RECIPES
Precaution • Innovation • Science

Urgent decisions in uncertain times

the case of global insect decline

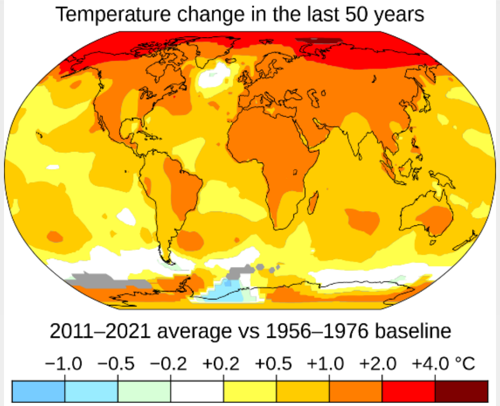
Jeroen P. van der Sluijs

Forskningsrådet
project number 309996

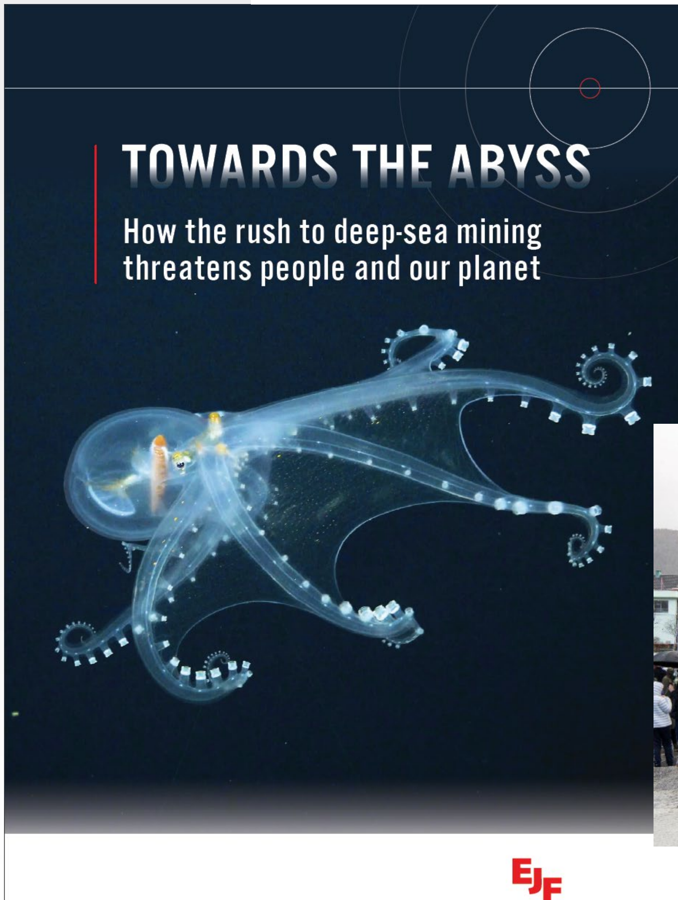
RECIPES was funded by the Horizon 2020 Framework Programme of the European Union under Grant Agreement no. 824665. Views and opinions expressed here are purely those of the lecturer and may not in any circumstances be regarded as stating an official position of the European Commission.

UNIVERSITY OF BERGEN

Climate crisis

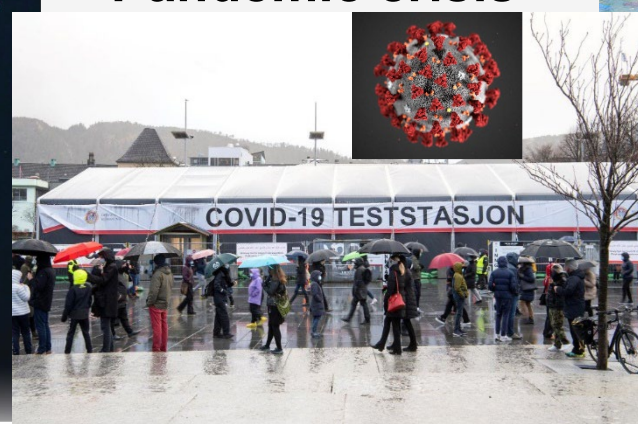


Ocean crisis



Pollinator crisis

Pandemic crisis



Microplastic crisis

https://ejfoundation.org/reports/towards-the-abyss-deep-sea-mining

Complexity, uncertainty & ambiguity: 3 conditions of scientific knowledge

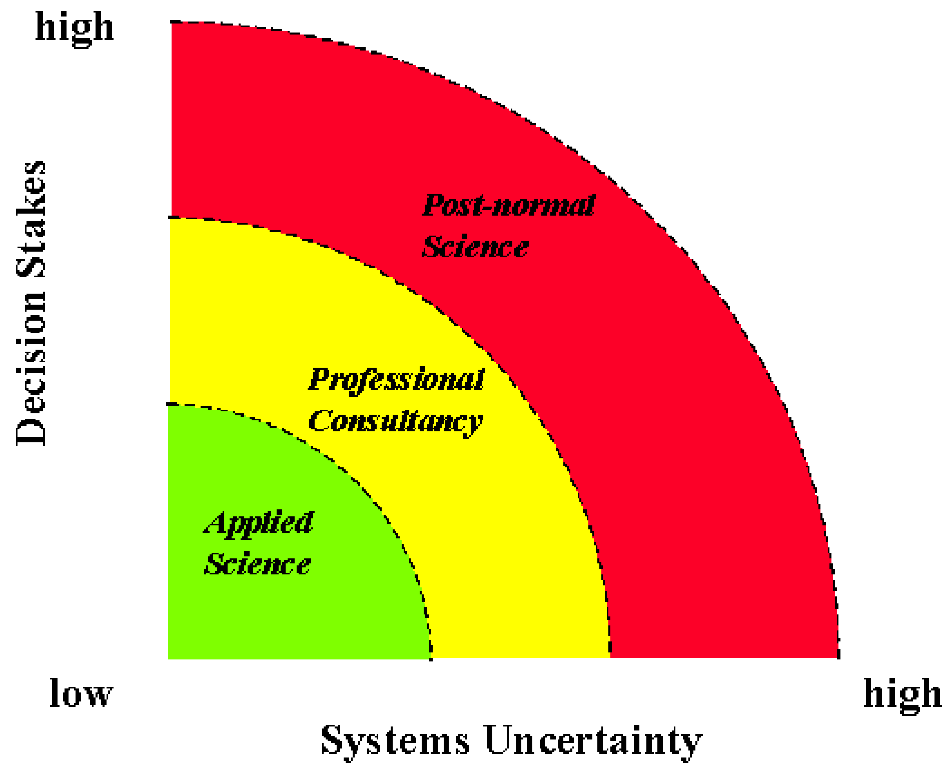
- **Complexity**
  - Density of interactions & multi-causality;
  - Non-linearity, multiple feedback loops, tipping points;
  - Time dependencies & path-dependencies;
- **Uncertainty**
  - Technical (inexactness)
  - Methodological (unreliability)
  - Epistemological (ignorance)
- **Ambiguity**
  - Diversity of interpretation of evidence
  - Diverging styles of scientific reasoning
  - Lack of coherence among competing scientific understandings

http://sapea.info/masos

Complex - *uncertain* - risks

Typical characteristics:

- Decisions urgent
- Stakes high
- Values in dispute
- Irreducible & unquantifiable uncertainty



- Assessment: models, scenarios, assumptions, extrapolations
- (hidden) value loadings in problem frames, indicators chosen, assumptions made

- **Knowledge Quality Assessment!**

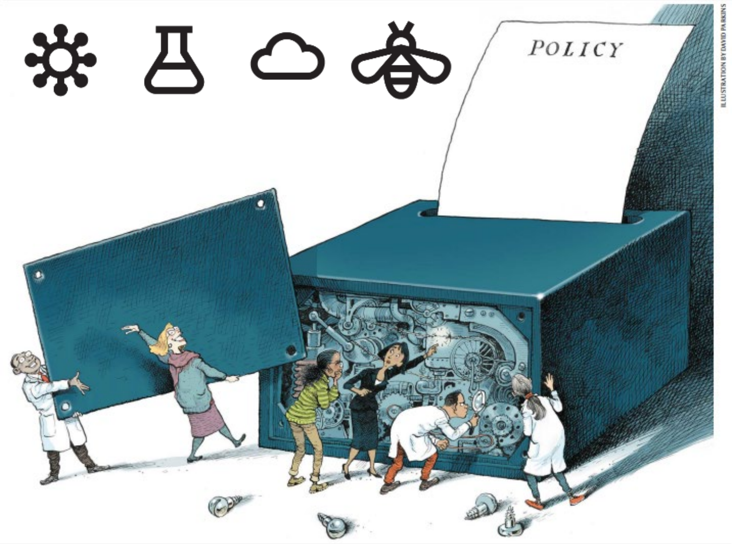
(Funtowicz & Ravetz, 1993)

Elements of Post Normal Science

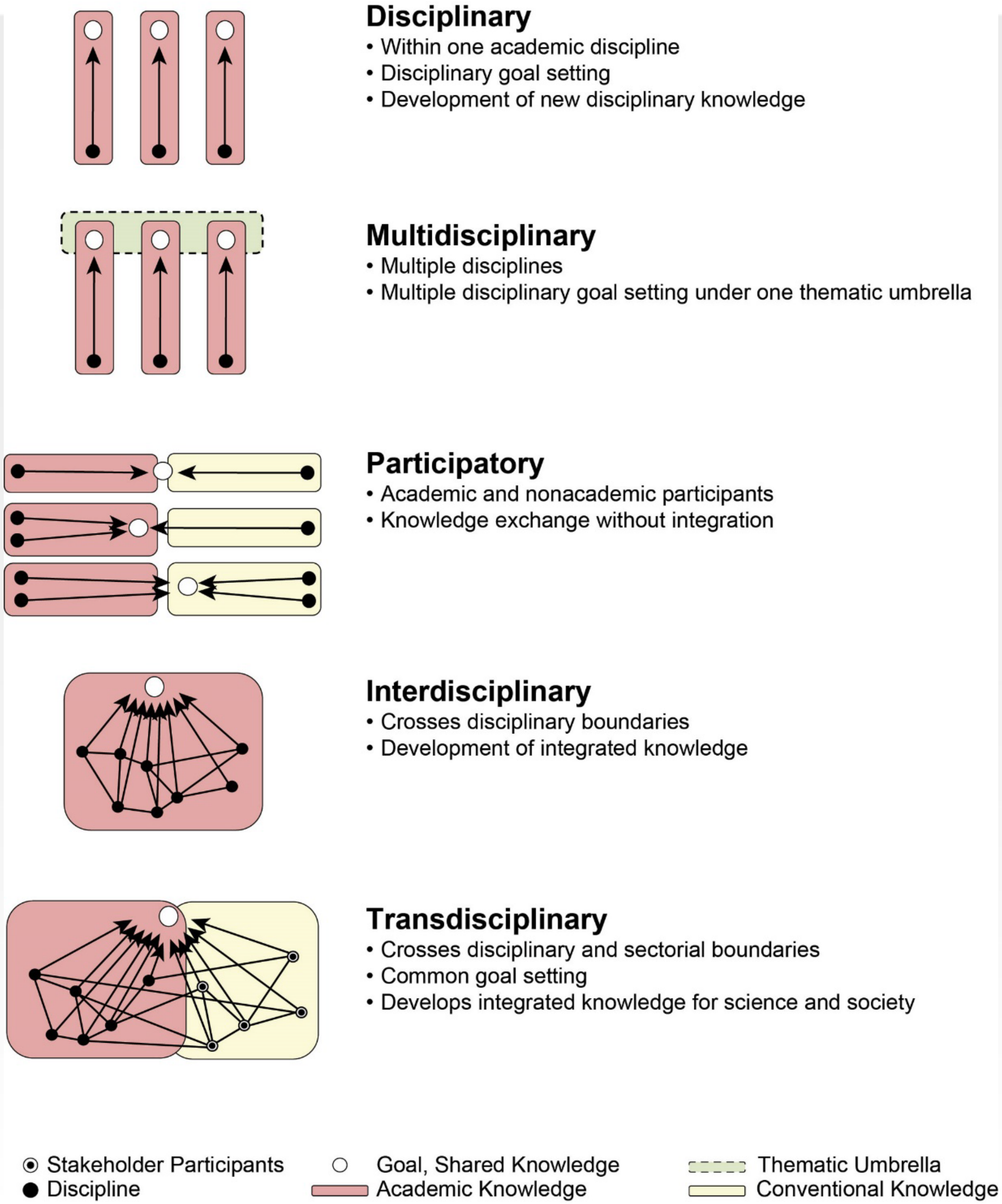
- Appropriate management of uncertainty quality and value-ladenness
- Plurality of commitments and perspectives
- Internal extension of peer community *(involvement of other disciplines)*
- External extension of peer community *(involvement of stakeholders in environmental assessment & quality control)*

Acting on pressing issues and crises

- Reliance on **institutionalised expertise**
- Narrow selection of knowledge privileged, **other knowledge silenced**.



→ Need for a more inclusive & socially robust knowledge base, attentive to **epistemic pluralism**



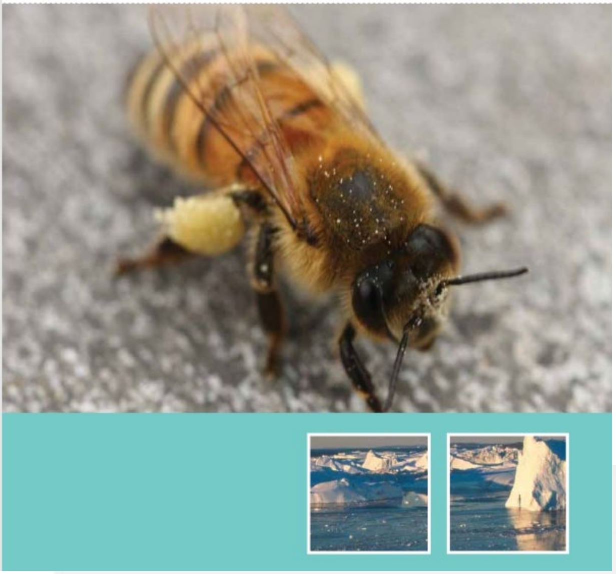
Wright Morton, L., S. Eigenbrode and T. Martin (2015), Architectures of adaptive integration in large collaborative projects, *Ecology and Society* 20(4) doi:10.5751/es-07788-200405.

2013

EEA Report | No 1/2013

Late lessons from early warnings:
science, precaution, innovation

ISSN 1725-9177



Parallel Declines in Pollinators and Insect-Pollinated Plants in Britain and the Netherlands

2006

J. C. Biesmeijer,[1*] S. P. M. Roberts,[2] M. Reemer,[3] R. Ohlemüller,[4] M. Edwards,[5] T. Peeters,[3,6] A. P. Schaffers,[7] S. G. Potts,[2] R. Kleukers,[3] C. D. Thomas,[4] J. Settele,[8] W. E. Kunin[1]

Despite widespread concern about declines in pollination services, little is known about the patterns of change in most pollinator assemblages. By studying bee and hoverfly assemblages in Britain and the Netherlands, we found evidence of declines (pre- versus post-1980) in local bee diversity in both countries; however, divergent trends were observed in hoverflies. Depending on the assemblage and location, pollinator declines were most frequent in habitat and flower specialists, in univoltine species, and/or in nonmigrants. In conjunction with this evidence, outcrossing plant species that are reliant on the declining pollinators have themselves declined relative to other plant species. Taken together, these findings strongly suggest a causal connection between local extinctions of functionally linked plant and pollinator species.

2011

PNAS

Patterns of widespread decline in North American bumble bees

Sydney A. Cameron[a,1], Jeffrey D. Lozier[a], James P. Strange[b], Jonathan B. Koch[b,c], Nils Cordes[a,2], Leellen F. Solter[d], and Terry L. Griswold[b]

[a]Department of Entomology and Institute for Genomic Biology, University of Illinois, Urbana, IL 61801; [b]United States Department of Agriculture-Agricultural Research Service Pollinating Insects Research Unit, Utah State University, Logan, UT 84322; [c]Department of Biology, Utah State University, Logan, UT 84321; and [d]Illinois Natural History Survey, Institute of Natural Resource Sustainability, University of Illinois, Champaign, IL 61820

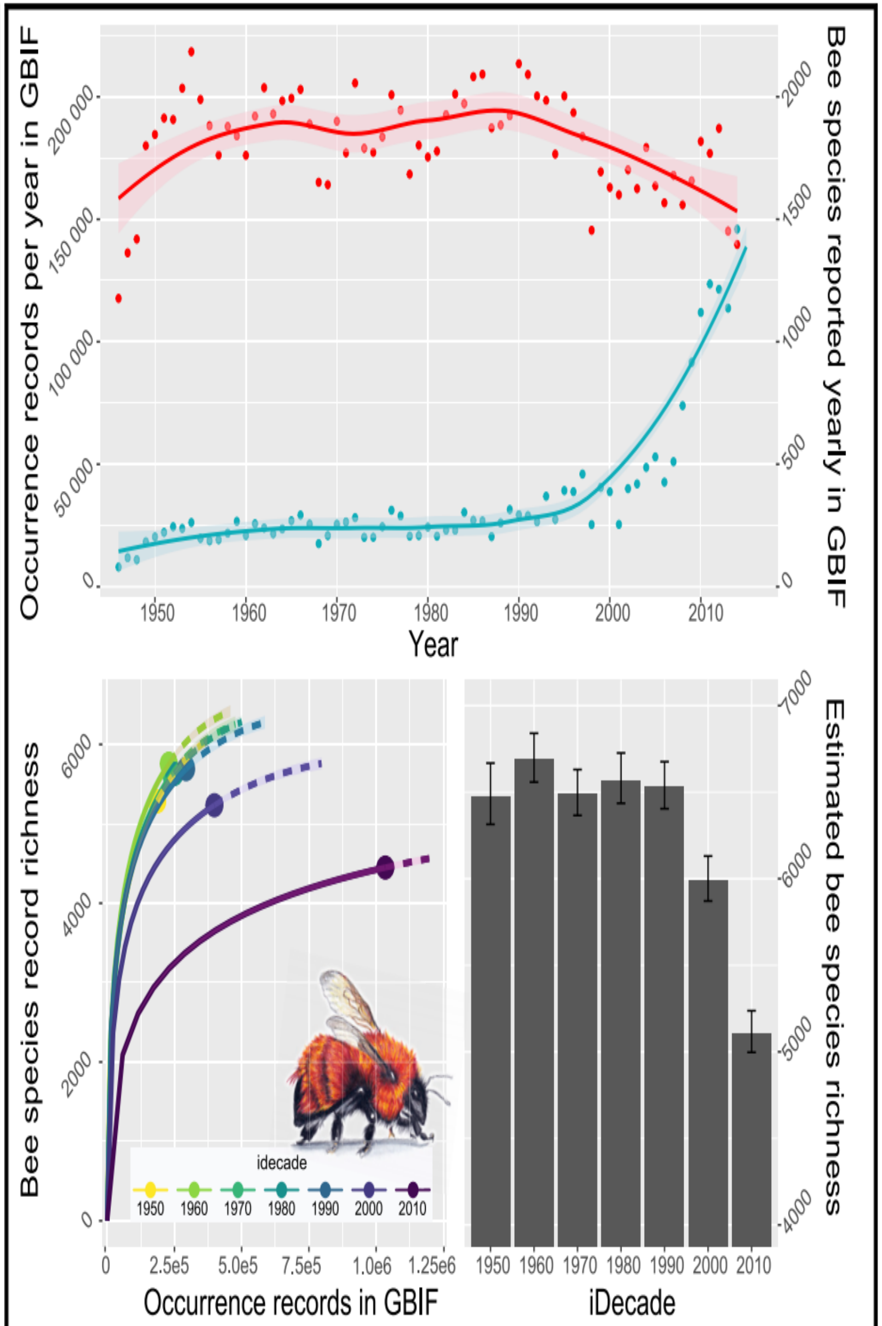
Edited* by Gene E. Robinson, University of Illinois, Urbana, IL, and approved November 24, 2010 (received for review October 3, 2010)

Bumble bees (*Bombus*) are vitally important pollinators of wild study in the United States identified lower genetic diversity and

2011

intensive nationwide surveys of >16,000 specimens. We show that the relative abundances of four species have declined by up to 96% and that their surveyed geographic ranges have contracted by 23–87%, some within the last 20 y. We also show that declining populations have significantly higher infection levels of the microsporidian pathogen *Nosema bombi* and lower genetic diversity compared

World wide: 25000 bee species; EU: 1965 In NL about 350 bee species, 181 of them are on the Red List / at risk of extinction



Number of worldwide recorded bee species is sharply decreasing

despite increasing number of observations in Global Biodiversity Information Facility

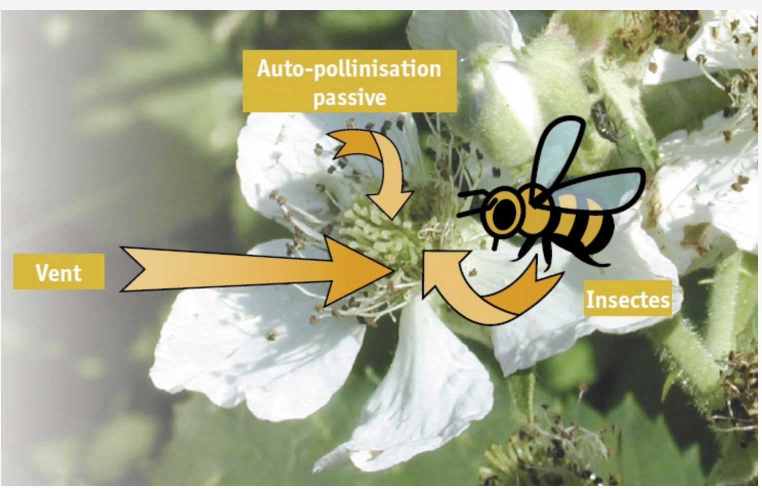
between 2006 and 2015, **25% fewer** species of **wild bees** were seen than was the case before 1990

https://doi.org/10.1016/j.oneear.2020.12.005

New pollinator emerging…

The importance of pollinators

- 90 major crops (35% world food production volume) depend on pollinators
- Key nutrients: 90-100% from pollinator mediated crops (vit C, antioxidants, lycopene, β-tocopherol, vit A and folic acid)
- Estimated global values of pollination (2020) range widely from US$ 195 billion to US$ 657 billion annually
- 94% of all flowering plants on Earth depends on insect pollinators for reproduction and evolution



Key role for insects in all categories of ecosystem services

- **Provisioning**
  - Nutrition (food for animals and humans: About 1,500 edible insect species are consumed by 3,000 ethnic groups in 113 countries), materials (silk, wax, lac, pigments), medicine
- **Regulation and maintenance**
  - **Pollination**, seed dispersal, **food web support**, **pest control**, **soil formation**, **decomposition**, **nutrient cycling**
- **Cultural**
  - Aesthetic, poetry, scientific, educational, inspirational (for many domains, technology, robotics, democracy, art, etc)

PLOS | ONE

RESEARCH ARTICLE

More than 75 percent decline over 27 years in total flying insect biomass in protected areas

Caspar A. Hallmann[1]*, Martin Sorg[2], Eelke Jongejans[1], Henk Siepel[1], Nick Hofland[1], Heinz Schwan[2], Werner Stenmans[2], Andreas Müller[2], Hubert Sumser[2], Thomas Hörren[2], Dave Goulson[3], Hans de Kroon[1]

1 Radboud University, Institute for Water and Wetland Research, Animal Ecology and Physiology & Experimental Plant Ecology, PO Box 9100, 6500 GL Nijmegen, The Netherlands, **2** Entomological Society Krefeld e.V., Entomological Collections Krefeld, Marktstrasse 159, 47798 Krefeld, Germany, **3** University of Sussex, School of Life Sciences, Falmer, Brighton BN1 9QG, United Kingdom

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OPEN ACCESS

Citation: Hallmann CA, Sorg M, Jongejans E, Siepel H, Hofland N, Schwan H, et al. (2017) More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PLoS ONE 12 (10): e0185809. https://doi.org/10.1371/journal.pone.0185809

Editor: Eric Gordon Lamb, University of Saskatchewan, CANADA

Received: July 28, 2017

Accepted: September 19, 2017

Published: October 18, 2017

Abstract

Global declines in insects have sparked wide interest among scientists, politicians, and the general public. Loss of insect diversity and abundance is expected to provoke cascading effects on food webs and to jeopardize ecosystem services. Our understanding of the extent and underlying causes of this decline is based on the abundance of single species or taxonomic groups only, rather than changes in insect biomass which is more relevant for ecological functioning. Here, we used a standardized protocol to measure total insect biomass using Malaise traps, deployed over 27 years in 63 nature protection areas in Germany (96 unique location-year combinations) to infer on the status and trend of local entomofauna. Our analysis estimates a seasonal decline of 76%, and mid-summer decline of 82% in flying insect biomass over the 27 years of study. We show that this decline is apparent regardless of habitat type, while changes in weather, land use, and habitat characteristics cannot explain this overall decline. This yet unrecognized loss of insect biomass must be taken into account in evaluating declines in abundance of species depending on insects as a food source, and ecosystem functioning in the European landscape.

http://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0185809&type=printable

theguardian

UK world sport football opinion culture business lifestyle fashion environment tech travel ≡ all

home › opinion | columnists letters editorials

Insects Opinion

Insectageddon: farming is more catastrophic than climate breakdown

George Monbiot

The shocking collapse of insect populations hints at a global ecological meltdown

"The impact on wildlife of changes in farming practice (and the expansion of the farmed area) is so rapid and severe that it is hard to get your head round the scale of what is happening. A study published this week in the journal Plos One reveals that flying insects surveyed on nature reserves in Germany have declined by 76% in 27 years. The most likely cause of this Insectageddon is that the land surrounding those reserves has become hostile to them: the volume of pesticides and the destruction of habitat have turned farmland into a wildlife desert."

Windshield phenomenon

Anecdotal observation that people tend to find fewer insects smashed on the windscreens of their cars now compared to a decade or several decades ago. This hints at continental-scale declines in insect abundance.

A 20-year study measured number of dead insects on car windshields on two stretches of road in Denmark from 1997 until 2017. **Reductions of 80% and 97%** were found at two transects of 1.2 km and 25 km respectively.

Parallel declines in abundance of insects and insectivorous birds in Denmark over 22 years
https://doi.org/10.1002/ece3.5236

Known Knowns

- Confirmed results
- Reproduced studies
- Protocolls
- guidelines

Unknown Knowns

- Results we do not have access to
- „grey literature“
- Data requests

Known Unknowns

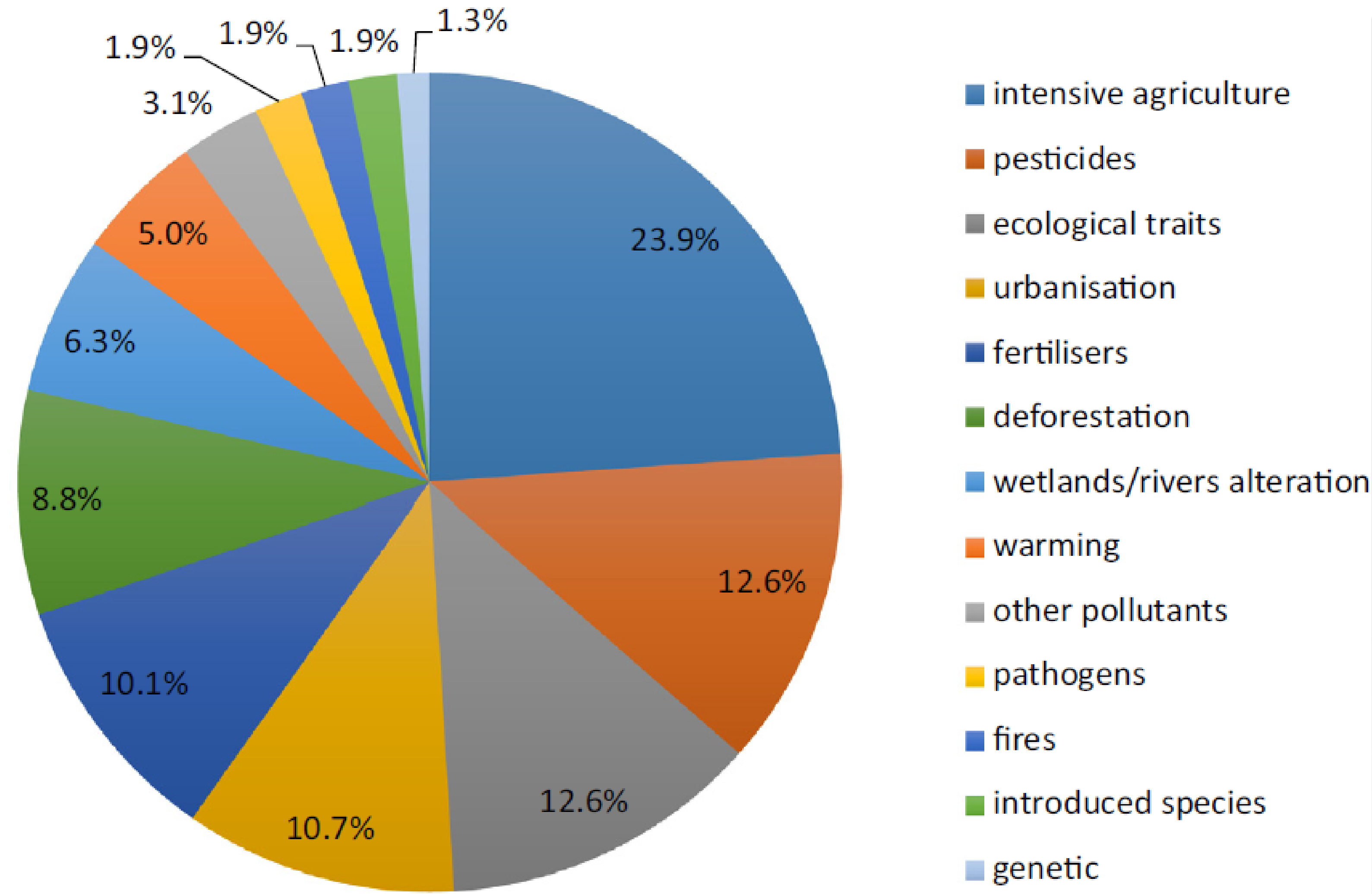
- Questions following from research
- Further research
- Research gaps

Unknown Unknowns

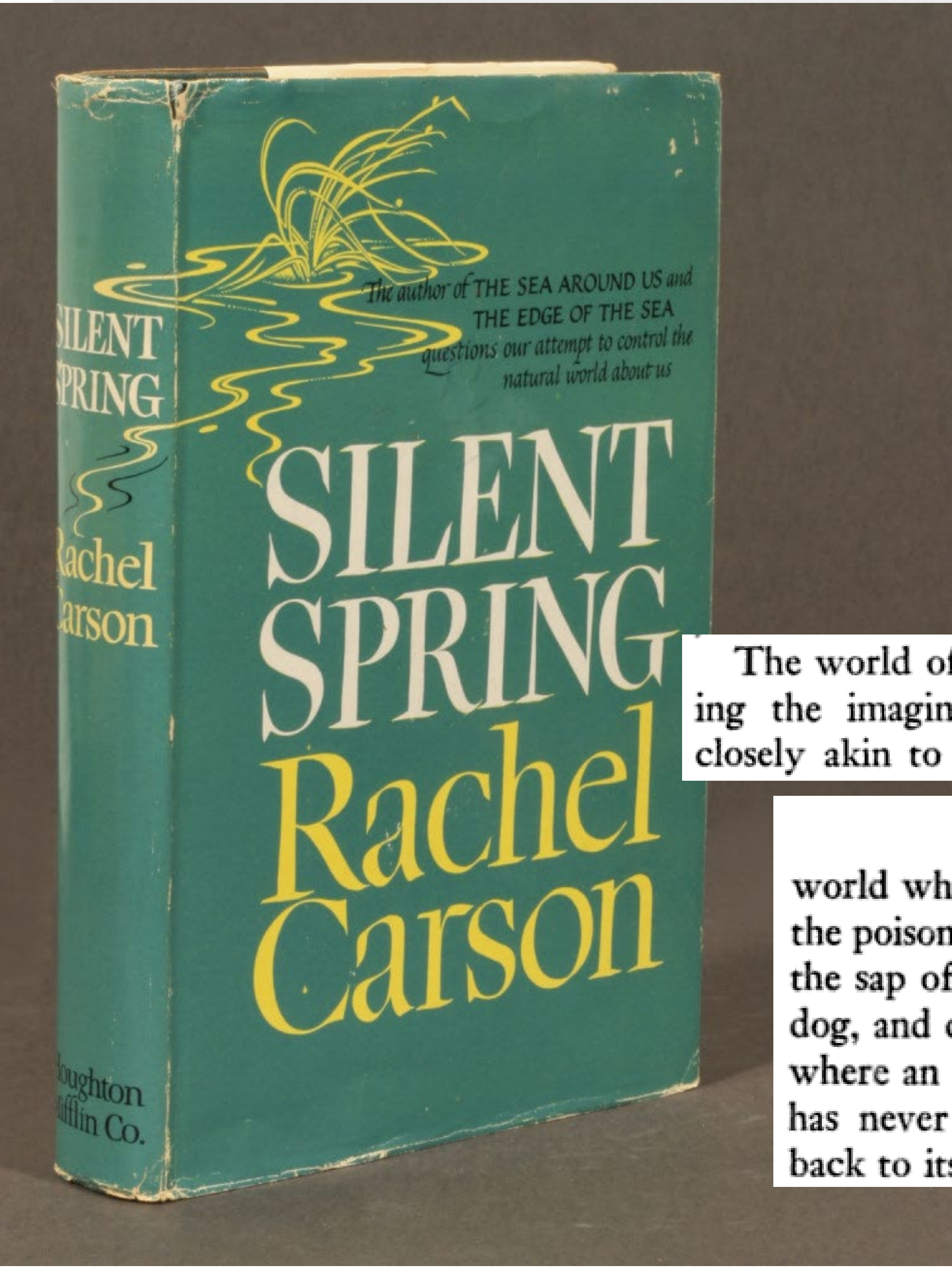
- We don‘t know what we don‘t know
- Irregularities
- unexpected phenomena

Governing under extreme unknowns

- "Insects are disappearing and we don't even have data"
- Globally, insects make up three quarters of animal and plant species
- There are approximately 5.5 million insect species
- Nearly 89 percent of these species has not even been named
- No global scientific monitoring of insect abundance in the past, present and near future
- Strong anecdotal evidence of dramatic declines of flying insects (windscreen phenomenon)
- Causes are poorly known, manifold, and(/or?!) highly contested



Scientific dissent on what drives insect declines (% of publications [*n*=73] mentioning cause *x* as the main driver of insect decline)
DOI: 10.1016/j.biocon.2019.01.020



1962

The world of systemic insecticides is a weird world, surpassing the imaginings of the brothers Grimm — perhaps most closely akin to the cartoon world of Charles Addams. It is a

ELIXIRS OF DEATH 33

world where the enchanted forest of the fairy tales has become the poisonous forest in which an insect that chews a leaf or sucks the sap of a plant is doomed. It is a world where a flea bites a dog, and dies because the dog's blood has been made poisonous, where an insect may die from vapors emanating from a plant it has never touched, where a bee may carry poisonous nectar back to its hive and presently produce poisonous honey.

NEONICOTINOIDS

2017

A worldwide survey of neonicotinoids in honey

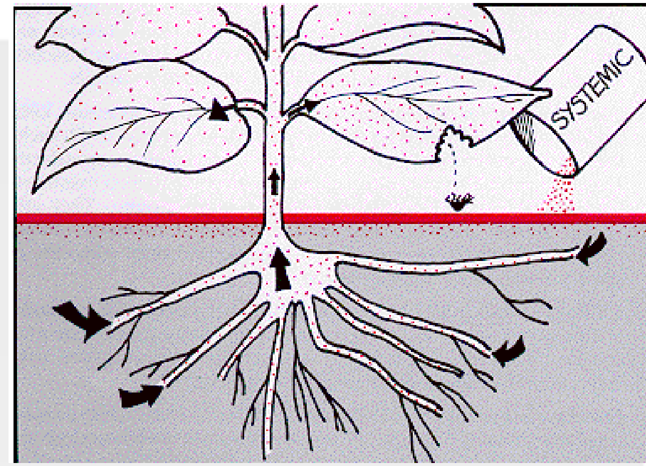
E. A. D. Mitchell,[1,2]* B. Mulhauser,[2] M. Mulot,[1]† A. Mutabazi,[3]‡ G. Glauser,[3] A. Aebi[1,4]

Growing evidence for global pollinator decline is causing concern for biodiversity conservation and ecosystem services maintenance. Neonicotinoid pesticides have been identified or suspected as a key factor responsible for this decline. We assessed the global exposure of pollinators to neonicotinoids by analyzing 198 honey samples from across the world. We found at least one of five tested compounds (acetamiprid, clothianidin, imidacloprid, thiacloprid, and thiamethoxam) in 75% of all samples, 45% of samples contained two or more of these compounds, and 10% contained four or five. Our results confirm the exposure of bees to neonicotinoids in their food throughout the world. The coexistence of neonicotinoids and other pesticides may increase harm to pollinators. However, the concentrations detected are below the maximum residue level authorized for human consumption (average ± standard error for positive samples: 1.8 ± 0.56 nanograms per gram).

https://science.sciencemag.org/content/358/6359/109/tab-pdf

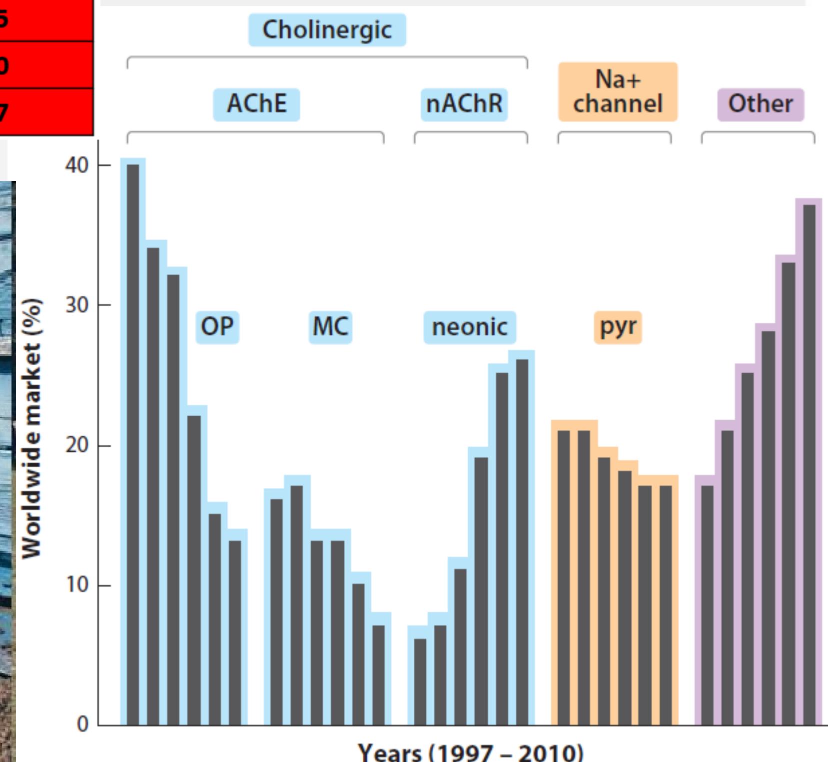
Toxicity of neonicotinoids

Pesticide	®	Use	LD50 (ng/honeybee)	Toxicity index relative to DDT
DDT	Dinocide	insecticide	27000	1
Amitraz	Apivar	insecticide / acaricide	12000	2
Coumaphos	Perizin	insecticide / acaricide	3000	9
Tau-fluvalinate	Apistan	insecticide / acaricide	2000	13.5
Methiocarb	Mesurol	insecticide	230	117
Carbofuran	Curater	insecticide	160	169
λ-cyhalothrin	Karate	insecticide	38	711
Deltamethrine	Decis	insecticide	10	2700
Thiamethoxam	Cruise	insecticide	5	5400
Fipronil	Regent	Insecticide	4.2	6475
Clothianidine	Poncho	Insecticide	4.0	6750
Imidacloprid	Gaucho	Insecticide	3.7	7297



Systemic = plant takes up the insecticide into its sap-stream, becomes toxic from the inside

Deadly sowing-dust killed millions of bees



Source: Casida and Durkin, 2013 doi: 10.1146/annurev-ento-120811-153645

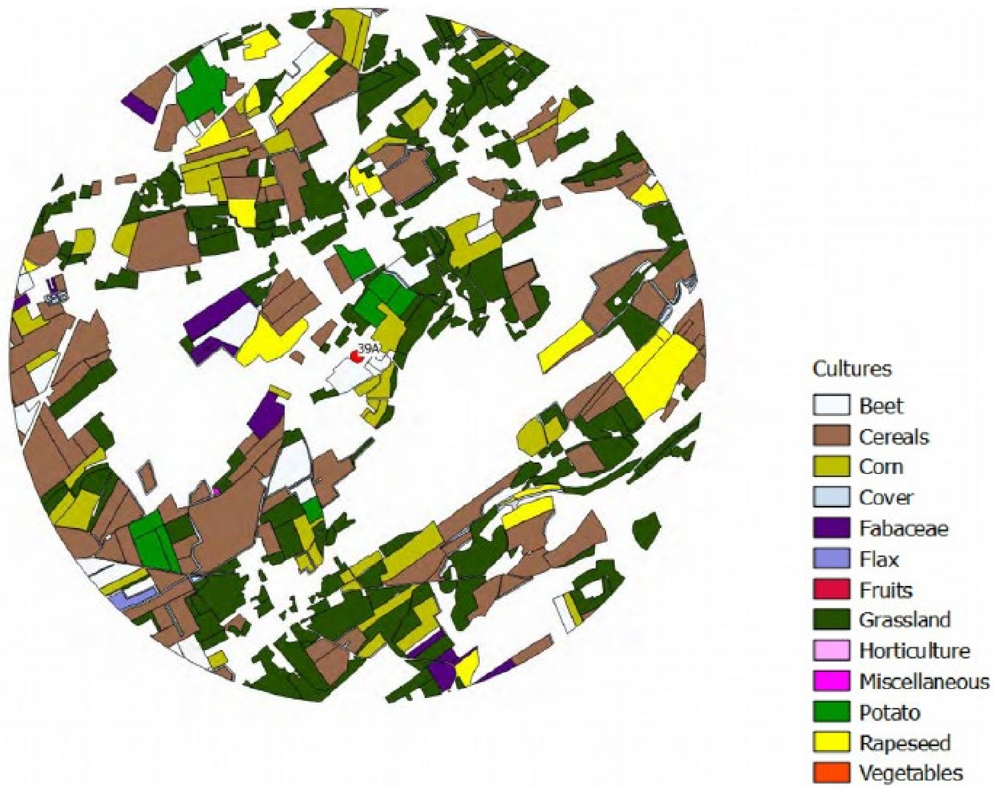
Timeline neonic case

- 1991 Market introduction imidacloprid
- 1994 Early warnings France
- 1999 First ban in France (sunflowers)
- 2002 EFSA established
- 2003 CST report France PEC>>PNEC
  - https://controverses.sciences-po.fr/archive/pesticides/rapportfin.pdf
- 2004 Ban in France (corn)
- 2013 EU ban 3 neonics on crops attractive to bees
- 2018 EU ban on outdoor use in crops
- 2019 EU ban thiacloprid

(historic) errors in risk assessment of neonics

Industry & regulatory science	Proven wrong by academic research	Issue
Does not translocate to flowers	Detected in pollen and nectar at ppb level.	Limit of detection
Key risk indicator is Acute Toxicity (+some times 10d chronic)	Sublethal effects are crucial	2003 CST PEC>>PNEC = No Go!
Honeybee is representative	Wild bees more sensitive and ecologically more key	Resilience of honeybee colony >> wild bees
Field tests can overrule lab tests	Field tests used are flawed by design & lack statistical power	Reproducibility
Assess single applications of single substances, assume 1 time exposure	Holistic, all applications together, all neonics together, year round exposure	**> 1000 allowed applications of 6 neonics in 200 products in EU (2015)**
Allow for recovery of hive after single exposure	Year round exposure makes recovery irrelevant	Recovery unrealistic
What is field realistic: what industry reports based on models / standard experiments	What we measure in the field	Invalid assumptions
Emissions based on models with assumptions	Measured levels of pollution proofs models wrong	Invalid assumptions

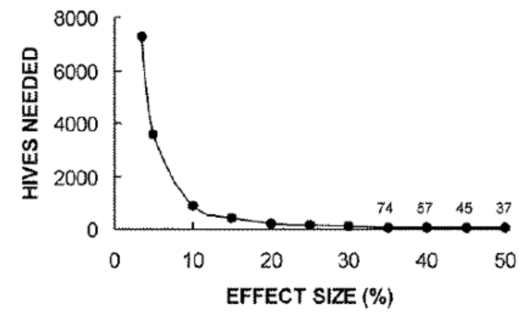
Honeybee field tests are hard to reproduce: Example land use in a 3 km radius around a honeybee hive (red dot)



Superficies (ha)

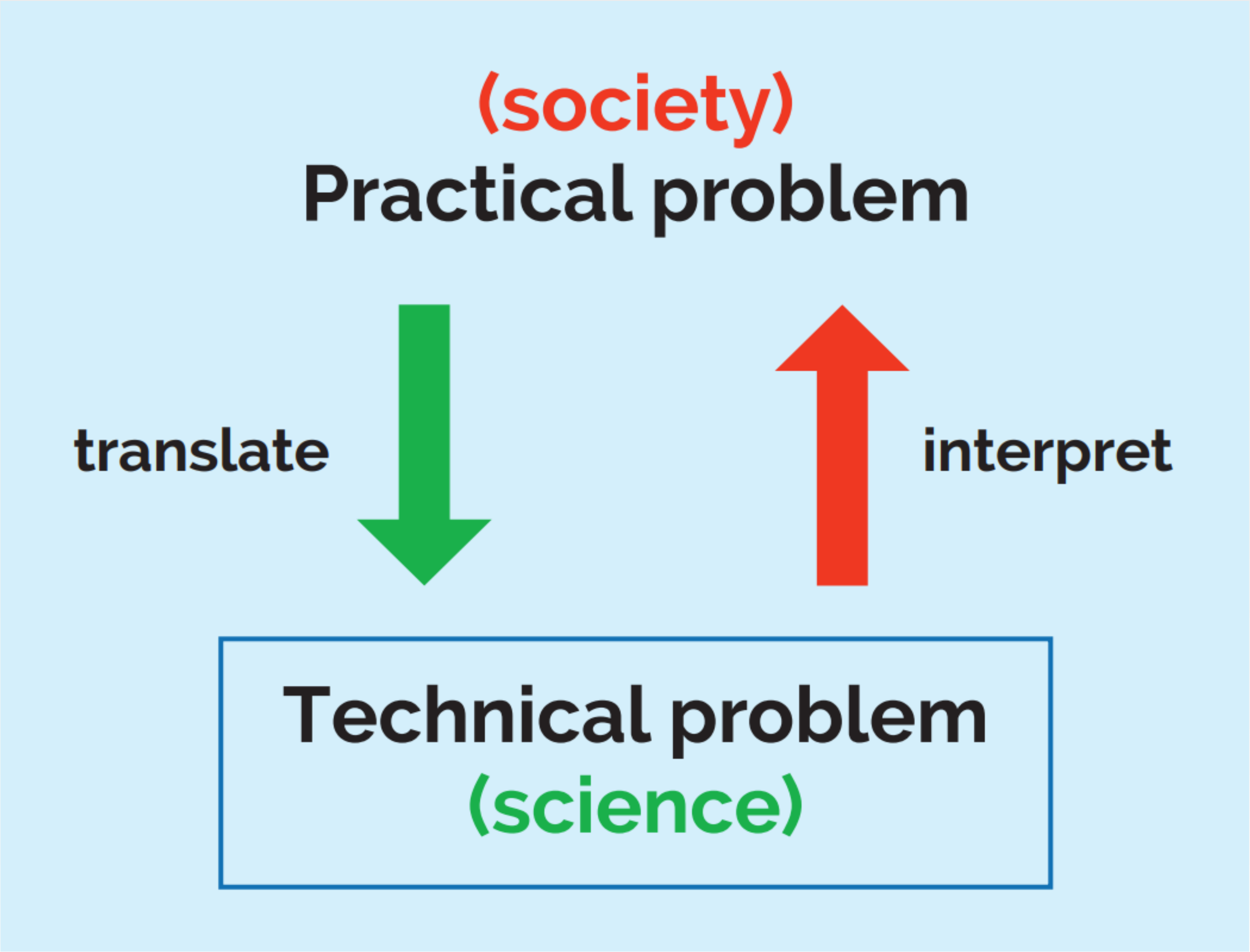
	39A
Grassland	535.0
Cereals	506.9
Corn	151.1
Rapeseed	102.3
Beet	78.5
Potato	51.7
Cover	38.7
Fabaceae	36.6
Flax	3.3
Miscellaneous	0.4
Vegetables	0.0
Horticulture	0.0
Fruits	0.0

Problem of statistical power honeybee field tests



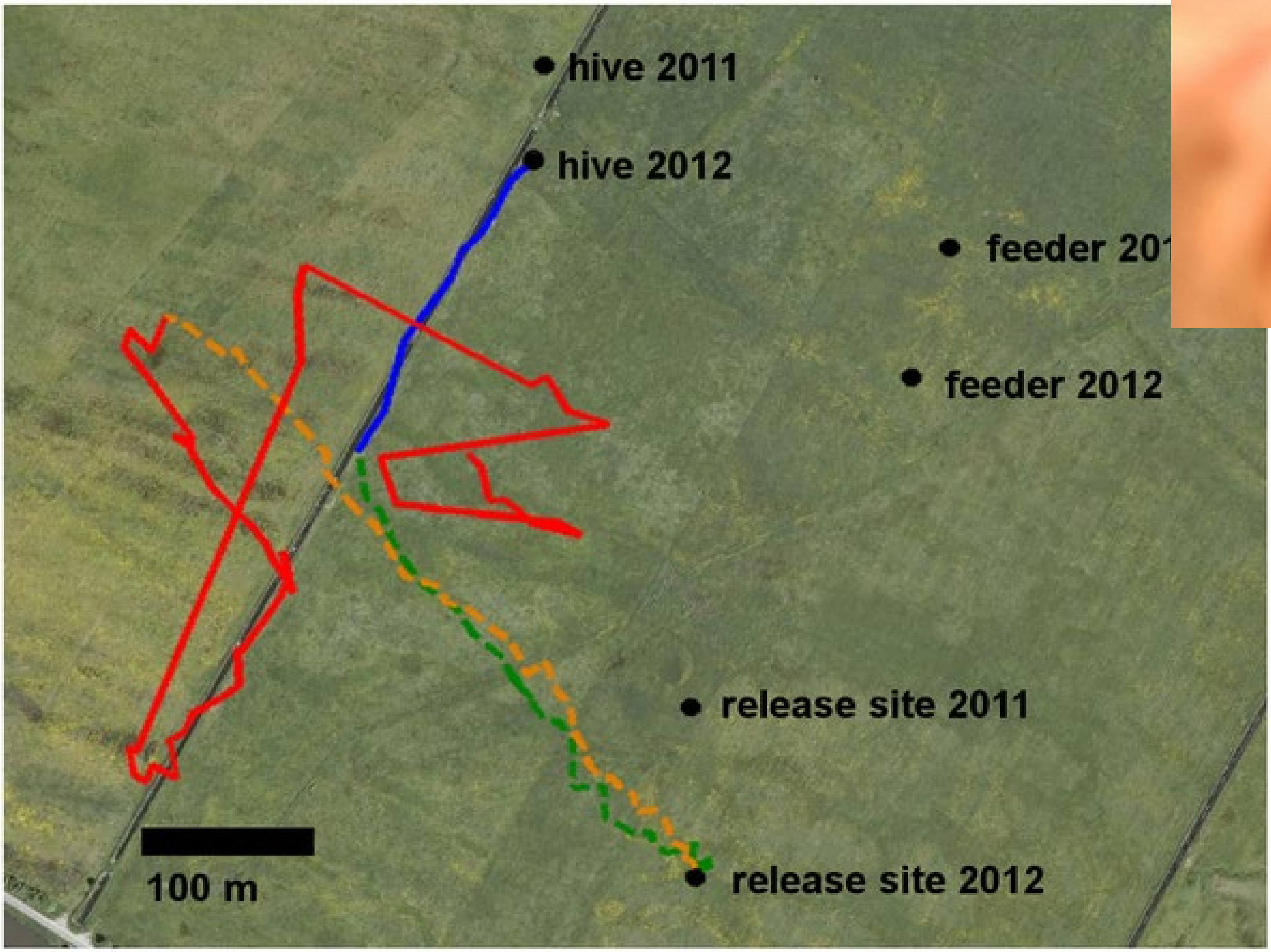
e.g. 74 hives needed to detect an effect of 35% with a significance level of 0.05 (R. Luttik, 2013)

Source: Noa Simon Delso, 2017. Fungicides and bees: a story of the unexpected.
PhD thesis, University Louvain la Neuve, Belgium
https://dial.uclouvain.be/pr/boreal/object/boreal:195698



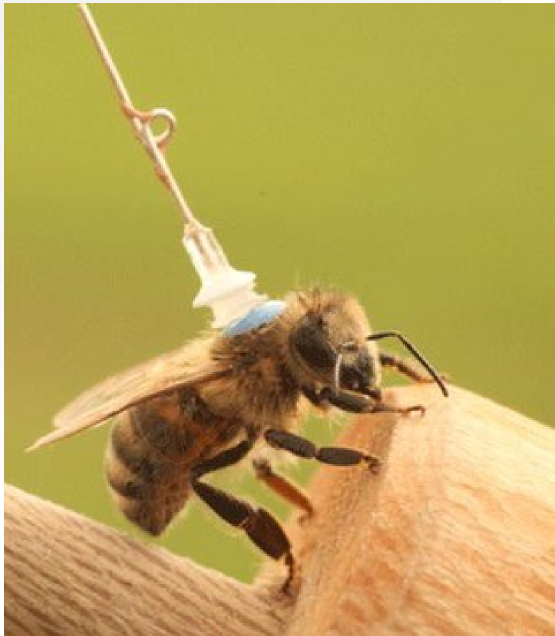
Ravetz, J., 1971, Scientific Knowledge and its Social Problems, Oxford University Press.

Radar-tracking experiment Randolf Menzel:
Bees exposed to neonicotinoids loose orientation



Yellow-Red
Thiacloprid-bees

Green-Blue
Control bees



Fischer J, Müller T, Spatz A-K, Greggers U, et al. (2014) Neonicotinoids Interfere with Specific Components of Navigation in Honeybees. PLoS ONE 9(3): e91364. doi:10.1371/journal.pone.0091364
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0091364

PLOS | ONE

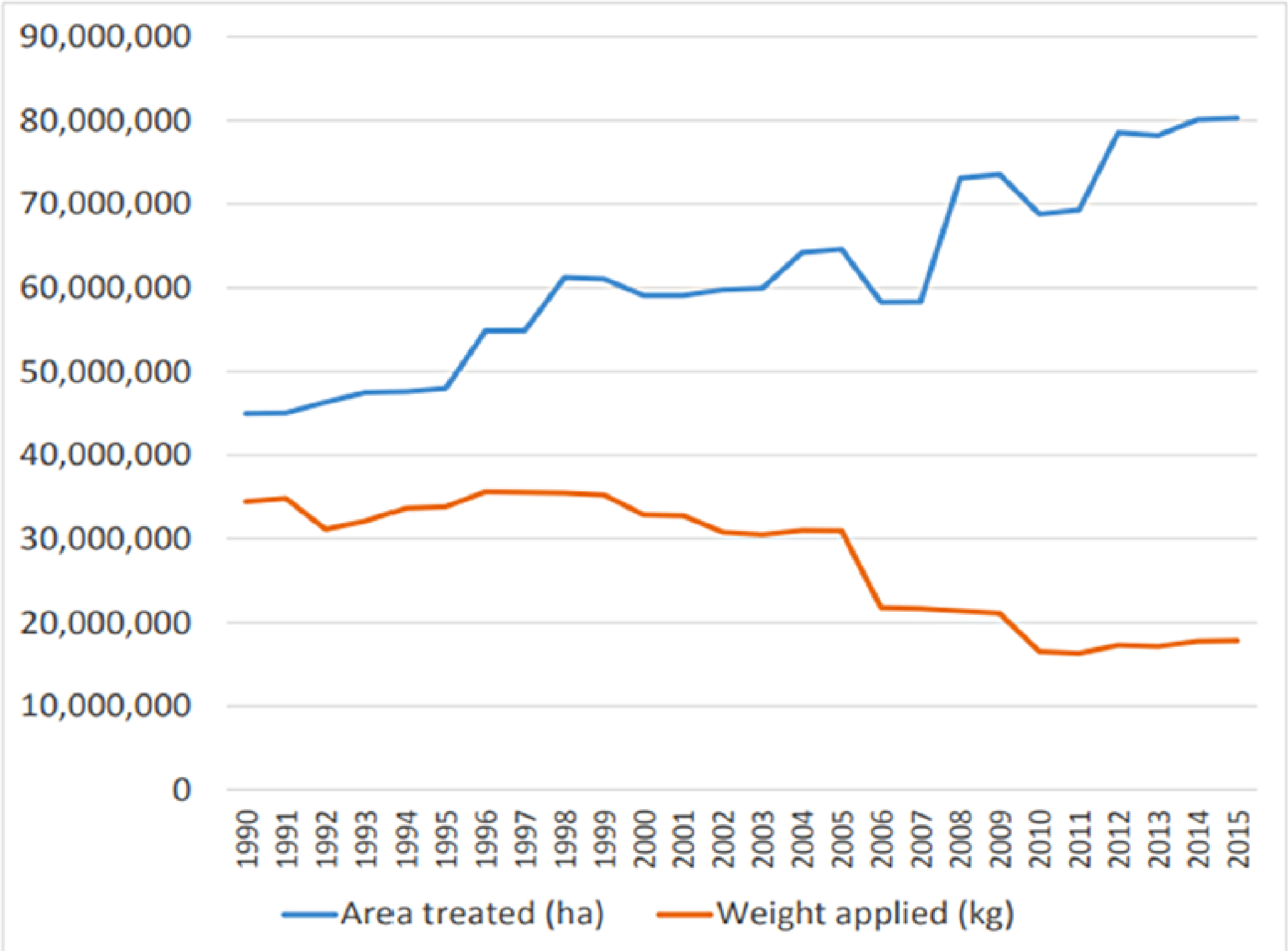
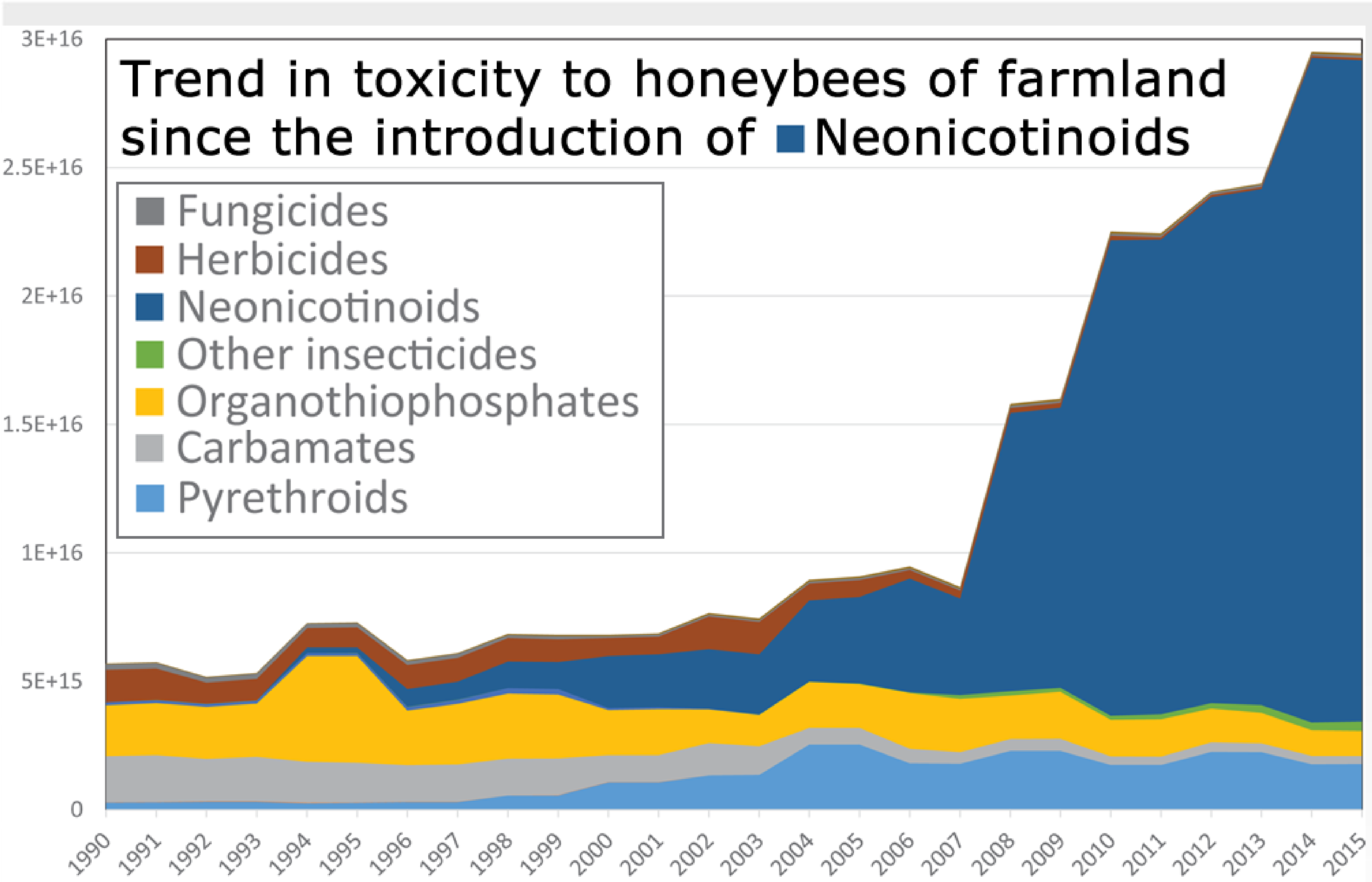


Figure 1 **Area of crop treated (blue line, hectares) and mass of pesticide applied (red line, kilograms) from 1990 to 2015.** The total area of crop remained approximately constant at 4.6 million hectares. In 1990 each hectare of cropped land on average received a total of 7.5 kg of pesticide active ingredient delivered in 9.8 applications. By 2015 each hectare of land received 3.9 kg of pesticide in 17.4 applications.

Full-size DOI: 10.7717/peerj.5255/fig-1

https://peerj.com/articles/5255/



Prophylactic pesticides: # of honeybee lethal doses (LD_{50}) in pesticides applied to UK farmland 1990-2015 DOI: 10.7717/peerj.5255/fig-2

Worldwide integrated assessment on systemic pesticides

Global collapse of the entomofauna: exploring the role of systemic insecticides

2014: Eight scientific papers (154 pages)

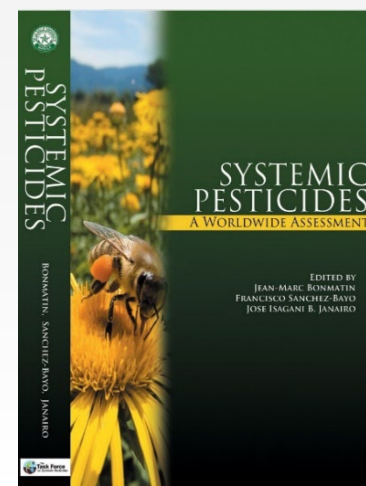
- Five years study
- First meta-analysis on neonicotinoids and fipronil
- 29 scientific authors (no conflict of interest)
- Comprehensive analysis (1121 publications & data from companies)
- Published in *Environmental Science and Pollution Research*, 2015

DOI: 10.1007/s11356-014-3220-1
DOI: 10.1007/s11356-014-3180-5
DOI: 10.1007/s11356-014-3332-7
DOI: 10.1007/s11356-014-3628-7
DOI: 10.1007/s11356-014-3470-y
DOI: 10.1007/s11356-014-3277-x
DOI: 10.1007/s11356-014-3471-x
DOI: 10.1007/s11356-014-3229-5

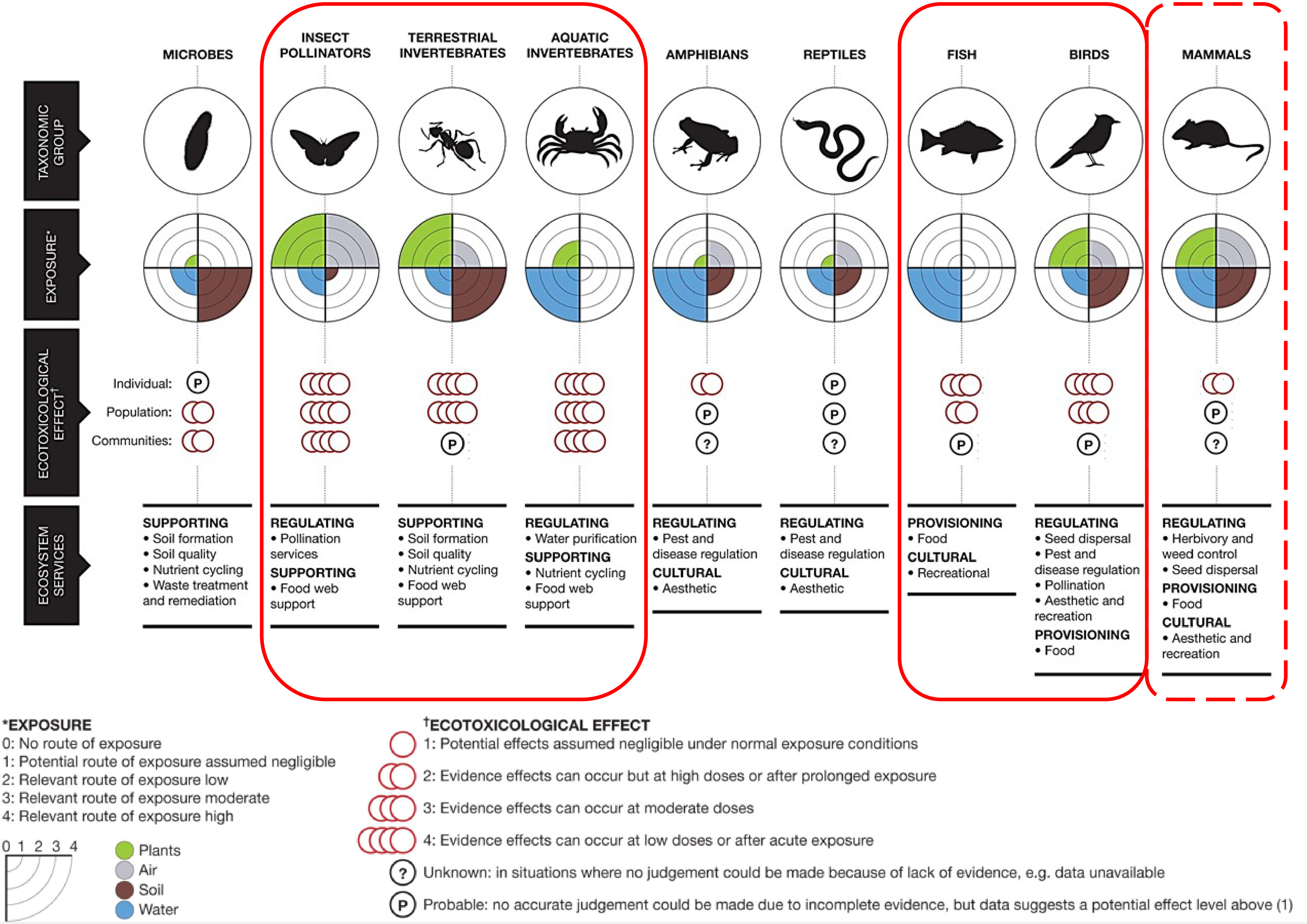
http://www.tfsp.info/assets/WIA_2015.pdf

2017-2018: Three new scientific papers (107 pages)

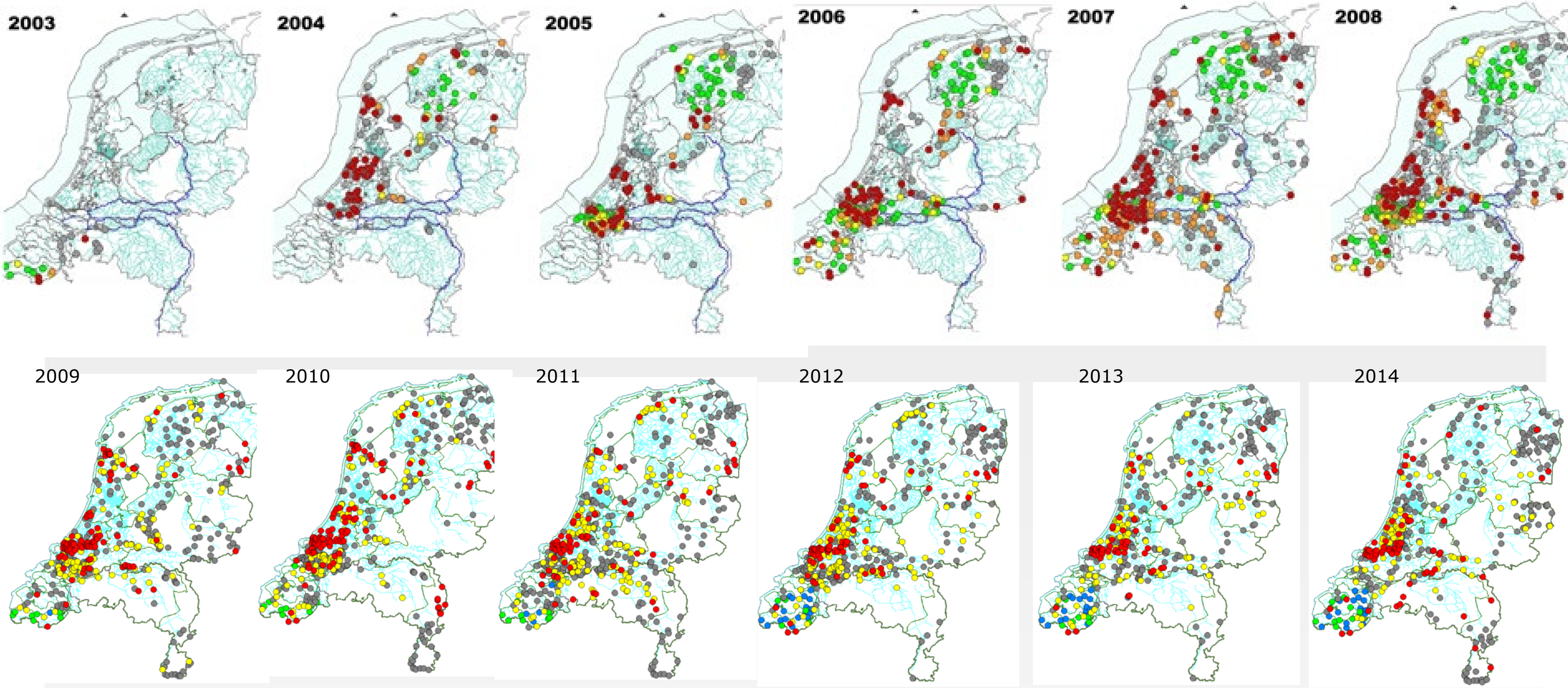
- Updated meta-analysis on neonicotinoids and fipronil
- 24 scientific authors (no conflict of interest)
- Comprehensive analysis (700 additional publications)
- 3 main chapters:
  - Exposures & Metabolism DOI:10.1007/s11356-017-0394-3
  - Impacts & Ecosystems DOI: 10.1007/s11356-017-0341-3
  - Resistances & Alternatives DOI: 10.1007/s11356-017-1052-5



Slide by: Dr. JM Bonmatin (CNRS) France



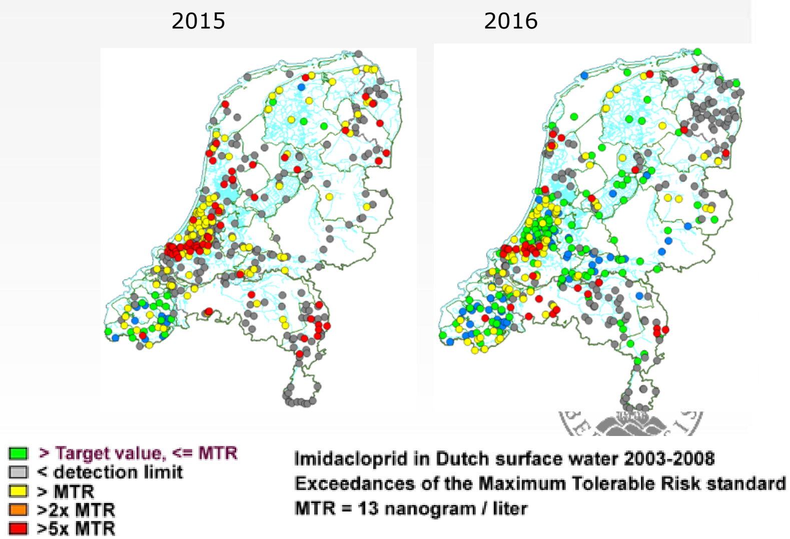
Pisa et al. 2017 https://link.springer.com/article/10.1007/s11356-017-0341-3



Since 2004, NL surface water is heavily polluted with Imidacloprid

www.bestrijdingsmiddelenatlas.nl

Only 1.6 to 20% of applied neonicotinoid is absorbed by the growing crop (Sur & Stork 2003)
80 to 98.4% leaches to soil & water!



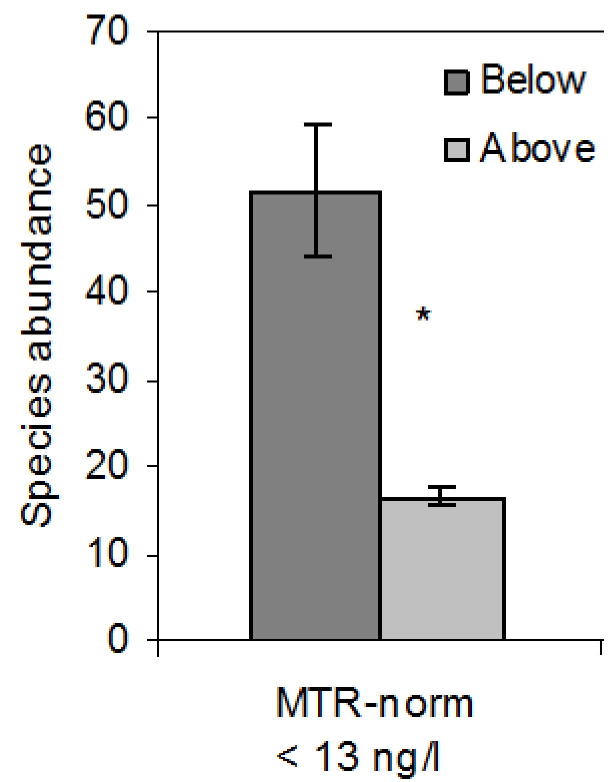
OPEN ACCESS Freely available online

PLOS ONE

Macro-Invertebrate Decline in Surface Water Polluted with Imidacloprid

Tessa C. Van Dijk, Marja A. Van Staalduinen, Jeroen P. Van der Sluijs*

- 45% of all samples (*n*=9037) on 801 locations: imidacloprid exceeds MTR (>13 ng/l)
- 70% reduction in macrofauna abundance in polluted water
- Permanent leaching of Imidacloprid year round from fields to surface water
- Meeting MTR requires reduction of use by at least 90%



https://doi.org/10.1371/journal.pone.0062374 nature International weekly journal of science

LETTER

doi:10.1038/nature13531

Declines in insectivorous birds are associated with high neonicotinoid concentrations

Caspar A. Hallmann[1,2], Ruud P. B. Foppen[2,3], Chris A. M. van Turnhout[2], Hans de Kroon[1] & Eelke Jongejans[1]

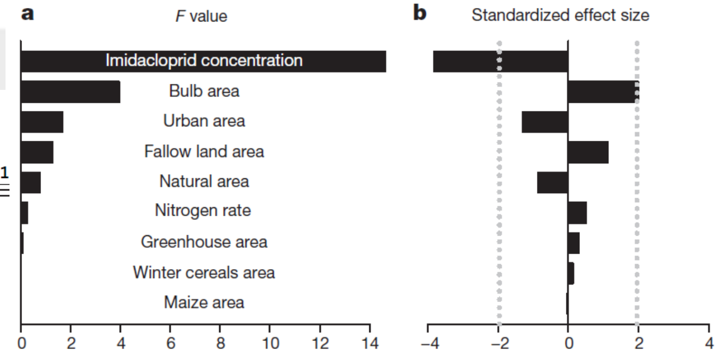
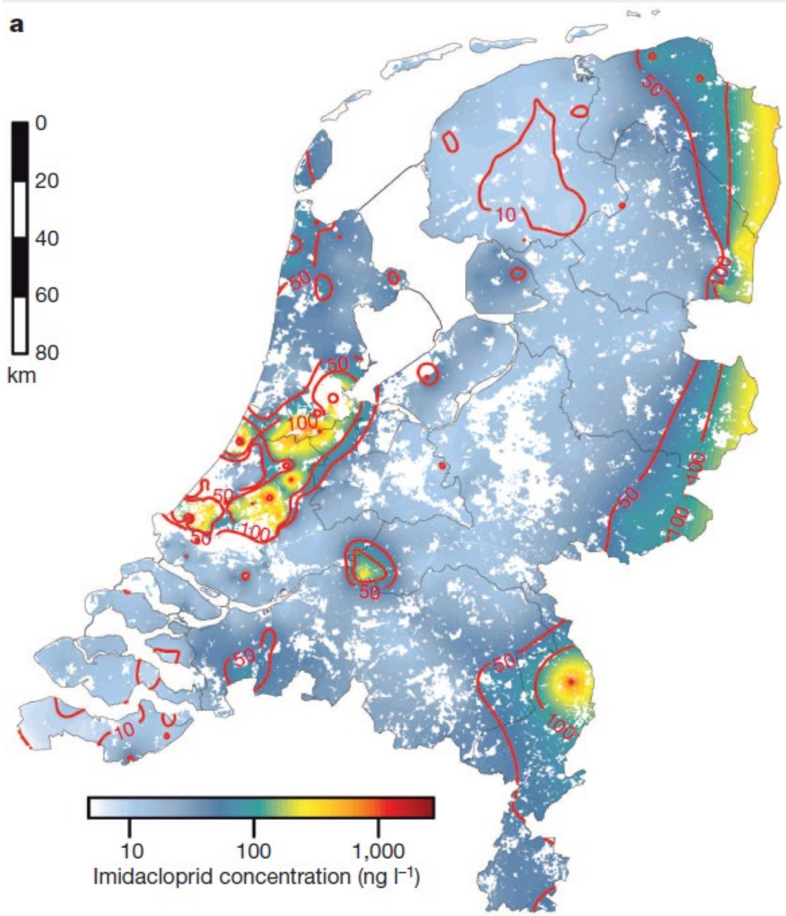
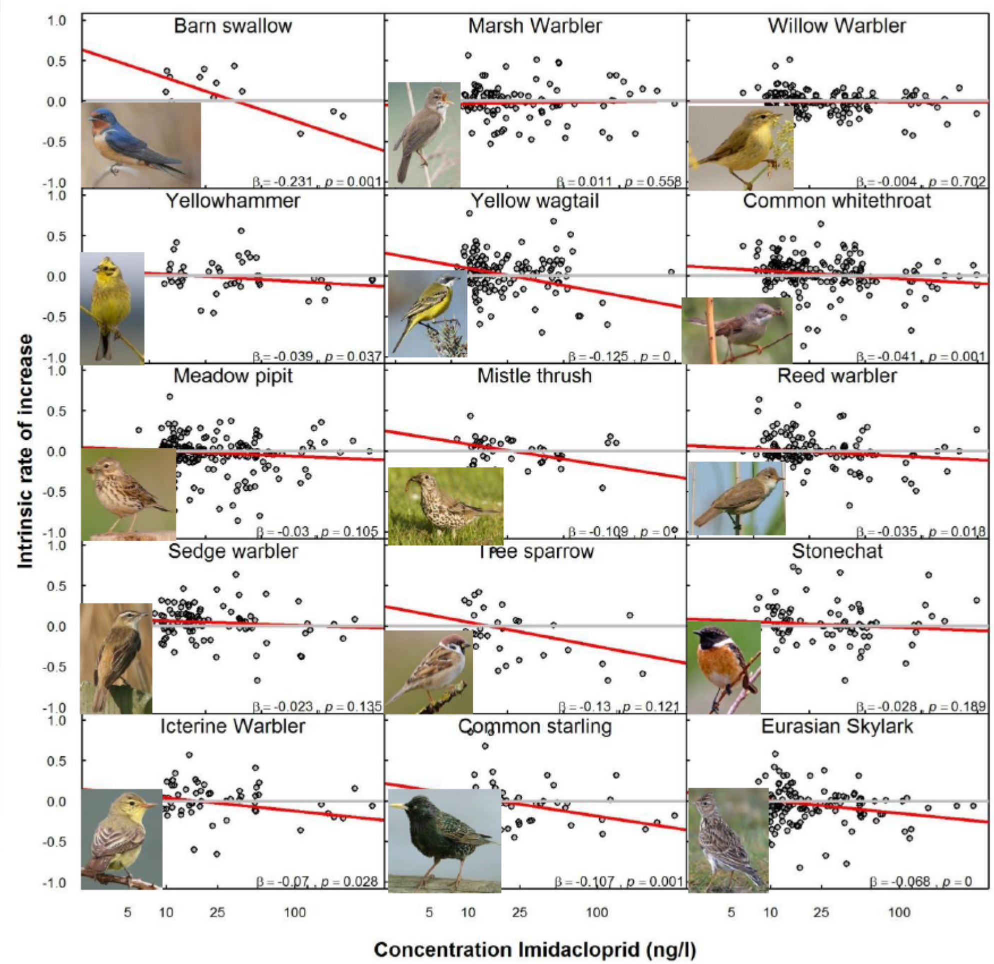


Figure 2 | Comparison of the effect of agricultural land-use changes and the effect of imidacloprid on bird population trends. **a,** The marginal variance





Loopholes

Neonics continue to pollute our environment

- "Emergency" authorisations

- Use as biocide continues
  - Bayt spray (imidacloprid) to kill flies in cattle breeding (stables, trucks, etc.)
  - Wood conservation (thiacloprid)

- Use as veterinary medicine continues
  – On pets and cattle (fleas and flies)

- Use outside EU on food (for humans and cattle) continues
  – Neonic residues in food are not fully metabolised, ends up in urine and manure.
  – Found in effluent of household waste-water treatment plants.

- Regrettable substitution Neonics:
  - Thiacloprid (replaced the 3 neonics banned in 2013/2018)
  - Sulfoxaflor [2015] & Flupyradifurone [2015]: same mode of action, *early warnings date from before authorisation decisions*

- New markets:
  – Lice treatment in Salmon farming authorised in 2021 in Norway (imidacloprid)

60 years of regrettable substitution

Can we stop the pesticide merry-go-round?

Insecticides:

- **DDT** (banned by many countries in 70s/80s, worldwide ban 2001)
- **Drins** (Aldrin, Dieldrin, Endrin) (Banned in EU in 1991, worldwide 2004)
- **Organophospates** (replaced DDT)
  (some banned recently in EU: 2002 omethoate; 2020 Chlorpyrifos)
- **Neonicotinoids** (replaced Drins and Organophosphates)
  (4 partly banned in EU in 2018 / 2019)
- **Sulfoximines** (sulfoxaflor, authorized in EU in 2015, banned in 2022)
- **Butenolides** (flupyradifurone)

Challenges

Too little

- Large scale use and pollution continues (see previous slide)
- How to fix the loopholes?

Too late

- How to reduce delays between early warning and action?
- How to improve the social organisation of expertise to timely inform decisions

Partial ban only in Europe

- World wide use Neonics still growing
- Europe produces and exports the banned neonics
- Human exposure still high and probably rising (residues in imported food)
- **Pollutant of emerging concern** in Marine and Arctic environments

Food ethics (2016) 1:75–91
DOI 10.1007/s41055-016-0003-z

CrossMark

DISCUSSION PAPER

Pollinators and Global Food Security: the Need for Holistic Global Stewardship

Jeroen P. van der Sluijs[1,2,3] • Nora S. Vaage[1,4]

Abstract Over the past decades, both wild and domesticated insect pollinators are in dramatic decline, which puts at stake the existence of species, ecosystem resilience and global food security. Globally, 87 of major food crops depend on animal pollination. Together these account for 35 % of the world food production volume. Pollinator mediated crops are indispensable for essential micronutrients in the human diet. Many ornamental plants as well as crops for fibre, fodder, biofuels, timber and phytopharmaceuticals also depend on insect pollinators. This article aims to map the current situation of pollinators worldwide, with a focus on the critical role of pollinators in the human food chain and ecosystem sustainability, their intrinsic and extrinsic value, as well as the causes of their declines and the interventions needed to conserve them, in order to develop an argument for the importance of conserving and restoring pollinator populations and diversity. The present pollinator crisis threatens global and local food security, can worsen the problems of hidden hunger, erodes ecosystem resilience, and can destabilise ecosystems that form our life support system. An integrated approach that simultaneously addresses the key drivers is needed. This includes creation and restoration of floral and nesting resources, a global phase out of prophylactic use of neonicotinoids and fipronil, improvement of test protocols in authorisation of agrochemicals, and restoration and maintenance of independence in regulatory science. The authors argue that an international treaty for global pollinator stewardship and pollinator ecosystem restoration should be initiated in order to systemically counteract the current crisis.

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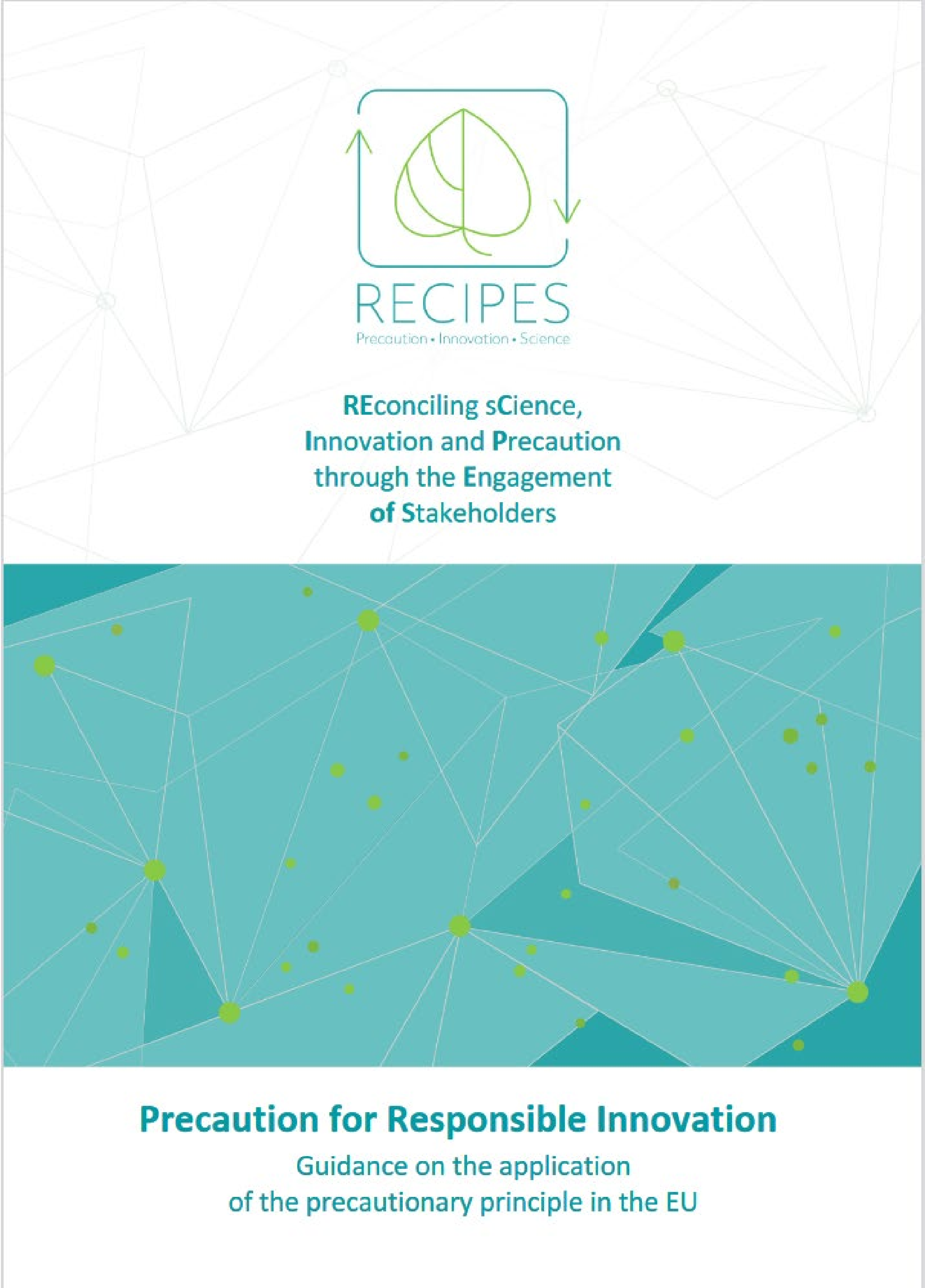
Pollinator Stewardship, an international challenge for science and policy

- At present the attention for insect decline is low in all domains, ranging from scientific research to policy-making to nature conservation.
- Global risk requires globally coordinated approach: international treaty on pollinator stewardship
- End pollinator habitat destruction
- Global phase out of the prophylactic use of ecotoxic agrochemicals such as neonicotinoids and fipronil
- Improve pesticide regulation and transition to agroecology


RECIPES
Precaution • Innovation • Science

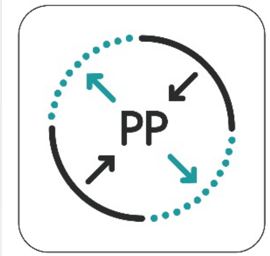
REconciling sCience, Innovation and Precaution through the Engagement of Stakeholders

Precaution for Responsible Innovation

Guidance on the application of the precautionary principle in the EU

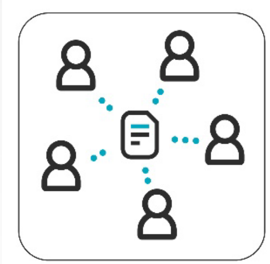
Three parts:

- Scope of application



- Organisation of expertise

- Participation



https://recipes-project.eu/results/guidance-future-application-precautionary-principle

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Precautionary Principle (PP)

evidence-informed action on uncertain risks

- Requires **scientifically underpinned grounds for concern**, not certainty, nor an exhaustive risk assessment

(*PP ≠ principle of prevention!*)

- Who or what gets the **benefit of the doubt** is a policy choice:

should be made explicitly

PP not only in risk management!

Risk assessment needs to be well-informed by the PP

- **Detect situations that require precautionary action** more adequately and timely
- Well-organised and timely collection of ***actionable knowledge*** is key for dealing prudently with uncertain risks
- Pluralization of expert knowledge in scientific assessment:

engage wider range of knowledge holders

Risk assessment must be open to 'non-standard' knowledge

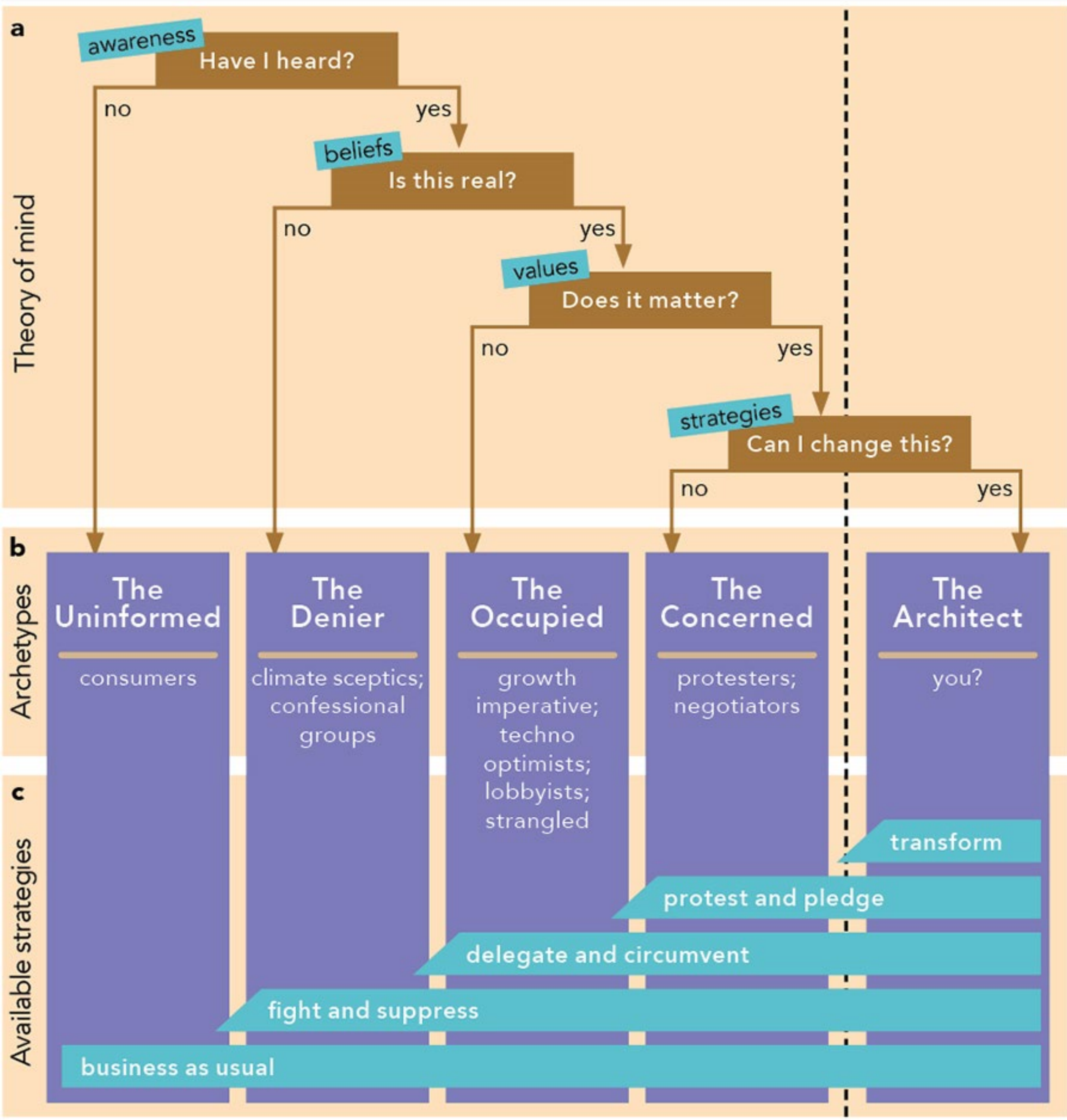
RECIPES cases showed:

- Blind spots in **overly reductionist** risk assessment protocols.
- Knowledge that do not fit in such protocols (e.g. end-points not covered by the protocols) is often downplayed, marginalised or ignored.
- Too often, coalitions of concerned scientists and societal actors need to **step in and 'break the script'** of routinised assessment and management processes to recognise key uncertainties and potential harm.

Lessons learned

- **Post-authorisation feedbacks missing**
  (extreme violation of norms has no consequences)
- **Power asymmetries bias weighting of evidence**
- **Epistemic diversity of the knowledge base not accounted for**:
  - Important knowledge systematically silenced, downplayed and ignored.
  - Full spectrum of available knowledge should be taken into account;
- **Robustness of the knowledge claims**
  - Include uncertainty, dissent and criticism in the analysis, synthesis and assessments;
- Make thorough **Knowledge Quality Assessment the key task in the science policy interface** and develop a joint language to communicate limitations to our knowledge and understanding clearly and transparently
- Make use of **information of non-scientific sources** (local knowledge)
  - But scrutinize this information and be clear on its status;
- **Clarify values, stakes and vested interests** that play a role in research and in the political and socioeconomic context within which the research is embedded.

(see also Maxim and van der Sluijs, 2007, 2012)



In order to successfully respond, decisions makers must:
1) be aware of the topic,
2) understand its causes,
3) value its significance,
4) have the means to respond effectively.

Figure modified from: Waeber et al (2021), doi.org/10.3390/su13063578

Source: https://researchfeatures.com/facts-not-enough-understanding-basis-make-decisions-change-planet/

Actionable knowledge for precautionary stewardship

- Fit for informing precautionary decision-making and action
- Resonates with the **concerns** for which it is raised

Explicit and transparent **problem scoping**

- What are relevant aspects of the problem?
- Set problem boundaries wide enough to **include** the **concerns** of those affected

Includes knowledge on:

- **severity and nature** of potential adverse effects
- nature of the **uncertainties** on risks and proclaimed benefits
- knowledge **gaps**, known and unknown <u>**unknowns**</u>
- **alternatives**

Further reading

- Insect decline, an emerging global environmental risk
  https://doi.org/10.1016/j.cosust.2020.08.012

- Pollinator conservation requires a stronger and broader application of the precautionary principle
  https://doi.org/10.1016/j.cois.2021.04.005

- Pollinators and global food security: the need for holistic global stewardship
  https://doi.org/10.1007/s41055-016-0003-z

- Halting the pollinator crisis requires entomologists to step up and assume their societal responsibilities
  https://doi.org/10.1016/j.cois.2021.08.004

- RECIPES Guidance on the application of the precautionary principle:
  https://recipes-project.eu/results/guidance-future-application-precautionary-principle

- EU Ban on Neonics: Too Little, Too Late
  https://www.greeneuropeanjournal.eu/eu-ban-on-neonics-too-little-too-late/