# Silent Earth

*Averting the Insect Apocalypse*

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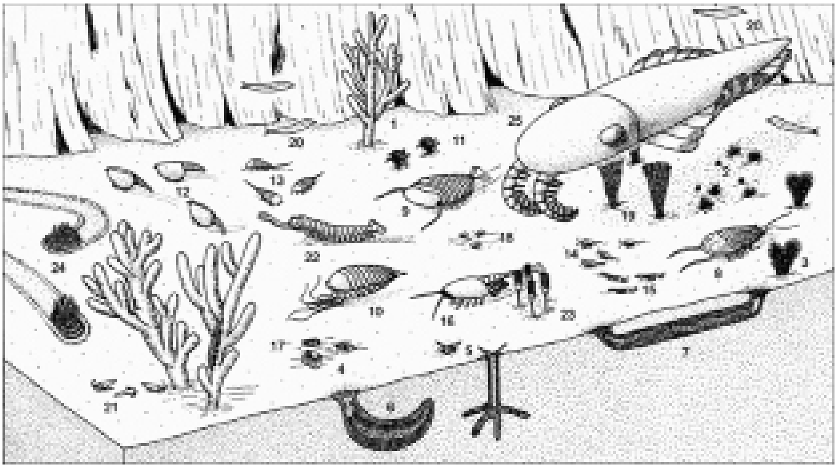
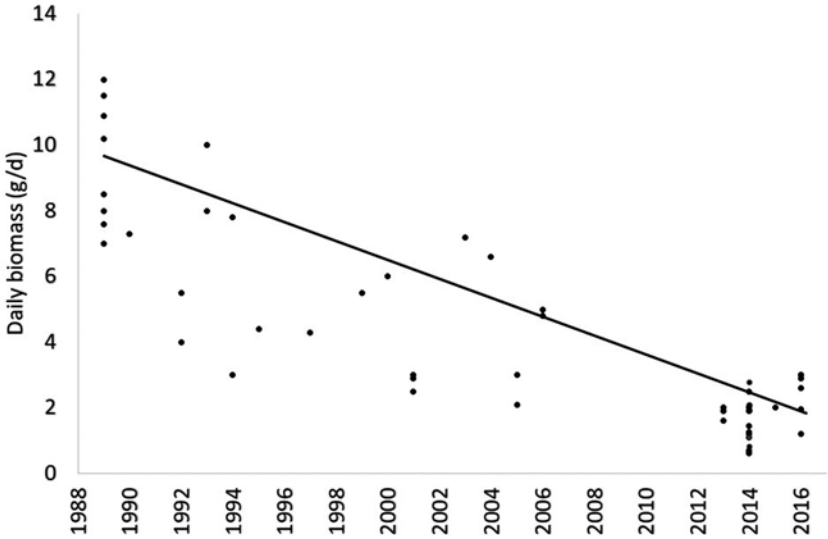
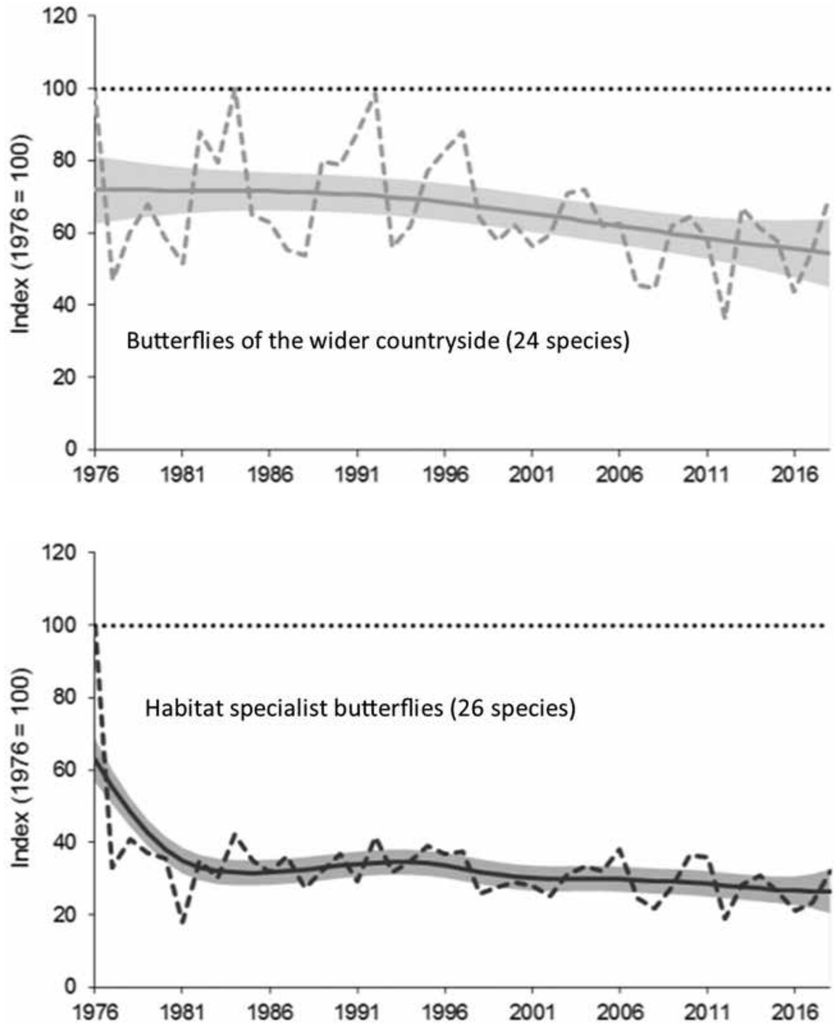


**Creatures of the Burgess Shale, animals that lived in the sea 500 million years ago:** These weird creatures include many early arthropods, ancestors of the insects: sponges *Vanuxia* (1), *Choia* (2), *Pirania* (3); brachiopods *Nisusia* (4); polychaetes *Burgessochaeta* (5); priapulid worms *Ottia* (6), *Louisella* (7); trilobites *Olenoides* (8); other arthropods *Sidneyia* (9), *Leanchoilia* (10), *Marella* (11), *Canadaspis* (12), *Molaria* (13), *Burgessia* (14), *Yohoia* (15), *Waptia* (16), *Aysheaia* (17); molluscs *Scenella* (18); echinoderms *Echmatocrinus* (19); chordates *Pikaia* (20); along with *Haplophrentis* (21), *Opabina* (22), lophophorate *Dinomischus* (23), proto-annelid *Wiwaxia* (24), and anomalocarid *Laggania cambria* (25). From Wikicommons https://commons.wikimedia.org/wiki/File:Burgess_community.gif

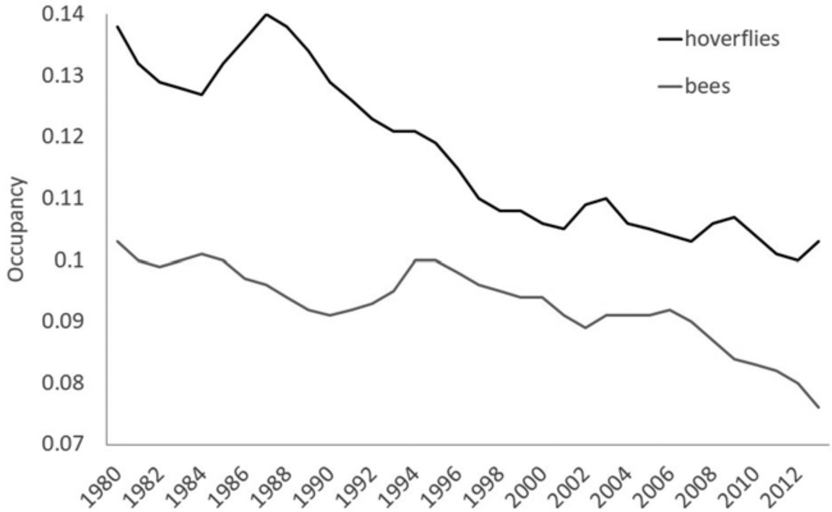

Some of the many bizarre Central American tree hoppers described and illustrated by William Weekes Fowler (1894). See Further Reading, pgs. 19-33.



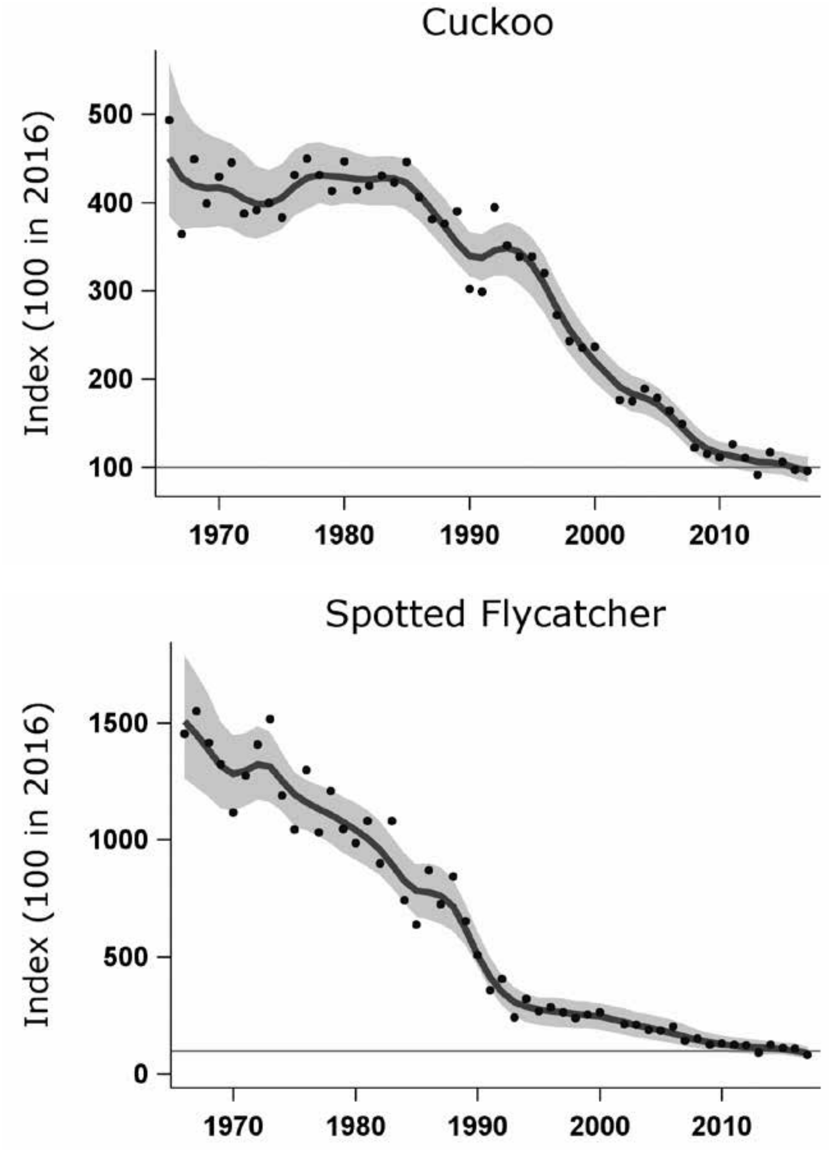

**Declines in flying insect biomass on German nature reserves, 1989–2014:** Insects were trapped using standardised Malaise traps (top right). The total weight of insects caught per trap per day declined by 76 per cent over the twenty-six years of the study. See Hallmann et al. (2017) in Further Reading, pgs. 19-33.



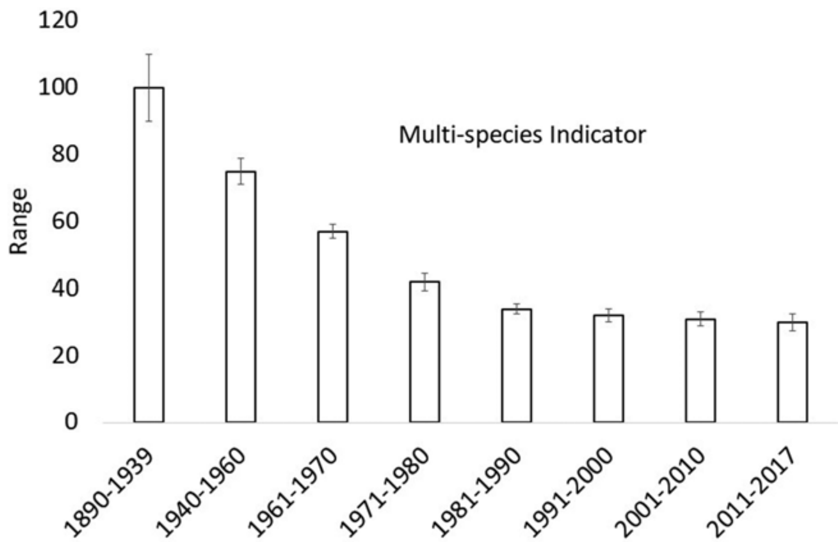

**Trends in butterfly populations in the UK, 1976 to 2017:** Numbers of butterflies recorded on transects across the UK vary from year to year, but broadly the pattern is one of decline. The upper diagram is for common, widespread species, which fell in abundance by 46 per cent; the lower diagram is for rare species, which fell by 77 per cent [Crown copyright, Department for Environment, Food and Rural Affairs, UK (2020). UK Biodiversity Indicators 2020].



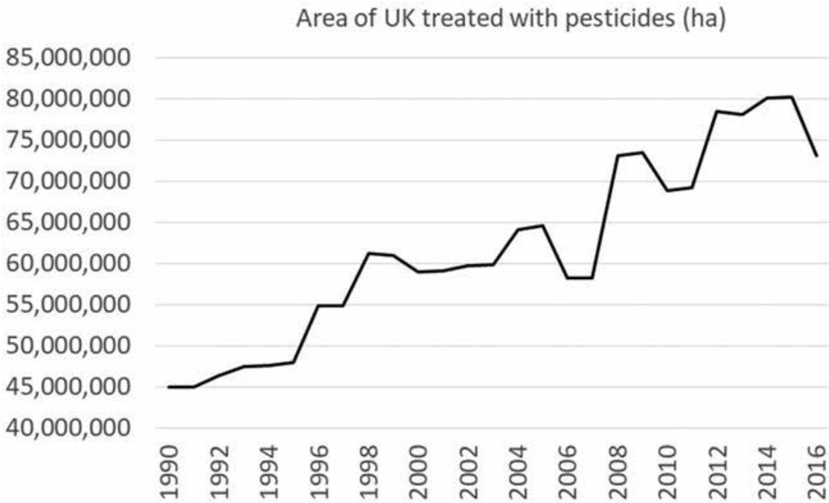

**Changes in geographic ranges of wild bees and hoverflies in the UK:** The trend lines show the average proportion of 1km grid cells occupied by each insect species in Britain. Wild bee species are shown in grey (based on 139 species) and hoverflies in black (based on 214 species). Thus, for example, in 1980, on average each hoverfly species occupied about 14 per cent of all 1km grid cells, but by 2013 it had fallen to about 11 per cent (from Powney et al., 2019).



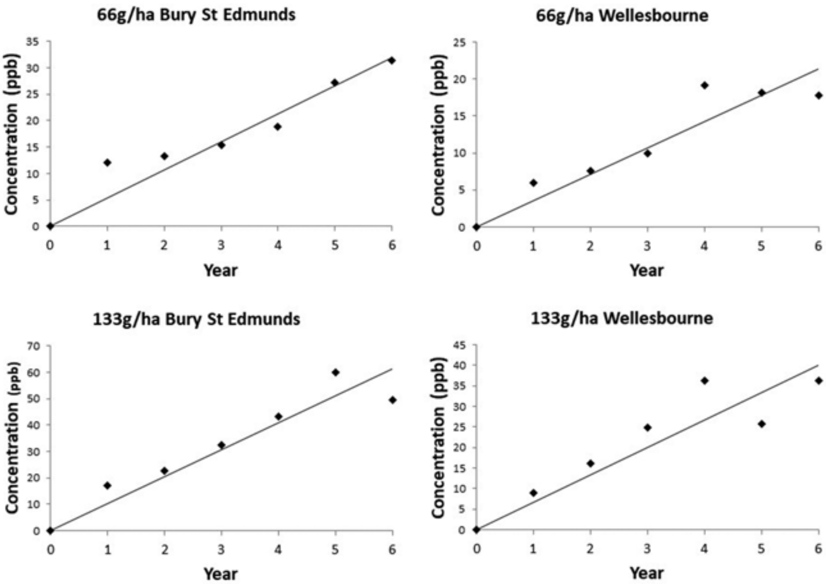

**Population change of two insectivorous birds in England:** The population index shown is scaled relative to 2012, which is set to 100. Thus one can see that the cuckoo population was just over four times larger in 1967 than in 2012 (top chart), while the spotted flycatcher population (bottom chart) was about fifteen times higher. Both species are specialists in eating insects, and both have undergone dramatic declines in England over the last fifty years. Within my memory, these have gone from being familiar, common birds to being such rarities that it is exciting to see or hear one. Reproduced from Massimino et al. (2020), with permission of British Trust for Ornithology.



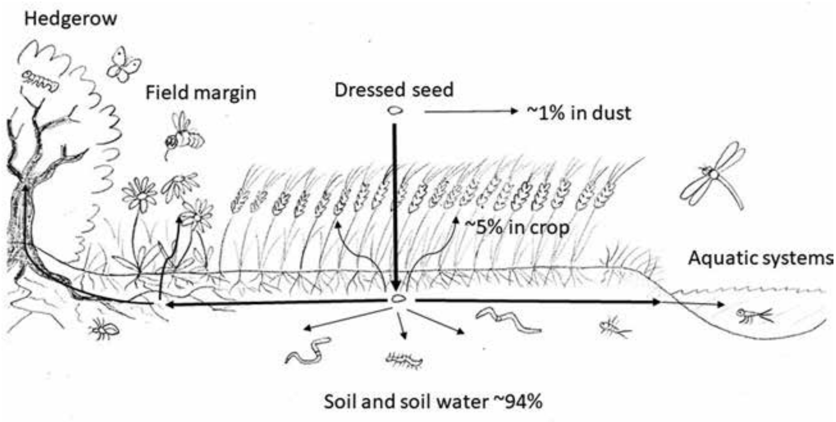

**Patterns of range change for butterflies in the Netherlands, 1890–2017:** The patterns are estimated from the locations of museum specimens, and are based on seventy-one species. The range changes are show relative to a value of 100 in the first time period. Declines appear to have been fastest in the first half of the twentieth century, before any detailed insect monitoring began (from van Strien et al., 2019).



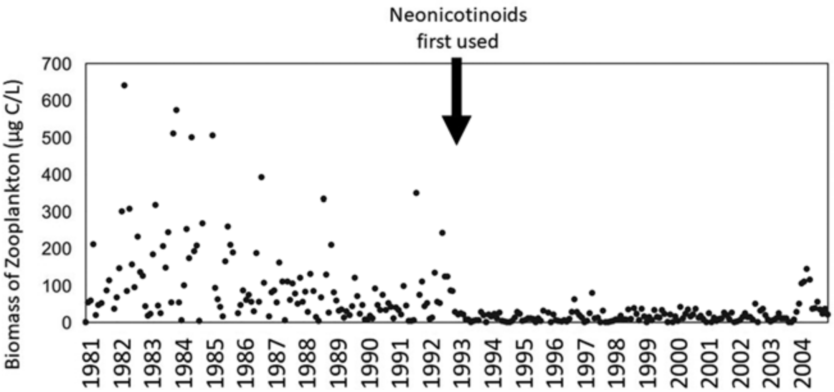

**The area of farmland treated with pesticides each year in the UK:** Every year, farmers make more pesticide applications to their crops. The chart shows the official government figures [from https://secure.fera.defra.gov.uk/pusstats/] for the total area of crops treated with pesticides each year in the UK (74 million hectares in 2016). This area increased by 70 per cent between 1990 and 2016. Given that there are only about 4.5 million hectares of arable and horticultural land in the UK, and that this area remained almost unchanged over this period, these figures mean that each field or orchard in the UK is now, on average, treated about sixteen times annually. It should be noted that this could be the same pesticide applied sixteen times, or sixteen different pesticides each applied once, or some combination of the two. These data do not include pesticides used by farmers for veterinary purposes, such as the avermectins routinely given to livestock to protect them against parasites.



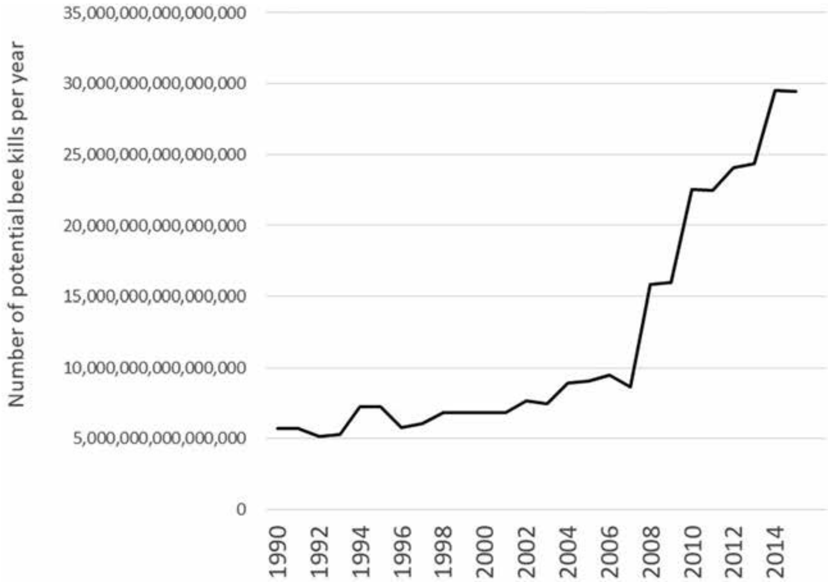

**Accumulation of a neonicotinoid insecticide in soil:** Levels of the neonicotinoid imidacloprid detected in soil into which treated winter wheat seeds were sown each autumn (1991–6). The two study sites were both in England. Treatment rates were 66g or 133g of imidacloprid/ha except in the first year, which was 56g in Bury St Edmunds, and 112g in Wellesbourne. The data are from the EU Draft Assessment Report for Imidacloprid, 2006, and show beyond any doubt that levels of the chemical build up over time. Yet, somehow, the report concludes from these data that 'the compound has no potential for accumulation in soil'.



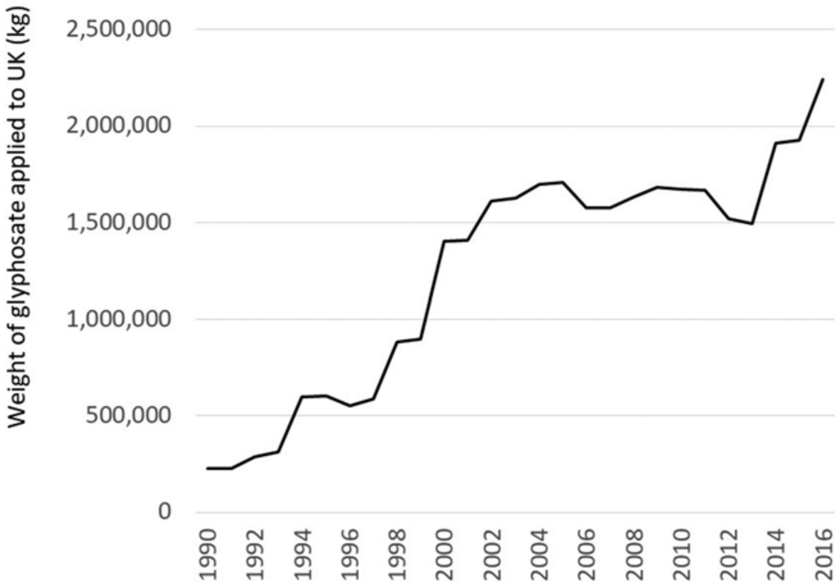

**The environmental fate of neonicotinoid insecticides used as seed coatings:** On average only about 5 per cent of the pesticide goes where it is intended to go – into the crop – a figure that was calculated by manufacturer Bayer's own scientists (see Sur and Stork, 2003, in Further Reading, pgs. 19-33). Most of it ends up in the soil and soil water, where it can build up over time if used repeatedly. From the soil the chemicals can be absorbed by the roots of wildflowers and hedgerow plants, spreading to their leaves and flowers, or they can leach into streams. There is also a fundamental problem with this mode of application, since it is necessarily prophylactic: the farmer cannot know whether the crop will be attacked by pests before he has sown it. Prophylactic use of pesticides is contrary to all the principles of 'integrated pest management' (IPM), an approach that seeks to minimise pesticide use by only applying them when absolutely necessary, and which is regarded by most agricultural scientists as the optimal strategy for pest management. Under IPM, a host of non-chemical techniques for pest management are deployed, such as encouraging natural enemies, using resistant crops, and long crop rotations. Only if these fail, and a significant pest population is detected, does the farmer resort to pesticides.




**Impact of neonicotinoid pollution on lake invertebrates:** Populations of zooplankton in Lake Shinji, Japan, fell dramatically after the introduction of neonicotinoid use on the surrounding rice paddies in 1993 (from Yamamuro et al., 2019).

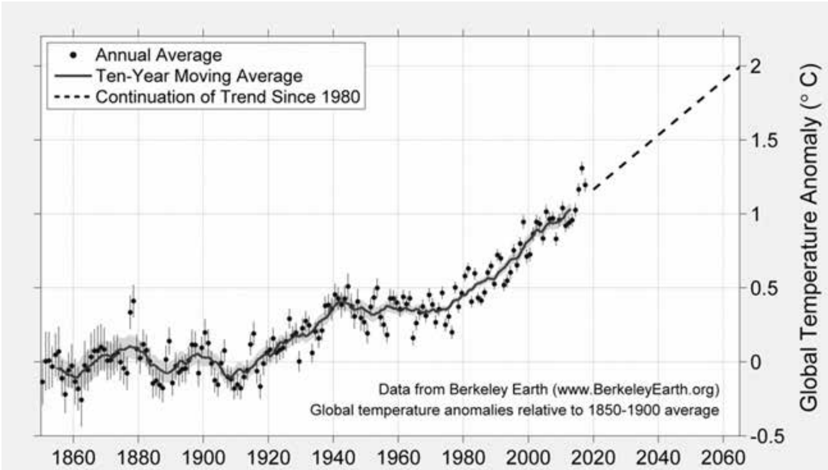



**Changing 'toxic load' over time:** The chart shows the potential number of honeybees that could be killed by the pesticides applied to UK crops each year, in the unlikely event that all of them were fed to honeybees. The number has increased six-fold since 1990, as newer, more toxic insecticides have been adopted by farmers. From https://peerj.com/articles/5255/. Note that this does not include the considerable volume of ivermectins fed to cattle, a class of pesticides that are highly toxic to insects and present in large quantities in livestock dung, contaminating soils.

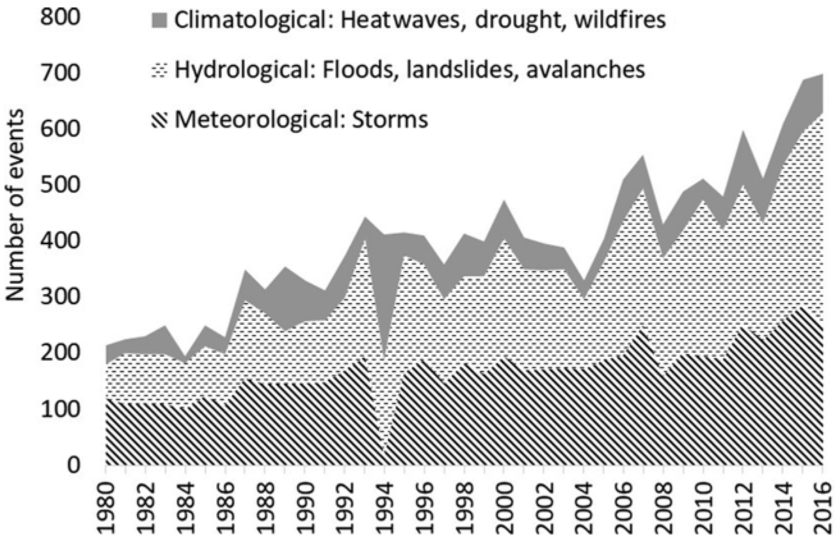



**The weight of the herbicide glyphosate used by UK farmers:** Glyphosate is most commonly sold as the formulation Roundup, and is the single most popular pesticide in the world, with use increasing year on year. The figures shown do not include domestic use, or use by local authorities. Data are from DEFRA's Pusstats website, an open-access database which reports annual use of pesticides in UK farming.

A subsistence farmer in Bengal, India, spraying herbicide using homemade equipment. Note the lack of any protective mask, gloves, or even footwear.




**Global temperatures from 1860 to the present, with projections to 2065:** At the current rate of progression, the increase in Earth's long-term average temperature will reach 1.5°C above the 1850–1900 average by 2040, and 2°C will be reached around 2065. From http://berkeleyearth.org/global-temperatures-2017/.




**The frequency of natural disasters from 1980 to 2016:** Natural disaster loss events due to floods, storms and fires have more than tripled in frequency since 1980. Data are based on insurance losses. Disasters that impact on humans will also have profound effects on insects. Data source: *Economist*.

# Further Reading

If you would like to know more about the subjects discussed in each chapter, there follows a selection of further reading. I have tried to include key scientific articles that provide the evidence underpinning our current understanding of insect declines and what we might do to reverse them. Sadly, many of these are not written for the layperson, and some of the technical jargon can be hard to follow. Nonetheless, non-specialists can usually glean the gist of an article without too much difficulty. Some of the articles are hidden behind paywalls, but if you are keen you can access most of them via the website Researchgate, which enables you to contact the authors directly and ask for copies of their work.

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