WITNESS: A garden without sparrows – from population to ecosystem collapse, and beyond

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It is late spring 2014 and I am visiting the Natural History Museum in Milan with my class of biology and natural science students.[1] We have seen the taxidermy lab, the alcohol collection and entomology in the morning, and are now taking a lunch break before continuing with the visit in the afternoon. The museum is a beautiful 19th century building in a corner of the Giardini Montanelli, one of the few historic public gardens in the centre of the city. It is sunny and nice to be in the park, a quiet green oasis (Fig. 1) in one of the largest, as well as most polluted cities in western Europe. As we sit outdoors at the tables of the Bar Bianco, in the central area of the park, sparrows land between our feet, pick up bread crumbs and rush away to have their little lunch sitting on a tree branch or hidden among the bushes. Quite few of them are bold and land directly on the table – they look carefully at the customers, make a few little jumps towards a dish with a sandwich or a croissant, steal a large crumb and fly away. Pigeons are there too, but they are not so daring and keep their distance until a customer leaves and they can peacefully search for tiny leftovers.

Sparrows and pigeons have been a constant presence in Milan since I was a child. They were in every park, a common sight on roofs and a frequent visitor on window sills, with sparrows announcing their arrival with loud chirps. I enjoyed their company and sometimes fed them (despite the complaints of the neighbours!). I took it for granted that they would be there forever. But I never paid much attention to their role, as little fellow citizens, who brought a bit of wildlife to the concrete jungle of the city.

One year has passed and, in May 2015, we are back at the museum: a different class of students, and the same but always exciting visit to the hidden wonders of the Natural History Museum. Again, we take a break in the park and sit outdoors at the same bar for a quick meal. There are a few pigeons, but no

Figure 1. Giardini Montanelli: views of the lake and some of the gardens feathered and 'non-feathered' wildlife (photos thanks to and courtesy of Giorgio Bardelli https://www.giorgiobardelli.org/). Clockwise from bottom right: common moorhen; grey heron; tongue mushroom on a European oak; crocodile gecko; fairy inkcap; common blackbird; European mantis; sulphur polypore on the deceased ancient red oak of the poet Montale (http://www.paolapastacaldi.it/quercia-montale.php).

sparrows. There are none. They are gone. They are gone in the Giardini Montanelli; they are gone in all other parks in the city; there are none on the roofs of the buildings. Even out of town, they are a rare sight. Today, I hardly see a sparrow in Milan and have not seen one in the city centre since that May, eight years ago.

Between the last decade of the 20th century and the beginning of this millennium, asynchronous collapses of urban populations of house sparrows (in Italy, to be more precise, of the Italian sparrow, a hybrid between Spanish and house sparrows; see Figure 2) have occurred in most European cities (Summers-Smith, 2003; Anderson, 2006; Brichetti *et al.*, 2008). Indeed, this is not just a European phenomenon. Once one of the most common city birds across most of the northern hemisphere, the house sparrow still numbers in the hundreds of millions worldwide, but has been decreasing in abundance almost everywhere. In North America, where they were introduced in the mid-19th century, sparrows are rapidly declining in urbanized areas, although still holding ground in rural areas (Berigan *et al.*, 2020); house sparrows are becoming rare in Moscow and, probably, other Russian cities (Morozov, 2022); in India, populations are decreasing in size and, there too, it happens faster in large conurbations compared to the countryside (Sharma and Binner, 2020).

The decline of sparrow populations in cities seems to begin very slowly and mostly goes unnoticed. Only where systematically monitored does the slow downward trend become visible (Summers-Smith, 2003). But after a few years of slow decline, urban populations rapidly collapse, without later signs of recovery. What are the causes? There is a variety of explanations (Anderson, 2006): a lack of nesting opportunities in modern buildings and less food availability in progressively cleaner cities; the starvation or suboptimal fitness of nestlings, inadequately fed by parents unable to find enough insects, whose diversity and abundance is also in decline (Sánchez-Bayo and Wyckhuys, 2019; Wagner *et al.*, 2021); a reduced survival rate due to sub-lethal doses of heavy

Figure 2. Female (left) and male (right) Italian sparrow (photo by Claudio Gennari; https://creativecommons.org/licenses/by/2.0/).

metals, herbicides and pesticides; the top-down predatory pressure of larger urban populations of sparrowhawks, other raptors and feral cats; a new undetected disease or simply the increasing burden of parasites and pathogens in an unbalanced, warmer ecosystem; the impact of traffic, noise, light pollution and potentially even of electromagnetic radiation from an endlessly expanding telecommunication network. Of all these potential explanations, however, none strongly indicates a clear process behind the common pattern. As with 'colony collapse disorder', that wiped out thousands of honeybee colonies across the world, several factors might play a role and interact in a complex synergy that, so far, we fail to understand.

The crash of the urban sparrow populations follows a non-linear dynamic, as Summers-Smith (2003) suggested 20 years ago. This can be seen in Figure 3, where from (roughly) 1940 to 1990 there is a gradual decline, which then suddenly turns into a dramatic crash. Predicting change in such non-linear systems is hard. A non-linear collapse in populations under environmental stress is, however, far from rare (Cerini *et al.*, 2023). Ecosystems too can have non-linearities and switch from one state to another in an ecological blink of an eye.

This is what happened in the sea otter–urchin–kelp system of the American Pacific north-west, a story beautifully told by James Estes in his autobiography *Serendipity* (Estes, 2020). Between the middle of the 18th century and the first decade of the 20th, no less than 500,000 but possibly almost one million sea

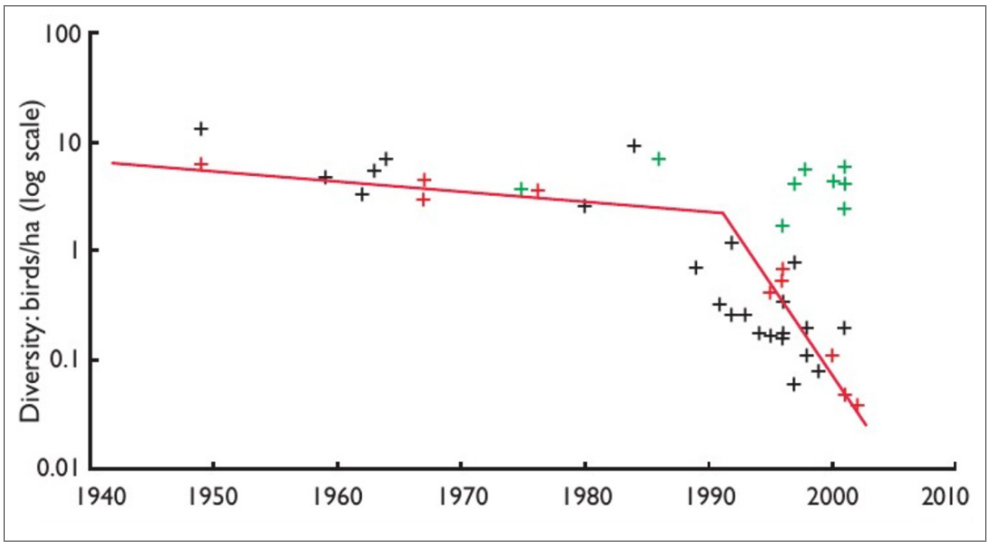

Figure 3. Number of house sparrows per ha in urban areas during the breeding season from the late forties to the early 2000 (reprinted with permission from Summers-Smith, 2003). Red crosses are Kensington Gardens; black ones are city-centres of several large towns in the UK, as well as Dublin and Hamburg; green are small rural towns. Note that the vertical axis is on a log-scale, which means a ten-fold change per unit. The rural populations, in green, hardly changed over time, whereas the urban sparrows first slowly declined (red line until 1990) and, then, suddenly crashed in just a decade (steep red line, from 1990 onward).

otters were killed in North America for the fur trade (Loshbaugh, 2021). When, in the early 1970s, Estes started his research program in Alaska, the almost extinct population of sea otter was slowly recovering. By comparing islands with and without sea otters, Estes and his collaborators showed that in the Aleutian Archipelago a healthy population of otters is key to preserving biodiversity-rich and productive kelp forests. Where the forest is healthy, fish are abundant and diverse, there are large populations of filter-feeding mussels and marine snails, bald eagles have a wider variety of prey and large amounts of CO2 are trapped in the tissues of the giant seaweeds (Estes, 2020). With few or no sea otters, however, the coastal habitat becomes barren. Estes called it a "sea urchin barren" because it is the demographic explosion of sea urchins, feeding on kelp, that destroys the marine forest. This happens when the size of the population of sea urchins is not kept in check by sea otters, whose predation on urchins has a top-down regulatory effect on the entire ecosystem. The story is, of course, more complex than my simplified account: more 'actors' are involved and there is regional variation in the system. Even today, researchers keep adding new pieces to this ecological puzzle (Tinker *et al.*, 2021).

In the context of this short paper, however, what matters most is the dynamic of change in the sea otter–urchin–kelp system: slow and gradual, if not imperceptible, at the beginning, but fast to move from kelp forest to urchin-barren, or *vice versa*, after a threshold in the size of the population of the predator is passed. In the Aleutian Islands a sea urchin-barren becomes a kelp forest when the density of sea otters is, on average, twelve individuals per km surveyed. In the reversed change, a kelp forest becomes a sea urchin barren when there are approximately less than six otters per km (Estes, 2020). In both directions the transition is swift. The ecosystem is resilient and resists change, but only up to a certain point. Then, it collapses and becomes something radically different. Thresholds for change are difficult to estimate and predict and, as in the otter–urchin–kelp system, they can be asymmetric. That is, the otter density for the trophic upgrade, from the simpler, species-poor and less productive, sea urchin barren to the richer state of the kelp forest, is not the same as for the trophic downgrade from forest to barren. Non-linearity, resilience and asymmetry are all indications of the complexity of demographic and ecological changes: hard to notice initially and often difficult to reverse, but unstoppable and fast once a threshold is reached.

In the case of sparrows, Milan has lost a population of a bird that has lived with its citizens for centuries. It may or may not come back. We do not know. With sea otters, the 1911 North Pacific Fur Seal Treaty, granting their protection, was signed just in time to save the species from complete extermination (Ravalli, 2009). Yet their future still looks uncertain. Today, despite being protected for more than a century, their populations have not recovered (Estes, 2020; Loshbaugh, 2021). The consequences of 170 years of overhunting may be written in the DNA of this species, as the title of a recent publication suggests: "Genomic analyses reveal range-wide devastation of sea otter populations" (Beichman *et al.*, 2023). Genetic diversity is extremely low in

the entire series of samples researchers have taken along the Pacific coast of North America – from the Kuril, Commander and Aleutian Islands to California. Fewer genetic differences imply a higher risk of genetic disease and a reduced potential for adapting to a rapidly changing environment. With the increasing impact of capitalist-driven consumerism and a huge but still growing human population, a bright future seems unlikely for the coastal ecosystems of the north west Pacific, as for most other terrestrial and marine ecosystems. In the last decade, sea otters have begun declining again in southwestern Alaska (Estes, 2020; Tinker *et al.*, 2021). As with urban house sparrows, despite various hypotheses (Estes, 2020; Tinker *et al.*, 2021), we do not yet know why.

Populations and ecosystems collapse with non-linear dynamics. We have measured the patterns and studied the mechanisms. We have learned a lot and, yet, are far from a clear understanding of even the most evident and best researched examples. The planet too might be following a non-linear path. We see changes, but they look small and unconcerning. Even when change is large, we often miss it on our myopic anthropocentric scale: the children born in Milan in the last decade have never seen a sparrow; nobody alive today has known what the north American coast of the Pacific looked like, before the Steller's sea cow disappeared and otters were almost exterminated. The extinction of species, ecosystems and habitats is followed by the extinction of experience. If there are planetary boundaries and potential tipping points that we should not pass, as with urban sparrows and kelp forests, we might become aware of their reality only when a large part of the system collapses and switches to a different state. Going back to the original condition cannot be fast and may not even be possible. Signs that the planet is sick are everywhere: we might have already wiped out tens of thousands of species and hundreds of thousands are in decline as ecosystems become impoverished, habitats destroyed, life overharvested and pollution persists and increases.

The questions in the conclusions of De Laet and Summers-Smith's (2007) review on the decline of the urban house sparrow are, after 15 years, still without an answer:

> *Birds are recognised as indicators of the 'quality of life'. What does a 95% decline of house sparrows tells us about the quality of life in our urban centres? We need to know.*
>
> *Is the house sparrow the present day equivalent of the 'miner's canary'? Is it telling us that something nasty is going on in our towns that might even affect us? This requires investigation.* (De Laet and Summers-Smith, 2007: S2780)

Some representatives of the avifauna have, in fact, become more common, and, among them, for instance, in Milan, as well as the rest of northern Italy, are the wood pigeon, Eurasian magpie, common kestrel and green woodpecker. Overall, however, the populations of many species of birds are shrinking, and, in North America alone, it has been estimated that 3 billions birds, which is

30% of the total, have vanished from the continent since the 1970s (International Union for Conservation of Nature, 2022). The same might be true for Europe, where the biomass of breeding birds has fallen by almost 20% since 1980. As this follows a general trend for most groups of organisms, it might not seem a surprise. However, it was unexpected that, among the birds in stronger decline, some are the most common species, like the house sparrow. Worryingly, these species are often the human commensals, which we thought were the most resilient to anthropogenic pressures.

As has been argued by the proponents of the World Sparrow Day (https://www.worldsparrowday.org/world-sparrow-day.html), species like sparrows might be an ambassador of environmental deterioration. Improving the conditions of the urban habitats for wildlife might aid the conservation of the house sparrow and the Italian sparrow, and contribute to protecting humans as well as many of their 'more-than human' cohabitants, in and around cities. As we focus on ourselves only, and our needs seem to require endless economic growth even in the wealthiest countries, we deny biophysical boundaries, oversell technological solutions, greenwash the environmental crisis with contradictory 'sustainable' goals, draw a deep divide between us and the rest of the living world – all while overlooking progress traps and ecological interconnections. In sum, we are sawing through the branch of the tree on which we sit.

The little, and apparently irrelevant, sparrow can teach us something. Seen as a pest by farmers, they might occasionally be disastrous for individual farmers, even if, on average, the loss of crop is around five per cent of the total yield (Anderson, 2006). Yet sparrows have been the target of eradication campaigns in Europe, America and Asia (Dunn, 2012). The most famous campaign was in China, at the time of Mao Zedong's Great Leap Forward. Sparrows (mainly tree sparrows, a species congeneric to the house sparrow) were one of the 'four pests' the communist leaders aimed to get rid of. The eradication campaign in 1958 was vast and effective (Chen and Wang, 2021). If there was any positive effect on crop yields, however, success was ephemeral. Crop production declined sharply soon after, leading to the greatest human famine on record. A variety of factors contributed to the famine and likely interacted in causing the precipitous drop in agricultural production. Contrary to the ecologically ill-informed and narrowly anthropocentric predictions of the political leadership, however, the extermination of sparrows might have been a significant contributor to the loss of crop yield (Chen and Wang, 2021). Adult sparrows raid cultivated field for grain and other seeds, but the negative effect may be more than counterbalanced by their predation on aphids, caterpillars, beetles, flies, grasshoppers and crickets, which are the main food for their chicks (Chen and Wang, 2021; Anderson, 2006). Unsurprisingly then, the years of the great famine saw an explosion in the population of insect 'pests' (Chen and Wang, 2021; Harrell, 2021). Administrative documents show a multi-fold, but largely ineffective increase in pesticide use between 1958 and 1961, with sharper increases in the regions that reported the largest number of sparrow killings (Chen and Wang, 2021). The government itself realized the

mistake and in 1960 reversed the policy of eradication, replacing sparrows with bed-bugs in their list of zoological 'enemies of the state'. Myopic technological solutions were oblivious to complexity, and the feedbacks and interactions within and among ecosystems. Unbalanced ecological networks lose resilience and removing predators can have cascading effects. Short-term predictions and the wide-scale application of simple, but apparently effective, one-measure-fits-all 'panacea solutions' lead to failure. The number of deaths in the Great Famine in China is uncertain, but is estimated at between 15 and more than 30 million in little more than two years (Chen and Wang, 2021). If the loss of ten per cent of the total grain output related to the killing of an estimated two billion sparrows in 1958 is an accurate estimate, most of the deaths could have been avoided by preserving the tree sparrow and its subtle but crucial function in the ecosystem.

Note

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