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Unfulfilled Promise: Pollinator Declines, Crop Deficits, and Diet-Associated Disease

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Although difficult to track, populations of wild pollinators across the globe appear to have declined for the past several decades.[1,2] Animal pollinators (e.g., birds, bees, wasps, small mammals) ensure the yield and quality of approximately one-third of the world's agricultural crops, including vegetables, fruits, nuts, and seeds.[3] A shortage of these foods in the diet influences human health in myriad ways, ranging from undernutrition to development of chronic diseases.[4,5] In a new study in *Environmental Health Perspectives*,[6] a team of scientists estimated effects of pollinator deficits on five diet-associated disease end points: stroke, cancer, type 2 diabetes, coronary heart disease, and all-cause mortality associated with changes in weight.

The authors started with a model of worldwide attainable yields for 63 important pollinator-dependent crops. They combined this model with a globally derived data set that quantified the proportion of crop yield gaps (difference between current and attainable yields) attributable to insufficient pollination. Then, for each country where those crops are grown, they estimated how much additional food would have been produced if pollination were sufficient. The team then used an agricultural–economic model to examine who would have consumed that food, and a comparative risk assessment framework to estimate the impact of altered consumption patterns on human disease and mortality.

"Linking all these different fields—pollination ecology, agriculture, food and diets, global economics, and human health—required building a multidisciplinary team with expertise in each area and linking their models together to understand how they interact," says lead author Matthew Smith, a research scientist at the Harvard T.H. Chan School of Public Health.

The researchers estimated that insufficient pollination results in a global loss of 4.7% of fruit, 3.2% of vegetables, and 4.7% of nuts produced every year. Next, using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT),[7] a multimarket model of the global food system, they

Most plants are pollinated by self-pollination, the wind, or animals such as birds, insects, bats, and other small mammals. Animals pollinate one-third of agricultural crops worldwide. Images, clockwise from top left: rufous hummingbird, Tom Koerner/U.S. Fish and Wildlife Service, under CC BY 2.0 license; western honey bee, Kirsten Strough/U.S. Department of Agriculture; swallowtail butterfly, Preston Keres/U.S. Department of Agriculture; grey-headed flying fox, Andrew Mercer, under CC BY-SA 4.0.

estimated how these lost foods might have been either traded globally or eaten locally. Combining these calculated dietary changes with relative risks that link dietary factors to health outcomes, they estimated that 427,000 deaths—mainly from stroke, coronary heart disease, and cancer—would have been avoided had there been no pollinator declines.

"That is on par with other major global risks like interpersonal violence, substance use disorders, or prostate cancer," says Smith. "It's a sobering reminder that a failure to protect nature has concrete and tangible consequences for human lives."

The research team estimated that food production losses were greatest in lower-income countries, with an estimated 26% of vegetable production and 8% of nut production lost. When the overall loss in production was translated to human consumption worldwide, estimates included 2%–5% lower consumption of fruits, 3% lower consumption of vegetables, and 4%–12% lower consumption of nuts, depending on income level and region. North America saw the greatest estimated reductions in consumption across all food categories, including: 5.7% for fruit, 4.4% for vegetables, and 11.3% for nuts.

Interestingly, the modeling suggested that effects of pollinator declines on human health would be less pronounced in lower-income countries. Smith explains, "The health effects of lost pollination are concentrated in areas where rates of chronic disease are [already] higher but where populations often cannot pay for expensive fruits, vegetables, and nuts," namely, Russia, Eastern Europe, China, India, and parts of Southeast Asia and North Africa. In other words, surplus food is routinely exported to higher-income countries, so consumption of those crops in lower-income countries would not be expected to change with fluctuations in yield. However, the results also showed significant economic losses for lower-income countries: Case studies on Honduras, Nepal, and Nigeria estimated 12%–31% of agricultural value was lost due to insufficient pollination.

"Most large-scale studies into the impacts of pollination have focused on fairly extreme versions of what we stand to lose," says Tom Breeze, a postdoctoral scholar in sustainable land management at the University of Reading in England, who was not associated with the study. For example, he points to a previous paper by Smith et al. that modeled consumption changes resulting from a more extreme loss of 50%–100% of pollinators.[6] "This new study, by including trade and yield deficit projections, shows not only what we stand to lose in a more realistic way, but also the scale of what we may already have lost," he says.

Breeze adds that although the study is very strong and the team used the best data available, they were limited by gaps in information data from across the world. For example, he says, "We simply don't have good [enough] pollination service monitoring to be able to accurately estimate any yield gaps at a national, never mind international, scale." Breeze adds that although the IMPACT model is global, it is very much grounded in western market economy thinking, so it does not factor in relevant activity in lower-income countries, such as bartering and trade in locally valuable crops produced on a small scale.

"Protecting pollinators is more than a crucially important goal for biodiversity; doing so also [protects] human health," says Smith. "The policy prescriptions are straightforward: Set aside nearby natural or semi-natural habitat, provide adequate food by planting a diversity of flowers on or near farms, and halt the use of harmful pesticides like neonicotinoids."

Wendee Nicole, a San Diego–based writer, contributes regularly to *Environmental Health Perspectives*.

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