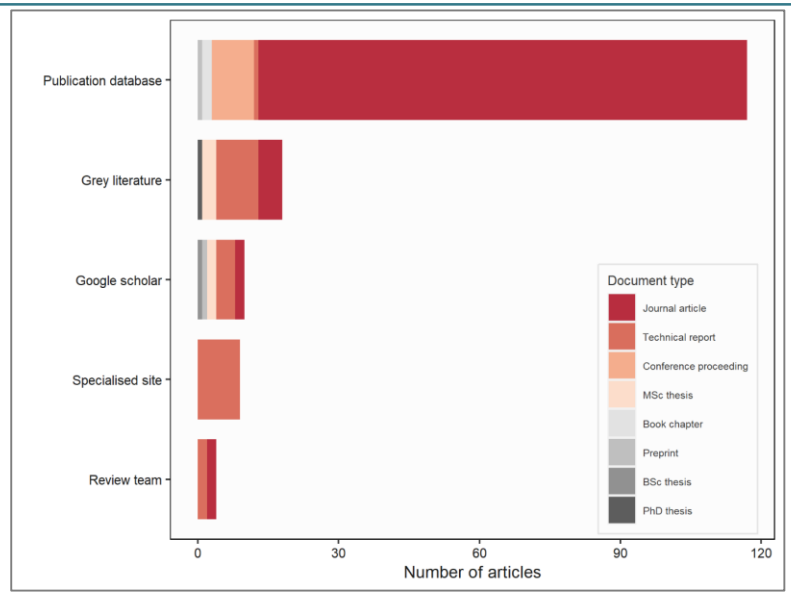


Terray et al. *in prep*

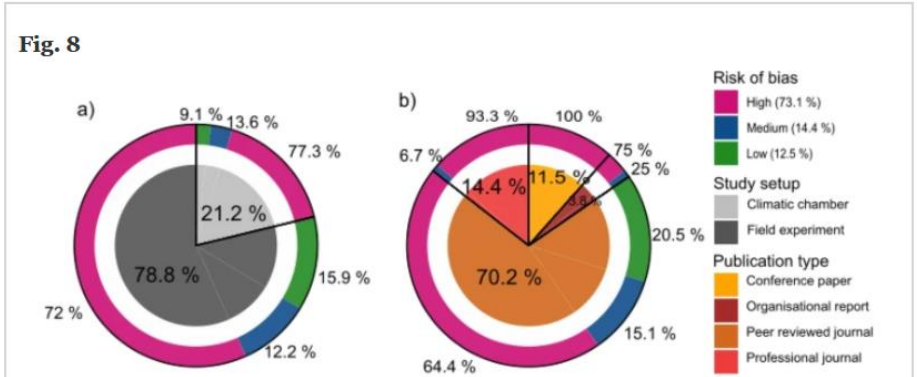


Langridge et al. 2021

Lafitte et al. 2023



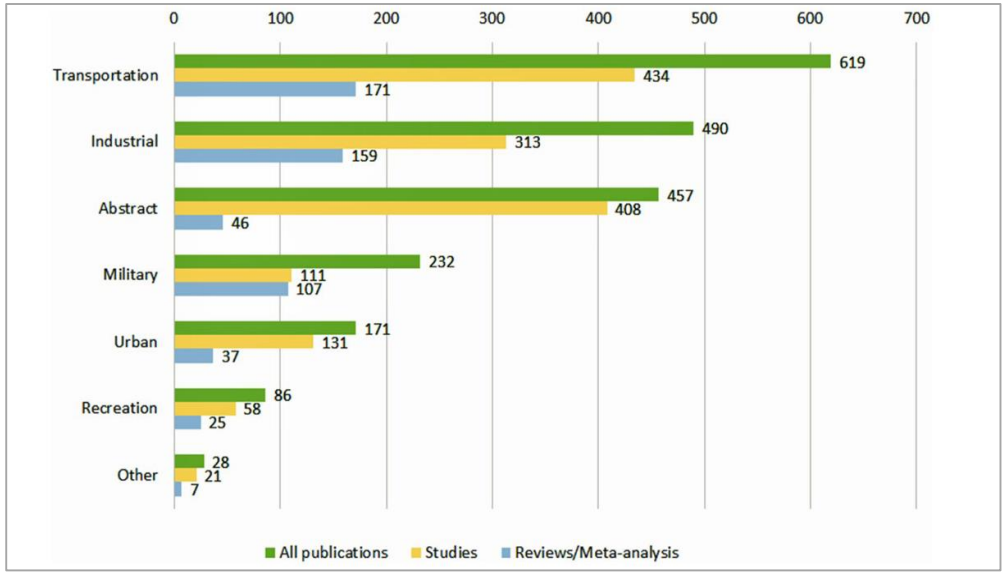
Drepper et al. 2022



Share of articles judged as having a low, medium or high risk of bias by (**a**) type of study (controlled or field environments) and (**b**) type of publication

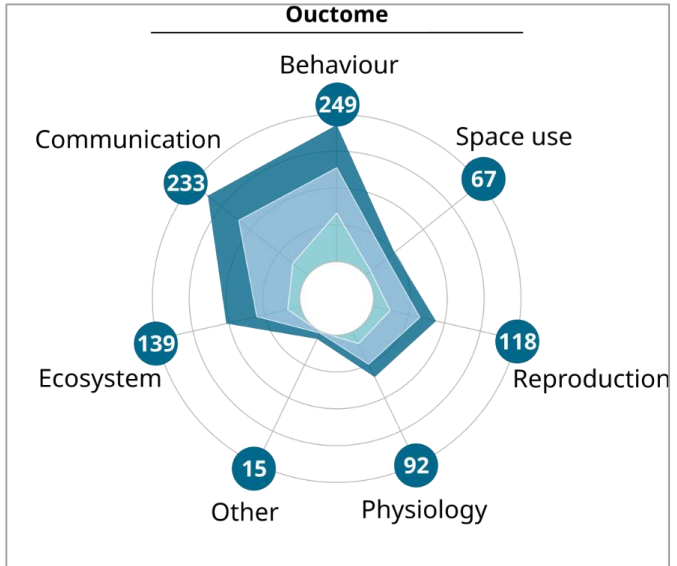
PEO elements

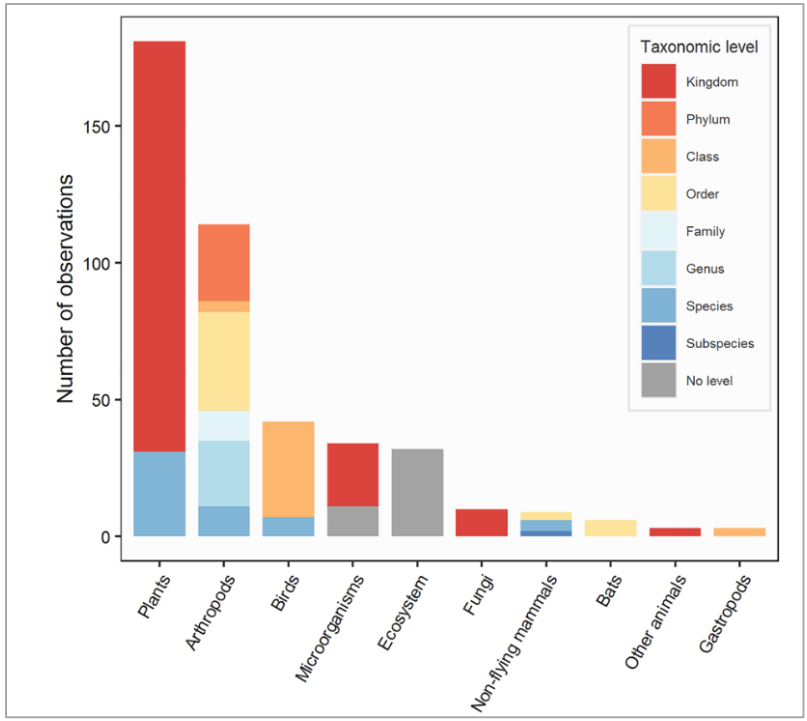
Population, exposition, outcomes



Sordello et al. 2020

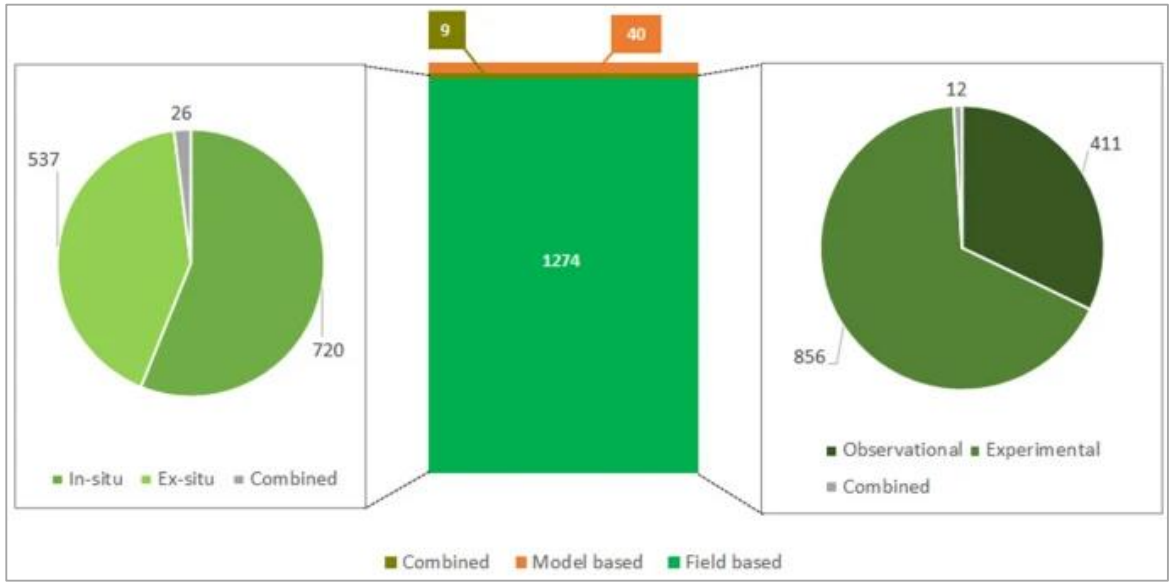
Terray et al. *in prep*





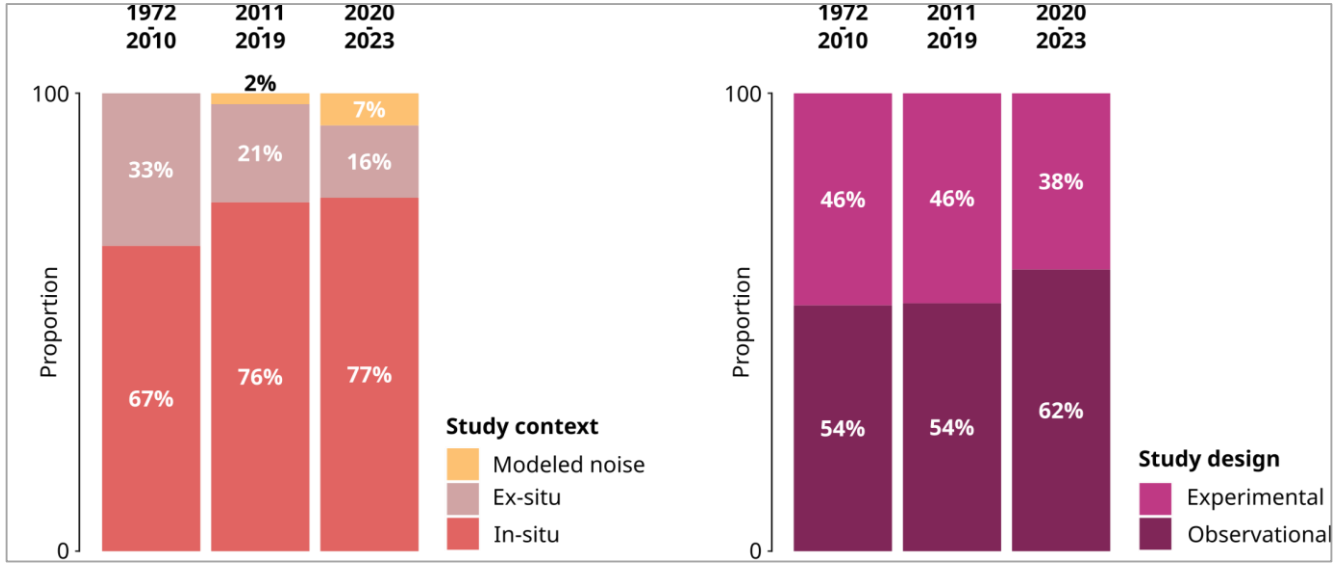
Lafitte et al. 2023

Context and methodology



Sordello et al. 2020

Terray et al. *in prep*



Context and methodology

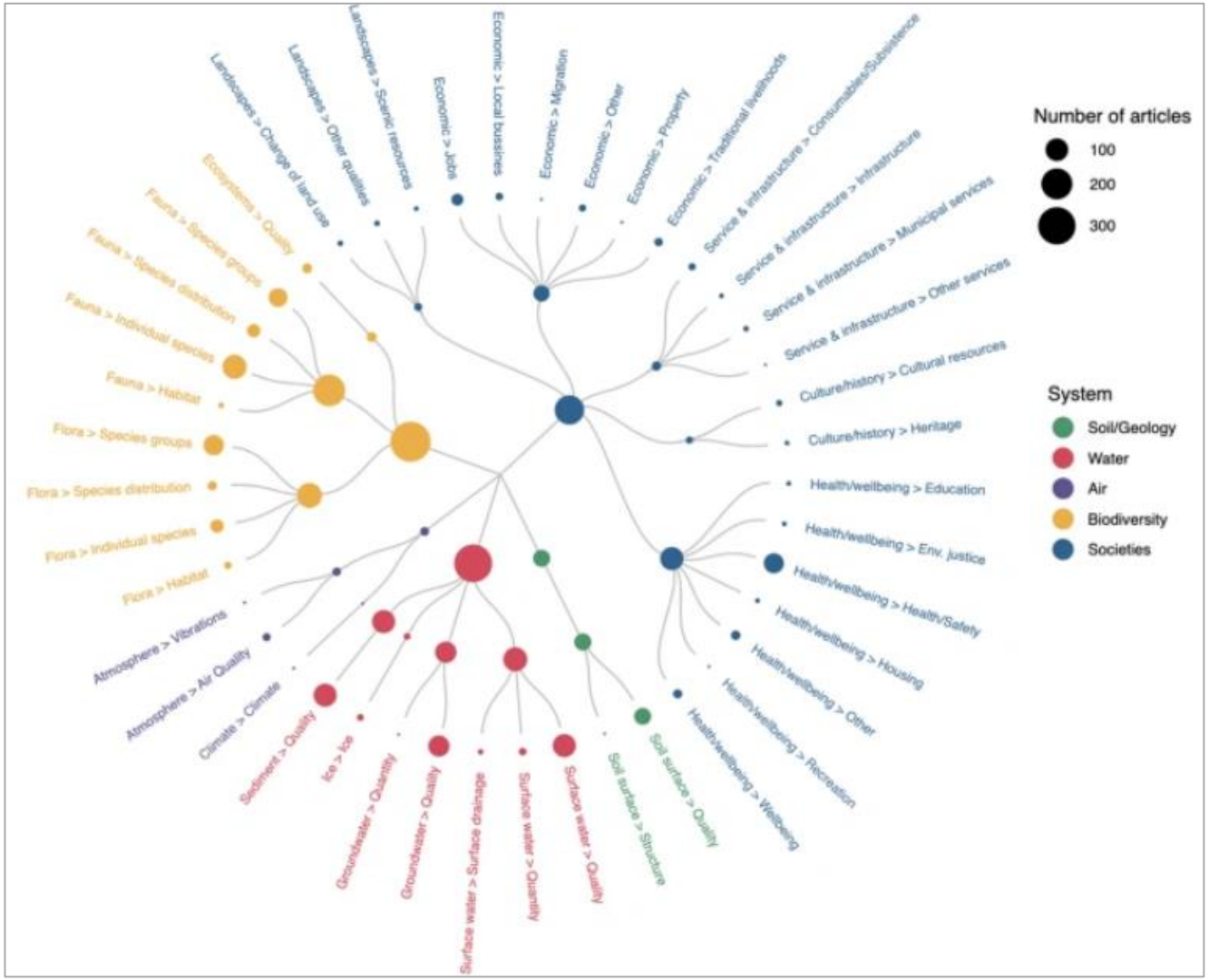
From: Evidence on the impacts of chemicals arising from human activity on tropical reef-building corals; a systematic map

Taxa	Total		Experimental		Observational	
Pocillopora damicornis	719	(9.1%)	546	(14.2%)	173	(4.2%)
Stylophora pistillata	603	(7.6%)	537	(14%)	66	(1.6%)
Coral	555	(7%)	33	(0.9%)	522	(12.8%)
Porites	255	(3.2%)	18	(0.5%)	237	(5.8%)
Scleractinia	218	(2.7%)	20	(0.5%)	198	(4.8%)
Acropora tenuis	207	(2.6%)	148	(3.8%)	59	(1.4%)
Acropora muricata	199	(2.5%)	154	(4%)	45	(1.1%)
Porites astreoides	197	(2.5%)	109	(2.8%)	88	(2.2%)
Porites lutea	190	(2.4%)	32	(0.8%)	158	(3.9%)
Acropora	184	(2.3%)	58	(1.5%)	126	(3.1%)
Orbicella annularis	169	(2.1%)	101	(2.6%)	68	(1.7%)
Acropora cervicornis	152	(1.9%)	146	(3.8%)	6	(0.1%)
Acropora millepora	149	(1.9%)	140	(3.6%)	9	(0.2%)
Siderastrea siderea	125	(1.6%)	64	(1.7%)	61	(1.5%)
Pocillopora verrucosa	122	(1.5%)	59	(1.5%)	63	(1.5%)
Porites porites	110	(1.4%)	89	(2.3%)	21	(0.5%)
Porites lobata	105	(1.3%)	34	(0.9%)	71	(1.7%)
Turbinaria reniformis	101	(1.3%)	100	(2.6%)	1	(0%)
Acropora valida	100	(1.3%)	34	(0.9%)	66	(1.6%)
Orbicella faveolata	99	(1.2%)	49	(1.3%)	50	(1.2%)

Ouédraogo et al. 2021

Complex representations

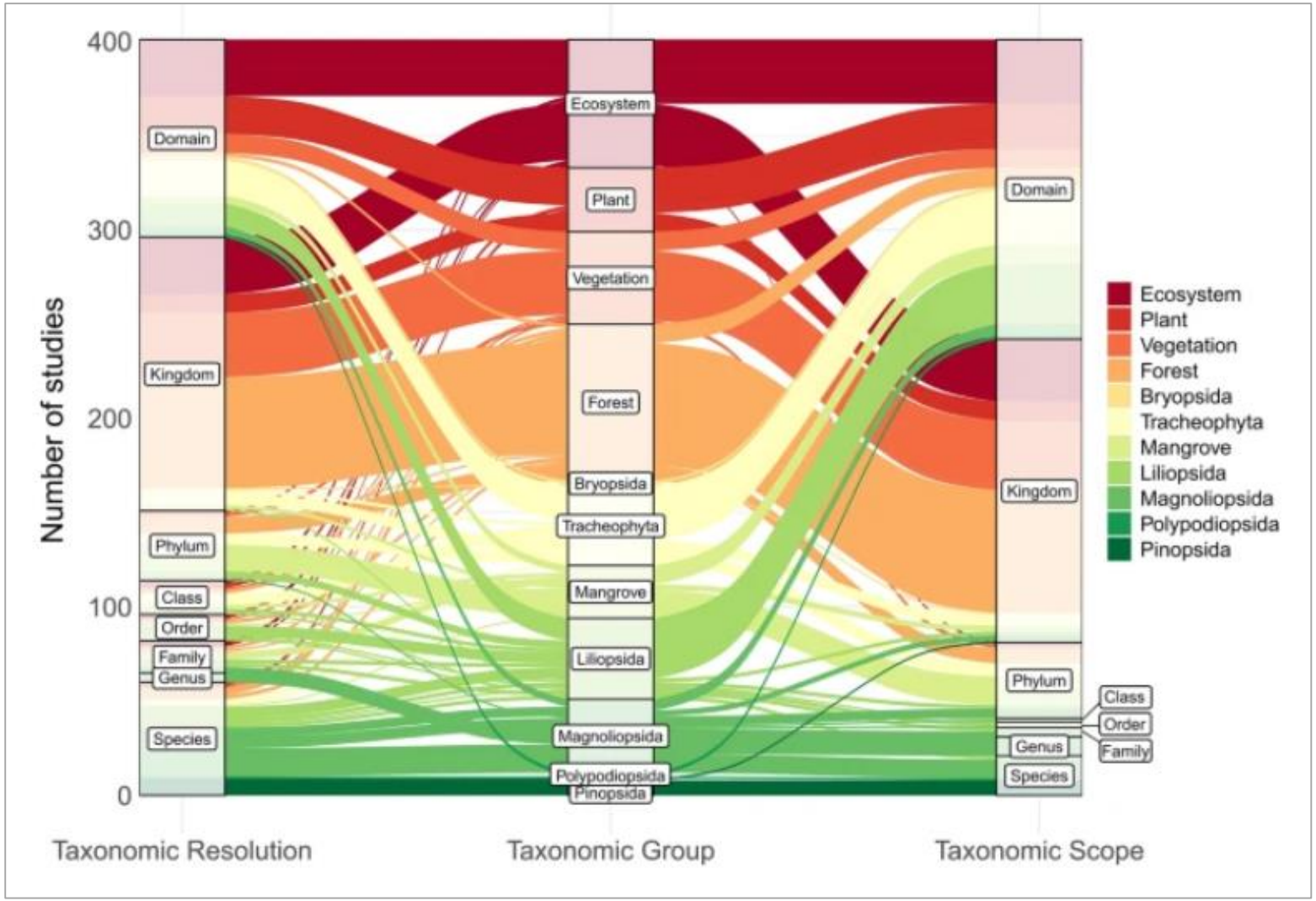
Dendrogram



Haddaway et al. 2022

Complex representations

Taxonomic tree



Ridley et al. 2022

Knowledge gaps and clusters

The purpose of the map is to identify :

- **Knowledge gaps** to prioritise future primary studies (calls for projects, for example)
- **Knowledge clusters** for future systematic reviews

Knowledge gaps and clusters

- Different methods exist:
  - Based on the volumes of the P, E, O elements
  - Based on functional grouping (design types, etc.)
  - …

- **Heatmap** are particularly relevant

- The process can - and should - extend to identifying clear issues that can be addressed in reviews

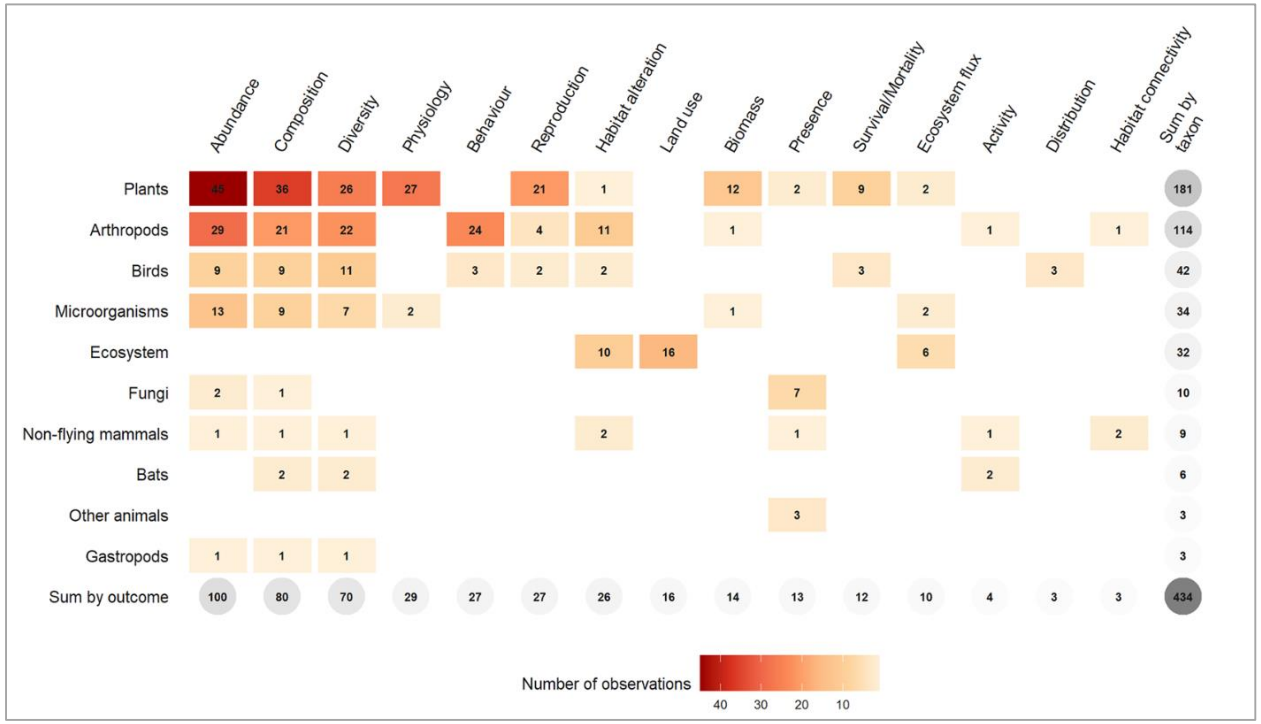
Knowledge gaps and clusters

Crossing of PEO elements

Taxonomic kingdom X Programme motivation	Intervention type						
	Intro+suppl	Introduction	Reintro+suppl	Reintroduction	Supplementation	Unknown	Total
Animalia	**6**	**6**	**176**	**158**	**158**	**182**	**686**
Conservation (improving status of focal species)	6	4	158	123	110	88	489
Experimental or trial translocations		1	4	12	13	16	46
Human-wildlife conflict				5	11	17	33
Rewilding (restoring natural functions)			3	3		2	8
Unknown		1	9	11	9	33	63
Wildlife rescue operation			2	4	15	26	47
Fungi				**4**	**3**		**7**
Wildlife rescue operation				4	3		7
Plantae		**4**	**10**	**11**	**41**	**82**	**148**
Conservation (improving status of focal species)		3	10	9	39	72	133
Experimental or trial translocations		1		2	2	5	10
Unknown						1	1
Wildlife rescue operation						4	4
Total	6	10	186	173	202	264	841

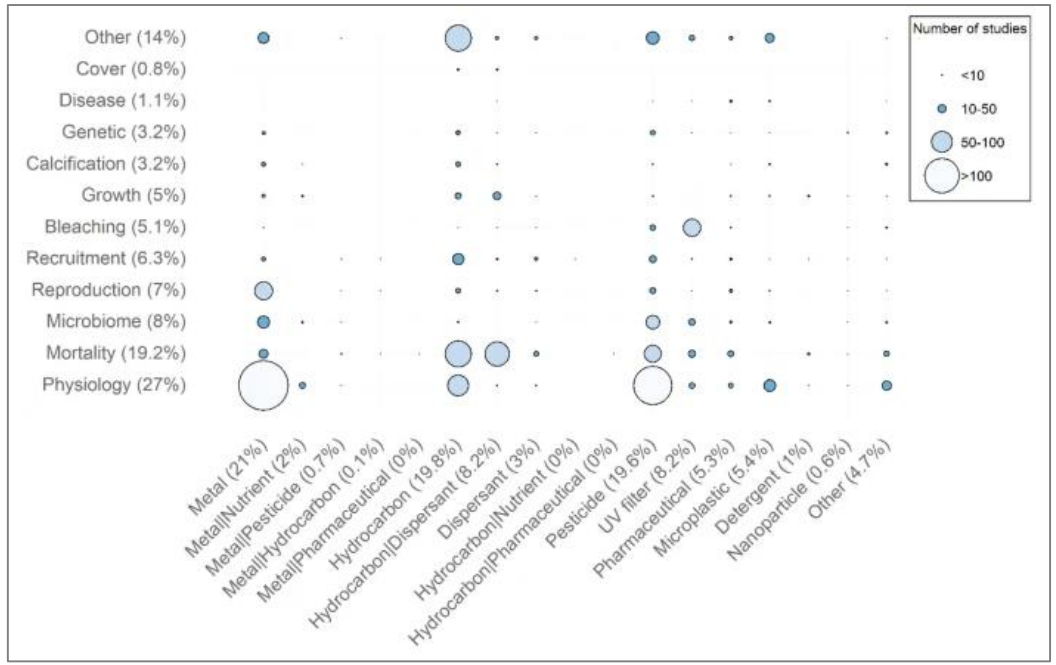
Langridge et al. 2021

Lafitte et al. 2023



Knowledge gaps and clusters

Crossing of PEO elements



Ouédraogo et al. 2021

Sordello et al. 2020

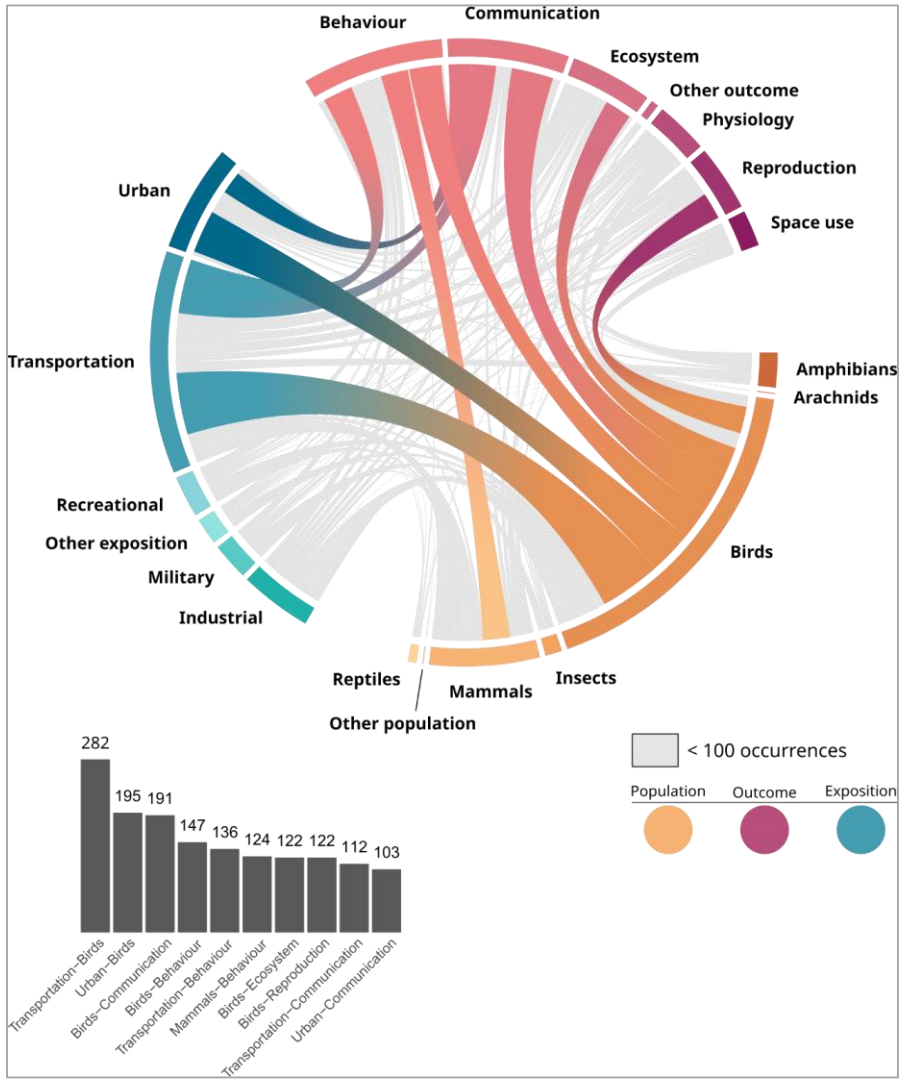
From: Evidence of the impact of noise pollution on biodiversity: a systematic map

Cluster	Number of studies	Combinations		
		P	E	O
Behavioural impacts of noise on mammals	355	x		x
Impacts of transportation noise on behaviour	216		x	x
Impacts of abstract noises on biophysiology	208		x	x
Impacts of abstract noise on behaviour	202		x	x
Impacts of industrial noises on behaviour	187		x	x
Impacts of abstract noise on mammals	181	x	x	
Biophysiological impacts of noise on mammals	181	x		x
Behavioural impacts of noise on fishes	159	x		x
Biophysiological impacts of noise on fishes	149	x		x
Impacts of industrial noise on mammals	145	x	x	
Impacts of transportation noise on mammals	145	x	x	
Impacts of transportation noise on birds	142	x	x	

Knowledge gaps and clusters

Crossing of PEO elements

➔ The 3 elements presented on a single figure

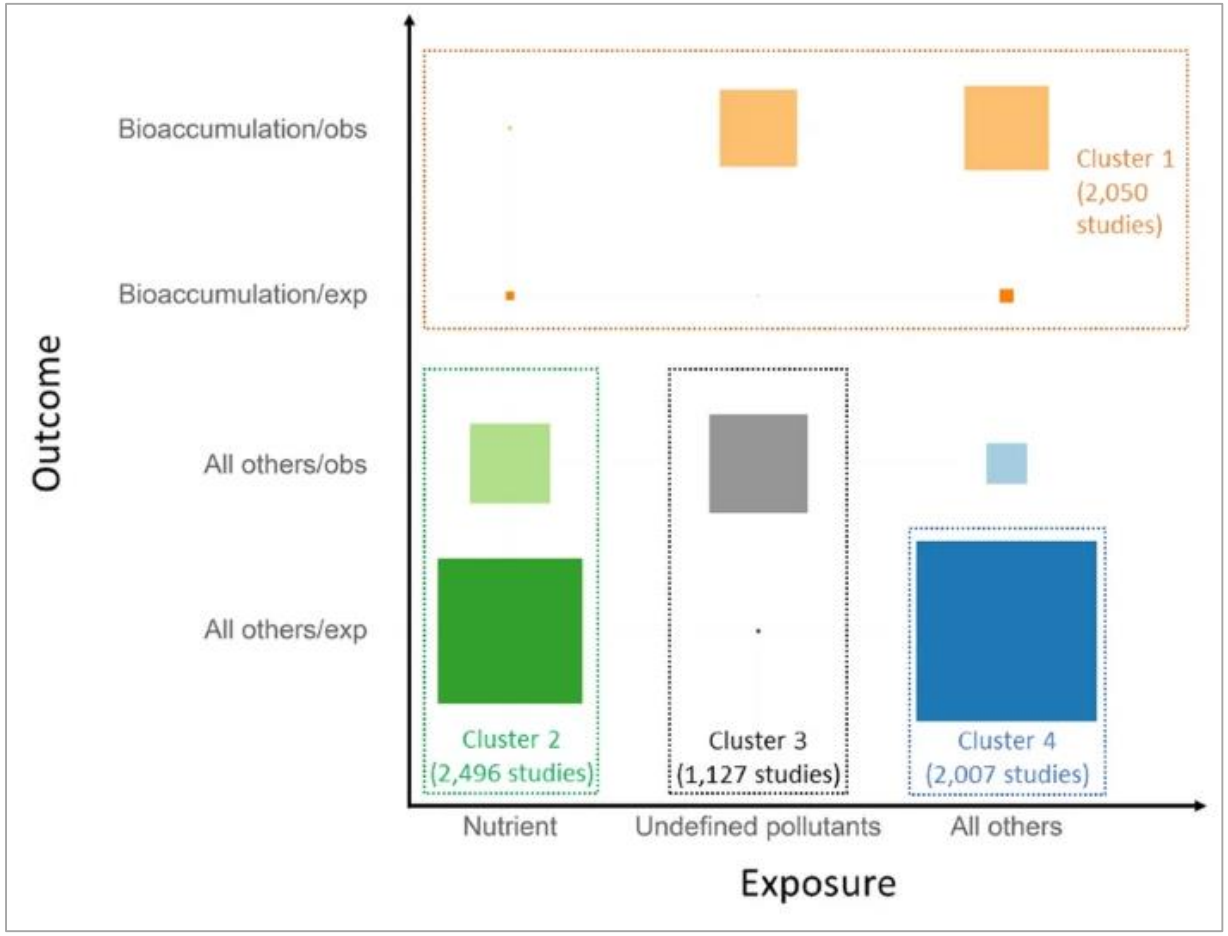


Terray et al. *In prep*

Knowledge gaps and clusters

Clusters on more than 2 criteria

- Outcome
- Exposure
- Study design

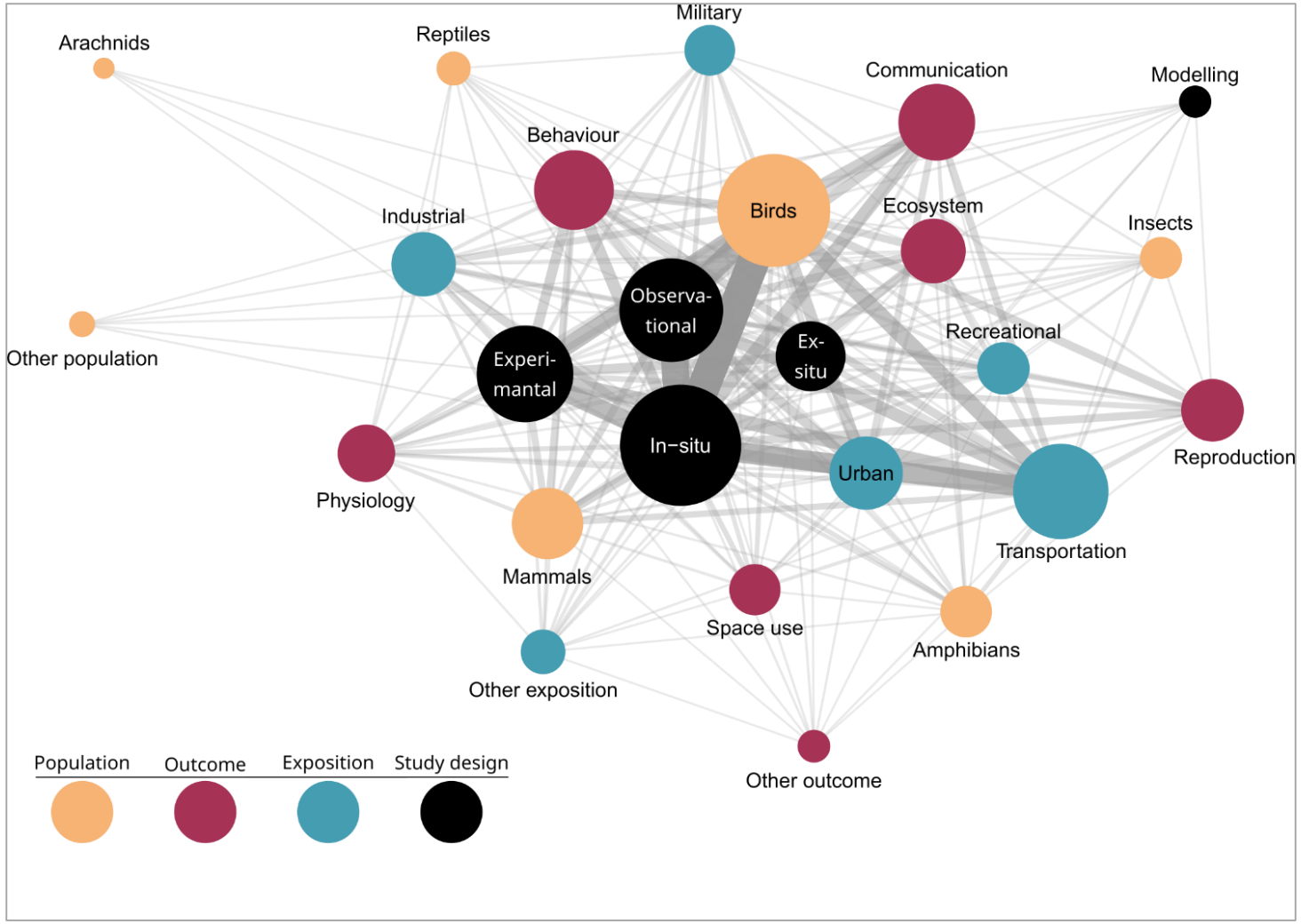


Ouédraogo et al. 2020

Knowledge gaps and clusters

Clusters on more than 2 criteria

- Outcome
- Exposure
- Population
- Study design
- Study context



Terray et al. *In prep*

Representing existing syntheses

Compare existing syntheses to our map

From: Existing evidence on the outcomes of wildlife translocations in protected areas: a systematic map

Citation	Scope of review	Nature of synthesis	Search databases	No. of other literature sources	Publication data range of included articles	No. of included publications
Our map (translocation synthesis)	*P: all biodiversity worldwide* *I: reintroductions, introductions, Supplementations* *C: protected areas*	*Systematic map*	*2 databases: WOS, SCOPUS*	*12 (+2 grey literature calls)*	*1969 to 2020*	*498*
Fischer J, Lindenmayer DB. An assessment of the published results of animal relocations. *Biological Conservation*. 2000; 96: 1–11	P: animals worldwide I: reintroductions, supplementations, introductions	Map-like	0 databases	A search for articles across 12 major journals only	1979 to 1998	124
Hale SL, Koprowski JL. Ecosystem-level effects of keystone species reintroduction: a literature review. *Restoration Ecology*. 2018; 26: 439–45	P: key-stone species I: reintroductions only	Map-like	1 database: WOS	0	1995 to 2016	69
Tetzlaff SJ, Sperry JH, DeGregorio BA. Effects of antipredator training, environmental enrichment, and soft release on wildlife translocations: a review and meta-analysis. *Biol Cons.* 2019; 236: 324–31	P: all biodiversity[a] I: translocations[a] C: antipredator training, soft release, or environmental Enrichment	Meta-analysis	0 databases (Search in google scholar only)	0	1981 to 2018	41
Resende, P., Viana-Junior, A., Young, R., Azevedo, C., 2020. A global review of animal translocation programs. *Anim. Biodivers.* Conserv. 221–232. https://doi.org/10.32800/abc.2020.43.0221	P: animals I: introduction, reintroduction, translocations[a]	Map-like	2 databases: WOS, SCOPUS	1	1986 to 2017	145

P population, *I* interventions, *C* context

[a]Methods unclear and exclusion criteria difficult to ascertain. The first line in italics corresponds to this map

Langridge et al. 2021

Representing existing syntheses

Add those syntheses to our visualisations

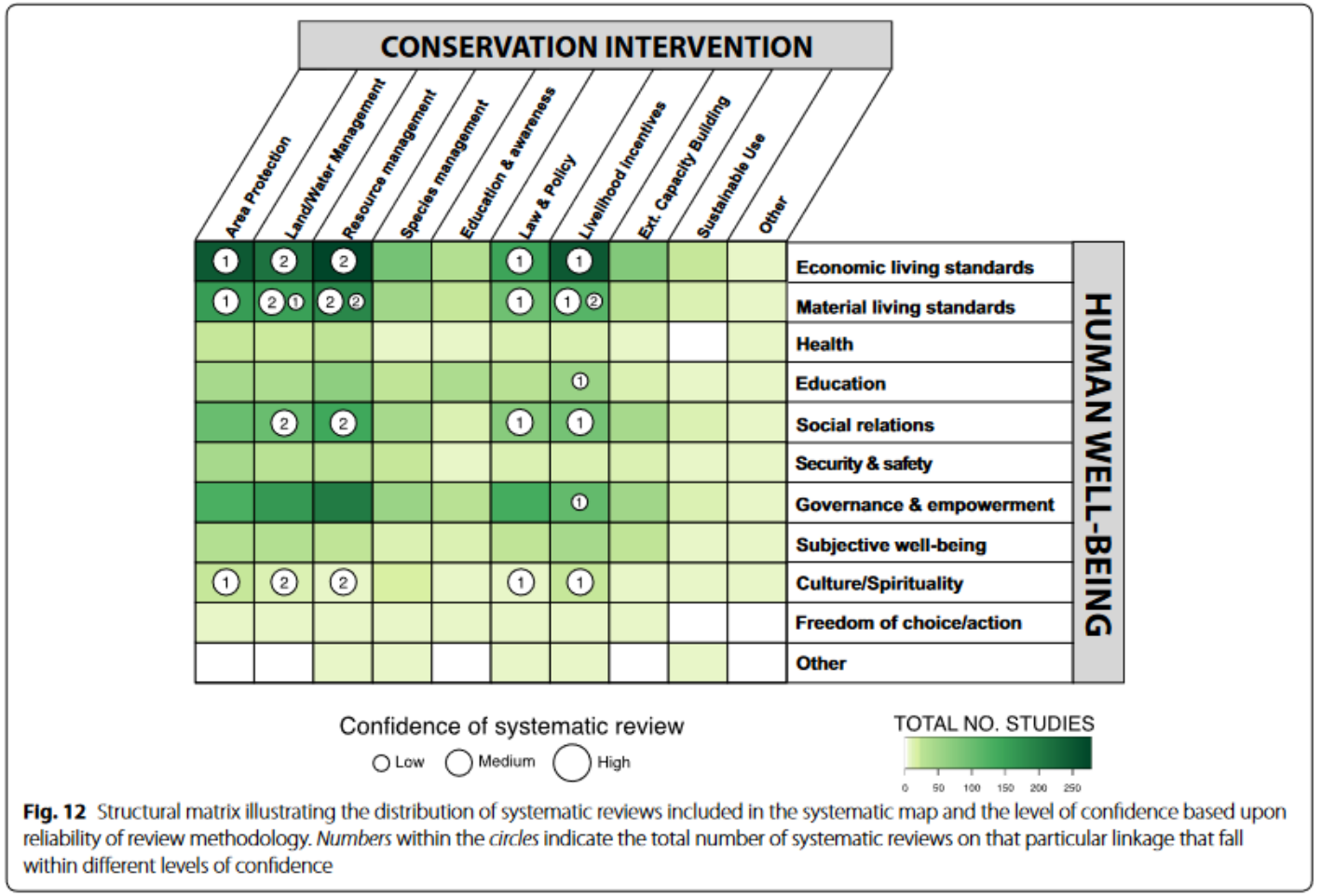
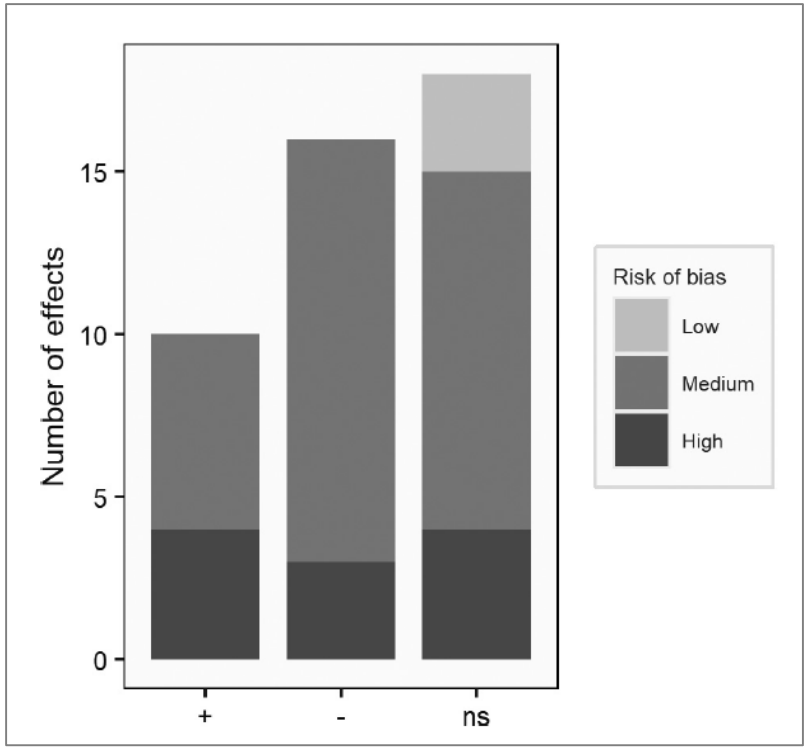


Fig. 12 Structural matrix illustrating the distribution of systematic reviews included in the systematic map and the level of confidence based upon reliability of review methodology. *Numbers* within the *circles* indicate the total number of systematic reviews on that particular linkage that fall within different levels of confidence

McKinnon et al. 2016

Narrative synthesis



Lafitte et al. 2022

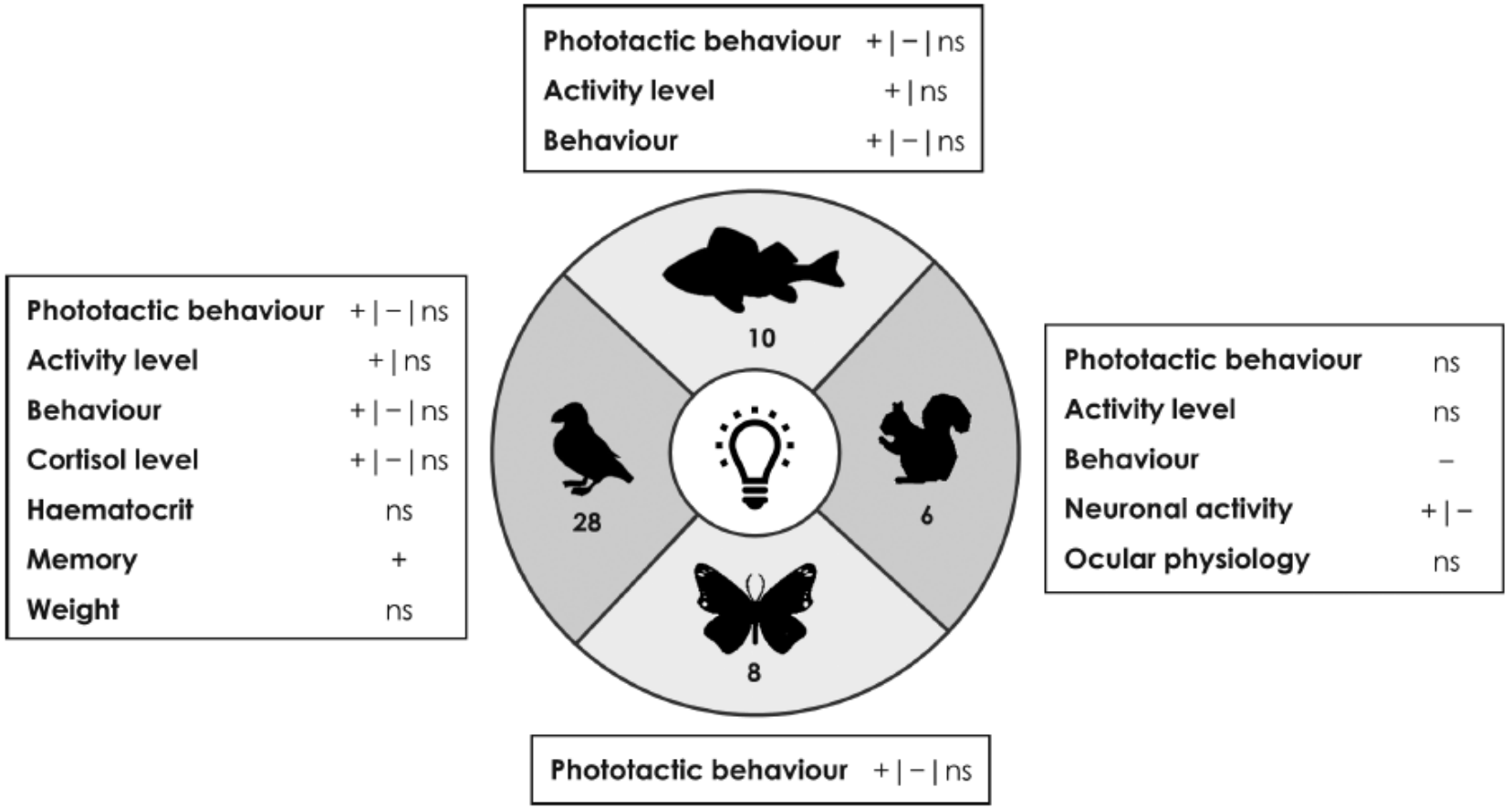
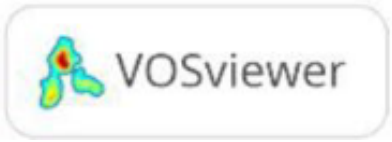
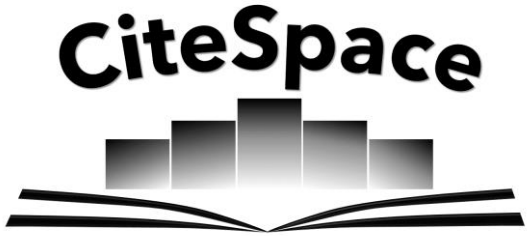


Figure 7. Summary of results for the four main studied taxonomic classes. '+' flashing light increases the outcome compared to continuous light, '-' flashing light decreases the outcome compared to continuous light, 'ns' no significant effect. For clarity, the two observations on plankton phototactic behaviour are not shown but were both found to be non-significant.

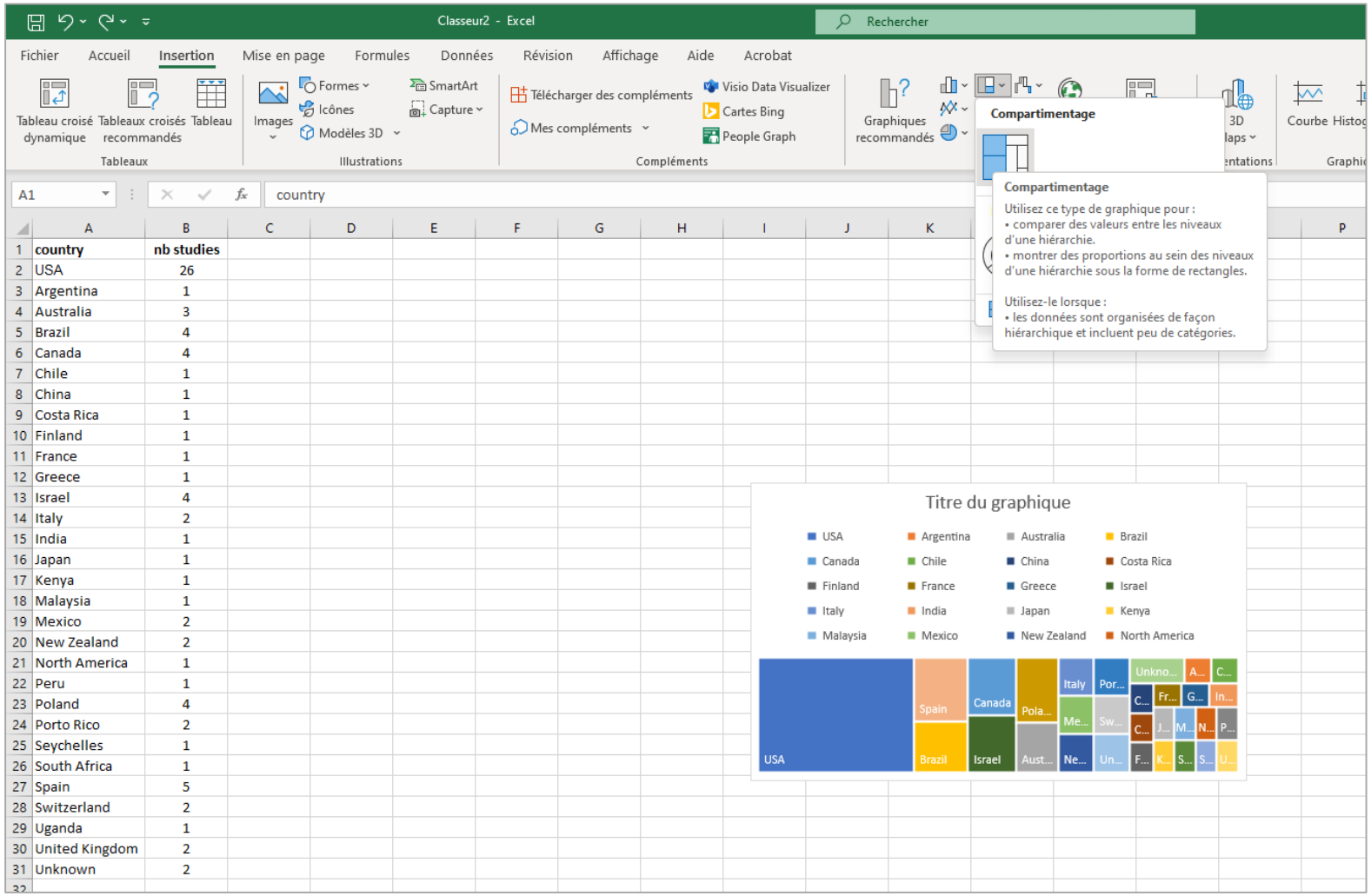
Tools





Tools

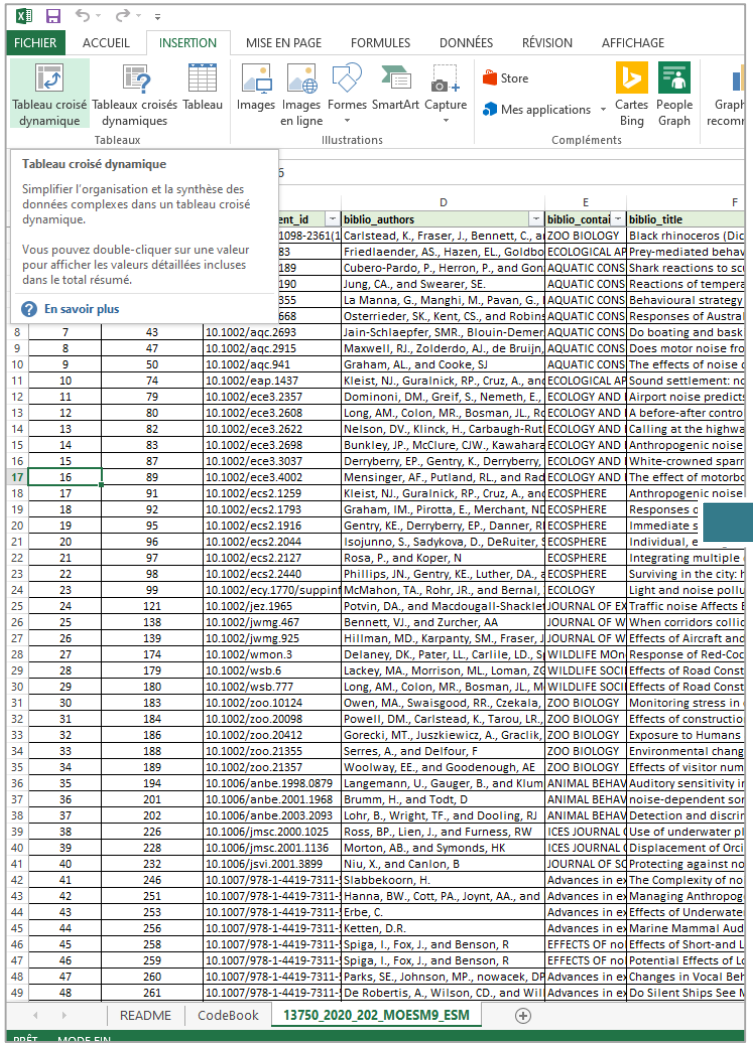
Excel: TreeMaps

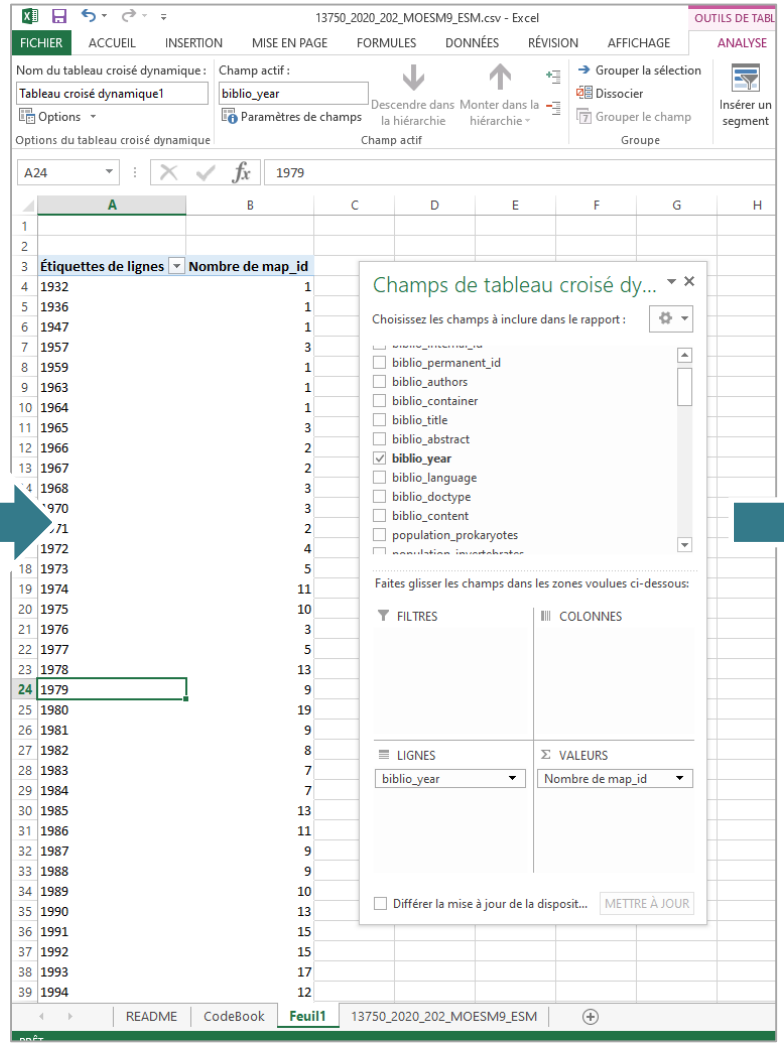


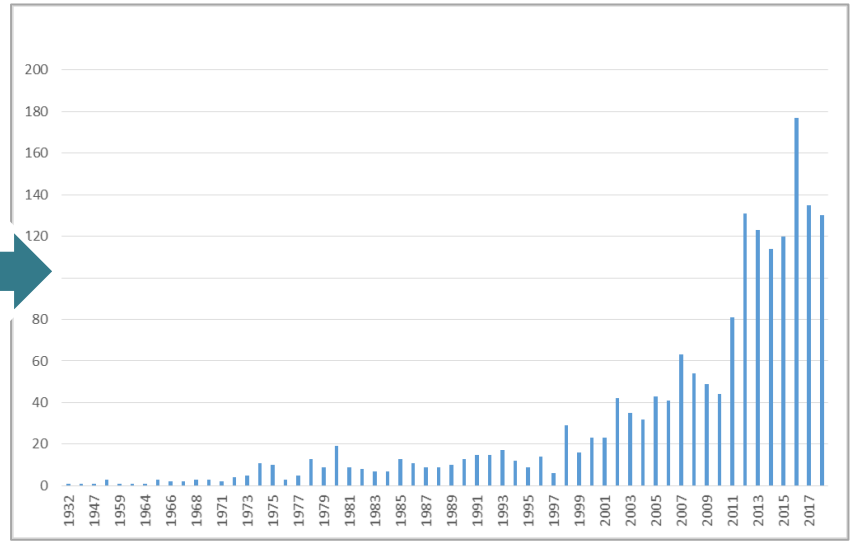
	A	B
1	**country**	**nb studies**
2	USA	26
3	Argentina	1
4	Australia	3
5	Brazil	4
6	Canada	4
7	Chile	1
8	China	1
9	Costa Rica	1
10	Finland	1
11	France	1
12	Greece	1
13	Israel	4
14	Italy	2
15	India	1
16	Japan	1
17	Kenya	1
18	Malaysia	1
19	Mexico	2
20	New Zealand	2
21	North America	1
22	Peru	1
23	Poland	4
24	Porto Rico	2
25	Seychelles	1
26	South Africa	1
27	Spain	5
28	Switzerland	2
29	Uganda	1
30	United Kingdom	2
31	Unknown	2

Tools

Excel: Tableau croisés dynamiques

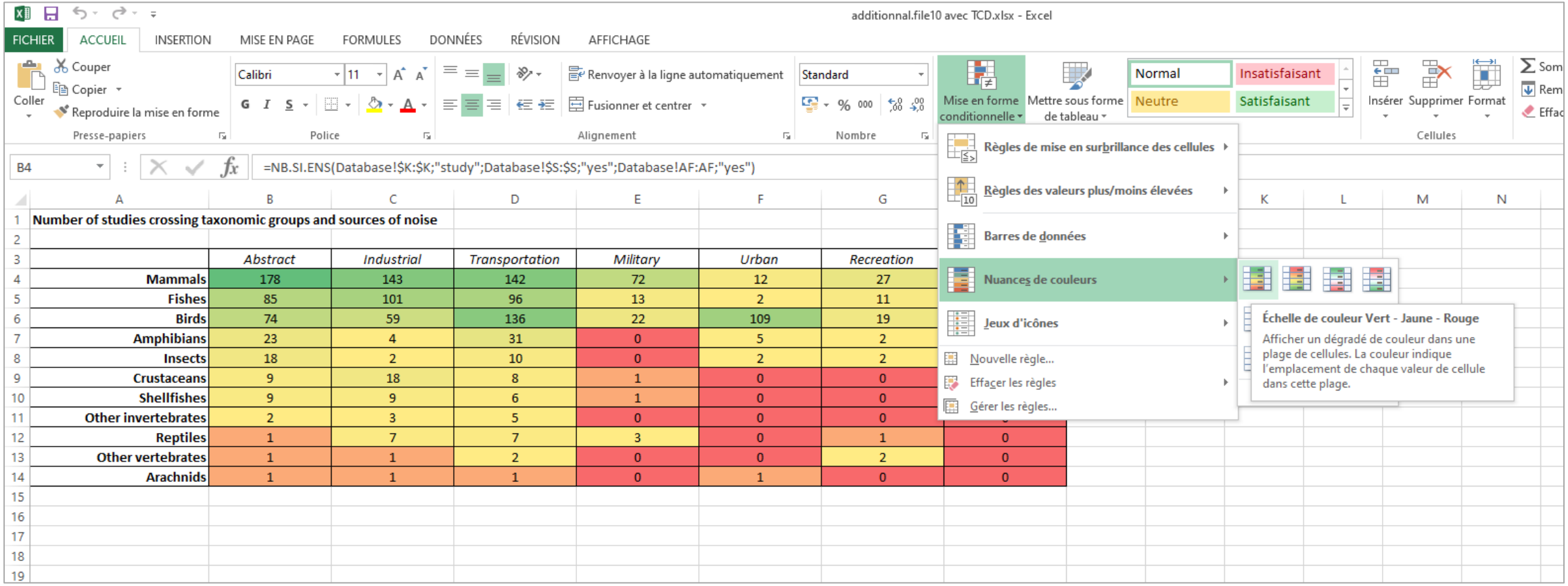






Tools

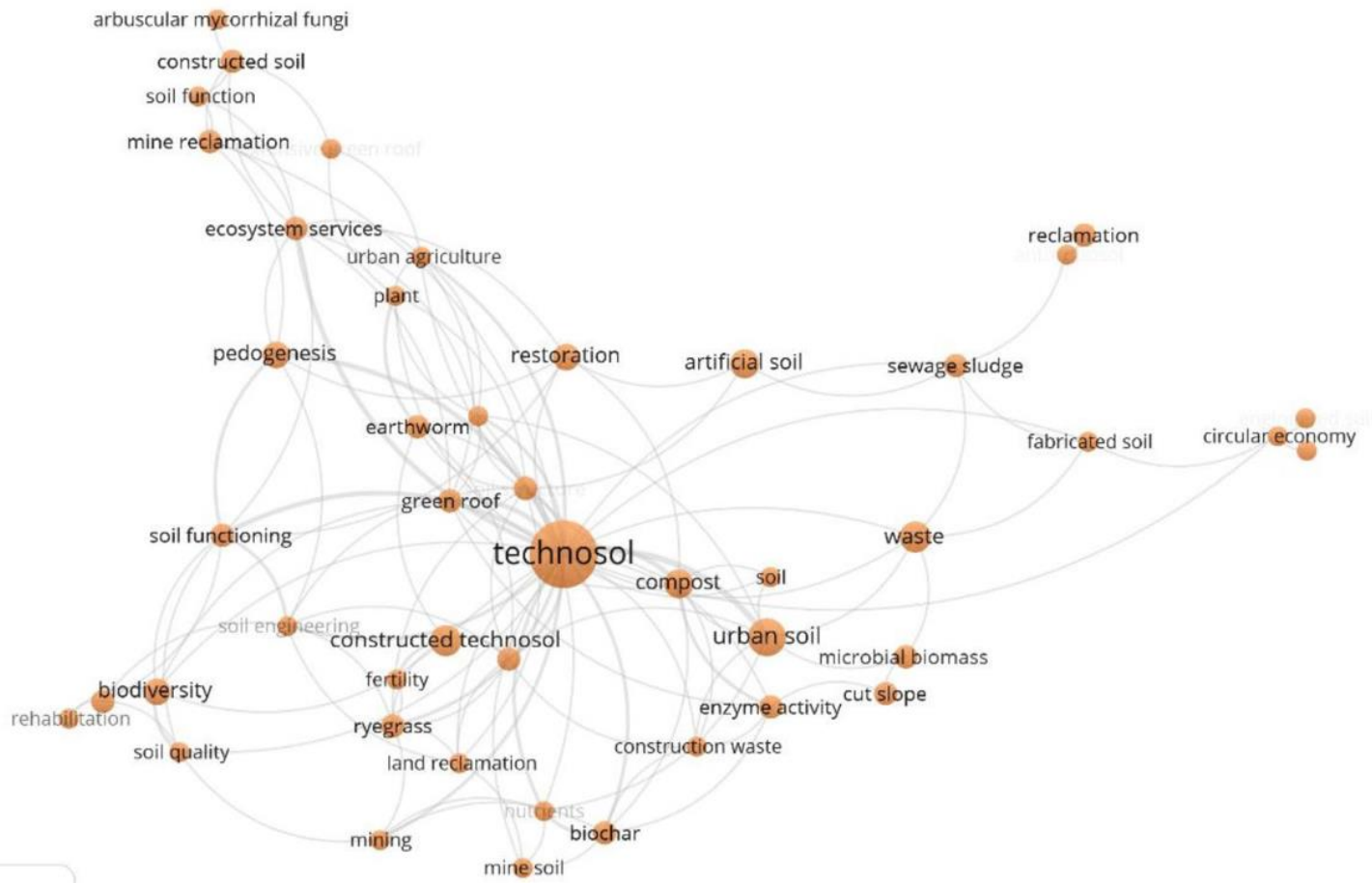
Excel: Heatmaps



	A	B	C	D	E	F	G
1	**Number of studies crossing taxonomic groups and sources of noise**						
2							
3		*Abstract*	*Industrial*	*Transportation*	*Military*	*Urban*	*Recreation*
4	**Mammals**	178	143	142	72	12	27
5	**Fishes**	85	101	96	13	2	11
6	**Birds**	74	59	136	22	109	19
7	**Amphibians**	23	4	31	0	5	2
8	**Insects**	18	2	10	0	2	2
9	**Crustaceans**	9	18	8	1	0	0
10	**Shellfishes**	9	9	6	1	0	0
11	**Other invertebrates**	2	3	5	0	0	0
12	**Reptiles**	1	7	7	3	0	1
13	**Other vertebrates**	1	1	2	0	0	2
14	**Arachnids**	1	1	1	0	1	0
15							
16							
17							
18							
19							

VOSviewer

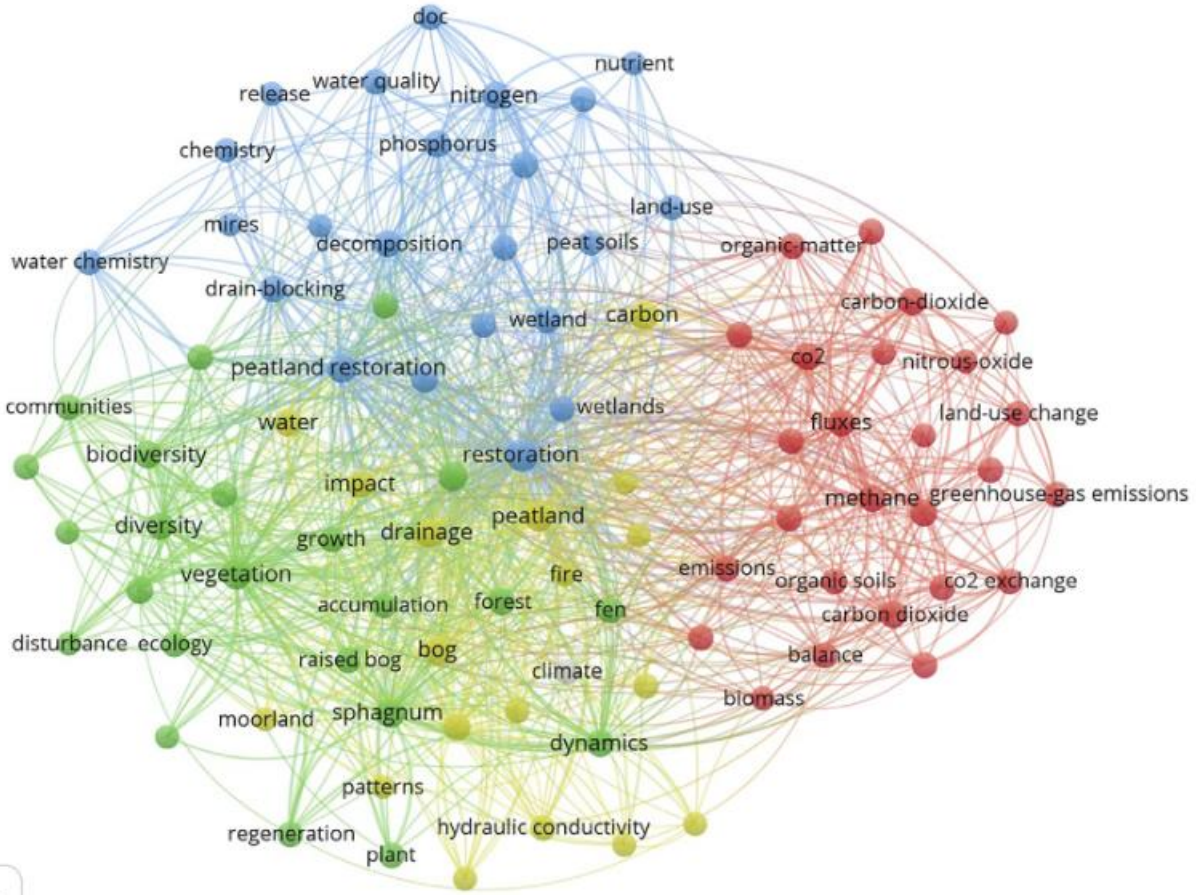
Network of keywords



Ouédraogo et al. 2024

VOSviewer

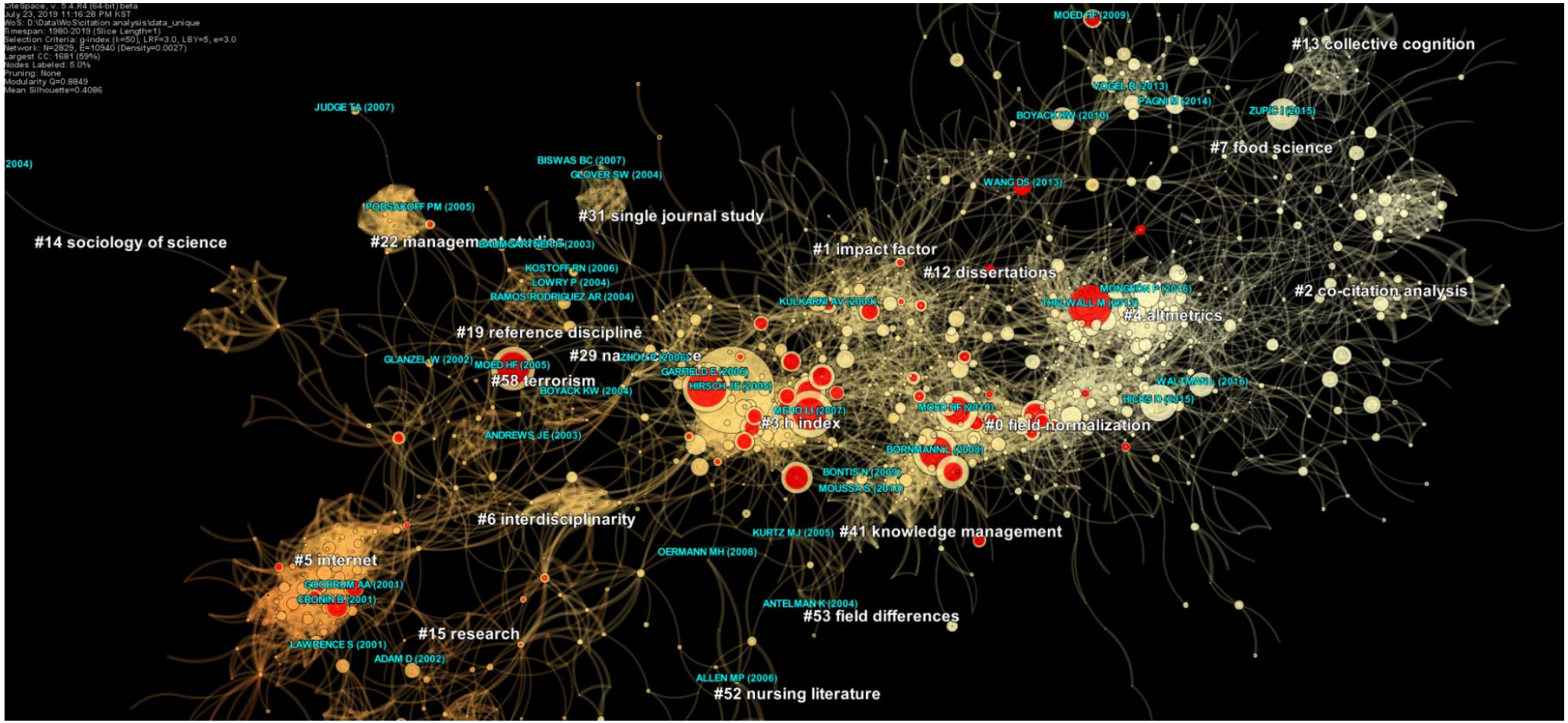
Network of keywords



Apori et al. 2022

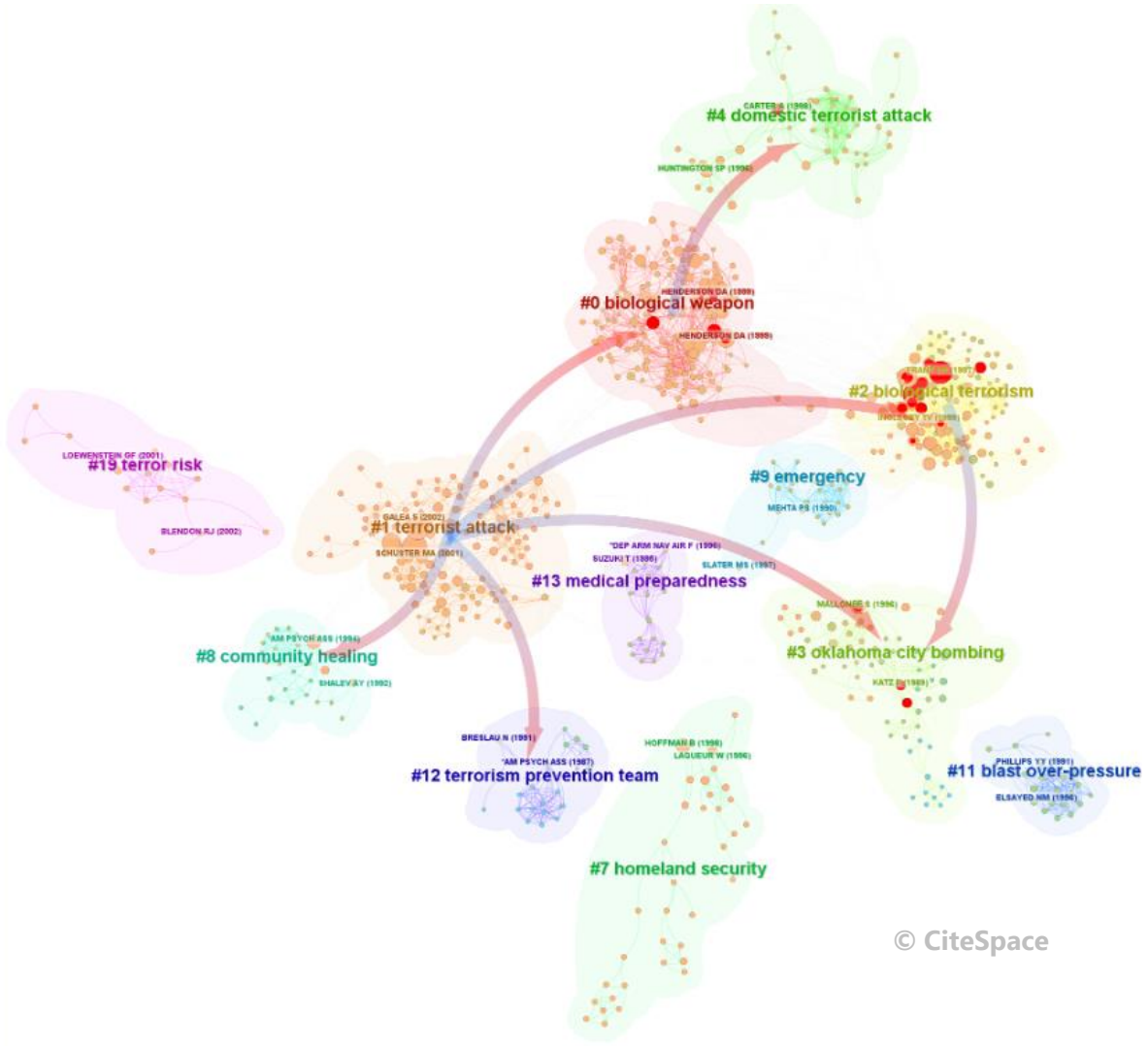
CiteSpace

Network of keywords



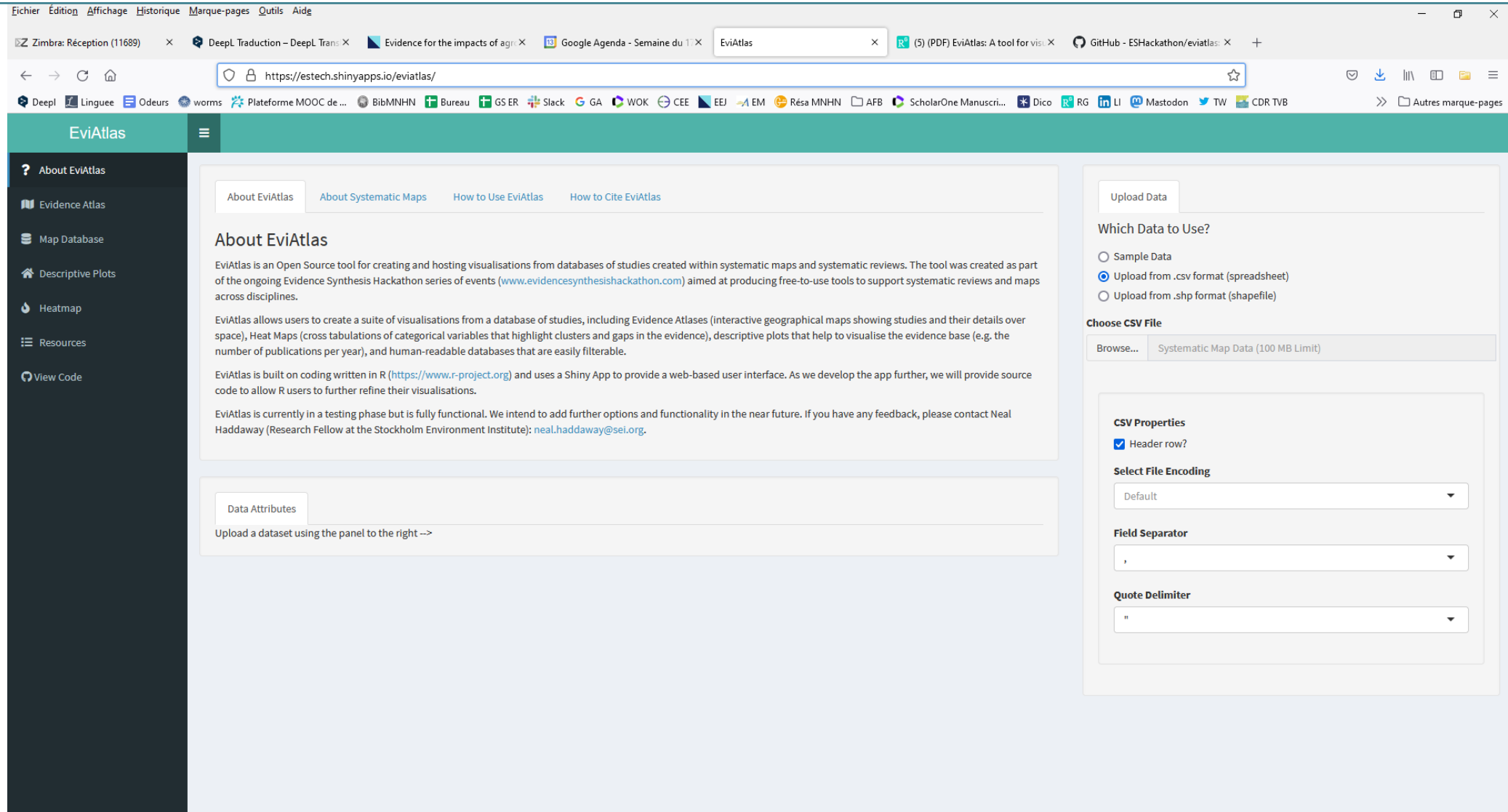
CiteSpace

Network of keywords



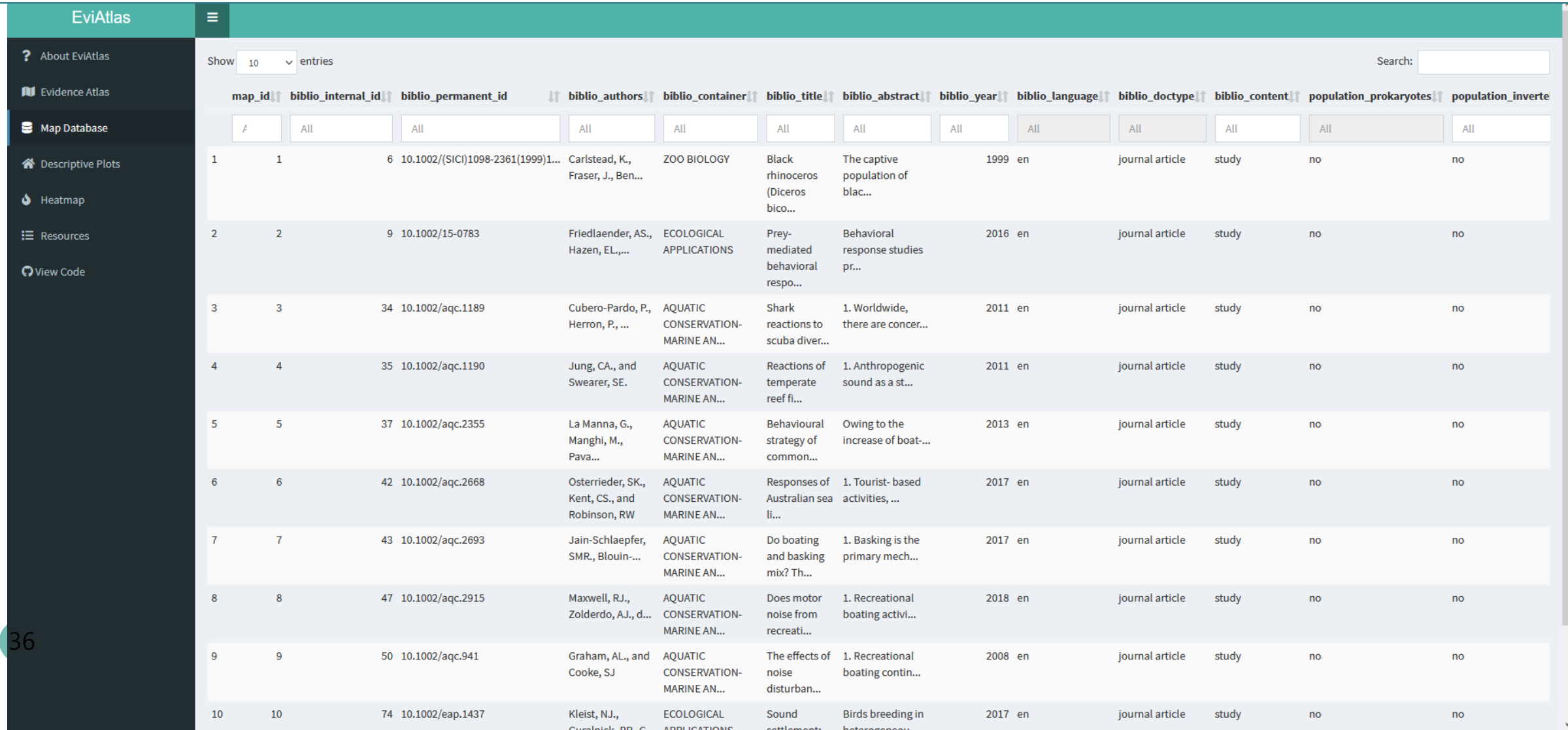
Tools

EviAtlas



Tools

EviAtlas



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	#	All	All	All	All	All	All	All	All	All	All	All	All
1	1	6	10.1002/(SICI)1098-2361(1999)1...	Carlstead, K., Fraser, J., Ben...	ZOO BIOLOGY	Black rhinoceros (Diceros bico...	The captive population of blac...	1999	en	journal article	study	no	no
2	2	9	10.1002/15-0783	Friedlaender, AS., Hazen, EL.,...	ECOLOGICAL APPLICATIONS	Prey-mediated behavioral respo...	Behavioral response studies pr...	2016	en	journal article	study	no	no
3	3	34	10.1002/aqc.1189	Cubero-Pardo, P., Herron, P., ...	AQUATIC CONSERVATION-MARINE AN...	Shark reactions to scuba diver...	1. Worldwide, there are concer...	2011	en	journal article	study	no	no
4	4	35	10.1002/aqc.1190	Jung, CA., and Swearer, SE.	AQUATIC CONSERVATION-MARINE AN...	Reactions of temperate reef fi...	1. Anthropogenic sound as a st...	2011	en	journal article	study	no	no
5	5	37	10.1002/aqc.2355	La Manna, G., Manghi, M., Pava...	AQUATIC CONSERVATION-MARINE AN...	Behavioural strategy of common...	Owing to the increase of boat-...	2013	en	journal article	study	no	no
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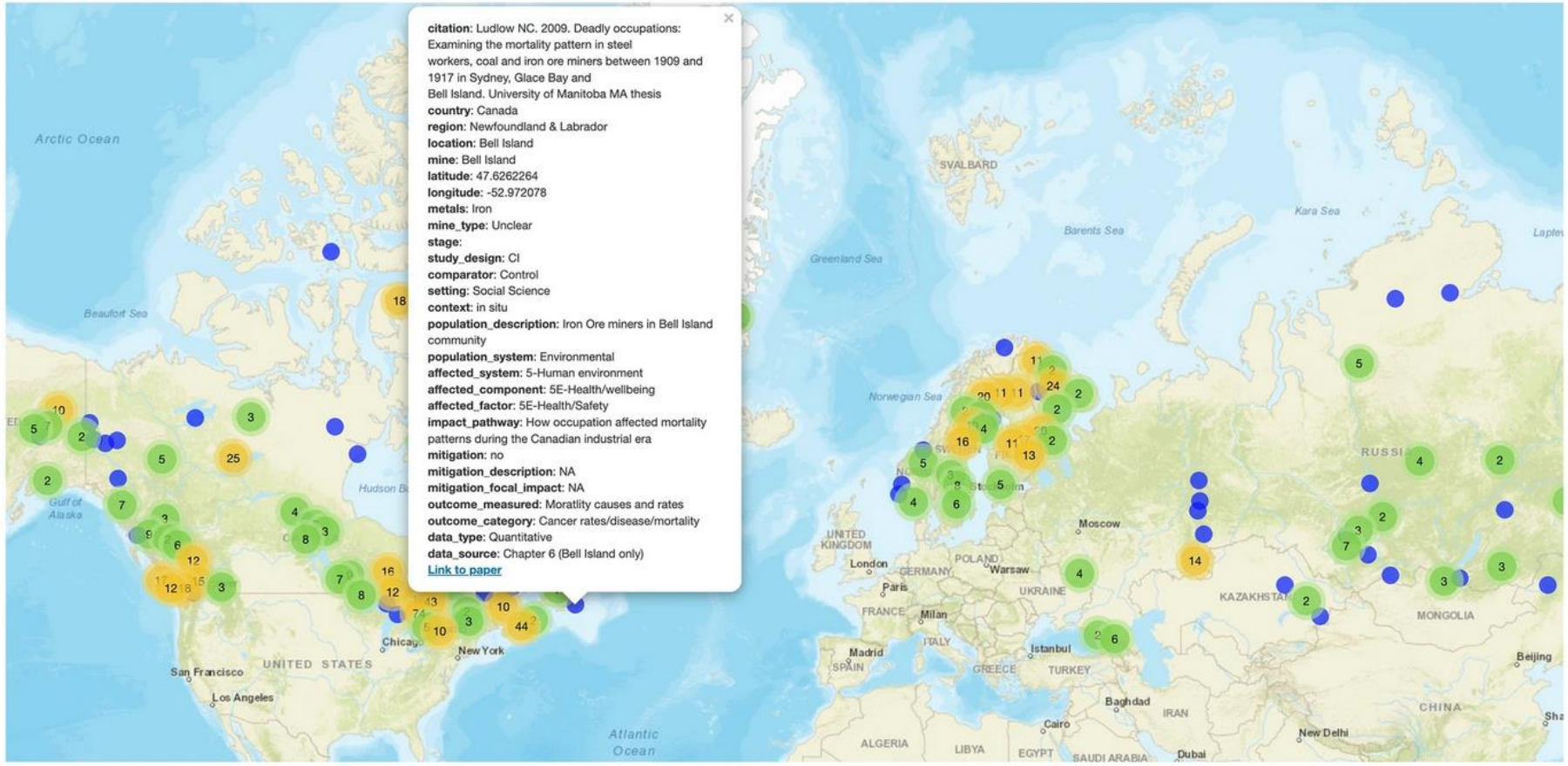
7	7	43	10.1002/aqc.2693	Jain-Schlaepfer, SMR., Blouin-...	AQUATIC CONSERVATION-MARINE AN...	Do boating and basking mix? Th...	1. Basking is the primary mech...	2017	en	journal article	study	no	no
8	8	47	10.1002/aqc.2915	Maxwell, RJ., Zolderdo, AJ., d...	AQUATIC CONSERVATION-MARINE AN...	Does motor noise from recreati...	1. Recreational boating activi...	2018	en	journal article	study	no	no
9	9	50	10.1002/aqc.941	Graham, AL., and Cooke, SJ	AQUATIC CONSERVATION-MARINE AN...	The effects of noise disturban...	1. Recreational boating contin...	2008	en	journal article	study	no	no
10	10	74	10.1002/eap.1437	Kleist, NJ.,	ECOLOGICAL	Sound	Birds breeding in	2017	en	journal article	study	no	no

EviAtlas

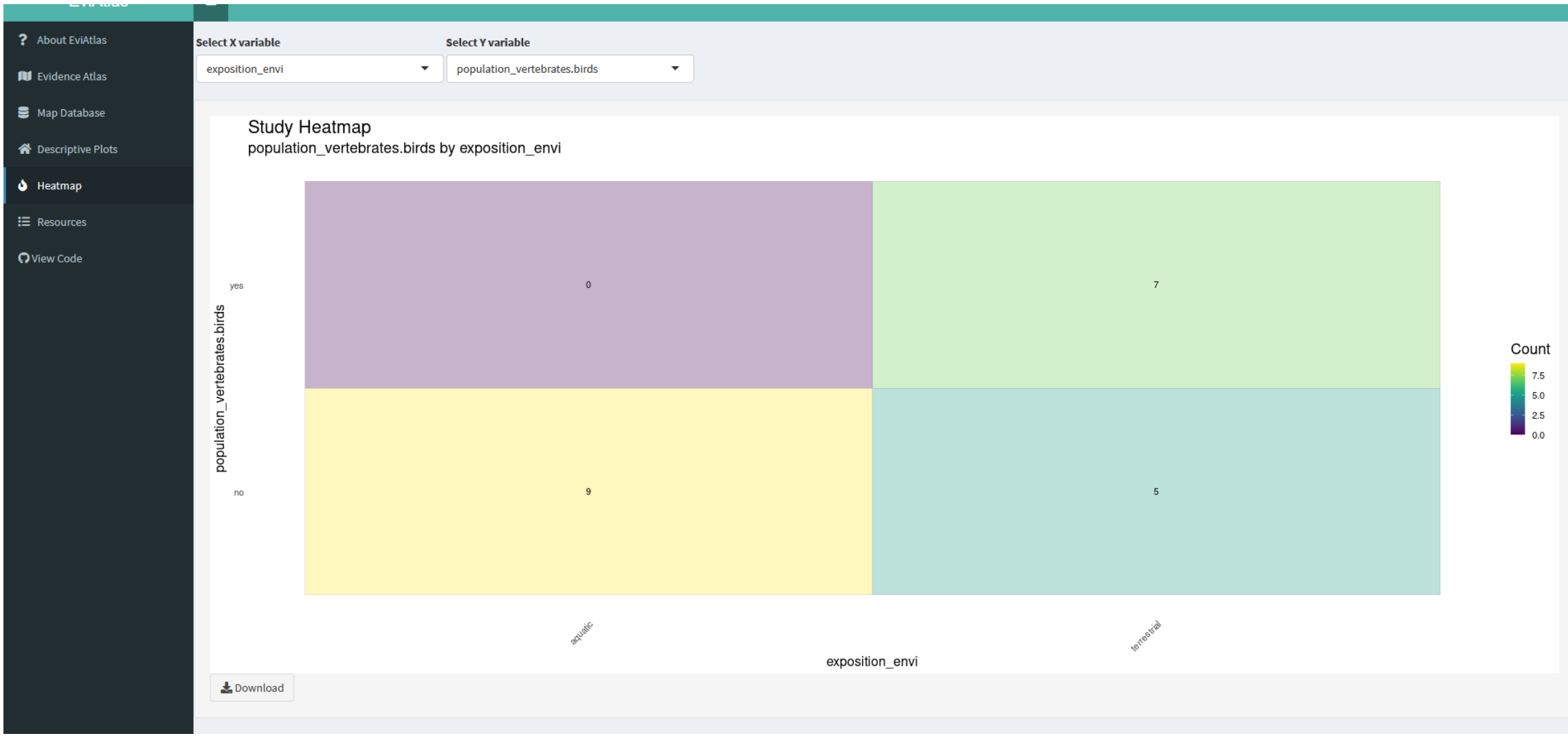
From: Evidence of the impacts of metal mining and the effectiveness of mining mitigation measures on social–ecological systems in Arctic and boreal regions: a systematic map



Screenshot of the interactive evidence atlas showing the location of all study systems in the 585 included studies across 902 total outcome measures. The popup contains descriptive meta-data and a link to the paper on Google Scholar. The interactive evidence atlas is available here: https://3mkproject.github.io/research.html

Tools

EviAtlas



Now it’s up to you!