Editorial

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Silent Spring at sixty

Rachel Carson's book has had lasting impacts on the global regulation of chemicals harmful to life. Six decades since its publication, however, novel threats to wildlife and human health are still emerging.

Two years ago, a study published in *Science* on the singing behaviour of white-crowned sparrows was prefaced with the title 'Singing in a silent spring'[1]. This analysis across the San Francisco Bay Area demonstrated how reductions in road traffic noise caused by COVID-19 lockdowns were having a measurable effect on the frequency of birdsong, as sparrows adjusted to their new, quieter soundscapes.

This amplification of wild sounds previously masked by road and aircraft noise was a welcome consolation for many. But the re-purposing of Rachel Carson's 1962 book *Silent Spring* in the study's title stands in stark contrast to the image conjured in the book's opening chapter, in which Carson imagines a once-biodiverse town in the heart of the United States of America, reduced to eerie quiet by the effects of pollution.

The connection between these two works, separated by almost six decades, is a reminder that novel sources of pollution and threats to wildlife continue to emerge. Sensory pollution, for example, would perhaps not have been anticipated as a threat in Carson's lifetime, but now pervasively affects wildlife in a human-dominated world. Noise pollution and night-time light pollution, on both land and in the water, have strong negative impacts on life-history and physiological responses[2] — a theme explored in Ed Yong's recent book about animal sensory worlds, reviewed by Devi Stuart-Fox.

Carson's book focused heavily on the bioaccumulative effects in wildlife of the synthetic pesticide DDT (Dichlorodiphenyltrichloroethane), a chemical which just 14 years earlier had earned its discoverer, Swiss chemist Paul Hermann Müller, a Nobel Prize. Just a decade after the publication of *Silent Spring*, DDT was banned for agricultural use in the US, and by 2004, a worldwide ban was in place under the Stockholm Convention on Persistent Organic Pollutants — with an exemption for the control of malaria.

Despite this remarkable, rapid policy impact of *Silent Spring* on the use and regulation of chemicals in the environment, multifaceted threats to wildlife from pollutants still persist, many of which, like sensory pollution, would probably not have been foreseen in the 1960s. In recent years, focus has shifted away from the likes of broadly applied pesticide sprays such as DDT towards neonicotinoid pesticides applied as seed treatments, which were initially thought to offer a more targeted approach to pest management. Their lethal and sub-lethal effects on non-target pollinator species have been the subject of a huge amount of research over the past decade[3], and although three of the most widely used neonicotinoids have now been banned in the European Union, they continue to be used on a global scale. Where they have been subject to a ban, alternatives such as sulfoximine-based pesticides that act in a similar neurotoxic manner have replaced them, for which there is also evidence of sub-lethal impacts on pollinators[4]. It seems likely that these conflicts will continue to exist where there is an agricultural need to control organisms that affect productivity and yield, and it also highlights the challenge of targeting specific 'pest' species without also having negative impacts on the broader ecosystem. Indeed, a study published last year in *Nature Geoscience* estimates that some 64% of global agricultural land is at risk of pesticide pollution from more than one active ingredient, with 34% of high risk areas occurring in biodiversity hotspots[5].

Of all the recent emerging threats, plastic pollution might have been least anticipated by Carson. At the time of *Silent Spring*'s publication in 1962, the world was producing some 11 million tonnes of plastic annually. By 2015, this had risen to 381 million tonnes. The massive accumulation of waste on a year-by-year basis continues to negatively affect wild species, both directly through plastic ingestion[6] and more indirectly through disruption of ecosystem processes by micro- and nano-plastics[7]. It is perhaps the defining pollution issue of our time from a public and policy perspective.

Similar to the degradation of plastics, novel threats emerge when useful chemical products transform into more harmful substances in the environment — for example, recent evidence reveals how oxybenzone-based sunscreens can turn into strong photosensitizers within sea anemone cells, posing a potential threat to coral reef ecosystems[8].

We are also still in the early stages of understanding the kind of interactive effects that other stressors such as a warming climate will have on the action of pesticides on non-target organisms. For example, both may influence metabolic processes, but the magnitude and breadth of effects should be the subject of urgent research[9]. These combinations of multiple stressors, which may include land use, pollution, climate change and ocean acidification, have been implicated in the 'death by a thousand cuts'[10] that has been used to describe global declines among insect species, using language reminiscent of the evocative tone characteristic of *Silent Spring*. How context- and scale-specific these effects may be, and the degree to which they interact additively, synergistically or antagonistically, remains a major area of research, requiring innovative analysis of complex ecological data.

The 2019 IPBES Global Assessment puts pollution as the fourth biggest threat to biodiversity, and the latest draft Post-2020 Biodiversity Framework includes ambitious targets specifying a reduction in pollution from all sources to levels that are not harmful to biodiversity and ecosystem functions. Part of the solution to this may be the more extensive use of nature-based approaches such as biological control by natural enemies, which may not only be more cost effective than the use of chemicals[11], but also avoid problems associated with evolved resistance. Sixty years on from *Silent Spring*, this is an evolving, complex issue, and tackling it will require continuous input and effort across the ecological, agricultural, chemical and social sciences, as well as from the agriculture and chemical industries, policymakers and the public alike.

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References

1. Derryberry, E.P., Philips, J. N., Derryberry, G. E., Blum, M. J. & Luther, D. *Science* **370**, 575–579 (2020).
2. Sanders, D., Frago, E., Kehoe, R., Patterson, C. & Gaston, K. J. *Nat. Ecol. Evol.* **5**, 74–81 (2021).
3. Godfray, H. C. J. et al. *R. Soc. B.* **281**, 20140558 (2014).
4. Siviter, H., Brown, M. J. F. & Leadbeater, E. *Nature* **561**, 109–112 (2018).

5. Tang, F. H. M., Lenzen, M., McBratney, A. & Maggi, F. *Nat. Geosci.* **14**, 206–210 (2021).
6. Roman, L., Hardesty, B. D., Hindell, M. A. & Willcox, C. *Sci. Rep.* **9**, 3202 (2019).
7. Galloway, T., Cole, M. & Lewis, C. *Nat. Ecol. Evol.* **1**, 0116 (2017).
8. Vuckovic, D. et al. *Science* **376**, 644–648 (2022).
9. Simmons, B. I. et al. *Nat. Ecol. Evol.* **5**, 1478–1489 (2021).
10. Wagner, D. L., Grames, E. M., Forister, M. L., Berenbaum, M. R. & Stopak, D. *Proc. Natl Acad. Sci. USA* **118**, e2023989118 (2021).
11. Wyckhuys, K. A. G. et al. *Nat. Ecol. Evol.* **4**, 1522–1530 (2020).