Left: Harnessed Moth (Apantesis phalerata) Caterpillar on Liatris Photo by Right: Two pollinators-Gray Hairstreak (Strymon melinus) and bee Photo by Jay Dee Miller.

NEONICOTINOID SEED TREATMENTS IN NORTH AMERICAN AGRICULTURE:

Hazards to Insects, Birds and Entire Ecosystems

J.P. MICHAUD
PROFESSOR OF ENTOMOLOGY, KANSAS STATE UNIVERSITY

The declining abundance of many bird species is readily apparent to any birdwatcher. Although the causes of declining bird populations are numerous, most share a single common denominator: human activities that kill birds either directly, or indirectly by diminishing their habitat or food supply. Some of these impacts will be difficult to prevent (collisions with cars, wind turbines, etc.), but others provide us with low-hanging fruit; they could be eliminated easily by legislation at little or no economic cost, and are thus ideal targets for public advocacy campaigns. One such target is the current practice of treating crop seeds with neonicotinoid insecticides, which eliminates not only pests, but many non-target insects that serve as food for birds, fish and other higher animals. Think about the fraction of total land area devoted to crops in Kansas (87.5 percent) and then consider that more than 95 percent of bird species rely on insects as their primary food source - even game birds like pheasants and nectar-feeders like hummingbirds require insect protein to raise their chicks. If our croplands no longer produce any insects, what are our birds going to eat?

As a professional entomologist engaged in crop protection, I counsel farmers on the best ways to protect their crops from pests, while at the same time avoiding non-target impacts—any harm to non-pest organisms. Although insecticides are often a necessary tool within our current model of agriculture, there are many ways to reduce their unwanted impacts, while

still achieving acceptable pest control. Farmers can wait until threshold numbers of pests are present, limit treatments to infested areas, and choose materials with selective activity that spare non-target organisms. These are among the principles of Integrated Pest Management (IPM), the paradigm of responsible pest management. They were developed sixty years ago and have helped us evolve beyond the indiscriminate use of insecticides that characterized agriculture over the past century, ultimately inspiring Rachel Carson to write *Silent Spring*. But now, **the corporate interests of "Big Ag" have quietly and insidiously abandoned these principles and effectively returned us to the environmental irresponsibility of 1950s agriculture,** promoting the prophylactic use of pesticides that are orders of magnitude more toxic to insects than DDT or the other compounds of that era.

Neonicotinoids are so named because they bind to the same nerve receptor as nicotine, which is also the binding site of acetylcholine, a key neurotransmitter. Both insects and higher animals possess these receptors, but they are much more abundant in the central nervous system of arthropods and other invertebrates, making them especially toxic to these animals. Their chemical properties enable them to be absorbed through plant roots and distributed throughout the vascular system. Thus, seeds coated with neonicotinoids grow into plants which remain toxic to any insect that feeds on them for many weeks, up to 60 or 70 percent of the entire lifetime of an annual plant. But these same properties mean they also move through the soil and into streams and lakes via runoff from farmers' fields, killing many other invertebrates—not just insects—in the process. Because they bind irreversibly to nerve membranes, there is no safe level of exposure for these organisms—even larger, longer-lived species can eventually accumulate a lethal dose, despite exposure to a very low concentration in the environment.

It is well known that the vast, synchronous monocultures that characterize modern industrial agriculture diminish biodiversity, but remarkably, even uniform fields of corn and wheat foster diverse communities of insects when left untreated with pesticides. Crop-based arthropod communities not only generate considerable biomass of flying insects to support bird populations, they also create stable food webs full of beneficial species that provide natural biological control of most pests, most of the time—including the many aphid species that are the primary target of seed treatments! These seed treatments not only kill everything that feeds on the plant, but also many innocent bystanders. These include invertebrates responsible for decomposition and nutrient recycling in both terrestrial and aquatic ecosystems, resulting in the accumulation of organic deposits in lakes and streams, contributing to reduced oxygen content and harmful algal blooms.

The broad-spectrum activity of neonicotinoids means they kill a wide range of organisms, potentially disrupting entire ecosystems. In cropland, they create a sterile culture where the natural enemies of pests must either die from starvation or abandon the crop. And these beneficial species don't escape exposure either. Neonicotinoids can be exuded by plants in droplets of fluid via a process called "guttation," and in floral and extrafloral nectar, all of which are utilized by many beneficial insects for hydration. Even flowering plants growing adjacent to a treated seed can become contaminated. Thus there are multiple routes of exposure, not only for pollinators, but also for predators and parasitoids, our natural pest control agents. And these insects need not be killed outright. Our research has shown that even small, sublethal doses can impede behaviors essential to their successful foraging and reproduction, thus driving population declines.

Giant Swallowtail (Papilio chresphontes) on Orange Butterfly Weed (Asclepias tuberosa). Photo by Dave Rintoul

In southern latitudes along the Gulf Coast, many pests breed year-round and can attack crop seedlings in very early stages, and it is here that seed treatments have been shown to provide marginal increases in crop yields, usually a few dollars per acre. Even there, the true costs of their use ("externalities" in the lingo of economists) are never factored into these calculations, as only the harvested product is considered. What about the loss of pollinators that diminishes fruit yield in a nearby orchard, or the decimation of ladybeetle and lacewing populations that otherwise would have migrated to neighboring fields to control pests later in the season? These might now require an insecticide application. **But at midwestern latitudes (Oklahoma, Kansas and parts north), there is no evidence at all of consistent yield benefits from seed treatments, and no justification for their uniform application on such a wide scale.**

In 2021, grain sorghum occupied almost 8.5 million acres on the High Plains, and virtually every seed was coated with thiamethoxam—and that is just one crop. Sadly, farmers are powerless to oppose the powerful oligopoly of the **seed/chemical companies, who now insist on treating all the seed of almost every crop, raising the farmer's cost of planting by $5-$10 per acre.** Now, even environmentally conscious farmers can no longer obtain untreated seed of most commercial crop varieties in a "free market" system that promised us choices!

The toxicological and environmental impacts of neonicotinoids are well documented in the scientific literature and beyond dispute. The European Union has responded by banning this entire class of chemistry, largely in response to evidence of massive declines in the total biomass of flying insects, using data obtained not from agricultural fields, but from adjacent nature preserves! Alternative pest control tactics have been implemented, and agricultural productivity continues apace, despite loud protestations by the chemical companies. **It is time for concerned citizens of the United States, catalyzed by organizations such as AOK, to demand federal legislation that bans the use of these compounds,** or at the very least, their needless and unjustifiable application to all the seeds of our crop plants.