‘We know that **insect species** are being lost **across the planet…** but no one is really looking.’

Insects are by far the most populous species on Earth, and they seem to be disappearing. So why aren’t more people concerned?

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"If all mankind were to disappear, the world would regenerate back to the rich state of equilibrium that existed ten thousand years ago. If insects were to vanish, the environment would collapse into chaos."

So said eminent biologist, philosopher and author E.O. Wilson, not coincidentally an entomologist who specializes in ants. Also not coincidentally, the aphorism recently resurfaced in a 2014 book by fellow biologist and author Dave Goulson, the world's foremost expert on the behaviour, ecology and conservation of bumblebees. In *A Buzz in the Meadow*, Goulson's compelling ode to the importance of insects, Wilson's quote is a springboard both to declare that insects are vanishing worldwide, and to question our lack of concern. Goulson contrasts the ramifications of no insects — potential global cataclysm — with something of far less consequence on which we expend much conservation capital: the ever-lovable panda, whose disappearance, while symbolic, might mean only "a tiny bit more bamboo in a forest in China."

His point: pandas are big and cute, qualities that speak to our charitable instincts. Most insects — animals we barely notice or, if we do, classify together under the singular banner of "bugs" — are not. Surmounting our attitude to insects would be the first step to taking declines seriously. The bigger problem, however, is figuring out whether they're threatened as a group at all.

FORTUNATELY OR NOT, the insect world has its own pandas, and these have our attention. Accelerating declines in wild pollinators, such as butterflies and bumblebees, and annual local losses of up to 80 per cent of hives of the yeoman European honeybee (employed in agriculture around the globe) have been news for a decade.

With pollinators required for reproduction in almost 90 per cent of flowering plants and three-quarters of crop species, worldwide declines raise the spectre of global food shortages. Beyond those concerns, fruits and seeds derived from insect pollination are major parts of the diets for a quarter of all birds and mammals.

But while pollinators' important ecological roles were once familiar to most, times have changed: a recent study by Disney's *The Hive* (a British animated children's television series) and the charity Adopt-a-Hive found one in five British children under age 10 had never seen a bee in the wild; worse, nearly half of their parents didn't know that bees help pollinate crops. No surprise then that bee declines have sparked an industry of public-awareness initiatives and global citizen-science partnerships such as Bumble Bee Watch. Goulson himself founded the Bumblebee Conservation Trust in 2006, a charity devoted to reversing bumblebee declines.

"People can tell a robin from a chickadee and numerous other birds, but when it comes to bees, they might only recognize the [European] honeybee and none of the 20,000 other species globally," says Elizabeth Elle, professor and chair of the department of biological Sciences at Simon Fraser University in Vancouver.

Elle's research on wild pollinators encompasses their roles in threatened natural ecosystems of British Columbia, as well as agricultural areas of the Lower Mainland. An important finding has been that farming benefits when there are natural landscapes nearby because wild pollinators visit as well. This, however, also makes the pollinators more vulnerable to the negative effects of certain agricultural practices. Bees supply their nests with pollen, so they visit flowers more often than most of the wasps, beetles, flies, hummingbirds and untold other species that do so simply for food. As a result, bees are increasingly susceptible to the cumulative effects of anything nasty that might be in that pollen.

"Our problems with honeybees have to do with how we raise and move them around, the pesticides we use, the diseases they carry and what happens when we try to treat those," notes Elle. "And yet wild pollinators are also in decline for reasons that are far less clear — though possibly related." About 20 years ago, the western bumblebee was considered the second most common bee in Lower Mainland blueberry fields. Ten years later it was uncommon. "In the five years I've been studying those areas," says Elle, "we didn't see it for the first four, then this year saw one bee."

THIS SAME STORY — insert different crop or different bee — could be excavated anywhere you cared to dig. It was made crystal clear in a 2011 study by American researchers who compared current and historical abundance and distribution in wild North American bumblebees. The study showed that four species had declined by up to 96 per cent, with geographic ranges contracting up to 87 per cent. More notably, declining populations exhibited less genetic diversity and significantly higher pathogen loads than non-declining populations, to the extent the authors felt such metrics were "realistic predictors of these alarming patterns of decline in North America, although cause and effect remain uncertain."

Determining the cause-and-effect relationship sparked a ton of ongoing research that identifies few direct linkages. While reasons for wild bee declines remain enigmatic, the precipitous downturn in monarch butterflies is sadly understood. As recently as the 1990s, a billion of the iconic orange-black "king of butterflies" migrated south each fall from central and eastern North America to overwinter in less than one hectare of fir forest in south-central Mexico. By 2014, only 56.5 million remained, a decline of more than 80 per cent from the 21-year average. Though the slide was quickly linked to agricultural practices that have decimated milkweed — the plant on which monarch eggs hatch and spend the larval stage before they pupate and metamorphose into adult butterflies — factors such as climate change, degradation of overwintering sites, pesticides, disease, predators and parasites have all exerted pressure on the species. With most of these issues ongoing, the milkweed deficit appears to have been a tipping point.

Wild pollinators are important not only to our crops, but to natural ecosystems as well; when pollination breaks down out there, less food for everything from bears to birds can lead to cascading changes in population balances everywhere in the food chain. Anything that visits a flower is a potential pollinator that contributes to ecosystem health — even mosquitoes. "The importance of these hidden species is overlooked in the greater story, yet they're so fundamental to ecosystems," says Elle.

Her work largely makes clear how widespread habitat loss and modification affects wild pollinators. It follows that those impacts would also affect other insects. But casting around for any information on population changes in insects beyond that available for pollinators or much-studied forest pests, such as the gypsy moth and the pine beetle, leads only to anecdote and conjecture.

"As a conservation biologist, I can tell you we know that insect species are being lost across the planet," says Elle. "Are we seeing the same thing for insects as in other groups with regard to biodiversity loss and the sixth great extinction? Yes. Are we recognizing insects as in particularly steep decline? No ... but no one is really looking."

If no one is looking at insects in general (a difficult enterprise in any event), how to judge broader patterns? Perhaps through something that depends on them — like birds.

"WE HAVE ONLY HALF the birds now that we did back in the 1960s," says migratory bird researcher Bridget Stutchbury in "SongbirdSOS," a CBC *Nature of Things* episode that first aired in March 2015. While the investigations into the loss of bird species span everything from habitat loss to light pollution, pet cats and collisions with buildings, severe, long-term declines in insectivorous birds stand out as a possible indication of a decline in their insect food sources. Such a broad-based factor is suggested in the nose-diving populations of 22 of 26 aerial insectivores that breed in Canada — including swifts, flycatchers, nightjars, swallows and whip-poor-wills.

"There's widespread concern that the decline of aerial insectivores is due to a shortage of insects," Stutchbury says from her York University office, "but there's little direct evidence of cause-and-effect because, unlike birds, for insects we do not have long-term studies looking at population numbers."

We do, however, have the University of Saskatchewan's Christy Morrissey, also profiled in the documentary, who suspects that the presence of widely used neonicotinoid insecticides in Prairie ponds and wetlands, which host the aquatic stages of many insects important to birds, is affecting the food supply of insectivores such as the tree swallow.

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On Canada's Prairies, some 8.5 million hectares of canola are grown every year from neonic-treated seed. These powerful neurotoxins are systemic, meaning they're taken up by all tissues of the plant as it grows, eliminating the need for continual spraying — a boon to farmers. Being water soluble, however, the compounds move easily into wetlands where they linger in sediments and can affect non-pest insects. Morrissey has found neonics present in wetlands in spring — prior to seeding. "If the wetlands aren't healthy, they're not producing insects. If we don't have insects, then we actually don't have birds. It's as simple as that," she says. "If we disrupt that pattern, we basically are disrupting the whole ecosystem — not just what's in the pond but everything around it."

Morrissey worries about further population declines if we continue "changing the environment faster than birds can cope with it." And nothing is proving harder to cope with than climate change, a de facto tipping point for many at-risk animals. In this widely acknowledged view, insectivore declines may be unrelated to insect populations per se, and instead be affected by the interaction of birds' inherited migration phenologies (the timing of departure from one place and arrival at another) and changing insect phenologies (the timing of various larval stages and emergence of flying adults). "It's obvious insect phenologies are changing — and you don't have to look at data," says Dick Cannings, former senior project manager for Bird Studies Canada, the group largely responsible for tracking insectivore declines. "I talked to a cherry grower who'd gotten whacked by a fruit fly this year. He'd sprayed at the usual time, but the flies were out two weeks earlier, and just hammered his crops."

THOUGH UNRAVELLING the causes of insectivore declines now occupies a legion of biologists and toxicologists, some direction has come from an unexpected place — the massive chimney of Fleming Hall at Queen's University in Kingston, Ont. Built between 1902 and 1904 to vent a campus heating plant, the chimney once attracted great numbers of swifts, enough to conduct banding studies between the 1920s and 1950s on a flock that reached 4,000 strong.

Researchers turned their attention back to the structure in 2009, searching for bands from birds that might have died in the chimney. Instead they found a two-metre-deep column of organic matter made almost entirely of the hard parts of insects coughed up by swifts over a 60-year period ending in 1993 (when the chimney was covered). Core samples from the deposit showed a well-documented population crash of swifts in the mid-1960s was accompanied by a dramatic dietary shift from insects of the order Hemiptera (aphids, leafhoppers, etc.) to less-nutritious Diptera (flies, mosquitoes, etc.) and a plunge in nitrogen levels, changes that affect both individual survival and reproduction. Though the exact reasons for this await further analysis (widespread use of DDT and other contaminants at the time is the leading contender), Fleming Hall's chimney provides the first historical evidence of what may be broadly affecting these bird species today — that is, you kill off bugs and beetles, you kill off the birds that eat them.

"Things had been going downhill since the '60s, but insectivore declines really kicked off in the 1980s," says Cannings, whose organization collects such information through its annual breeding bird surveys. In July 2015,

scientists from the Canadian Wildlife Service and Environment Canada published a landmark study not only confirming this but demonstrating that the timing of significant changes in population trends of North American aerial insectivores were synchronized across all species and regions. It's both bombshell and *cri de coeur*. As the paper concludes, these similar negative population trends across the continent are likely evidence of a response to a common environmental factor with similar effects on many species, and the timing and geographic patterns identified form a basis for research into that cause.

While sudden and dramatic change in insect-dependent animal populations offers a research roadmap into some declines, cases of slow, steady attrition present a more devilish problem.

WALK THE SHOULDER of any Canadian highway in summer and you'll likely notice an unusual number of ants underfoot. While these warm, exposed areas have the kind of easily excavated substrate conducive to colony building, there's a more compelling reason for their abundance: roadsides offer a 24-7, all-you-can-eat buffet for ants. So concluded Walter Pickles in the *Journal of Animal Ecology* back in 1942, the first empirical reference to insect mortality via motor vehicles. The surprisingly few published studies since then support his observation, including one by a team from Sudbury's Laurentian University led by James Baxter-Gilbert. Although he was investigating road mortality in reptiles on sections of Ontario's Highway 400 that traverse the amphibious landscapes east of Georgian Bay, his study was an opportunity to look at the effects of roads on other organisms — including insects.

Over the course of two summers, Baxter-Gilbert and co-workers collected more than 117,000 road-killed insects during daily surveys of a two-kilometre stretch of divided highway south of Sudbury. Though large, this number represented only a fraction of what was actually killed: countless individuals were stuck to vehicles, obliterated on the pavement, too small to see or scavenged by small animals, including, as Pickles suggested, ants. Fully 96 per cent of the collection was dominated by three insect orders that mostly represent pollinators: Hymenoptera (bees, wasps, etc.), Lepidoptera (butterflies, moths) and Diptera (flies, mosquitoes, etc.). "That might seem disproportionate," notes Baxter-Gilbert, "but makes sense when you think about who's flying around at car level."

That metric alone serves to illustrate why transportation corridors should also be conservation tools, a line of thought that has given rise to its own burgeoning science: road ecology. Overpasses, underpasses, tunnels, fences — all are employed with varying degrees of

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success with larger animals. The scarce attempts to lower insect mortality, however, have seen little success. An example: the alkali bee is a solitary ground-nesting species and the best pollinator of economically important alfalfa, increasing yields some 50 per cent. Looking to mitigate the impact of a major highway that bisects an alfalfa-growing area of Washington state, a fine-mesh roadside fence was erected in the area bees nested with the hope they'd fly up and over, avoiding traffic at a safe height. After clearing the barrier, however, 99 per cent of bees immediately descended to their normal flight level of two metres or less with predictable outcomes — the same documented in spades by the Baxter-Gilbert study. "Ultimately, we conclude insects are dying on roads in astronomical numbers," he says, "especially those species we know to be super-important to ecosystems."

What does astronomical mean? Even the most conservative estimates seem insane. Ontario's Highway 400 is a medium-use road of 10,000 vehicles per day in an area of medium insect diversity. Extrapolating their estimate to the entire length of similar roads in Canada and the continental United States, Baxter-Gilbert's group came up with 10 billion Lepidoptera, 25 billion Hymenoptera, and a staggering 60 to 190 billion Diptera deaths per year.

For high-use roads in areas of higher insect diversity and abundance, you'd expect the numbers to skyrocket. And they do. In a study of Lepidoptera mortality in central Illinois, weekly collection along 13 roadside areas showed, unsurprisingly, more animals killed per 100 metres at higher traffic rates, and that the peak in monarch butterfly mortality coincided with their migration through the area. The data suggested more than 20 million Lepidoptera were killed on state roads during a single week — monarchs alone possibly exceeding 500,000. "We don't yet know what these kinds of numbers mean," notes Baxter-Gilbert. "But we should watch them into the future as roads grow."

Context is indeed elusive when you can't monitor populations by reliably counting individuals as, say, you might do with caribou. "There are so many unknowns when you're dealing with animals that only live [as adults] a few days or weeks," says Baxter-Gilbert. "For instance, if a high proportion are killed before they can mate, that seems like a problem. If every bee that should live 15 days and collect pollen for its colony dies on the highway after three, that also seems like a problem," he continues. "Of course, we're assuming the loss of 10 or 25 billion individuals is significant; however, we have no clue what carrying capacity for a species would be before it crashes, or how much loss an ecosystem can sustain — especially with pollinators."

SUCH AMBIGUITY POINTS in the same direction as the notions of a broad range of researchers: that the best way to preserve insect diversity and abundance is the same as it is for all animals — maintaining habitat and habitat diversity. It's a subject on which Simon Fraser's Elle has much to say. "If our farming practices aim to preserve diversity, then it will wind up being good for the farmer. For instance, preserving a hedgerow creates habitat for bees to nest in, and is also habitat for birds and small mammals. Preserving species on this planet can't just be a thing we do out in the wildest spaces — it also has to happen in human landscapes," she notes.

Those landscapes include cities, whose less-complex insect faunas reflect an environment of mostly invasive plant species and the monocultures common to landscaping. "In urban areas, the diversity of birds and insects in native trees versus non-native trees is higher. If we're all living in cities, then we need to make them better," says Sandy Smith, a forestry professor at the University of Toronto. "Currently we're reducing things to something that either looks good or is easy to manage. It's this kind of homogenization that worries me most because you're creating a vulnerable world."

It's the same vulnerability, she suggests, that humans experience when we reduce the number of beneficial symbiotic bacteria that live on our body, opening us up to everything from viral and bacterial infection to nutritional and behavioural disorders, all of which will have a cumulative effect. When it comes to the certain but still nebulous notion of declines in pollinators and other insects, and what might be driving them, ecosystem vulnerability seems like a good place to look. "Just because we can't put a finger on an exact cause doesn't mean that they aren't all important contributors," says Elle. "As Dave Goulson puts it, and I'm paraphrasing here, 'if a middle-aged, out-of-shape, overweight guy dies from a heart attack, you don't ask what killed him — it was, obviously, everything.' "

Find out what the most important insects in Canada are at mag.cangeo.ca/dec15/insects.