HIGHLIGHTS FROM THE 2017 UPDATE TO THE WORLDWIDE INTEGRATED ASSESSMENT OF THE EFFECTS OF SYSTEMIC PESTICIDES ON BIODIVERSITY AND ECOSYSTEMS

The Task Force on Systemic Pesticides — an international group of independent scientists convened by the International Union for Conservation of Nature — produced the world's first comprehensive scientific assessment of the ecological effects of neonicotinoids in 2015.[1] This landmark review, which considered more than 1,100 peer-reviewed studies, as well as data from manufacturers, identified clear evidence of harm to honeybees as well as to a large number of other beneficial species, including aquatic insects at the base of the food chain, soil arthropods such as earthworms, and common birds (by cascade effects).

In 2017, the Task Force updated its assessment to take into account hundreds of new peer-reviewed studies (published since 2014) on systemic insecticides in the environment and their ecological effects. **The new assessment reveals broader impacts that reinforce the conclusions of the original 2015 review: neonics and fipronil represent a major worldwide threat to biodiversity and ecosystems/ecosystem services.[2]**

The 2017 update will be published in a forthcoming edition of the scientific journal Environmental Science and Pollution Research.

MAJOR FINDINGS

Extensive environmental contamination

Recent water surveys in more than a dozen countries, including Canada, have documented widespread contamination of surface waters around the world at levels that frequently exceed water-quality guidelines. New studies also confirm environmental contamination by neonics in soil, plants (including pollen and nectar), agricultural produce, bees, beehives and honey.

Despite equipment innovations designed to reduce dust during planting of neonic-treated seeds — a major route of exposure for bees — dust drift continues to contribute to environmental contamination and highly toxic effects on non-target species. Moreover, efforts to control dust without reducing the volume of neonic-treated seeds planted does not address overall environmental loading: to the extent that less of the active ingredient is released into the air as dust during planting, more is deposited directly into the soil. Neonics are persistent in soil and can accumulate from one planting season to the next. Soil and foliar runoff are the most common pathways for neonic contamination of surface and groundwater.

New evidence of toxicity

The 2017 assessment notes new data on the mode of action and metabolism of neonics and their resulting toxicity. In honeybees, related effects include expressional changes in genes related to the immune system, and neurological effects influencing spatial navigation and thermoregulation.

Synergistic and additive effects with fungicides commonly applied to neonic-treated crops can enhance toxicity. Neonics and fipronil interact with or promote natural stressors as well via adverse effects on immune response. Exposure to these systemic insecticides is a key factor in parasitic infections in bees, increasing the number of parasites (varroa) and boosting the pathogenicity of some natural infectious agents that would otherwise remain asymptomatic.

New studies confirm previous findings that chronic exposure to very low levels of neonics can cause a "delayed mortality" effect: the rate of mortality among exposed organisms increases over time as a result of cumulative neurological effects (because affected neurons do not regenerate). Acute toxicity thresholds determined for short exposures (24 or 48 hours) are therefore not an appropriate basis for risk assessments, and short-term field studies are not representative of impacts in the long term.

Impacts on pollinators

New information on the lethal and sublethal effects of neonicotinoids confirms the high toxicity of neonics to bees. Recent studies have revealed additional sublethal effects, including reproductive disorders and negative interactions between parasites and the immune system. Recent studies on bumblebees suggest exposure to neonicotinoids in nectar at environmentally realistic concentrations can have sublethal effects on the ability to feed at both the individual and colony level, impacting reproductive output and colony growth. Other wild bees appear to be more sensitive to neonics than the honeybee, although most studies have focused on the latter.

In 2013, the European Union imposed a moratorium on certain uses of the three most toxic neonics on bee-attractive crops. These measures appear to have been somewhat successful in reducing honeybee acute exposure, based on a comparison of honey, bee and hive samples from before and after the moratorium came into effect. Notwithstanding this general trend, there was no significant change in the frequency of detection in wax samples, perhaps because beekeepers commonly reuse the centre walls of hives. Also, the use of neonics on other crops not subject to the moratorium increased during this period. The continuance of neonic contamination in beeswax even after the EU moratorium came into effect is a reminder that environmental loading takes time to reverse and underscores the need for comprehensive approaches to prevent further contamination.

"Impacts on pollinators are a real cause for concern."

"The [ecosystemic] consequences of losing the invertebrate fauna due to continuous exposure to ubiquitous residues of neonicotinoids... are thus far-reaching and cannot be ignored any longer."

Impacts on aquatic invertebrates

Neonics now contaminate surface waters in many countries at levels harmful to aquatic insects. Chronic exposure to very low levels of neonic residues in water can be lethal to most aquatic invertebrate species in the long term, and entire populations can be eliminated from the affected areas. While most previous studies on this subject involved imidacloprid, new studies have evaluated acute and chronic toxicity of clothianidin and thiamethoxam, and also revealed their impacts on a wider range of aquatic invertebrate species.

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Impacts on other beneficial species

New research adds to previously available information about the negative effects of neonics on beneficial insects that play a role in biological pest control, with additional species now tested. Exposure of predatory insects to agricultural neonics can be direct and through secondary poisoning from contaminated prey. Effects on soil organisms have yet to be fully evaluated.

Scientists now have a better understanding of the mechanisms of toxicity in vertebrates. In laboratory settings, the neonics imidacloprid and clothianidin induce a wide range of deleterious sublethal neurological effects in terrestrial vertebrates such as rats, bats and birds. These include: impacts on growth, reproduction and immunity, as well as neuro-behavioural effects such as diminished learning ability and impaired memory. In some cases, sublethal effects occur at levels of exposure several orders of magnitude lower than the reference lethal dose.

New evidence has emerged suggesting that terrestrial vertebrates can be exposed to high concentrations of neonics by ingesting treated seeds. For example, acute poisoning from ingesting neonic-treated seeds accounted for 70 per cent of wildlife mortality incidents reported in France (mainly birds) associated with exposure to imidacloprid from authorized agricultural uses.

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Ecosystem effects

The overall negative impacts of neonics on terrestrial and aquatic invertebrates translate into indirect impacts on entire ecosystems. Detrimental effects on pollinators is likely to affect pollination services and, in turn, pollinator-dependent crop production (for example, fruits and vegetables). There is now enough mechanistic understanding to put the question of causality beyond reasonable doubt. Likewise, there is now sufficient evidence to state that detrimental effects on aquatic invertebrates disrupt essential nutrient-cycling services. Impacts on invertebrates threaten the main food source for a diverse array of insectivorous vertebrates.

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Diminishing value of neonics in agriculture

Research continues to demonstrate the efficacy of neonics in controlling certain pests, although after two decades of use, there is now evidence of neonic resistance in many pests. However, efficacy does not guarantee an increase in crop yields. Studies show that without insecticide use, arable crop yields do not usually decrease significantly because plants compensate for minor insect damage and the risk of large-scale pest damage is very low on a year-to-year basis.

Furthermore, harm to non-target predators of insect pests undermines the effectiveness of neonics in pest control and can lead to pest resurgence. Moreover, overreliance on insecticides for pest control is inflicting serious damage to the ecosystem services that underpin pest control and agricultural productivity. Overall, the global experiment with neonics is emerging as a clear example of pest control failure.

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New chemicals (fourth-generation neonics)

The new systemic pesticides sulfoxaflor and flupyradifurone have chemical structures similar to neonics, comparable modes of action and even some common metabolites (sulfoxaflor was conditionally approved for use in Canada in 2010 with full registration in 2016; flupyradifurone was approved for use in Canada in 2015). Although manufacturers propose to classify them in separate subgroups for commercial purposes, these new pesticides are expected to have similar effects and impacts to the older neonics and are therefore not suitable replacements from a sustainability perspective.

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Alternative pest control

Integrated pest management (IPM) tools are already available and can achieve efficient pest control while maintaining agricultural productivity. However, implementation lags. Regulatory requirements to implement robust IPM practices are needed to significantly reduce insecticide use without undermining agricultural production. Insurance mechanisms can reduce farmers' financial risk, at lower costs, without the significant environmental damages of neonics.

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About the Task Force on Systemic Pesticides

The Task Force on Systemic Pesticides, convened by the International Union for Conservation of Nature, is the response of the scientific community to global concern about the impact of neonicotinoid insecticides on biodiversity and ecosystems.

[1] The Worldwide Integrated Assessment of the Effects of Systemic Pesticides on Biodiversity and Ecosystems was published in a special edition of the journal *Environmental Science and Pollution Research* in January 2015, available online at https://link.springer.com/journal/11356/22/1/page/1.
[2] Ecosystem services are the benefits provided by ecosystems that contribute to human well-being. For example, trees clean our air; wetlands filter our water; urban green spaces absorb carbon, cool our cities and protect us from storms; aquatic ecosystems stabilize the climate, prevent flooding and regulate water quality.