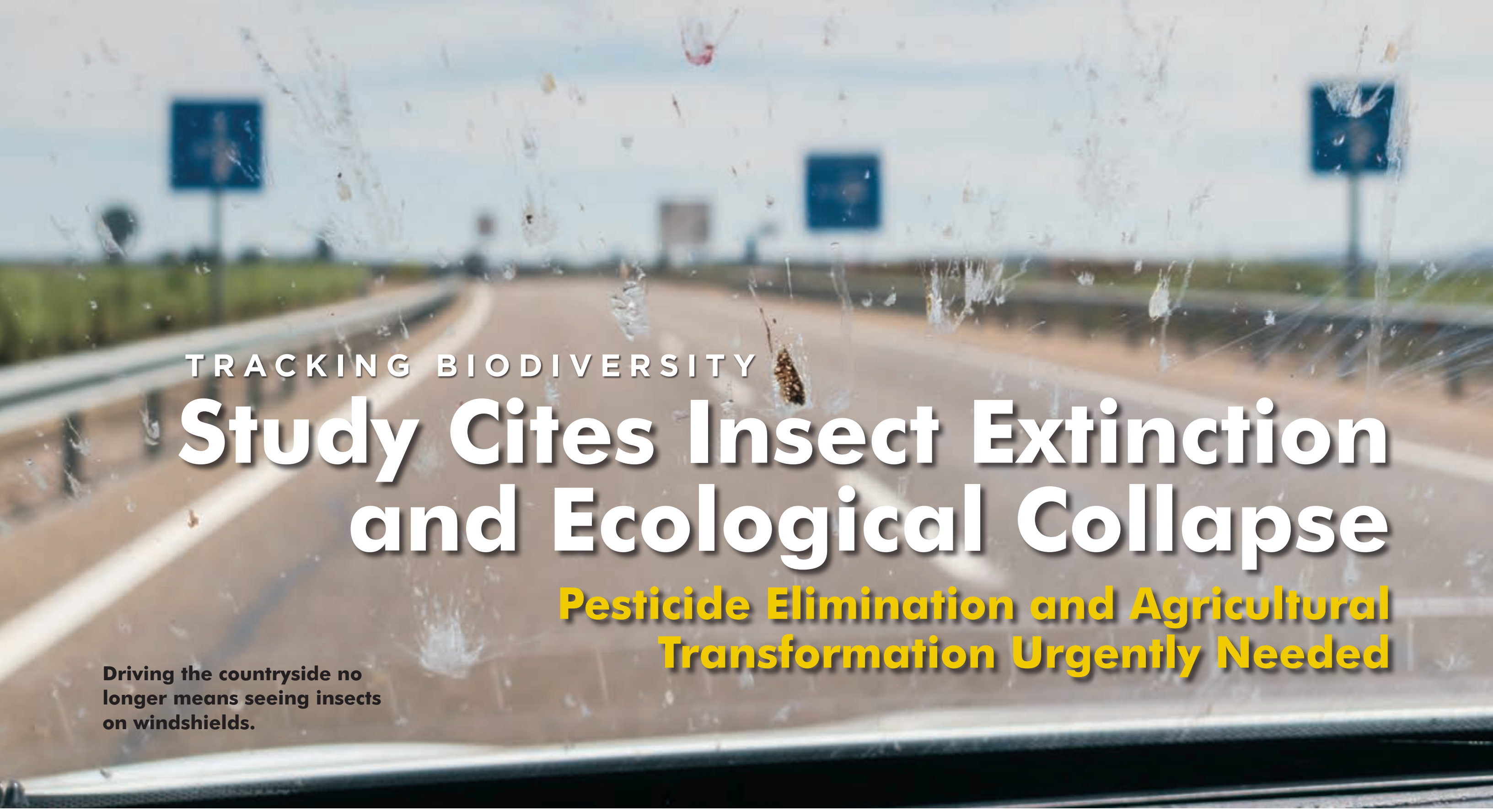

TRACKING BIODIVERSITY

Study Cites Insect Extinction and Ecological Collapse

Pesticide Elimination and Agricultural Transformation Urgently Needed

Driving the countryside no longer means seeing insects on windshields.

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A new systematic review of insect population studies worldwide reports on "the dreadful state of insect biodiversity in the world," concluding with the dire prediction that at least 40% of the world's insect species will go extinct within 20–30 years if patterns of intensive agriculture and pesticide use continue. In the words of the authors, "[U]nless we change our ways of producing food, insects as a whole will go down the path of extinction in a few decades."

THE DEPTH AND SPEED OF INSECT DECLINE

The review, "Worldwide decline of the entomofauna: A review of its drivers" (January 2019), published in *Biological Conservation*, analyzes 73 insect population studies conducted within the past 40 years, including only those that quantitatively assess all insect species within a taxa over a span of 10 or more years. Researchers Francisco Sánchez-Bayo, PhD and Kris A.G. Wyckhuys, PhD uncover the disturbing truth behind this mass of data: one in every three insect species monitored worldwide is threatened with extinction. Even more concerning is the finding that 41% of insect species worldwide are in decline, outpacing vertebrate declines by 200%. Only a few species are expanding in range or occupying vacant niches—not nearly enough to compensate for the massive losses.

Citizen data is analyzed in 8% of the studies in the review. The authors note that any bias in citizen science reports would dampen the observed species loss effects due to their emphasis on documenting rare species. The authors believe their estimates for biodiversity losses are a conservative lower bound on the true scale of insect declines.

CHEMICAL-INTENSIVE PRACTICES ARE DEVASTATING

More than half of the studies that Drs. Sánchez-Bayo and Wyckhuys review point directly to intensive agriculture and increased reliance on agrochemicals as causal factors driving insect declines. Several more consider pesticides to be the most likely agent, masked under the category of "unexplained factors" in cases where tested variables, such as habitat loss, land use conversion, and climate change, are insufficient in explaining losses. "[T]he intensification of agriculture over the past six decades stands as the root cause of the problem, and within it the widespread, relentless use of synthetic pesticides is a major driver of insect losses in recent times," the authors state.

The review includes a thorough treatment of pollinator declines, pinpointing pesticides as the main driver of massive population and species losses. Worldwide, authors note, "One in every six species [of bees] have gone regionally extinct." The study highlights a comprehensive analysis of nearly half a million records from Britain, which reveal that four separate phases of wild bee extinctions followed directly from specific policy changes expanding the use of chemical fertilizers and pesticides. Similarly, in a study of 576 species of butterflies in Europe, researchers found that 80% of species are negatively impacted by herbicide and pesticide use.

The study notes that systemic insecticides are particularly devastating for pollinator populations. Honey bees serve as well-studied proxies for wild bees and other native pollinators. Historic records and scientific studies confirm that increased honey bee colony losses began immediately following the introduction of DDT and spiked again due to compromised immunity induced by neonicotinoids and other systemic insecticides.

Systemics such as neonicotinoids are incorporated into plants through seed treatment, drenching, or spraying. Systemic insecticides spread through the vascular system of the whole plant and are expressed across all plant parts including pollen, nectar, and guttation droplets. Research findings across several studies confirm pesticide-induced declines in pollinator immune function, resulting in increased susceptibility to common pathogens and parasites:

> The new generation of systemic insecticides, particularly neonicotinoids and fipronil, impair the immune system of bees (Di Prisco et al., 2013; Vidau et al., 2011) so that colonies become more susceptible to Varroa infections (Alburaki et al., 2015) and more prone to die when infected with viral or other pathogens (Brandt et al., 2017). Apart from bringing about multiple sub-lethal effects that reduce the foraging ability of worker bees (Desneux et al., 2007; Tison et al., 2016), neonicotinoid and fipronil insecticides equally impair the reproductive performance of queens and drones (Kairo et al., 2017; Williams et al., 2015), thus compromising the longterm viability of entire colonies (Pettis et al., 2016; Wu-Smart and Spivak, 2016).

Native pollinators are similarly threatened by increased use of systemic insecticides. A California study of butterfly populations monitored from 1972-2012 captured a 65% drop in species counts beginning sharply in 1997, following the introduction of neonicotinoid insecticides to the state in 1995 (Forister et al., 2016). Similarly, a study of wild bee populations in varying U.S. landscapes found the greatest population declines in regions dominated by corn production, a sector in which neonicotinoid use tripled through the study period, accounting for 54% of total use in 2013 (Bennett and Isaacs, 2014).

HERBICIDES AND FERTILIZERS ARE MAJOR FACTORS

The authors point out that insecticides are not the sole culprits behind mass insect declines, citing the adverse impacts of herbicides and chemical fertilizers on biodiversity. Herbicides wipe out valuable habitat and forage in the watersheds surrounding agriculture zones and rights-of-way. Chemical fertilizers replace interplanted legumes—such as clover in lawns—and cover crops, reducing the managed land plant biodiversity that supports insects.

According to the review,

> In terms of toxicity, insecticides are by far the most toxic to all insects and other arthropods, followed by fungicides but not herbicides (Mulé et al., 2017; Sánchez-Bayo and Goka, 2014). Herbicides, however, reduce the biodiversity of vegetation within the crops and in surrounding areas through drift (Egan et al., 2014) and runoff, thus impacting indirectly on the arthropod species that depend upon wild plants, which either disappear completely or decline significantly in numbers (Goulet and Masner, 2017; Marshall et al., 2003). Thus, the application of herbicides to cropland has had more negative impacts on both terrestrial and aquatic plants and insect biodiversity than any other agronomic practice (Hyvonen and Salonen, 2002; Lundgren et al., 2013).

The proof is in the numbers: among insects threatened by pesticide use, those species that rely on farm flowers and traditional nitrogen-restoring crops for forage have experienced some of the largest reductions. Three independent studies conducted in England, Denmark, and Sweden show that long-tongued bumblebee species, which rely on farm flowers, clover, and other legumes for forage, have experienced larger declines over the last half century than short-tongued species. A U.S. study found that regions with high percentage intensified agricultural land ranked among the worst for bumblebee declines, contributing in large part to the steep drop in half of all U.S. bumblebee species, by up to 96% of initial counts. Critically, once plant specialists die out due to herbicide and fertilizer use, lack of available forage prevents the spread of new specialists, while surviving generalist species fail to fill the vacant niche. With no new specialized pollinators to aid their spread, the plants that extinct specialists once pollinated are threatened by reduced yield, in the case of managed crops, or reduced range and eventual extinction, for wild plants.

While specialist losses are alarming, the authors warn that losses of generalist species are even more so. Generalist pollinator species, such as the peacock butterfly and v-moth, have experienced major declines in the last half century. Once ubiquitous freshwater generalists (among them stoneflies, caddisflies, mayflies, and dragonflies) are rapidly disappearing from North American and European waterways. Such generalist declines signal a systemic, chemical-induced problem that extends beyond niche habitat loss.

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BEYOND POLLINATORS: DAMAGE TO SOIL BIOLOGY

While pollinators hold the spotlight, they constitute only one class of insects that are relied on for food production. The study contains further data on declines across insects that prey upon and parasitize common crop pests, as well as insects that are critical to soil fertility.

Both dung beetles and saprophytic beetles, whose actions in soils unlock critical nutrients trapped in feces and dead wood, are in decline. The impacts of dung beetles on soil fertility are vital to the sustainability of farms and pastures used to maintain livestock. By burying and processing feces on cattle farms, dung beetles introduce 80% more nitrogen into the soil than would otherwise remain. By increasing soil organic matter, dung beetles simultaneously increase water infiltration, thus stabilizing farms and heavily grazed areas against erosion, flooding, and drought.

Monitoring in Europe, specifically in the Mediterranean region, shows the greatest terrestrial loss of insect biodiversity on record: more than 60% of documented dung beetle species are in decline. In Spain, dung beetle populations began to decline in abundance and range in the 1950s. Multivariate analyses pinpoint agricultural intensification as a main driver of these declines (Lobo, 2001). Roller dung beetles in Italy declined by 31% in both abundance and distribution beginning in the 1960s, tracing the conversion of pastures to intensive agriculture (Carpaneto et al., 2007). A 1996 survey of dung beetles in a region of France recovered only 11 species out of 72 known species in the region (Lumaret, 1990). Abundance of one species was documented to have decreased 45-fold over a period of 24 years, due in large part to increased insecticide use for livestock maintenance and mosquito control (Lobo et al., 2001).

Dung beetles that unlock critical soil nutrients are in decline.

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These patterns carry a lesson. Insects that act to control crop pests and fertilize the soil reduce the need for pesticide and chemical fertilizer use. Reliance on chemical controls creates a vicious treadmill: pesticide use kills insect agents of pest control, thus creating a demand for more pesticide use, which kills more of the beneficial insects, and so on.

The impacts of mass dependence on pesticides reach far beyond affected farmers. Insects form the base of the ecosystem that all organisms rely upon. Insects serve as critical food items for vertebrates, such as shrews, moles, hedgehogs, anteaters, lizards, amphibians, bats, birds, and fish. Insects act as natural agents of pest control, maintaining on-farm ecological balance. Insects fertilize and stabilize soil by increasing soil organic matter, and their decline has far-reaching consequences for all plants and animals in terrestrial ecosystems.

INSECT EXTINCTION AS A CALL TO ACTION

The evidence implicating pesticide use in the loss of insect biodiversity is both astounding and unsurprising. Insecticides kill insects, often indiscriminately and with devastating consequences for biodiversity, ecosystem stability, and critical ecosystem services. Herbicides and chemical fertilizers extinguish invaluable habitat and forage critical to insect survival. Taken together, insecticides, fungicides, herbicides and chemical fertilizers make large and growing swaths of land unlivable for vast numbers of insect species and the plants and animals they sustain. More overwhelming still is the authors' prediction about the future with continued reliance on agrochemicals—continued mass extinction of insects that form the foundation of the entire ecosystem.

The authors offer a solution to the sobering reality they present. "A rethinking of current agricultural practices, in particular a serious reduction in pesticide usage and its substitution with more sustainable, ecologically-based practices, is urgently needed to slow or reverse current trends, allow the recovery of declining insect populations and safeguard the vital ecosystem services they provide."

Beyond Pesticides holds the position that toxic pesticides can be eliminated in organic land management systems, and that pesticide reduction is not sufficient in the face of the escalating crisis. We can commit to complete transformation of our agricultural system to stave off the dire fate this study predicts. Go to bp-dc.org/organic.