



# How do pesticides affect pollinators?

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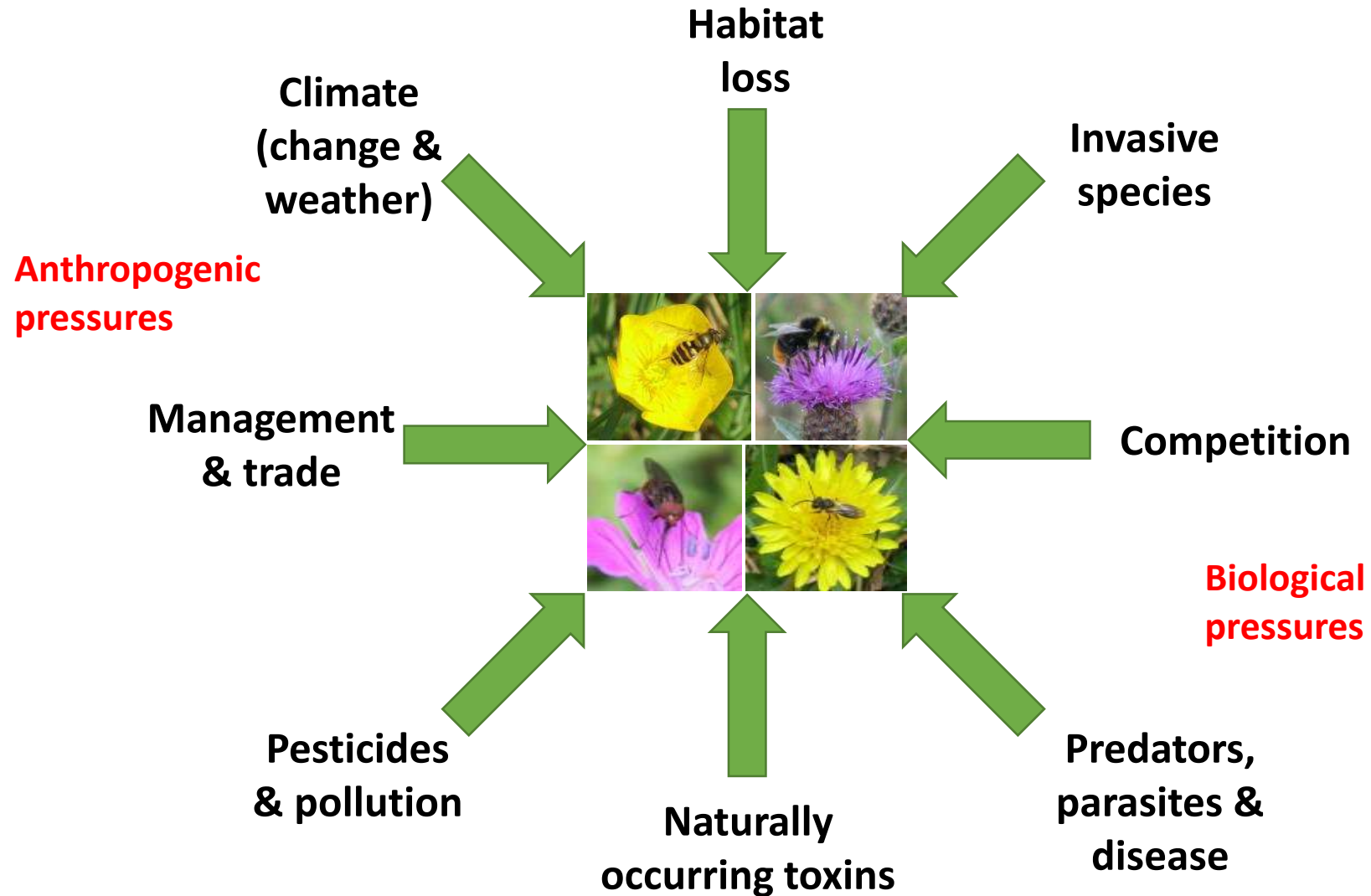
[stoutj@tcd.ie](mailto:stoutj@tcd.ie)



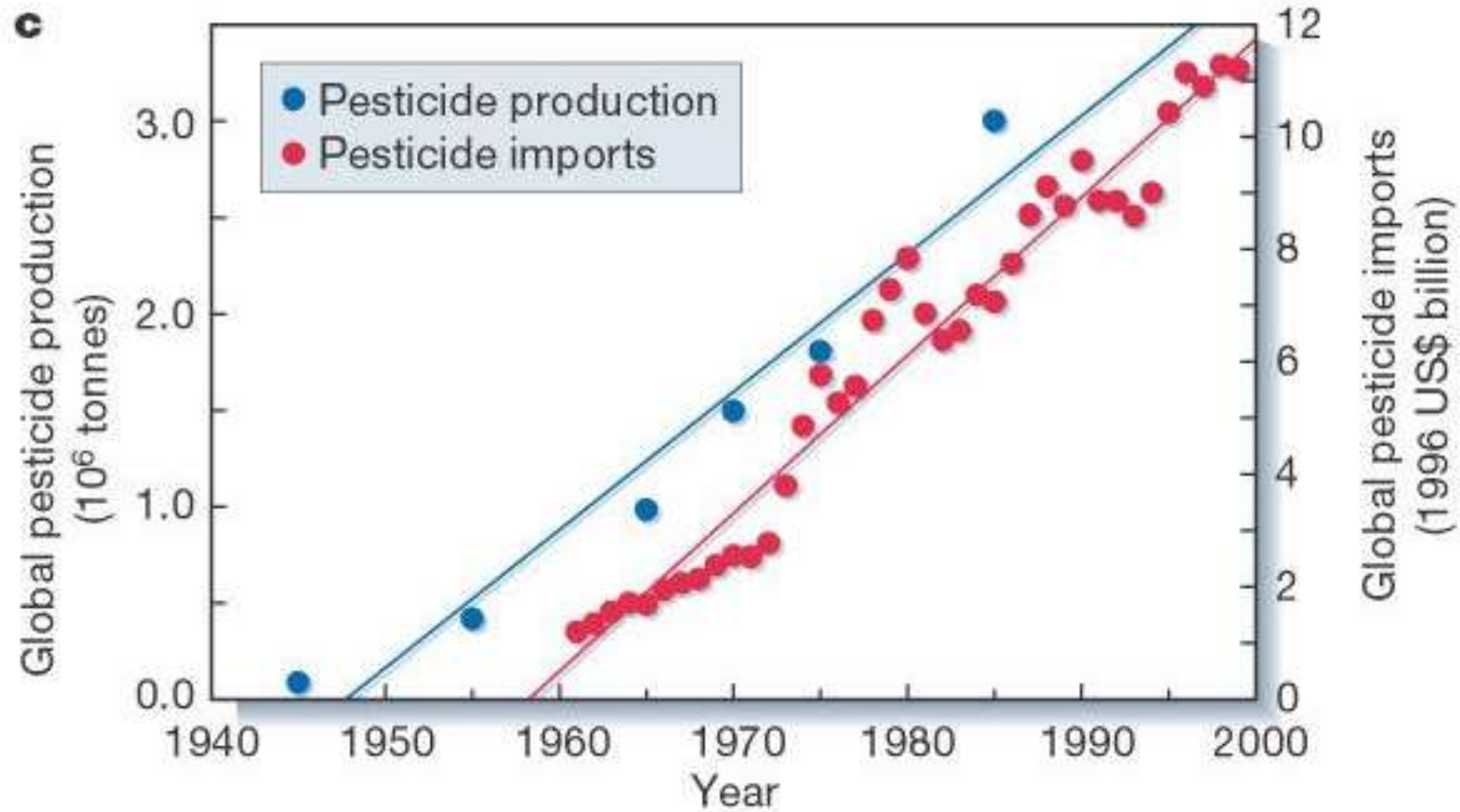
@JaneCStout



# Drivers of decline - Pollinators are exposed to multiple stresses...



# Pesticides use worldwide



Tilman, D., K. G. Cassman, P. A. Matson, R. Naylor, and S. Polasky. 2002. Agricultural sustainability and intensive production practices. *Nature* **418**:671.





[https://cdn.agriland.ie/uploads/2015/09/Sprayer\\_2\\_OGP.jpg](https://cdn.agriland.ie/uploads/2015/09/Sprayer_2_OGP.jpg)



[http://www.knotweed.ie/\\_media/media/160314113447-2156.jpg](http://www.knotweed.ie/_media/media/160314113447-2156.jpg)



Donna Rainey  
@donnarainey4

<https://pbs.twimg.com/media/DljYzpUXcAAISUA.jpg>



<https://21z6r9yf8x02eaff51wxrs58-wpengine.netdna-ssl.com/wp-content/uploads/2019/03/chemical-spray-690x300.jpg>



<http://www.rtjgc.com/images/dynamic/getImage.gif?ID=101380>

# 3 main groups

## Insecticides



cdn2.vectorstock.com

## Herbicides



utah1st.com

## Fungicides

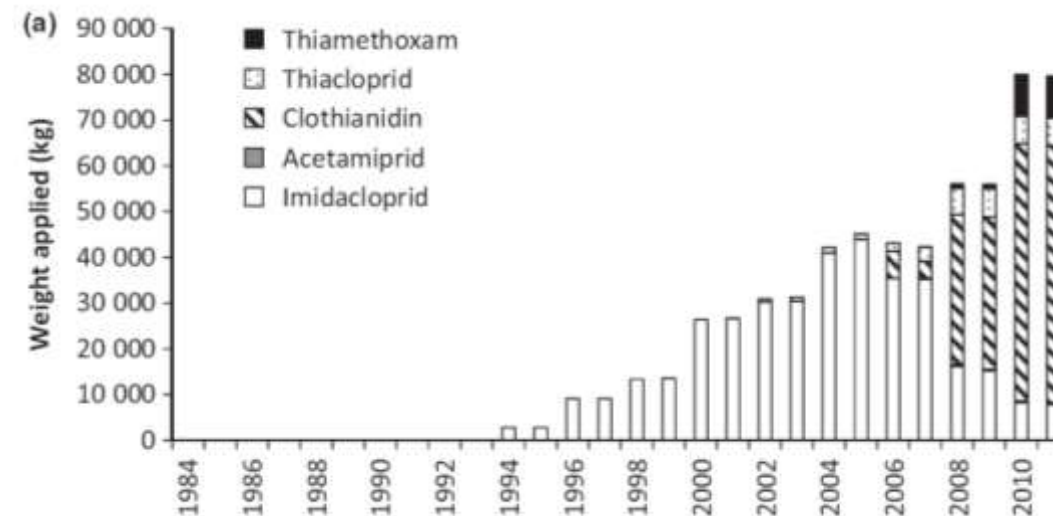
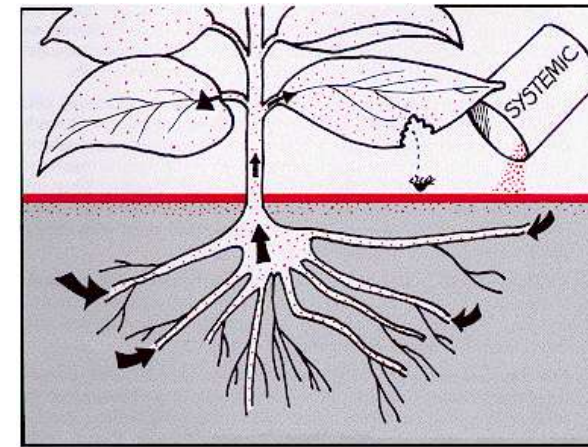


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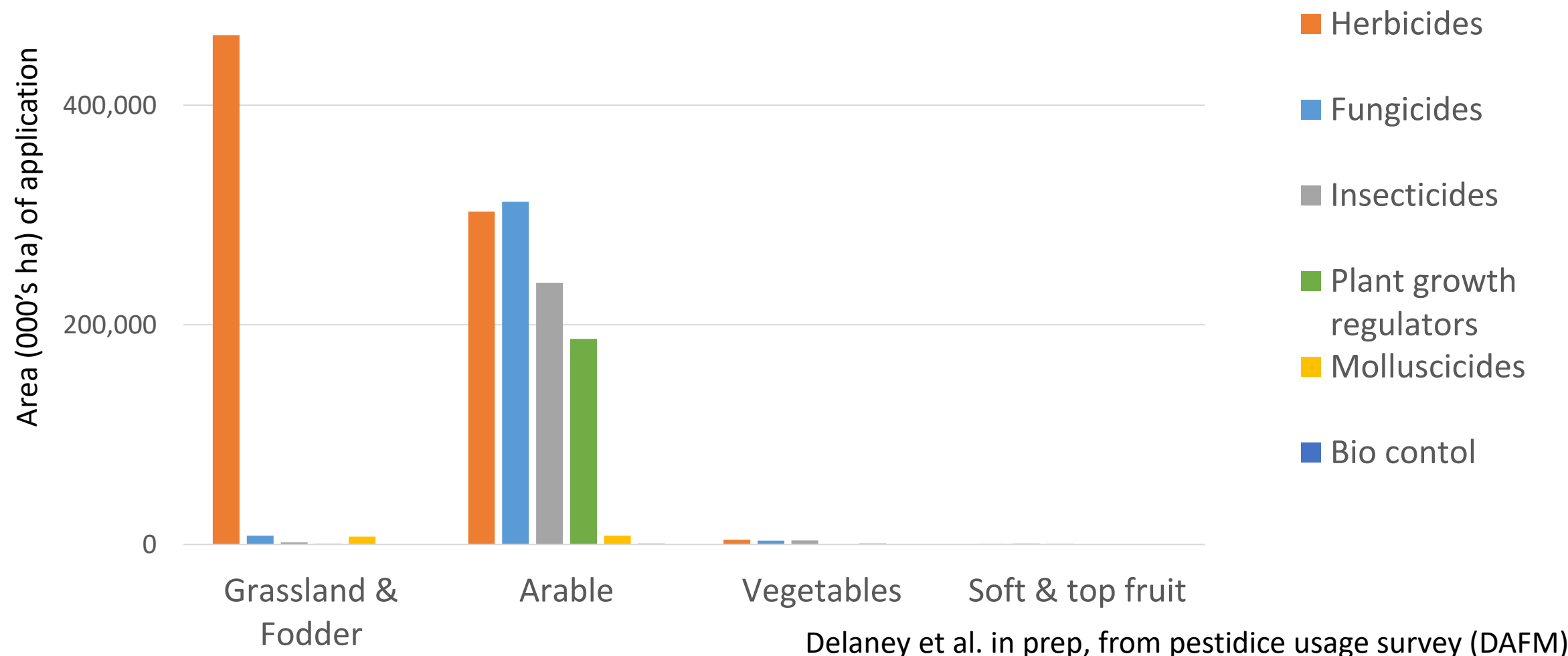
# Neonicotinoids

- Systemic pesticides
- Application and use:
  - Seed dressing – rape, cereals, maize, sunflower, beet
  - Sprayed on fruit crops
  - Soil drench or in granular form for pasture
  - Domestic use in gardens

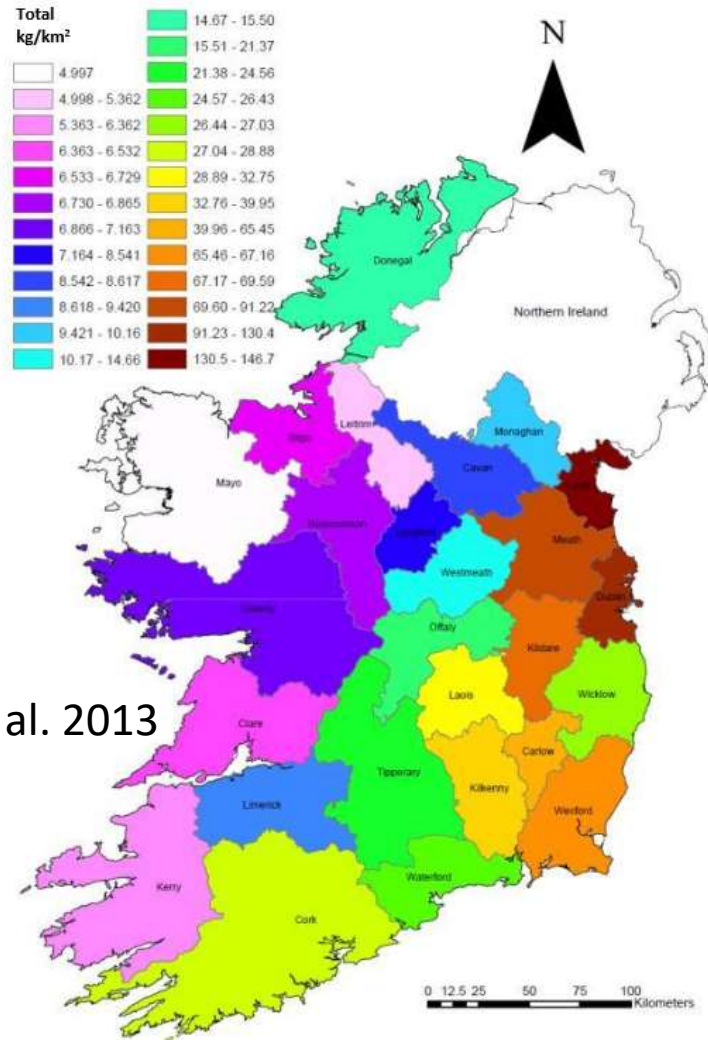


Goulson 2013

# Plant Protection Product (PPP) use in Irish agriculture



# Pesticide use in Irish agriculture



Zhao et al. 2013

- Regulated by EU Directive on the sustainable use of pesticides (DIRECTIVE 2009/128/EC )
- PPPs – plant protection products
- National Action Plan
  - Reviewed at least every 5 years
  - Training, use (equipment, storage, supply, use in specific areas) & IPM
  - Pesticide usage survey

Figure 2 GIS profile of the total amount of pesticide usage of ROI



# Pesticide use outside agricultural settings



<http://www.camdenfoe.org.uk/wp-content/uploads/2016/04/Homebase-shelves.jpg>



[www.shutterstock.com](http://www.shutterstock.com) • 439675153



**Exposure routes...** Depend on method of application and mode of action of pesticide

Direct – Spraying

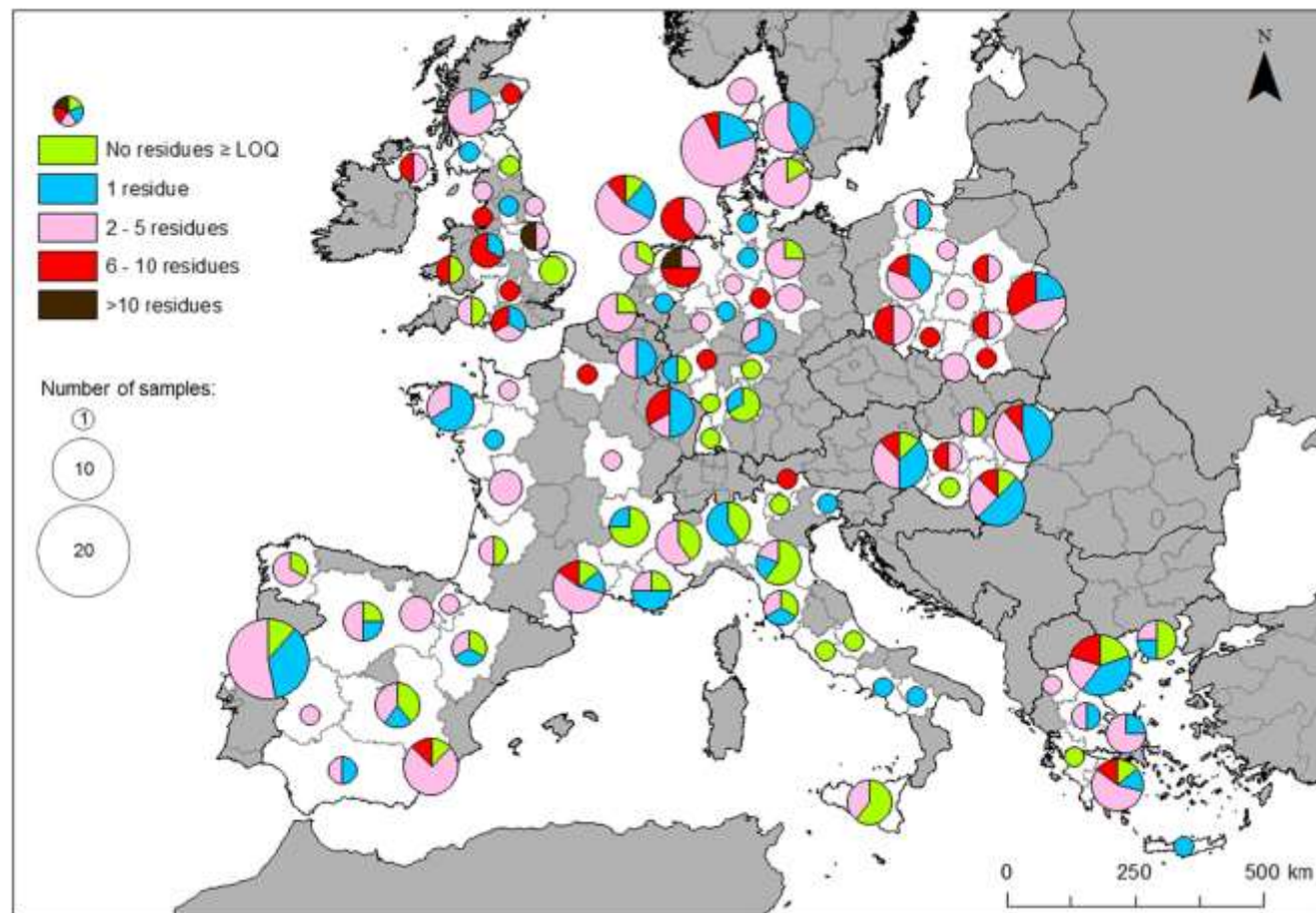


Indirect – seed dressings, soil and water contamination...





## Residues in soils....



> 80% of the tested soils contained pesticide residues

Silva et al. 2019 Science of the Total Environment 653: 1532–1545

## Residues in water....

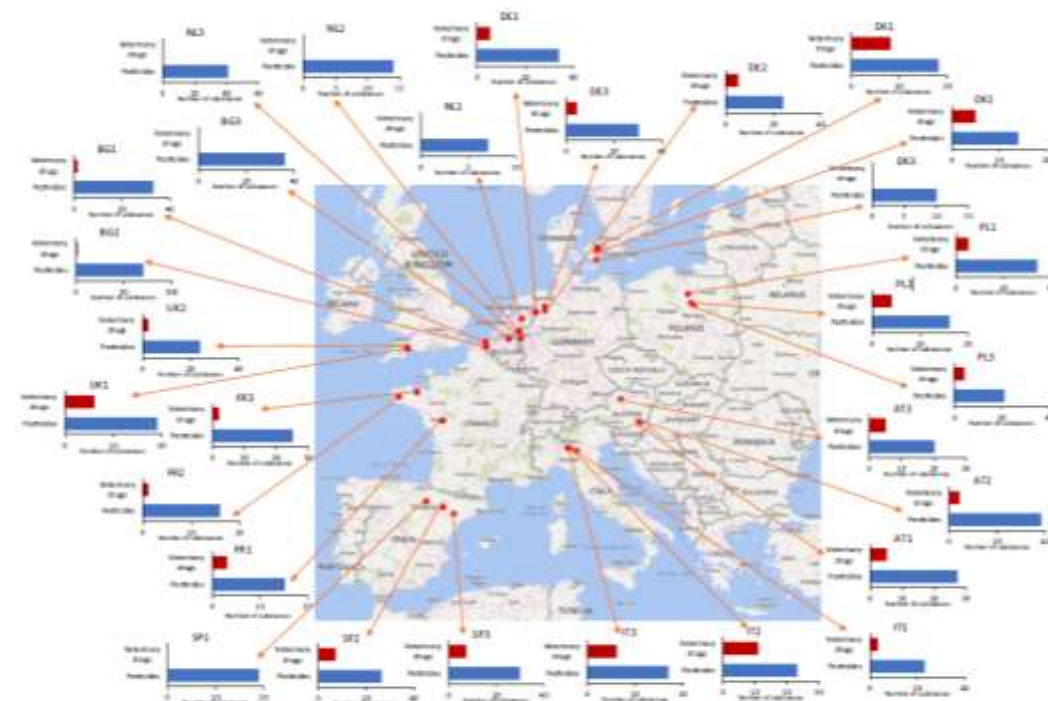


Fig. 1. Sampling locations with horizontal bar-charts showing the number of pesticides (blue) and number of veterinary drugs (red) found in each sample. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

**All the sampled streams were contaminated with pesticides and, in most of the cases, veterinary drugs.**

Casado et al. 2019 Science of the Total Environment 670: 204–1225

# Residues in nectar and pollen of...

Wildflowers...

Flowering crops...



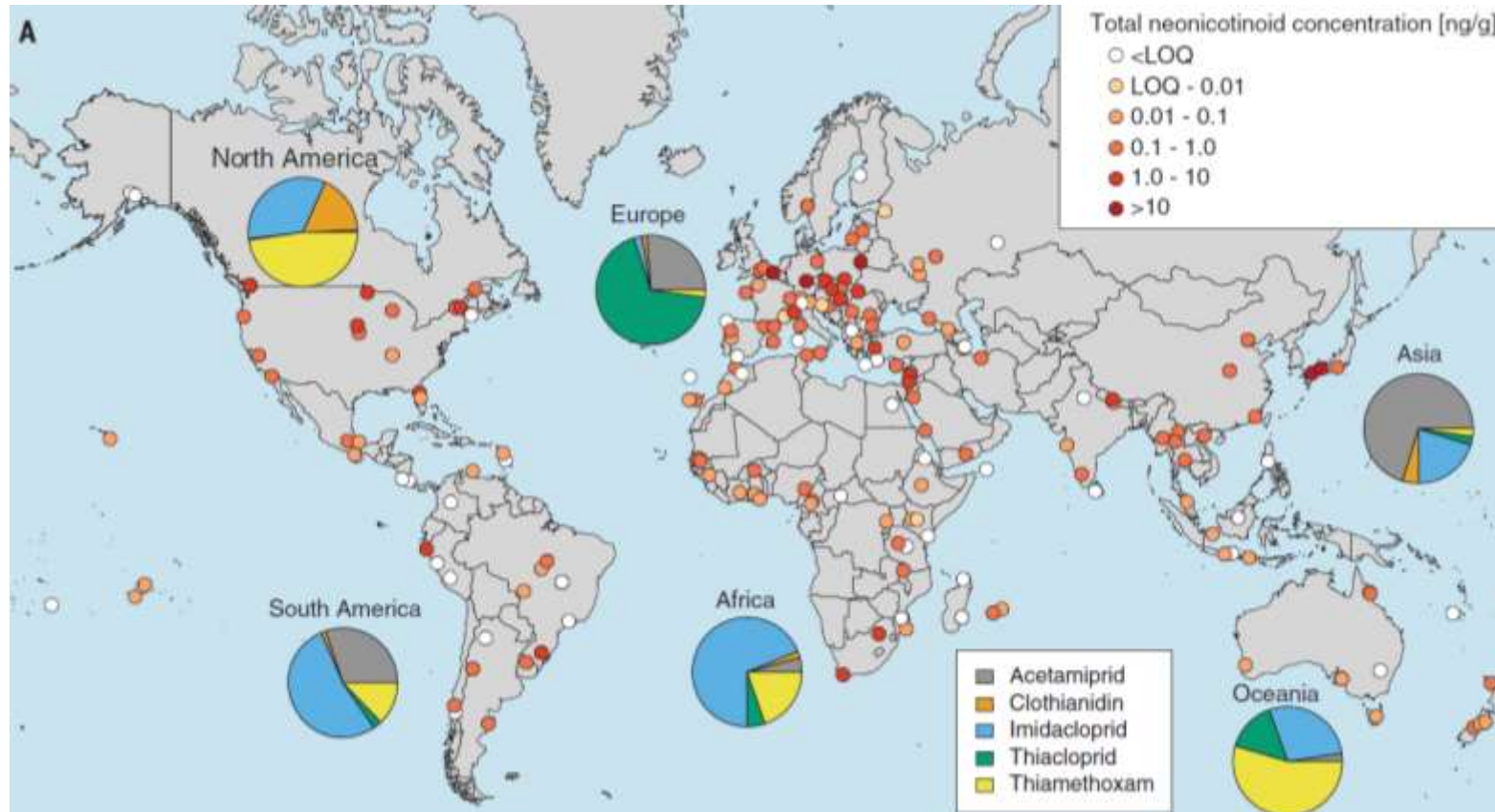
Horticultural plants...



Maize & dandelions: Krupke et al. 2012  
OSR & wildflowers: Botías et al. 2015  
Horticultural flowers: Lentola et al. 2017



# Pesticides found in honey



Pesticides in **77%** of honey samples from 30 sites in Ireland

Kavanagh et al. (in prep)

Pesticides in **75%** of honey samples

Mitchell et al. 2017 Science **358**:109-111

# What are the impacts of insecticide exposure?

Soil and aquatic invertebrate mortality



Pisa et al. (2014)



Bird decline



Hallaman et al. (2014)

Widespread threat to wildlife and ecosystems



EASAC (2015)

# Impacts of neonicotinoids on pollinators

- Lethal effects

- Honeybees  $LD_{50}$  = 4ng (Imidacloprid), 27,000ng (DDT)

- Sublethal effects



↓ colony growth and queen production (Whitehorn et al. 2012 Science)



↓ homing ability (Henry et al. 2012 Science)



↓ worker production, ↑ worker mortality, ↓ pollen collection (Gill et al. 2012 Nature)



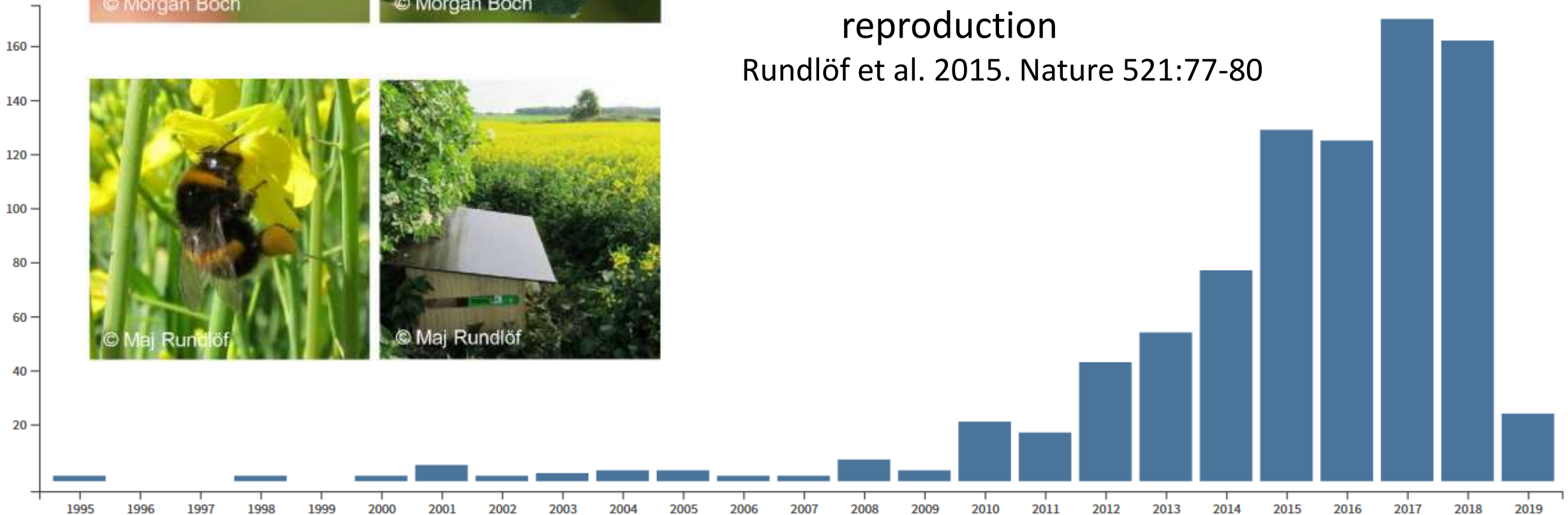
↓ fecundity (Laycock et al. 2012 Ecotoxicology)...





- Insecticide treated crops reduced
  - wild bee density
  - solitary bee nesting
  - bumblebee colony growth and reproduction

Rundlöf et al. 2015. Nature 521:77-80





# Effects of herbicides on pollinators

- Reduced food availability
- Direct toxicity low (WHO 1994)



- Affects honeybee navigation

Balbuena et al. 2015. JEB **218**:2799-2805.

- Affects honey bee gut bacteria & susceptibility to pathogens

Motta et al. (2018) PNAS **115**:10305-10310.

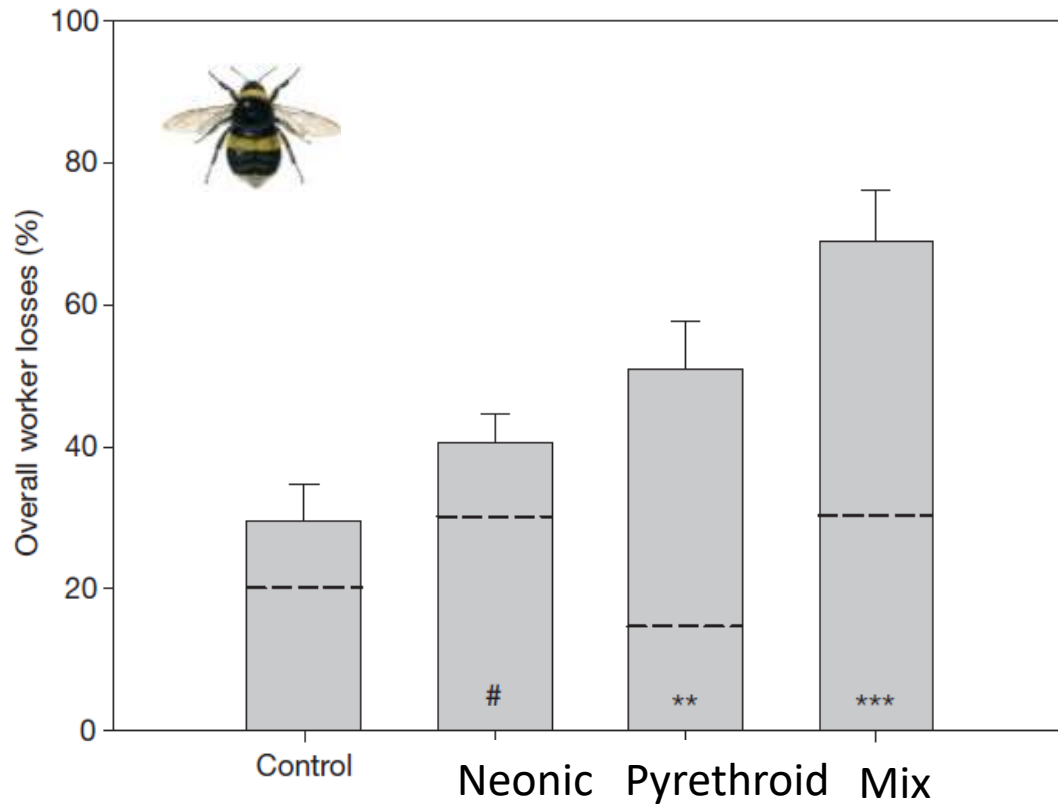
# Effects of fungicides on pollinators

- Impacts on the gut microflora Kakumanu et al. 2016. *Frontiers in Microbiology* 7.
- Sublethal impacts on respiration rates of honeybee and bumblebee mitochondria Syromyatnikov et al. 2017. *Pesticide Biochemistry and Physiology* **135**:41-46.

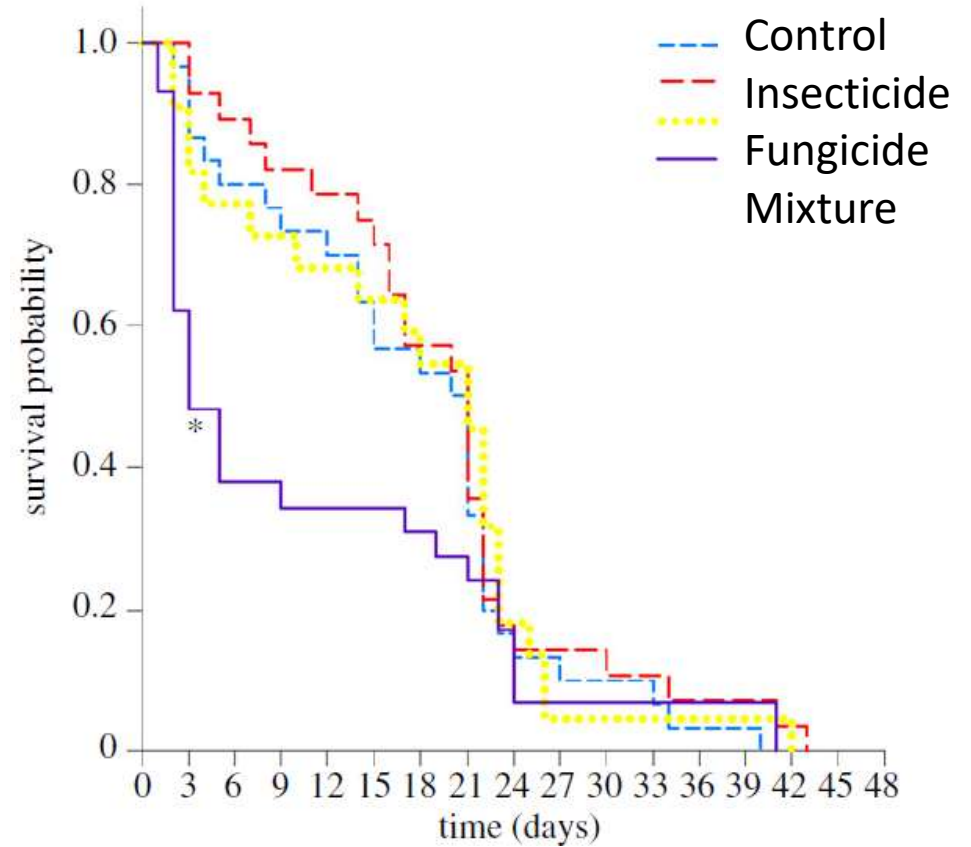


- Effects on individual behaviour and colony success...

# Synergistic effects



Gill et al. 2012 Nature **491**:105-108.



Sgolastra et al. 2018. Proc R Soc B **285**:20180887.

# What is current situation in Ireland?



- Unknowns
  - Use
  - Quantity and persistence of residues
  - Exposure
  - Impacts of herbicides and fungicides
- Solutions
  - Research!



# Creating the evidence base



Sarah Gabel  
Impacts  
pesticides on  
hoverflies



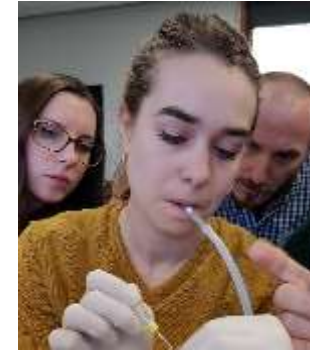
Cian White  
Urban Nature-  
based Solutions  
for bees



Steph Maher  
Habitat quality and  
pollinators on farms  
[@FarmEcos](#)



Elena Zioga  
Pesticide residues in  
nectar and pollen  
[@ProtectsProject](#)



Irene Botterro



Simon Hodge



EU H2020 Bee Health project

[@poshbee eu](#)



Coláiste na Tríonóide, Baile Átha Cliath  
Trinity College Dublin

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# PROTECTS project

- Review of usage and soil risks
- Exposure levels in nectar and pollen (Elena Zioga, TCD) and soils (Mathavan Vickneswaran)
- Impacts of herbicides and fungicides on bumblebees at:
  - Molecular level (proteomics) (Merissa Cullen, UM)
  - Colony level (Linzi Thompson, UCD)



# What can we do?

Increase awareness of  
impacts on bees and  
other wildlife



Reduce use, find  
alternatives



Change perceptions







# How do pesticides affect pollinators?

- ❖ Through widespread exposure
- ❖ Lethal and sub-lethal effects
- ❖ Reduce, rethink, replace