EEA Webinar: Drivers of change, risks and opportunities: navigating an uncertain and complex world – 30 June 2020

Uncertainty, risk, precaution

science for policy under complexity

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How does science-policy interface cope with uncertainties

Two strategies dominate:

- **Overselling certainty**
  - to promote political decisions (enforced consensus)
- **Overemphasising uncertainty**
  - to prevent political action

- Both promote decision strategies that are **not fit for meeting the challenges** posed by the uncertainties and complexities faced.

- Need for a third voice next to alarmists and skeptics: Coping with uncertainty, scientific dissent & plurality in science for policy.

https://dspace.library.uu.nl/handle/1874/386038

A practical problem:

Protecting a strategic fresh-water resource

5 scientists addressed same question:

"which parts of this area are most vulnerable to nitrate pollution and need to be protected?"

(Refsgaard, Van der Sluijs et al, 2006)
https://dspace.library.uu.nl/handle/1874/21696

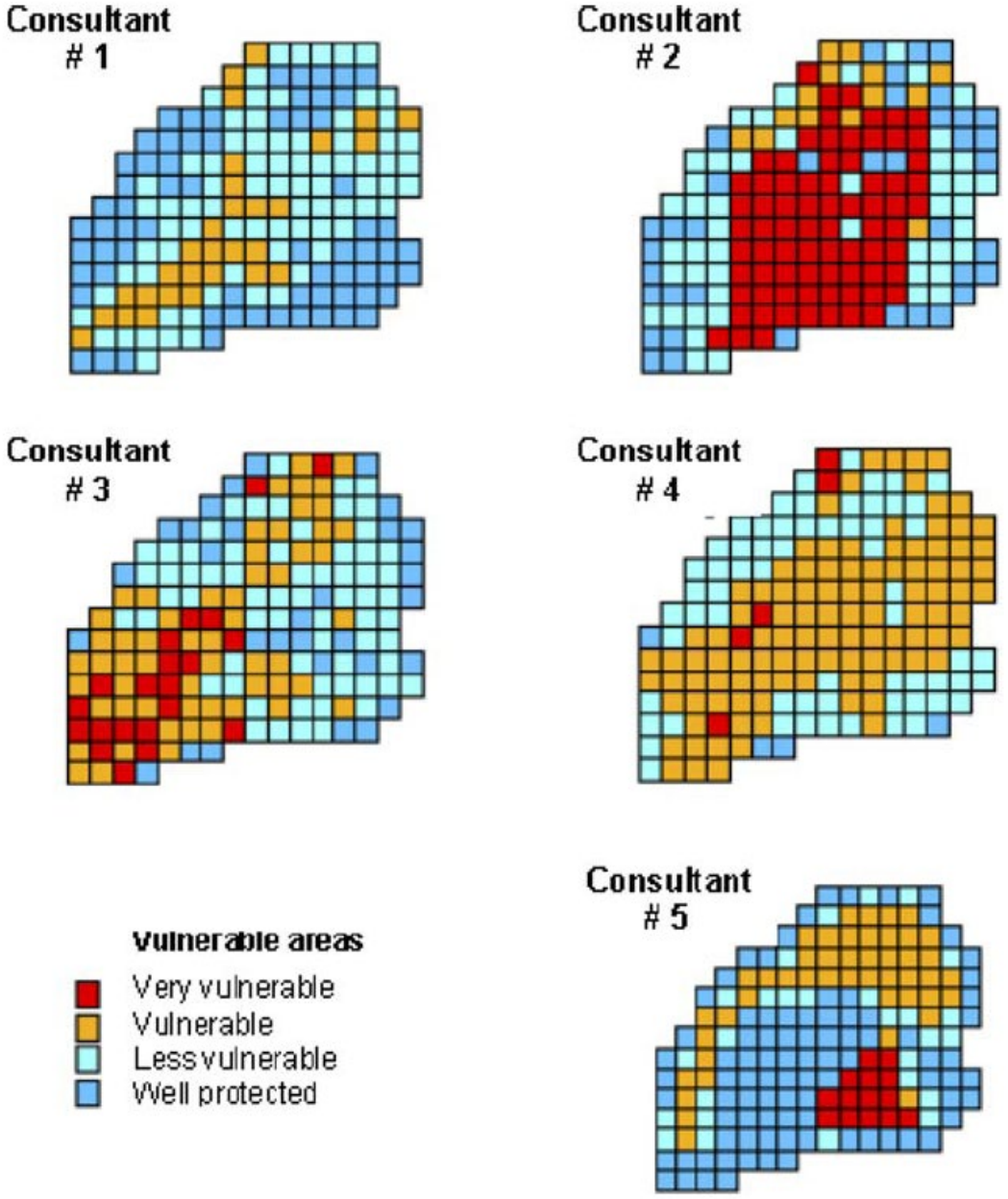


Fig. 1. Model predictions on aquifer vulnerability towards nitrate pollution for a 175 km^2 area west of Copenhagen [11].

3 understandings of uncertainty

'deficit view'

- Uncertainty is provisional
- Reduce uncertainty, make ever more complex models
- *Tools:* quantification, Monte Carlo, Bayesian belief networks

  – ***Speaking truth to power***

'evidence evaluation view'

- Comparative evaluations of research results
- *Tools:* Scientific consensus building; multi disciplinary expert panels
- focus on robust findings

  – ***Speaking [consensus] to power***

'complex systems view / *post-normal* view'

- Uncertainty is intrinsic to complex systems
- Openly deal with deeper dimensions of uncertainty
- *Tools:* Knowledge Quality Assessment

  – ***Working deliberatively within imperfections***

Van der Sluijs, 2016 http://www.andreasaltelli.eu/file/repository/Science_on_the_Verge_FINAL_.pdf#page=165

482 | Nature | Vol 582 | 25 June 2020

Five ways to ensure that models serve society: a manifesto

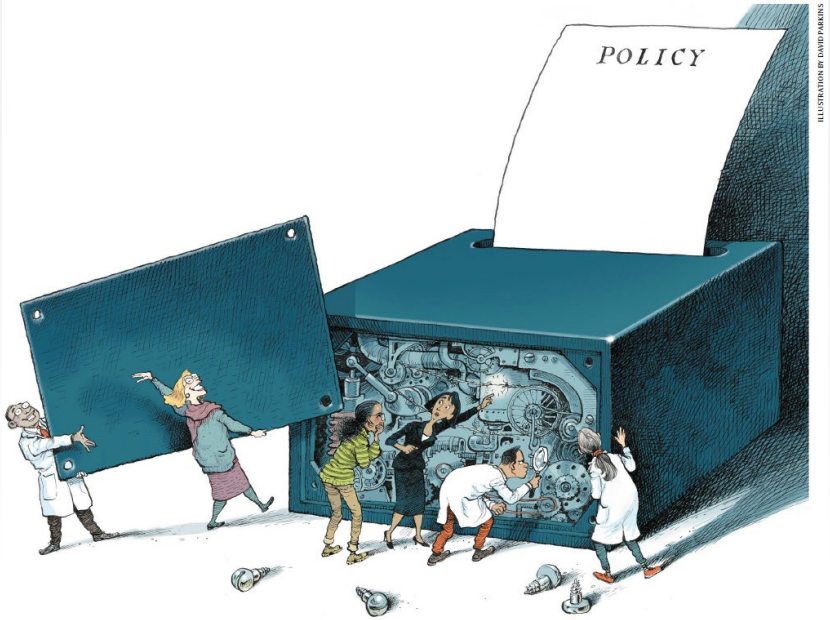
Andrea Saltelli, Gabriele Bammer, Isabelle Bruno, Erica Charters, Monica Di Fiore, Emmanuel Didier, Wendy Nelson Espeland, John Kay, Samuele Lo Piano, Deborah Mayo, Roger Pielke Jr, Tommaso Portaluri, Theodore M. Porter, Arnald Puy, Ismael Rafols, Jerome R. Ravetz, Erik Reinert, Daniel Sarewitz, Philip B. Stark, Andrew Stirling, Jeroen van der Sluijs & Paolo Vineis

Pandemic politics highlight how predictions need to be transparent and humble to invite insight, not blame.

The COVID-19 pandemic illustrates perfectly how the operation of science changes when questions of urgency, stakes, values and uncertainty collide – in the 'post-normal' regime.

Well before the coronavirus pandemic, statisticians were debating how to prevent malpractice such as *p*-hacking, particularly when it could influence policy[1]. Now, computer modelling is in the limelight, with politicians presenting their policies as dictated by 'science'[2]. Yet there is no substantial aspect of this pandemic for which any researcher can currently provide precise, reliable numbers. Known unknowns include the prevalence and fatality and reproduction rates of the virus in

- **Mind the assumptions**
  perform global uncertainty & sensitivity analyses
- **Mind the hubris**
  Avoid over-complexity
- **Mind the framing**
  Recognise value ladenness & bias
- **Mind the consequences**
  Opacity about uncertainty damages trust
- **Mind the unknowns**
  Acknowledge ignorance, be honest about model limits

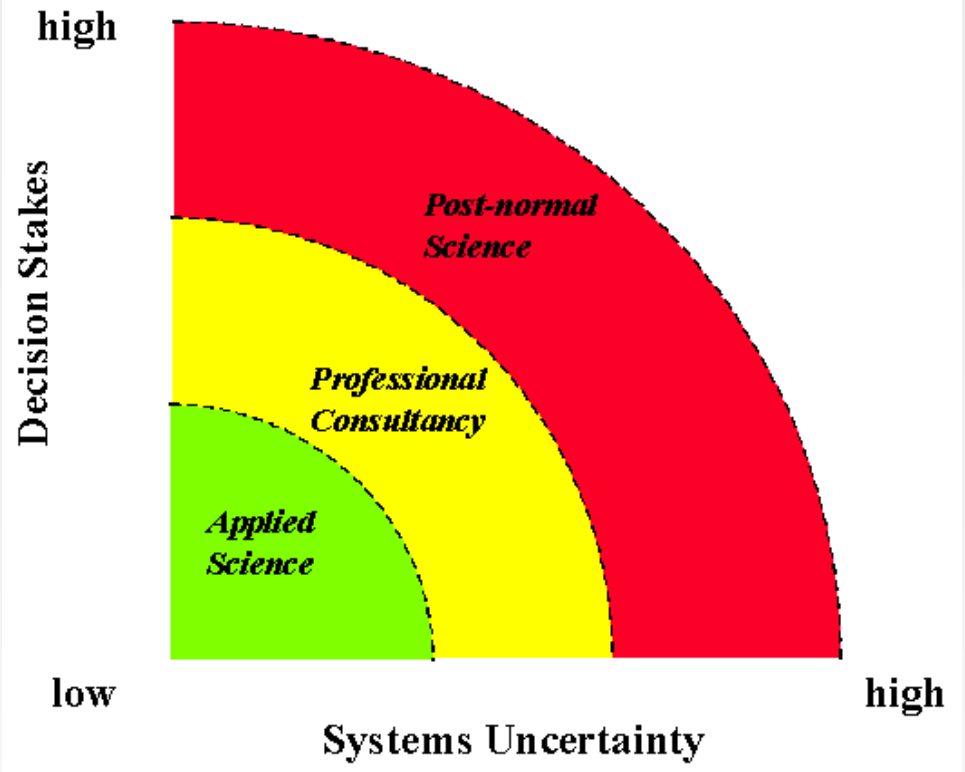


https://www.nature.com/articles/d41586-020-01812-9

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!**

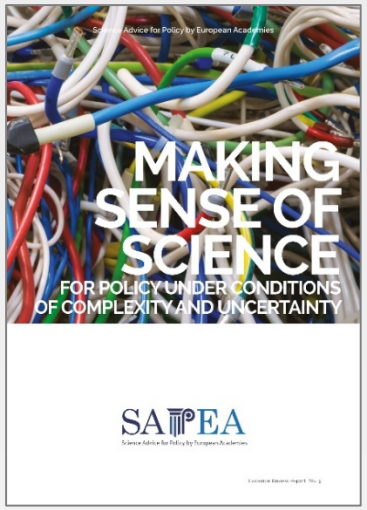
(Funtowicz & Ravetz, 1993 / 2020)
https://commonplace.knowledgefutures.org/pub/6qqfgms5/release/1

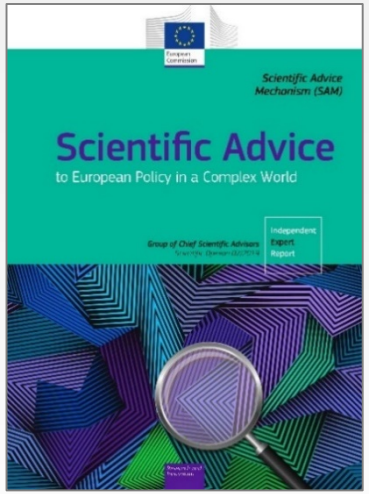
Making Sense of Science

- Evidence review by SAPEA, for
- European Commission's Group of Chief Scientific Advisors (GCSA)
- Overarching question:

> How to provide good science advice to European Commission policymakers, based on available evidence, under conditions of scientific complexity and uncertainty?

- launched July 2019
- Informed GCSA's Scientific Opinion
- GCSA's Scientific Opinion *Scientific Advice to European Policy in a Complex World* was launched in September 2019
- The Scientific Opinion is primarily addressed to policymakers across the European Commission





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Unrealistic assumptions about scientific evidence

- **Illusion of certainty**: making policymakers more confident about knowing the future than is justified
- **Illusion of transferability**: making policymakers overconfident that certainty in one aspect of the problem applies to all other aspects as well;
- **Illusion of 'absolute' truth**: making policymakers overconfident with respect to the truthfulness of evidence;
- **Illusion of ubiquitous applicability**: making policymakers overconfident in generalising results from one context to another context;
- **Illusion of a linear relationship between evidence and problem-solving**: making policymakers believe that science will offer right solutions to complex problems.

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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

Integration of different types of knowledge in the policy process

- Distinguish what is known, what is uncertain and what is unknown
- Impact on different aspects of human life must be made clear
- precautionary principle must be taken in account
- Clarify the values involved
- Involve expertise outside academia (local knowledge, know-how, citizen science etc.)

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Precautionary Principle (PP)

PP justifies policy interventions in cases where:

- scientific evidence of risk is insufficient, inconclusive or uncertain *and*
- there are indications through preliminary objective scientific evaluation that there are reasonable grounds for concern
- that the potentially dangerous effects on the environment, human, animal or plant health may be inconsistent with the chosen level of protection. (EU 2000)

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2000:0001:FIN:EN:PDF

The RECIPES-Project

***RE**conciling s**C**ience, **I**nnovation and **P**recaution through the **E**ngagement of **S**takeholders*

The objective

The RECIPES project aims to reconcile innovation and precaution by developing tools and guidelines to ensure the precautionary principle is applied while still encouraging innovation.

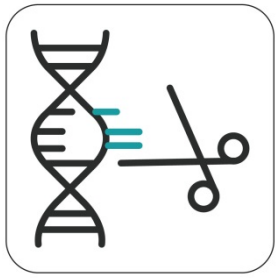
The RECIPES project will work closely with different stakeholders through interviews, workshop and webinars.

To this end, RECIPES will

1. Analyse legal and policy initiatives on the precautionary principle at the international, European and national level and describe the emergence of an 'innovation principle'
2. Examine the application of the precautionary principle in eight specific cases
3. Develop scenarios for the future of the precautionary principle taking into account innovation
4. Introduce mechanisms for public involvement in scientific and technological decision-making
5. Create tools and guidelines to the precautionary principle to help policymakers and other stakeholders to assess risks and take into account innovation.

RECIPES
Precaution • Innovation • Science

Case studies



New gene-editing techniques
Rathenau Institute

GMOs
ARC

Financial risks
HU Berlin

Neonicotinoid insecticides
University of Bergen

Endocrine disruptors
Maastricht University

Glyphosate
Maastricht

Nanotechnologies
OEAW

Artificial Intelligence in healthcare
Rathenau Institute

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

Preliminary findings RECIPES

- PP has a role in law and policy at all levels (international, EU, national)
- About 100 EU legal acts refer to PP
- Endorsed as a powerful framework for improving decision-making for the environment, human health and consumer safety
- Conflation of Prevention Principle and Precautionary Principle
- Unwanted secondary impacts: Regrettable substitution
- Various calls for reform:
  - Industry lobby calls for "Innovation Principle"
  - No evidence that PP hampers innovation; evidence that PP can stimulate sustainable innovation (confirms EEA **Late Lessons** reports 2001 & 2013)
  - Environmental and health-oriented NGOs and many scientists ask for wider use and stronger enforcement of the PP
  - Coupling PP with RRI?

Climate Change and the Precautionary Principle

- UN Framework Convention on Climate Change, **Art. 3.3** "The Parties should take **precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects."**

- Enhance the role of vulnerability science: **systematic search for surprises** and ways to constrain them
- Enhance the role of **monitoring** and empirical research
- Search for robust solutions that increase **resilience**
- Increase societies **capacity to act upon uncertain early warnings**
- **Knowledge partnerships** for precaution and sustainable development

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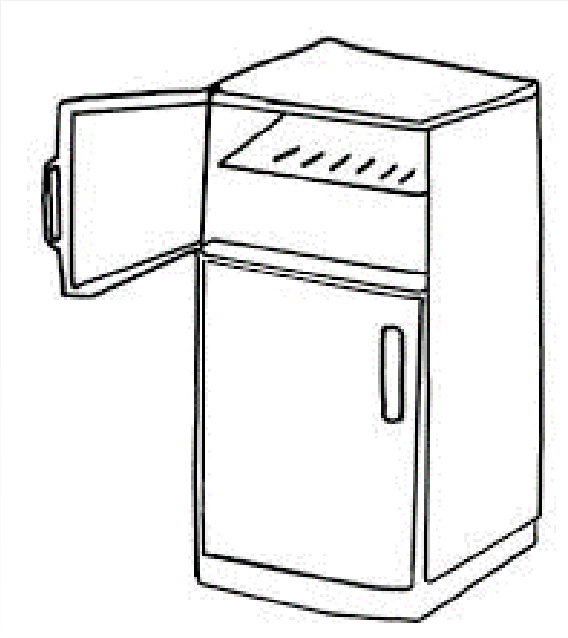
Conservation of misery

"Regrettable substitution" or "risk migration"

classic example: refrigerator coolant



- NH_3 -> acute health risk
- Propane -> explosion risk
- CFC -> ozone layer
  - *1987 Montreal Protocol*
- PFC -> greenhouse gas
  - *1997 Kyoto protocol*
- HFCs (HFO-1234yf)

Risk migration in the circular economy

Propelling plastics into the circular economy – weeding out the toxics first

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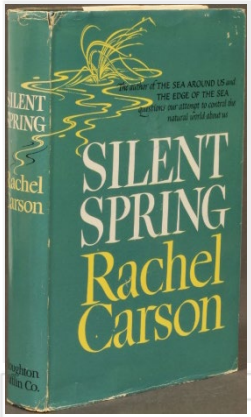
ABSTRACT

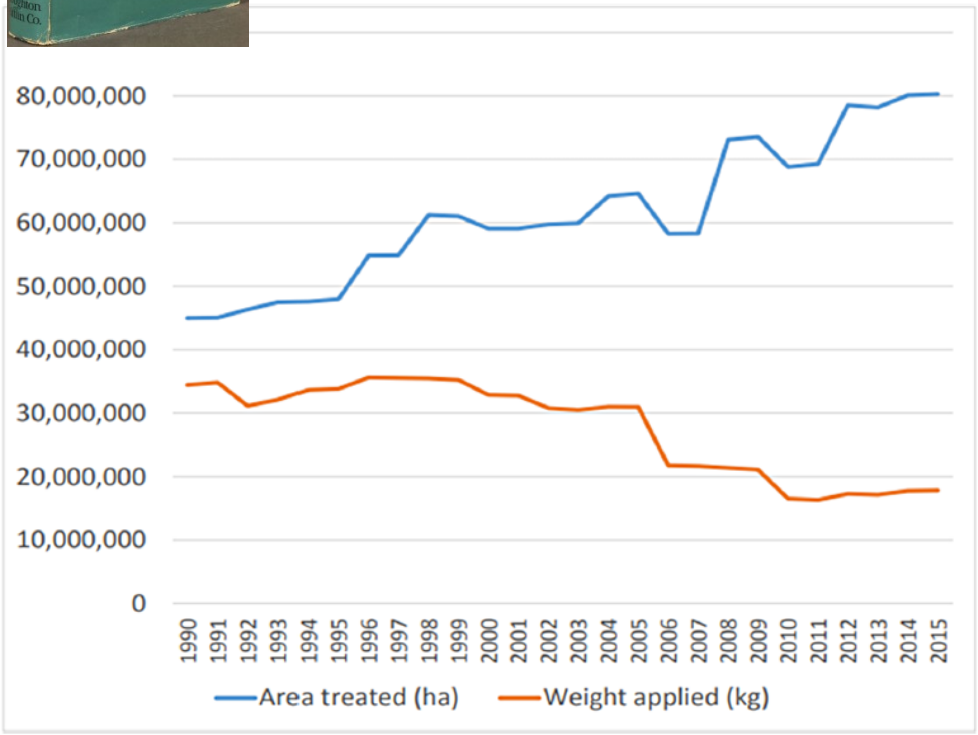
The Stockholm Convention bans toxic chemicals on its persistent organic pollutants (POPs) list in order to promote cleaner production and prevent POPs accumulation in the global environment. The original 'dirty dozen' set of POPs has been expanded to include some of the brominated diphenyl ether flame retardants (POP-BDEs). In addition to cleaner production, there is an urgent need for increased resource efficiency to address the finite amount of raw materials on Earth. Recycling plastic enhances resource efficiency and is part of the circular economy approach, but how clean are the materials we are recycling? With the help of a new screening method and detailed analyses, we set out to investigate where these largely obsolete BDEs were showing up in Dutch automotive and electronics waste streams, calculate mass flows and determine to what extent they are entering the new product chains. Our study revealed that banned BDEs and other toxic flame retardants are found at high concentrations in certain plastic materials destined for recycling markets. They were also found in a variety of new consumer products, including children's toys. A mass flow analysis showed that 22% of all the POP-BDE in waste electrical and electronic equipment (WEEE) is expected to end up in recycled plastics because these toxic, bioaccumulative and persistent substances are currently not effectively separated out of plastic waste streams. In the automotive sector, this is 14%, while an additional 19% is expected to end up in second-hand parts (reuse). These results raise the issue of delicate trade-offs between consumer safety/cleaner production and resource efficiency. As petroleum intensive materials, plastic products ought to be repaired, reused, remanufactured and recycled, making good use of the 'inner circles' of the circular economy. Keeping hazardous substances – whether they are well known POPs or emerging contaminants – out of products and plastic waste streams could make these cycles work better for businesses, people and nature.



Green Deal:

☐ Measures to reduce the use and risk of chemical pesticides, as well as the use of fertilizers and antibiotics | 2021

Example: Regrettable substitution pesticides



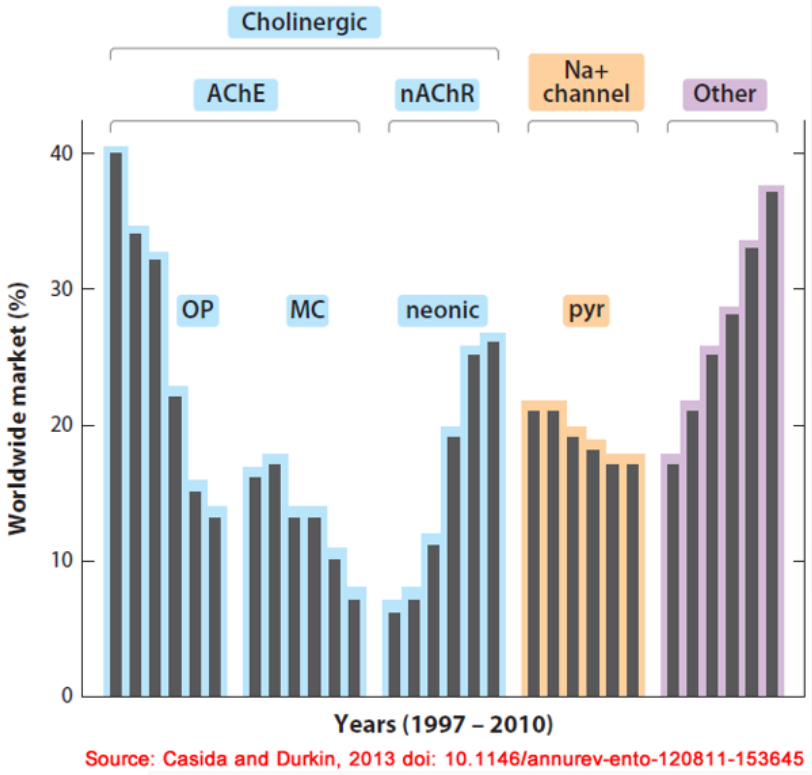
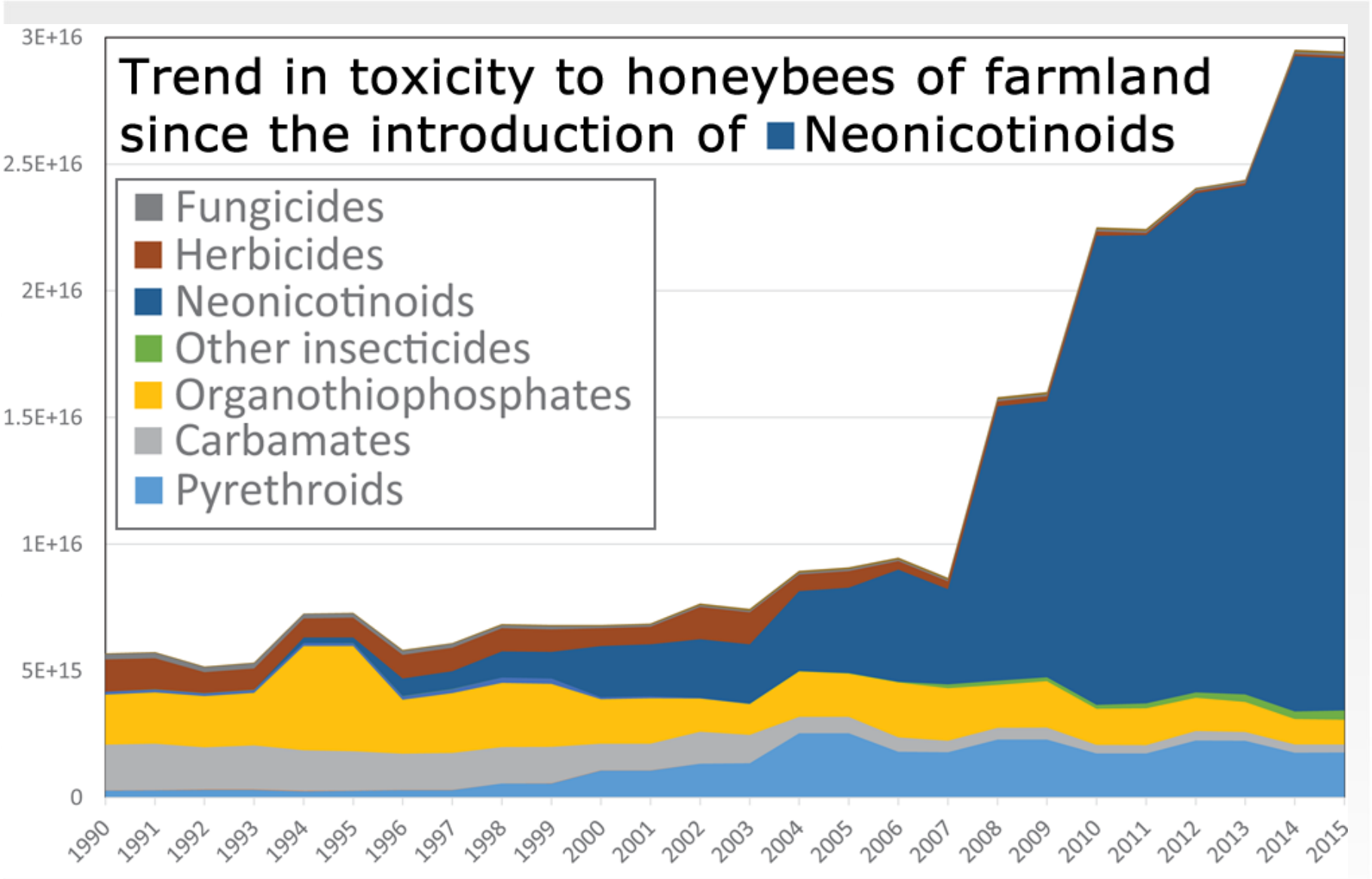


Figure 1 Area of crop treated (blue line, hectares) and mass of pesticide applied (red line, kilograms) from 1990 to 2015. The total area of crop remained approximately constant at 4.6 million hectares. In 1990 each hectare of cropped land on average received a total of 7.5 kg of pesticide active ingredient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

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

Top 10 characteristics of risk migration

Rank	Circumstance / characteristic	# cases
1	Lack of systems analytic approach	37
2	Incomplete life cycle assessment	27
3	Lack of critical reflection on risks and promised benefits	25
4	No incentives to meet ALARA	25
5	Persistence and/or bioaccumulation	17
6	Ignoring ignorance	14
7	Novel material / special unfamiliar properties	11
8	Mismatch novel aspects and authorization tests / standards etc	10
9	Unreflective upscaling from small scale experiences	9
10	Non standard situations	4

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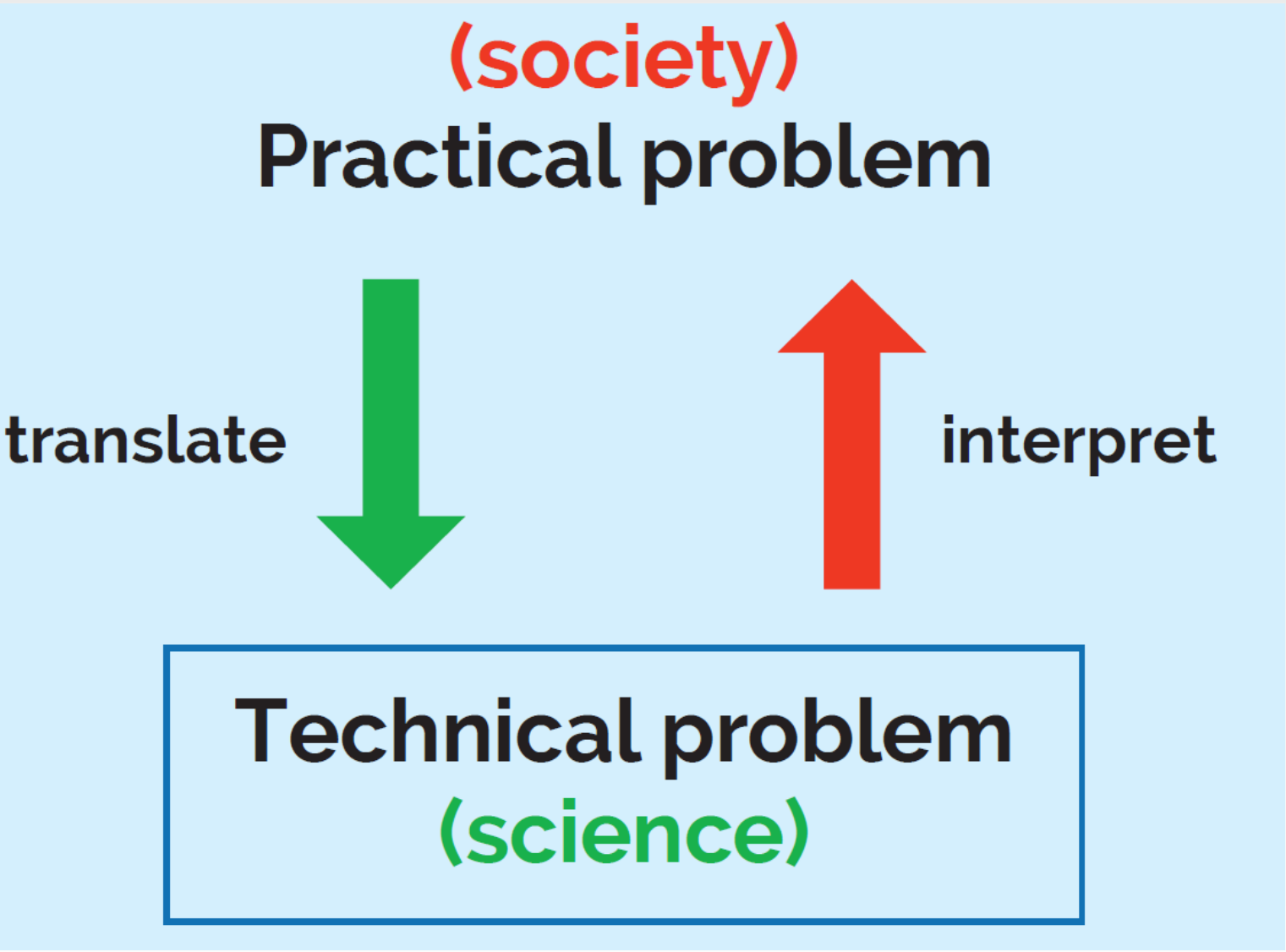

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Conclusions

The world's most pressing problems are also incredibly complex
Scientific knowledge around these areas can often be uncertain or contested

- **Science advice** supports effective policymaking by providing the best available knowledge, which **can then be used to understand a specific problem, generate and evaluate policy options and monitor results of policy implementation**.
- **Complexity, uncertainty & ambiguity** are unavoidable conditions of scientific knowledge at the science-policy interface
- Responsible quantification and model use requires to **mind the assumptions, hubris, framing, consequences and unknowns**
- **Science advice is always affected by values, conventions and preferences;** be **transparent** about values and goals
- **Precautionary Principle is key** in risk governance in face of complexity, uncertainty and ambiguity
  - Should not be conflated / confused with the prevention principle
  - Beware conservation of misery (regrettable substitution etc.)

Further reading:

Making Sense of Science for Policy report
https://www.sapea.info/topics/making-sense-of-science/ twitter: @SAPEAnews

Nature comment: Five ways to ensure that models serve society
https://www.nature.com/articles/d41586-020-01812-9 twitter #ModelResponsibly

RECIPES project (on precaution and innovation)
https://recipes-project.eu/ twitter @RECIPESproject

UNESCO report The Precautionary Principle / Book chapter on Climate & precaution
https://unesdoc.unesco.org/ark:/48223/pf0000139578
https://dspace.library.uu.nl/handle/1874/21723

Conservation of Misery report / circular economy report
https://dspace.library.uu.nl/handle/1874/314855
https://www.documents.clientearth.org/library/download-info/keeping-it-clean-how-to-protect-the-circular-economy-from-hazardous-substances/

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