Testimony statement provided February 24, 2026 regarding
Seventy-fifth General Assembly STATE OF COLORADO
Second Regular Session, **SENATE BILL 26-065**

Introduction: My name is Dr. Judy Wu-Smart spelled J-U-D-Y W-U-hyphen-S-M-A-R-T. I am an Associate Professor and Extension Specialist at the University of Nebraska–Lincoln Bee Lab, with expertise in pesticides and bees. My work is regional in scope and directly relevant to Colorado beekeepers and this topic. I want to first thank the committee for this opportunity to testify regarding **SB26-065, the Strengthening Economic and Environmental Decisions Act (SEED Act)**. And I am providing testimony in a personal capacity and not on behalf of the university.

I speak from both professional and personal experience. In Nebraska, we saw major bee and wildlife losses from pesticide pollution caused by improper disposal of surplus unmarketable pesticide-treated seeds through ethanol production. While local contamination has been addressed, the national issue of treated seed disposal remains unresolved, and it's unclear where discarded seed should go now since the 2021 closure of the AltEn facility. Because these seeds fall under the federal "treated article exemption," they evade standard pesticide regulations despite their systemic, water-soluble nature, and toxic effects on non-target organisms, leaving states to manage the fallout. This experience underscores why state legislation like SB26 065 is essential to protect pollinators, water, and farmers.

1) Wild pollinators and honey bees are in decline: Pollinators, including managed honey bees, wild bees, butterflies, and birds, are essential to agriculture and ecosystems, yet all are in decline. Research shows that even low-level exposure to neonicotinoids reduces foraging, weakens immunity, impairs navigation, disrupts reproduction, and can lead to colony failure, with effects compounded by repeated exposure through pollen, nectar, soil, air, and water. In Colorado, data from the National Agricultural Statistics Survey (NASS) Census (1997–2022) show that ***while beekeeping operations grew ≈735%, from 123 to 1,027 (Fig. A), honey production fell 22.7% (Fig. B) and colony numbers dropped ≈51%, from 25,892 to 12,722 colonies in 2022. The most recent USDA estimate reports only ~11,000 colonies in 2024, representing an overall loss of 57% over the past 30 years (Fig. C).*** These trends demonstrate that, despite growing interest, managed bees face pressures beyond what individual beekeepers can mitigate, particularly the loss of diverse forage and increasing pesticide exposures. This underscores the urgent need for policies that protect pollinators, safeguard ecosystems, and support sustainable agriculture.

2) Widespread use of treated seeds contaminates water and ecosystems, threatening Colorado's ecotourism economy. A 2025 report by Mineau detected neonicotinoids in Colorado surface water and groundwater at concentrations exceeding levels known to harm aquatic life, with evidence identifying treated seeds as a primary source. Because systemic pesticides like neonicotinoids are highly water-soluble, they readily move through runoff and leach into streams, rivers, and aquifers, where they kill aquatic insects and disrupt freshwater food webs. ***Aquatic insects form the foundation of the food chain that supports trout and other fish species central to Colorado's fishing and outdoor recreation industries. Colorado's outdoor recreation economy contributes approximately $13.9 billion annually and supports nearly 130,000 jobs, while broader tourism generated about $28.5 billion and nearly 188,000 jobs in 2024.*** Declines in water quality and aquatic biodiversity therefore pose not only ecological risks, but direct economic consequences for communities that depend on fishing, rafting, wildlife viewing, hiking, and birding. Neonicotinoid contamination also extends beyond waterways. These chemicals can be taken up by non-target plants, including wildflowers and crops, threatening pollinators, birds, and other wildlife that rely on insect prey. Similar findings in other states underscore the persistence, mobility, and chronic exposure risks associated with these compounds. Protecting water quality is essential not only for ecosystem health, but for safeguarding Colorado's tourism economy and the communities it sustains.

3) Prophylactic seed treatments often provide little benefit or choice to farmers: One of the core problems addressed by the SEED Act is the prophylactic use of pesticide-treated seeds, meaning seeds are pre-treated before pests are even present and before farmer even need it, marketed as "cheap insurance". For many major field crops, independent studies have shown that ***seed treatments offer negligible agronomic or economic benefit*** under typical conditions, yet farmers have little choice because most commercial seed arrives pre-treated and there are few untreated alternatives available. Eliminating routine, mandatory insecticide coatings *does not* prohibit use when genuinely warranted, SB26-065 simply conditions use on verified need. That safeguards farmer access while curbing unnecessary exposure that only adds to environmental harm. A prescription-style model already adopted in places like New York, Vermont, Québec, and Ontario has shown that farmers can adapt without loss of productivity while reducing systemic insecticide dependence.

4) Persistent chemical pressure promotes pesticide resistance in pests and diseases: Large-scale, routine use of treated seeds creates continuous chemical exposure that accelerates the development of resistance across multiple pest and disease systems. Prophylactic applications (used regardless of documented pest pressure) intensify selection pressure, enabling resistant populations to survive and reproduce. As resistance develops, farmers, turf managers, and public health officials increasingly report reduced efficacy of standard treatments. In response, higher application rates, more frequent treatments, or more complex chemical mixtures are used, compounding risks to non-target and sensitive organisms. This *vicious* cycle of escalating treatment use drives both ecological harm and rising production costs. Limiting routine seed treatments would reduce unnecessary selection pressure, preserve the effectiveness of existing pest management tools, and support long-term agricultural resilience and economic sustainability.

5) Specialty and organic producers, local markets, and regenerative agriculture need bees: Colorado's agricultural economy includes a growing community of specialty crop growers, farmers' market vendors, and producers focused on organic and regenerative practices, many of whom depend heavily on pollinators for crops like fruits, vegetables, berries, and herbs. According to the 2022 Census of Agriculture, ***Colorado is home to 24,166 new and beginning producers, up from 21,157 in 2017, reflecting diversification into specialty and local food systems that are inherently pollinator dependent. Across the U.S., organic and specialty food markets continue to expand: certified organic product sales reached $71.6 billion in 2024, growing more than twice as fast as the overall food market, with produce as the largest category at $21.5 billion, demonstrating strong consumer demand for sustainably produced food.*** Yet when the only viable seed options come pre-treated with systemic insecticides, these farmers are forced into a chemical centric paradigm that runs counter to their business goals and regenerative agriculture principles. This lack of choice not only limits market opportunities but also jeopardizes investments in pollinator habitat and soil health, investments that have long term economic and ecological benefits. By ensuring untreated seed options and conditioning treated seed use on actual need, SB26 065 protects pollinators, supports specialty and organic producers, and enables Colorado farmers to tailor pest management to their specific conditions with flexibility and agency.

6) Federal regulatory gaps make state action critical: At the federal level, pesticide-treated seeds are currently exempted from pesticide registration under an EPA "treated article exemption," meaning they evade many of the safeguards applied to other pesticide uses. This exemption has been challenged by environmental and beekeeping groups as inappropriate given the environmental risks posed by systemic coatings, but EPA has so far not made any decisive action. While the federal Pollinator Protection Program, administered under FIFRA, oversees the sale, use, and disposal of pesticides, and safety to pollinators, it does not address pesticide pollution, a major concern for highly mobile chemicals like neonicotinoids. Because treated seeds are not tracked or regulated like other pesticides, accountability for disposal, storage, and the documented environmental impacts caused by leeching, run-off, and non-target uptake, is extremely limited, as demonstrated by events in Nebraska. This regulatory shortfall makes state legislation like SB26 065 even more critical, empowering Colorado to set protective standards in the face of federal inaction.

Conclusion: SB26 065 provides a balanced, science-based framework that supports both environmental protection and agricultural productivity. The bill safeguards pollinators, water quality, and ecosystems while preserving farmer choice, promoting specialty and organic agriculture, and ensuring access to tools when genuinely needed. I encourage thoughtful consideration of SB26 065 as a practical measure to protect Colorado's agriculture, water resources, and pollinator populations.

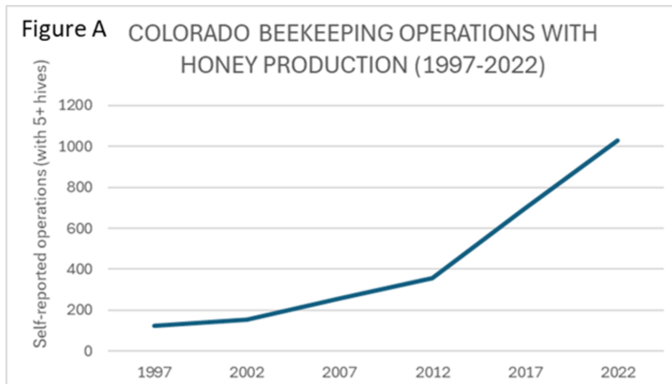
I thank the committee again for the opportunity to speak today and I welcome any questions.
With great sincerity and appreciation,

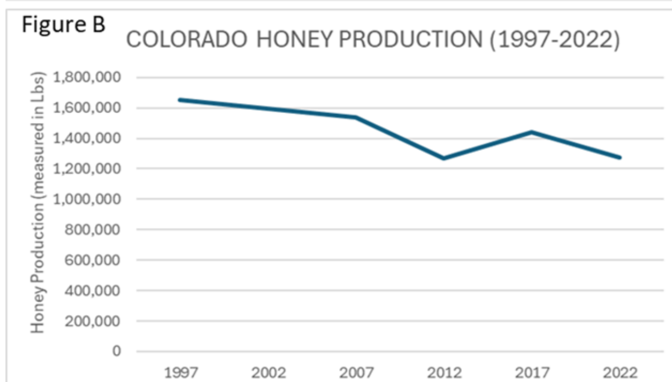
Dr. Judy Wu-Smart
Associate Professor & Extension Specialist
University of Nebraska-Lincoln Bee Lab
Email: jwu-smart@unl.edu
UNL Bee Lab Website: https://beelab.unl.edu/
Regional Great Plains Master Beekeeping Program Website: https://gpmb.unl.edu/

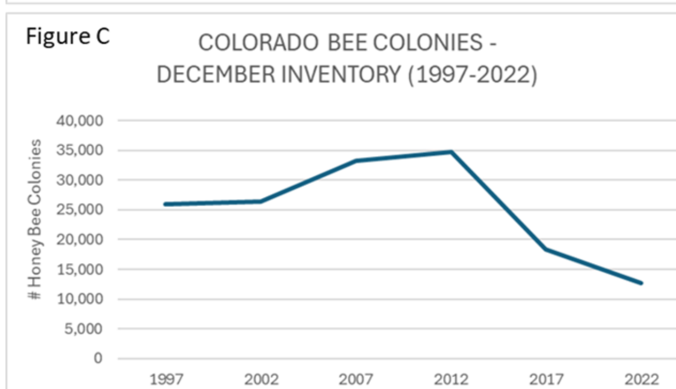
BEEKEEPING IN COLORADO:

Productivity and colony survival in Colorado are declining despite growing interest in beekeeping and rapid industry expansion.

Figures A-C: Data from the National Agricultural Statistics Survey Census (1997–2022) show rapid growth in beekeeping operations in Colorado, rising ≈735% from 123 to 1,027 operations (Fig. A), while honey production declined by 22.7% (Fig. B) and colony numbers fell by 13,170 (≈51%) (Fig C.). These trends highlight the challenges beekeepers face despite increasing interest and numbers of operations. (https://www.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Census_by_State/Colorado/)







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February 26, 2026
Sen. Dylan Roberts, Chair
Agriculture & Natural Resources
Colorado State Capitol
200 E. Colfax Ave
Denver, CO 80203

Testimony of Louis Robert, Former Agronomist at the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ), and Dr. Geneviève Labrie, PhD, Principal Investigator, Le Centre d'Expertise et de Transfert en Agriculture Biologique (CETAB+)

Dear Chair Roberts and Members of the Committee:

We are Louis Robert – an agronomist and grain crops specialist who worked with the Department of Agriculture[i] in the Province of Québec, Canada, for 33 years – and Dr. Geneviève Labrie, PhD – a Principal Investigator with the Centre d'Expertise et de Transfert en Agriculture Biologique (CETAB+). Dr. Labrie has published extensively on the subject of crop pests and pest control methods.

We write to inform your consideration of SB26-065, the SEED Act. Our testimony conveys our experience with neonicotinoid (neonic)-treated field crop seed in Québec, Canada – where these seed coatings have become virtually obsolete. We also explain the science regarding their lack of benefit to farmers.

In summary:

- In response to a "prescription" program for neonic seed coatings similar to the SEED Act, farmers in Québec have almost completely stopped using neonic seed treatments in corn and other field crops (wheat, oats, barley, soybean, canola). Whereas nearly 100% of corn grown in Québec was grown with neonic-treated seeds prior to 2019, today, virtually none (0.003%) is grown from neonic-treated seed.

- After neonic seed treatments disappeared, crop yields remained constant, and no crop failures have been attributed to the lack of neonic-treated seeds.

- Seed companies reacted quickly to the regulatory restrictions when they took effect, providing alternative seed treatment products to farmers.

- Leading research by Dr. Labrie, which includes side-by-side field trials on 68 sites, as well as monitoring at over 1,000 sites, finds that neonic seed treatments provide no yield benefit for corn farmers. Early season pest presence does not typically impact yield, so insecticides are not necessary at this stage.

- The prescription program has been so successful at reducing neonic pollution, without negative impacts on farmers, that in August 2025, the province expanded it to all insecticide coatings.

- Although there was significant pushback from the chemical industry before 2019, today, farmers and seed dealers are convinced that these coatings don't provide much value and have long ago moved on to other concerns.

Our more detailed comments are as follows:

The Experience in Québec and the Science Regarding Insecticide-Treated Seeds

In April 2019, the Department of Environment of the Province of Québec made it mandatory for anyone wishing to use a neonic pesticide coating on field crop seed (corn, wheat, barley, oat, soybean, and canola) to obtain a written recommendation from one of the province's registered agronomists. In its consultations before the restrictions took effect, the Department had made it clear that the use of those coatings would be restricted based on their proven acute toxicity to the environment and public health concerns. At the time, the vast majority (70-90%) of the corn, soybean, and canola acreage (approximately 2 million acres) in Québec were planted with seed coated with the neonicotinoids clothianidin, imidacloprid, or thiamethoxam. Residues of any one or combinations of those molecules were detected in significant concentrations in over 90% of samples collected in rivers and streams being monitored by the Department.

This "prescription" requirement resulted in substantial reduction in use of neonic coatings on crop seeds. The seed suppliers reacted very swiftly to this regulatory change, having seen it coming. As soon as 2019, most field crop seeds used in Québec were no longer carrying any neonicotinoids. (All corn seed and a major part of the soybean seed sold in Québec is grown in Ontario or the U.S. Midwest). Surveys from the Department of Environment report Québec farmers used neonicotinoids on about 0.2% of their fields in 2020, and as little as 0.003% in 2023.[ii, iii] As a result, neonicotinoid contamination of surface waters decreased significantly.

Prior to those regulatory initiatives, word had already spread around that insecticide-treated seeds may not bring any advantages to Québec farmers, at least among crop advisers and top cash croppers. Dr. Labrie led a large research project carried out from 2012 through 2016 (5 cropping seasons) in 7 different regions, which found no significant difference in yield between plots with treated and untreated seeds.[iv] This result held for both corn and soybean (see attached study). Thanks to continued public funding, the network was expanded to just short of 1000 sites, with no difference in the results or conclusions.

Although there are agricultural differences between Colorado and Québec, Dr. Labrie's findings are consistent with other studies conducted across the U.S. and Canada. For example, Pacenka et al. (2021) found in another four-year study that "the absence of a neonicotinoid [corn] seed treatment had no impact on yields."[v] Smith et al. (2020) concluded after a four-year study of 160 corn and soybean fields in Ontario "that widespread use of seed-applied insecticides in corn and soybean is unlikely to provide benefit to producers."[vi] Krupke et al. (2017) found that three years of field studies in Indiana "failed to demonstrate a significant benefit of planting treated maize seeds."[vii] Dubey et al. (2020) found that "neonic seed treatments are not warranted for grain production in the Mid-Atlantic" because of overall low pest pressure and lack of yield improvement for maize, winter wheat, and soybean.[viii] And Grout et al. 2020, a review of hundreds of studies across North America, found there was "no overall net economic benefit" for using

neonicotinoid coatings on corn and soybean seeds.[ix] Each supports the conclusion that neonic seed treatments in corn, wheat, and soybean almost always fail to provide benefit to farmers, but unnecessary pollution that contaminates ecosystems.

Given the success of the program, as of August 2025, the prescription requirement was extended to all insecticide seed coatings.[x] This came after the Department of Environment noted a partial switch by farmers to seeds treated with another class of insecticides: diamides (cyantraniliprole, chlorantraniliprole). Based on an in-house survey of suppliers, farmers, and agronomists in early 2025 and conversations that we have had with seed dealers and agronomists across Québec, it is likely that less than a third of corn seed and little to no wheat seed was treated with a diamide in 2025. For 2026, those numbers will likely be even lower. Although this marks a considerable decrease in the total use of insecticide-treated seeds from the period before the neonicotinoid restrictions took effect and diamides are not as dangerous as neonics in many ways, they do pose some of the same risks. They are equally persistent and water soluble, are extremely toxic to butterflies, and now appear in rivers and streams at levels that reach toxicity thresholds for freshwater invertebrates.[xi, xii]

But Dr. Labrie's research suggests that other insecticides, like diamides, are no more useful to farmers than neonicotinoid-treated seeds. Neonicotinoids were the active ingredients in all trials, but the fact that the non-treated plots did not yield less than the treated ones (despite the presence of significantly more targeted insects) made it clear that the conclusions would hold true for any class of insecticides. **Early season pest presence did not decrease yield, so insecticide use was not necessary at all.**

Since the neonicotinoid regulations were implemented in Québec and other research has emerged, farmers, agronomists, and the general public are much more aware of the risks of insecticide treated seeds from an environmental and public health standpoint, as well as their uselessness. In fact, most seed dealers and growers we are in communication with openly acknowledge that these seed treatments don't provide much value.

Indeed, despite there being intense pressure and outcry from the chemical industry before the prescription program took effect in 2019, in the past year there was little to no opposition to the expansion of the program to cover all insecticides on seeds. As such, we believe wasteful insecticide use will be further reduced in the coming seasons.

Importantly, since the verification of need program was first implemented for treated seeds, yields for field crops across the province have stayed the same or increased, adding yet further support for the shift towards less pesticides. Of course, farmers themselves are the ones benefiting the most from a reduction of risks associated with direct exposure to toxic compounds, in addition to paying $5 to $10 less for a bag of seed.

Agricultural Production in Québec After the Prohibition

Based upon conversations with crop advisors and FADQ, we can say that no crop failures have been documented based upon the 2019 restrictions on neonic coated seeds. Although some cases were brought up, after investigation, there were no cases of damage to seedlings, stand (population of plants/acre), or yield that could be traced back to the absence of neonics (or any insecticide for that matter).

This reality is reflected in the total yields produced in Québec, which have been roughly consistent over the past fifteen years, although influenced by climatic factors. For corn and soybean, those factors made 2019 and 2020 poor growing seasons, similar to those experienced during 2011-2014, a period of high use of neonic seed treatments. Several of the last seasons, however, have produced higher than average yields, even as the total use of insecticide treatments on seeds continues to fall.[xiii]

Personal Experience with Industry Interference with Research

On January 24, 2019, Mr. Robert was fired for having leaked (in March 2018) an internal memo to the press. In that memo, Mr. Robert warned the deputy minister that the industry exerted its influence to prevent the publication of publicly funded research that showed no advantages from the use of neonicotinoids. His firing sparked a cascade of news reports in various medias and the installment of an official inquiry by the inspector general of Québec. The report issued June 2019 publicly cleared him: in the months and years prior to going to the media, he had gone through (unsuccessfully) all the appropriate procedures detailed in the Whistleblowers Act of May 2017, and was fully in his right in going to the press.

Official apologies from the Minister (Secretary) André Lamontagne and Prime Minister François Legault shortly followed, along with full compensation and his re-installment at his position, on August 6, 2019.

He carried on his duties at MAPAQ until his retirement in 2023. Since the time that he initially leaked the memo, the science showing that seeds treated with neonicotinoids provide no benefits to Québec farmers has only grown stronger.

Dr. Labrie has faced significant harassment from the industry as well as from the research center's board of directors where she worked. She was forced to leave her position in 2017 due to relentless pressure, along with five out of the seven researchers on her team. They had just been banned from publishing any scientific research. Upon leaving the research center, Dr. Labrie was also required to leave behind all of her data. In 2019, she requested copyright over the data from the Québec government, and in 2020, she published the results of her research in the journal *PLOS One*, with the support of her colleagues who had also left the research center. An investigation by the Québec Ombudsman concluded that the research center, while obstructing Dr. Labrie's research: (1) seriously breached ethical and professional standards, (2) misused public funds, and (3) was guilty of mismanagement within a public institution. Following this report, corrective measures were implemented to improve governance and research ethics standards across all semi-public agricultural research centers in Québec.[xiv]

Conclusion

Prior to its passing, the industry had warned that Québec's proposed restrictions on neonic treated seeds would mean the collapse of the grain sector, and the Farmers Union's director went as far as calling for a government blanket payback matching at least the 5% overall reduction in grain production they expected. Since its implementation in 2019, however, the restriction on the use of neonics in Québec has not been disputed at all. To our knowledge, it is not even mentioned in the press (general or farm) anymore, nor amongst the field crop

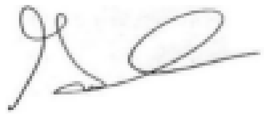
advisors.

This is because the experience of farmers, as well as the scientific literature, has made it abundantly clear that insecticide coatings, including neonics, are not useful in corn and soybean production. The reality in Québec has been that seed companies reacted quickly to the regulatory change with no effect on production or a switch to more harmful agricultural practices. While some farmers have switched to diamide coatings, the science shows that even these are unnecessary, and the growing trend has been toward abandoning insecticide treatments altogether.

If you have any questions, please do not hesitate to contact us.

Sincerely,

/s/ Louis Robert
Louis Robert Agronomist (retired)
Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec- MAPAQ



Dr. Geneviève Labrie, PhD Researcher
Centre de Recherche Agroalimentaire de Mirabel

[i] Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec- MAPAQ.

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RESEARCH ARTICLE

Impacts of neonicotinoid seed treatments on soil-dwelling pest populations and agronomic parameters in corn and soybean in Quebec (Canada)

Geneviève Labrie [1¤a*], Annie-Ève Gagnon [1¤b], Anne Vanasse [2], Alexis Latraverse [1], Gilles Tremblay [1¤c]

1 Centre de recherche sur les grains Inc. (CÉROM), St-Mathieu-de-Beloeil, Québec, Canada, **2** Département de phytologie, Université Laval, Québec, Québec, Canada

¤a Current address: Centre de recherche agroalimentaire de Mirabel (CRAM), Mirabel, Québec, Canada ¤b Current address: Agriculture and Agri-Food Canada, Saint-Jean-sur-Richelieu, Research and Development Centre, Saint-Jean-sur-Richelieu, Québec, Canada
¤c Current address: Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, Saint Hyacinthe, Québec, Canada
* glabrie@cram-mirabel.com

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Abstract

Agricultural soil pests, including wireworms (Coleoptera: Elateridae), are managed primarily with pesticides applied directly to seeds before sowing. Seeds coated with neonicotinoids have been used widely in Quebec (Canada) for several years. To assess the agronomic and economic value of neonicotinoid seed treatments in soybeans and corn in Quebec, trials were conducted from 2012 to 2016 in 84 fields across seven regions in Quebec. We evalu ated the effect of neonicotinoid seed treatments on soil pest densities, crop damage and yield. The results showed that 92.6% of corn fields and 69.0% of soybean fields had less than 1 wireworm per bait trap. However, no significant differences in plant stand or yield were observed between treated and untreated corn or soybeans during the study. This study shows that neonicotinoid seed treatments in field crops in Quebec are useful in less than 5% of cases, given the very low level of pest-associated pressure and damage, and that they should not be used prophylactically. Integrated pest management (IPM) strategies need to be developed for soil insect pests to offer effective alternative solutions to producers.

Introduction

Since the middle of the 1990s, neonicotinoids (i.e. imidacloprid, clothianidin and thia methoxam) have become the main class of insecticides routinely used to protect seeds and seedlings against injuries caused by soil insects [1, 2, 3]. Corn, canola, soybeans, wheat and cot ton are the principal crops grown worldwide for which seed treatments are used on a large scale, with a rapid increase in the acreages treated [1, 4]. A vast body of scientific literature has demonstrated that the scale of use of those insecticides has resulted in widespread contamina tion of agricultural soils, freshwater resources, wetlands, and non-target vegetation, along with design, data collection, analysis, decision to publish or preparation of the manuscript.

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repeated and chronic exposure of the organisms inhabiting these habitats to potentially harm ful concentrations of these pesticides [2, 5, 6, 7, 8, 9, 10, 11, 12, 13]. In Canada, widespread contamination of water [14, 15, 16, 17, 18, 19, 20, 21] and impacts on non-target organisms, such as pollinators [22, 23, 24, 25], have already been demonstrated.

In the province of Quebec, Canada, seeds coated with neonicotinoid insecticides are widely used as a prophylactic treatment on almost 100% of corn acreages and canola, and about 60% of soybean acreages, representing over 500,000 ha sown with treated seeds each year [26]. These seed treatments are mainly used to control soil pests, such as white grubs (Coleoptera: Scarabaeidae), seedcorn maggot (Diptera: Anthomyiidae) and wireworms (Coleoptera: Elater idae), and represent an attractive option as "insurance" against those pests because of their rel atively low cost, ease of handling and low toxicity to mammals [1, 3, 27, 28]. The treatments are generally used in the absence of any documented increase in pest threats [1, 2, 29], partially driven by current market efficiencies [30], and few studies have examined their usefulness against soil-dwelling insect pests such as wireworms and seedcorn maggots.

Wireworms are considered major soil pests worldwide [31]. More than 1,000 species are found in North America [32] and 370 species in Canada [33, 34, 35], including 30 economi cally important species. A recent study reported that 9 genera of wireworms occur in Quebec, with the abbreviated wireworm, ***Hypnoidus abbreviatus*** Say, being the most abundant species, accounting for 72% of all wireworms collected in field crops [36]. Wireworms are early-season pests that can injure seeds and seedlings in spring, reducing the establishment and growth of young plants in the field [37, 38]. Seedcorn maggots (***Delia platura*** Meigen, ***D. florilega*** [Zetter stedt, 1845]) are pests of numerous vegetable and field crops and can cause serious economic losses when larvae penetrate the germinating seeds or seedlings and mine cotyledons, small shoots and/or young roots before sprouting occurs [39, 40, 41, 42]. They are usually sporadic pests in field crops, mainly attracted by organic matter or cover crops incorporated into the soil before sowing [43, 44, 45]. In Quebec, the seedcorn maggot is observed sporadically in soy bean or corn fields, but its impact has not been evaluated on a large scale.

The debate surrounding the prophylactic use of neonicotinoids has mainly focused on the potential yield increase in corn and soybeans. Recent studies have sought to analyze whether yield differences can be observed in soybean with or without neonicotinoid seed treatments targeting soybean aphids, ***Aphis glycines*** Matsumura [46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56]. A few studies demonstrated yield increases with the use of neonicotinoid treated seeds, mainly when more than one type of pest was present in the field [51, 52], while other studies presented no differences. However, those studies focused only on above-ground pests, and none evalu ated the usefulness of neonicotinoids against soil-dwelling insect pests in soybean.

In corn, some studies have examined yield differences between treated and untreated seeds [30, 53, 57, 58, 59, 60, 61]; however, the results are inconsistent, with a recent meta-analysis covering 15 years of high dose of neonicotinoids applied to control western and northern corn rootworm in Indiana demonstrating no yield differences [30], while another study spanning 14 years and 91 trials in the southern part of the USA showed a 700 kg/ha higher yield in treated corn [59]. In the northeastern part of Canada, which has different climatic conditions and agronomic practices, no studies have been done to evaluate soil-borne insect pest pressure or the impact of using insecticide seed treatments in corn and soybean.

Our study was designed to evaluate agronomic parameters related to soybean and corn planted with neonicotinoid treated seed or untreated seed on a large scale over a five-year period in the province of Quebec, Canada. The main objectives of this project were to evaluate the impact of neonicotinoid seed treatments on 1) the incidence and abundance of wireworms and other soil-dwelling insect pests and 2) soybean and corn yield.

Materials and methods

Experimental sites

In 2012–13, an experiment was conducted at 12 and 13 corn growing sites in the Monteregie region (the main corn growing area), while in 2014–15, the study was conducted at 19 and 24 sites in seven corn producing regions across the province of Quebec, for a total of 68 sites. All sites were on commercial growers' farms. No specific permissions have been requested to col lect insects and agronomic parameters on grower's farm for the 84 trials of the project. Each site was the property of a grower, and all of them give us the right to collect insects and soil samples. The study did not involve any endangered or protected species. In 2015–16, a study on soybean was conducted at 7 and 9 sites located in the Monteregie and Centre-du-Quebec areas. The locations were carefully chosen to represent sites with high risk factors (sandy soil, grassland as previous crop, no till, organic fertilization; high organic matter) or low risk factors (clay, soybean rotation, conventional tillage, mineral fertilization) to ensure that soil-dwelling pests would be present [31, 40], and to represent the variability observed in field crops in the province. The characteristics of each site are summarized in S1 Table (Appendix).

Each site was sown with two alternating strips of treated seed and untreated seed, repeated three times for a total of 6 plots (plots were 6 to 9 m wide × 200–300 m long). Seeds were sown at a depth of approximately 4.5 cm and with 76-cm spacing between rows. The approximate sowing rate was between 80,000 and 89,000 seeds per hectare (ha) for corn, and 400,000 and 500,000 seeds per ha for soybean. All sites were sown in the direction of the slope to prevent insecticide contamination of untreated plots caused by surface runoff. Fertilization differed according to the growers' practices and consisted of mineral or organic manure (S1 Table, Appendix).

Seed treatments

For the corn study, different hybrids as well as different insecticide and fungicide seed treat ments were used, depending on the year and the corn heat units (CHU) associated with the region. In 2012, the hybrid used was K293 RR (Horizon Seeds Canada Inc.) treated with Pon cho1 600 (insecticide; clothianidin 0.25 mg/seed, Bayer CropScience Inc.) and Maxim1 Quattro (fungicides; fludioxonil + metalaxyl-M and S-isomer + azoxystrobin + thiabendazole, Syngenta Canada Inc.). In 2013, the hybrid was HZ872BtGT (Horizon Seeds Canada Inc.) treated with Cruiser Maxx1 (insecticide; thiamethoxam 0.25 mg/seed, Syngenta Canada Inc.) and Maxim1 Quattro. Hybrids with 2850 CHU were used in both years. In 2014–15, hybrids with different CHU were used depending on the region (R E50G22: RR2, Genuity, 2400 CHU [14 sites]; E61P12 R: RR, Genuity VT Double Pro, 2700 CHU [17 sites] and R E65F12: RR Genuity VT Double Pro 2850 CHU [12 sites], all from Elite1). The seeds were treated with Poncho1 600 and Maxim1 Quattro. The seeds used for the control plots in the corn assays between 2012 and 2015 were treated only with Maxim1 Quattro (fungicides). Treated and control seeds came from the same seed lots in 2012, 2013 and 2015.

In both years of the soybean study, the plots were sown with the cultivar Montero RR (Pro grain) treated with Cruiser Maxx1 (Syngenta Canada Inc.), which includes an insecticide (thiamethoxam 0.25 mg/seed) and fungicides (difenoconaxole + metalaxyl-M + sedaxane). The seeds used for the control plots in the soybean assays were treated only with fungicides (difenoconaxole, metalaxyl-M and sedaxane). Treated and control seeds came from the same seed lots.

Insect sampling

Three 3 × 3 m sampling stations, each covering four rows of crop, were installed in each strip, for a total of 18 stations per site. Stations in the same strip were installed at least 50 m apart. Each site was visited five to eight times during the growing season to install and replace insect traps, collect data on seedling damage, and harvest plants.

Soil insects were sampled using two different methods: bait traps (2012–15 in corn and 2015–16 in soybean) and soil sampling (2014–15 in corn and 2015–16 in soybean). Bait traps were used to sample wireworms, while soil sampling was used to capture wireworms, white grubs and other soil-dwelling pests. One bait trap per station was installed (18 per field) just after sowing (in May). The traps consisted of a 15 × 15 × 15 cm hole in the ground filled with bait (one cup of an equal parts mixture of wheat flour, untreated wheat seeds and oatmeal), and covered with soil. The baits were dug out and destructively inspected in the field once a week. The wireworms in each trap were collected in vials (to be counted and identified in the laboratory), and a new trap was set up near the old one. Five soil samples (10 cm diameter × 15 cm depth) were taken weekly from each strip (i.e. one per sampling station and one between each station, for a total of 30 samples per site). Insects were extracted in the laboratory using Berlese funnels (kept for 24 h under 60W incandescent light bulb) and counted. Identification was done by morphological analysis using a species key [34, 62, 63, 64, 65]. Voucher specimens have been added to the Collection nationale des insectes du Que´bec (Que´bec, QC, Canada).

Plant and seedlings observations

Plant stand and seedling damage. Corn and soybean populations were evaluated when the plants were between the 4- to 8-leaf stages. An assessment of plant stand was done by counting all the plants along the two central rows of each station over a length of 3 m.

Once a year, between 2013 and 2016, corn and soybean seedlings (2–6 leaves) were observed at each site to evaluate the main causes of damage. Three seedlings presenting symp toms (less vigorous, small or yellowing or stunted plants) or damage (holes, chewed parts) or dead seedlings were dug out at each station (i.e. 54 seedlings per site). Special care was taken when recovering the seeds to identify holes or galleries made by wireworms or other insects. Seedlings were taken to the laboratory to identify the damage. Any wireworms found were identified to species level.

Yields

To estimate crop yields under neonicotinoid treated and untreated seed treatments, soybean and corn were mechanically harvested in each strip. For the corn assays, a commercial har vester was used, and the grain car was weighed separately for each strip. For the soybean assays, the two middle rows of each strip were harvested with an experimental plot combine harvester (Wintersteiger AG, Ried im Innkreis, Austria). Subsamples of grain (corn and soy bean) were collected to measure moisture in the laboratory and results were reported based on 15% moisture content for corn and 13% for soybean. In 2015, one soybean site (Roxton Pond) was not harvested because of water accumulation during summer.

Statistical analyses

The corn and soybean data were analyzed separately using a mixed model approach to account for the non-independent spatial associations (pseudoreplication) in the data and the unbal anced replication due to missing data at some of our sites [66, 67]. Plant stands and yields were analyzed using linear mixed models (LMM) assuming a Gaussian distribution of the error and

the identity link function. Wireworm captures (bait traps and soil samples) were analyzed using generalized linear mixed models (GLMM) with a Poisson distribution of the error and a log link function. The Poisson distribution is recommended for the analysis of count data which are discrete and positive. Although plant stand is a count variable, it was normally dis tributed with a constant standard deviation. Proportions of damaged seedling were analyzed using GLMMs with a binomial distribution of the error and a logit link function. This distribu tion is recommended to analyze proportional data based on number of "success" over a known number of "trials". The bait traps and soil samples analyses were conducted on the most abundant trapping survey. Because of the high number of zeros, wireworm captures were pooled per treatment per site prior to analysis and the number of traps or soil samples was used as an offset to account for the sampling effort. Only sites with more than five captures of wireworms were included in the models.

All response variables were modelled with seed treatments (treated or untreated) and year as fixed effects. The full model for the plant stands analysis included a random intercept and slope for Site and Block (nested within Site) as random effect, while the bait traps, soil samples and yield analyses, included a random slope for Site. The best random structure for each analy sis was then determined using Akaike's Information Criterion for smaller sample sizes (AICc) [68] using restricted maximum likelihood estimation (REML). Once determined the best ran dom structures, the resulting models were refitted with maximum likelihood (ML) and the seed treatment effect was tested using likelihood ratio tests (LRT). The parameter estimates presented for the final models were evaluated based on restricted maximum likelihood.

Data exploration was carried out following the protocol described in Zuur et al. [69] and the assumptions of the models were checked visually. Analyses were performed using R lan guage [70]. Linear mixed models and generalized linear mixed models were fit with the func tions lmer and glmer, respectively, from the package lme4 [71]. The AICc values were calculated using function AICc from the package MuMIn [72] and the LRT test were per formed using function drop1.

Results

Effect of neonicotinoids on insect populations

Corn pests. A total of 1,032 wireworms were captured in the bait traps over the four years of the project (2012 to 2015). The mean number of wireworms in each trap per visit varied between 1 and 21. Among the 68 sites sampled, only five exceeded 1 wireworm per trap (three in 2013 and two in 2014; Fig 1). The main species was *H. abbreviatus*, representing 56%, 82%, 48% and 76% of the assemblage in 2012, 2013, 2014 and 2015, respectively, followed by *Agriotes mancus* Say and *Melanotus similis* (Kirby, 1837), accounting for 2 to 17% of the assemblage depending on the year. Other wireworms captured belonged to the genera *Limonius*, *Dalopius* and *Ampedus*.

The number of wireworms per bait trap did not differ significantly across locations-years between neonicotinoid treated and untreated strips (LRT; $\chi_{(1)}$ = 0.975; *p* = 0.32).

In 2014 and 2015, the number of wireworms captured in soil samples per sampling period varied between 0 and 94 larvae/m^2 (Fig 2). The main species observed was *H. abbreviatus*, rep resenting 47% and 87% of the assemblage in 2014 and 2015, respectively. For the bait traps, the number of wireworms did not differ significantly between neonicotinoid treated and untreated strips (χ^2 = 0.728; df = 1; *p* = 0.393; Fig 2).

Other soil insect pests have been observed in bait traps and soil samples, such as seedcorn maggot (*Delia platura* Meigen) pupae, white grubs (*Phyllophaga anxia* [Leconte]), *Ataenius* sp., *Aphodius* sp.), Noctuidae larvae (Lepidoptera), such as black cutworm (*Agrotis ipsilon*

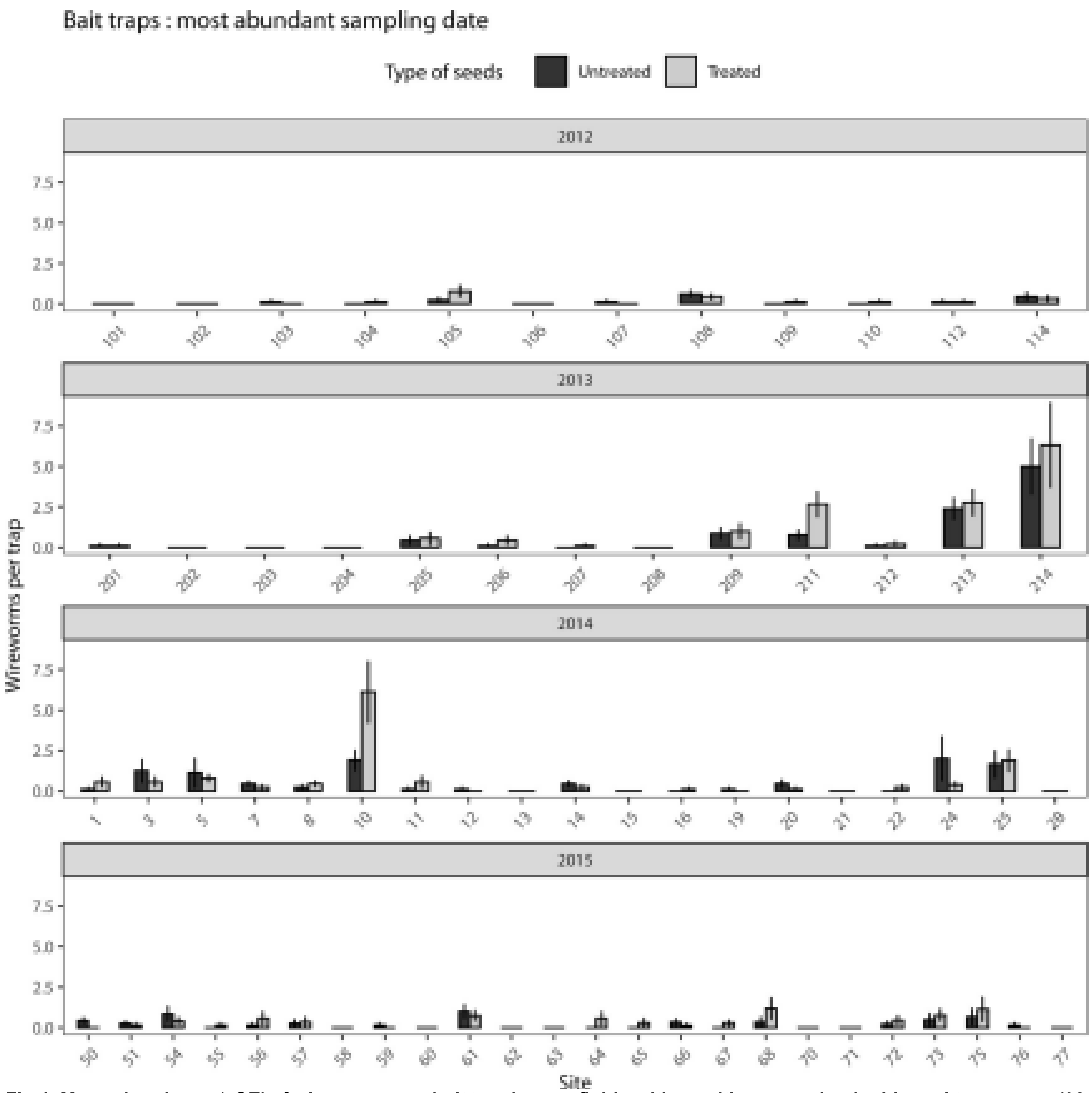

Fig 1. Mean abundance (±SE) of wireworms per bait trap in corn fields with or without neonicotinoid seed treatments (68 sites). The average number of wireworms found at each site for the most abundant visit is presented for each year: (A) 2012, (B) 2013, (C) 2014, (D) 2015. Neonicotinoid seed treatment varies between years; complete information on treatments is described in the Materials and Methods section.

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[Hufnagel]) and Tipulidae larvae (Diptera). Seedcorn maggots were omnipresent in all fields but did not affect seedlings in a systematic manner (see next section for a description of damage). Of the 239 larvae captured, only 16 were white grubs (*P. anxia*); all others belonged to the genera *Ataenius* and *Aphodius*. A total of 84 Tipulidae larvae were observed, of which 54 belonged to the species *Tipula paludosa* (Meigen). These low numbers precluded a comparison of neonicotinoid treated and untreated plots with respect to the abundance of other soil-dwelling insect pests.

Soybean pests. A total of 271 wireworms were captured in bait traps over the two years during which this sampling method was used (48 in 2015 and 105 in 2016). The mean number of wireworms captured in bait traps per sampling period varied between 0 and 2.78 (Fig 3A

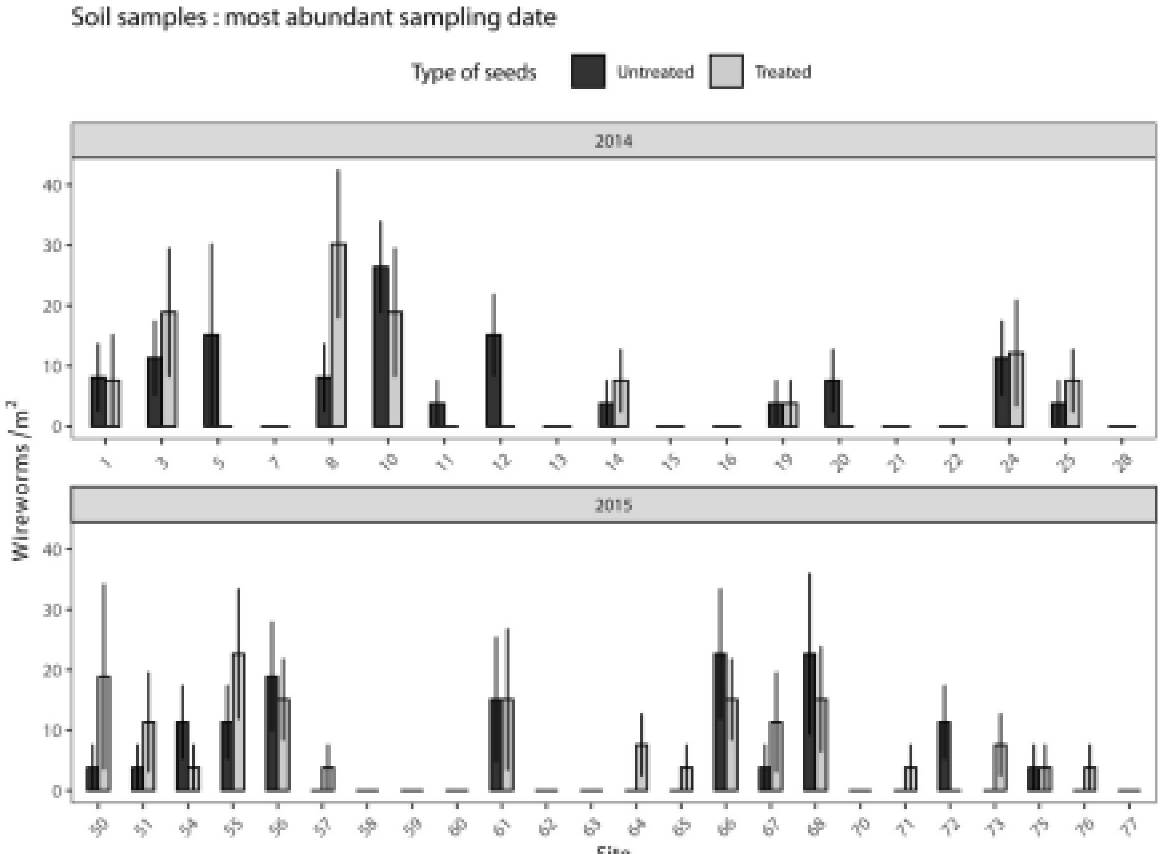

Fig 2. Mean abundance (± SE) of wireworms per m^2 in soil samples from corn fields with neonicotinoid treated strips and untreated strips in 2014 (A) and 2015 (B) (total of 43 sites).

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and 3B). The main species observed was *H. abbreviatus*, with a total of 241 specimens captured, accounting for 84% and 86% of the assemblage in 2015 and 2016, respectively. The other wireworms collected belonged to the species *A. mancus* and the genera *Hemicrepidius*, *Melanotus*, *Limonius* and *Oestodes*. Among the 15 sites sampled, 5 sites (two in 2015 and three in 2016) exceeded a mean of 1 wireworm per trap (Fig 3A and 3B). Wireworm population density did not differ significantly between the neonicotinoid treatment and the control in 2015 (LRT; $\chi^2 = 0.407$; df = 1; $p = 0.52$) and 2016 (LRT; $\chi^2 = 0.044$; df = 1; $p = 0.83$).

A total of 72 wireworms were captured in soil samples. The mean abundance varied between 0 and $59/m^2$ or 51 larvae/m^2 in 2015 and 2016, respectively (Fig 3C and 3D). The main species observed was *H. abbreviatus*, with a total of 59 specimens captured, representing 81% of the species during both years of the study. The other wireworms collected belonged to the species *A. mancus*, *M. similis* and the genera *Hemicrepidius* and *Oestodes*. Only two larvae of *P. anxia* were captured on one site in 2015 and five larvae on two sites in 2016. A higher abundance of wireworms was observed in neonicotinoid treatment strips compared to control strips in 2015 (LRT; $\chi^2 = 5.21$; df = 1; $p = 0.02$) but not in 2016 (LRT; $\chi^2 = 0$; df = 1; $p = 0.99$).

Plant stand

Corn plant stands varied between 4 and 7 plants/m during the four-year study. Overall, for all sites and years, no significant differences in corn stand was observed between treated

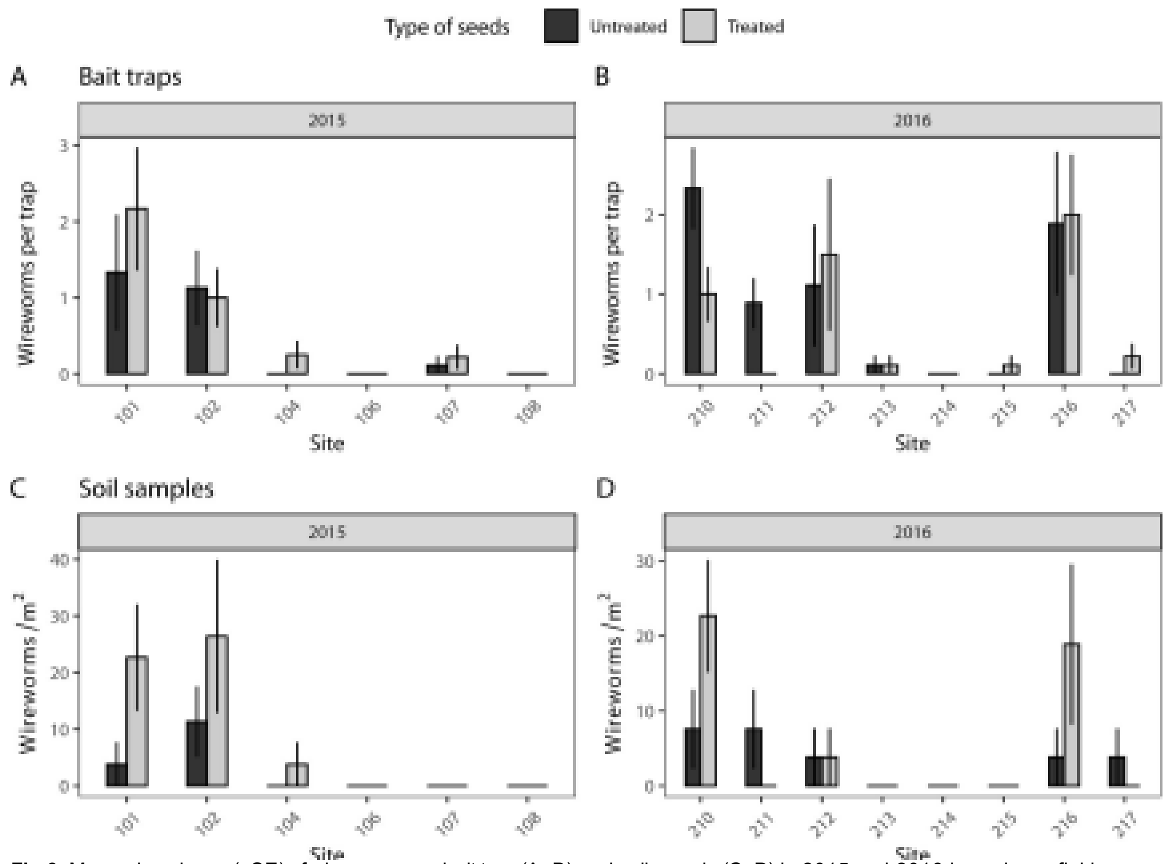

Fig 3. Mean abundance (±SE) of wireworms per bait trap (A, B) and soil sample (C, D) in 2015 and 2016 in soybean fields with or without neonicotinoid seed treatments. in 2015, only 6 of the 7 planted sites were harvested.

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(5.80 ± 0.07 plants/m) and untreated plots (5.73 ± 0.07 plants/m) (LRT; $F_{1, 67.1} = 3.20$; $p = 0.078$).

In soybean, plant stands were very variables among sites (between 16 plants/m and 76 plants/m) during the two-year study. For all sites, no significant differences in the stand of soy bean were observed between treated and untreated plots (LRT; $F_{1, 12.14} = 2.76$; $p = 0.122$).

Seedling damage

Visual inspection of three damaged plants in each plot showed that the damage associated with soil-dwelling insect pests in corn was characterized by a hole in the grain (caused by wire worms), or by smaller or less vigorous plants (caused indiscriminately by wireworms or seed corn maggot larvae). Damage was observed in 8, 17 and 19 fields (62%, 89% and 79%) in 2013, 2014 and 2015, respectively. In all years, the percentage of corn seedlings damaged by soil borne insect pests (wireworm, seedcorn maggot) was significantly higher at untreated stations (13.0%, 1.6% and 12.1% respectively) than in treated stations (7.0%, 0.6% and 7.4%) (LRT; $\chi^2 = 8.11$; df = 1; $p = 0.004$; Fig 4).

In soybean, very little damage to seedlings was observed, with only two sites presenting damage in 2015 (Nicolet: 1 plant/54 with a hole in the grain caused by wireworms; Roxton Pond: 3 plants/54 with stem damage caused by seedcorn maggot).

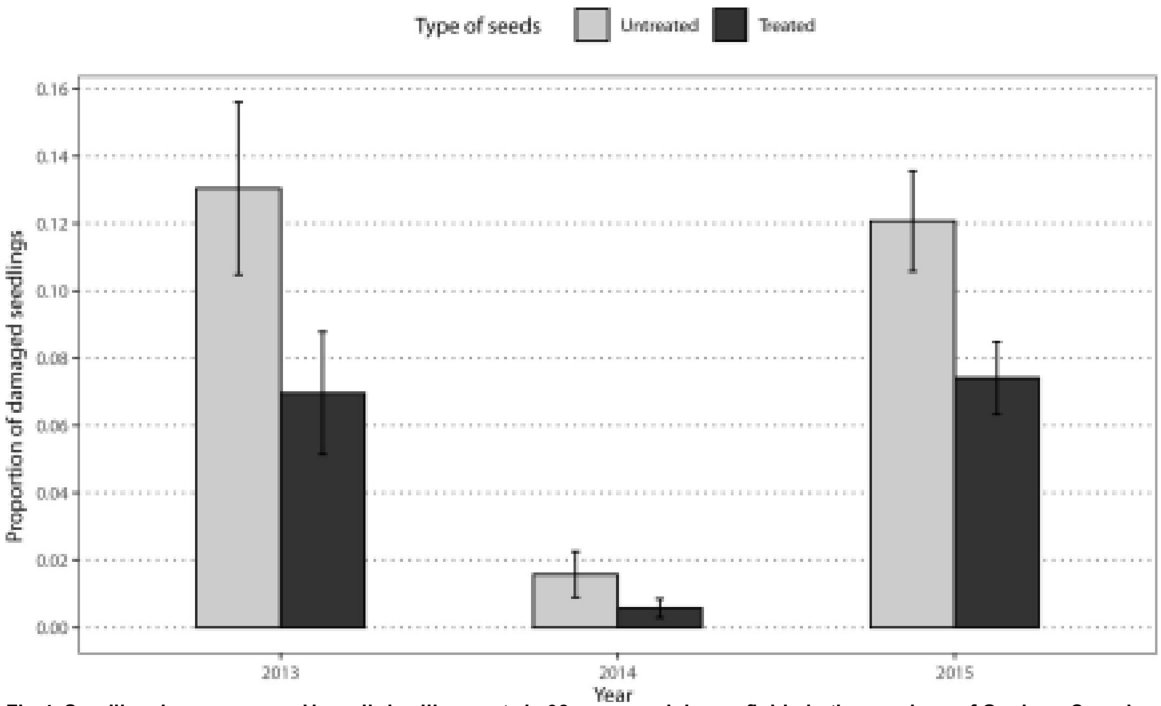

Fig 4. Seedling damage caused by soil-dwelling pests in 68 commercial corn fields in the province of Quebec, Canada, over a three year period.

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Effects of neonicotinoids on yields

In corn, yields were not significantly different between neonicotinoid treated and untreated strips regardless of the site, or the year (LRT; $\chi^2_{1, 186.42} = 3.24$; $P = 0.073$; Fig 5).

In soybean, yield did not differ significantly between neonicotinoid treated (4413 ± 170 kg/ha) and untreated strips (4330 ± 170 kg/ha) during the two-year study (LRT; $\chi^2_{1, 32.45} = 1.54$; $P = 0.223$) (Fig 6).

Discussion

This study provides a strong demonstration that insecticide seed coatings on corn and soybean are not needed as a prophylactic control measure against soil-dwelling insect pests in field crops in Quebec, Canada. Overall, the abundance of such pests, including wireworms, was low in most fields monitored and no yield difference was observed between neonicotinoid seed treatments and control plots in corn or soybean.

Effects of neonicotinoids on insect populations and damage

The main group of soil insect pests found at our corn study sites that could be managed by neonicotinoid seed treatments were wireworms. The seedcorn maggot was observed on only a few seedlings but did not cause major damage during the four-year study. White grubs were largely absent from our 68 sites. Corn rootworms were also monitored in 2012 and 2013 but were present in very low numbers [73]. This could be explained by the main rotation scheme used in Quebec (corn/soybean), which is known to reduce the prevalence of this pest species [74, 75]. Insect pressure was low at almost 90% of our corn study sites (below a threshold of 1 wireworm/bait trap), which is representative of the extensive surveys that have been done in

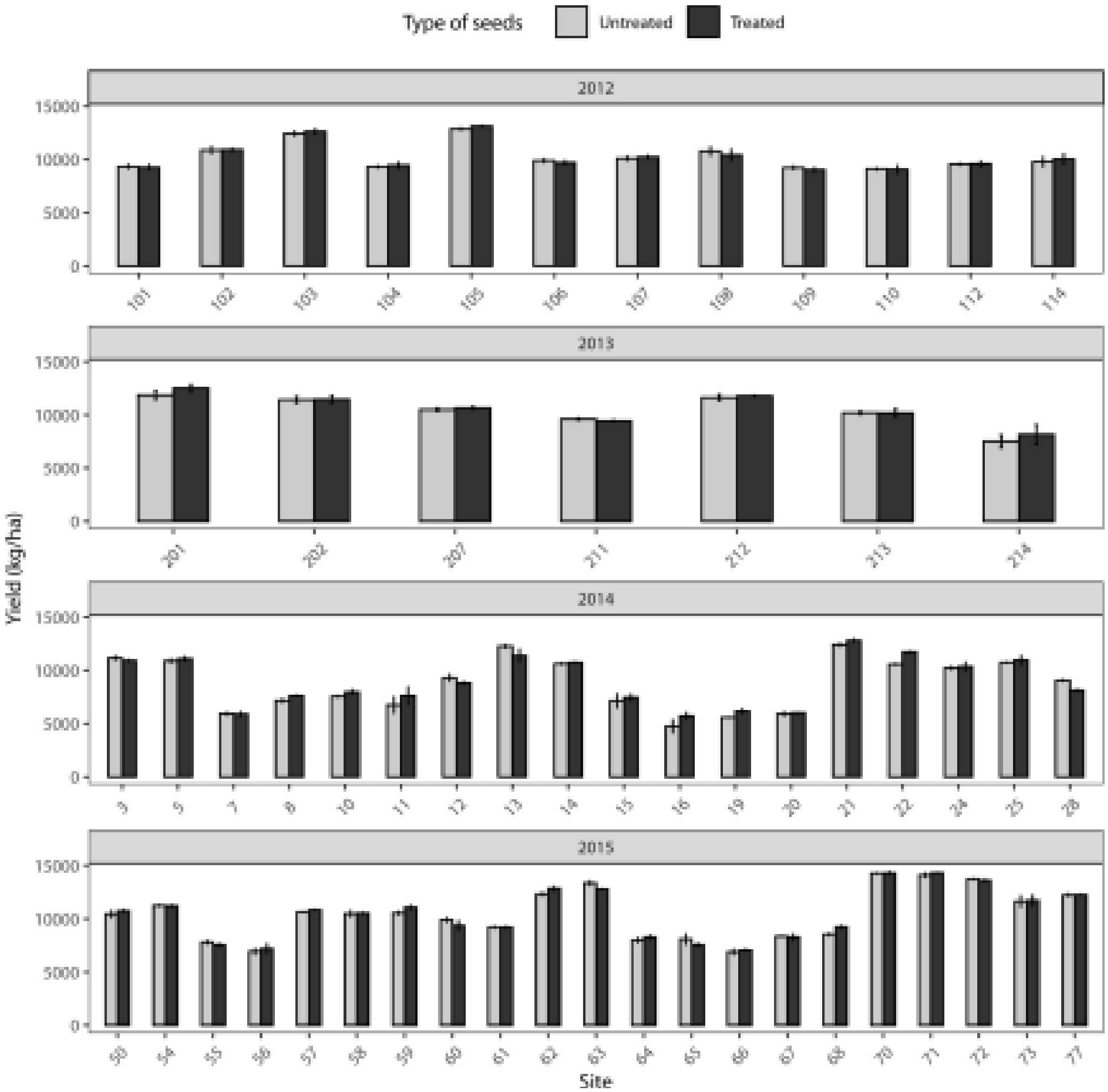

Fig 5. Mean yield (kg/ha) (±SE) in 68 commercial corn fields in the province of Quebec, Canada with neonicotinoid seed treatments or without (control strips).

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the province since 2011 [36]. Therefore, IPM strategies for soil insect pests in Quebec corn fields should focus on wireworms.

In our study, with neonicotinoid seed treatments, no decrease in wireworm abundance was found from one year to another [36]. Some studies [76, 77] have shown that neonicotinoid treatments induce a prolonged intoxication of wireworms, making them moribund for several weeks, but do not reduce their populations. Our results confirm that those insecticides did not affect wireworm population levels.

The study by Furlan [78] showed that the type and intensity of damage to corn differed between wireworm species. In this study, the three species of *Agriotes* (*A. brevis*, *A. sordidus* and *A. ustulatus*) differed in length and did not affect corn in the same manner. In our case, the main wireworm species observed was *H. abbreviatus*, very little information is available on this species' biology and food preferences and the damage it causes in corn. This species was

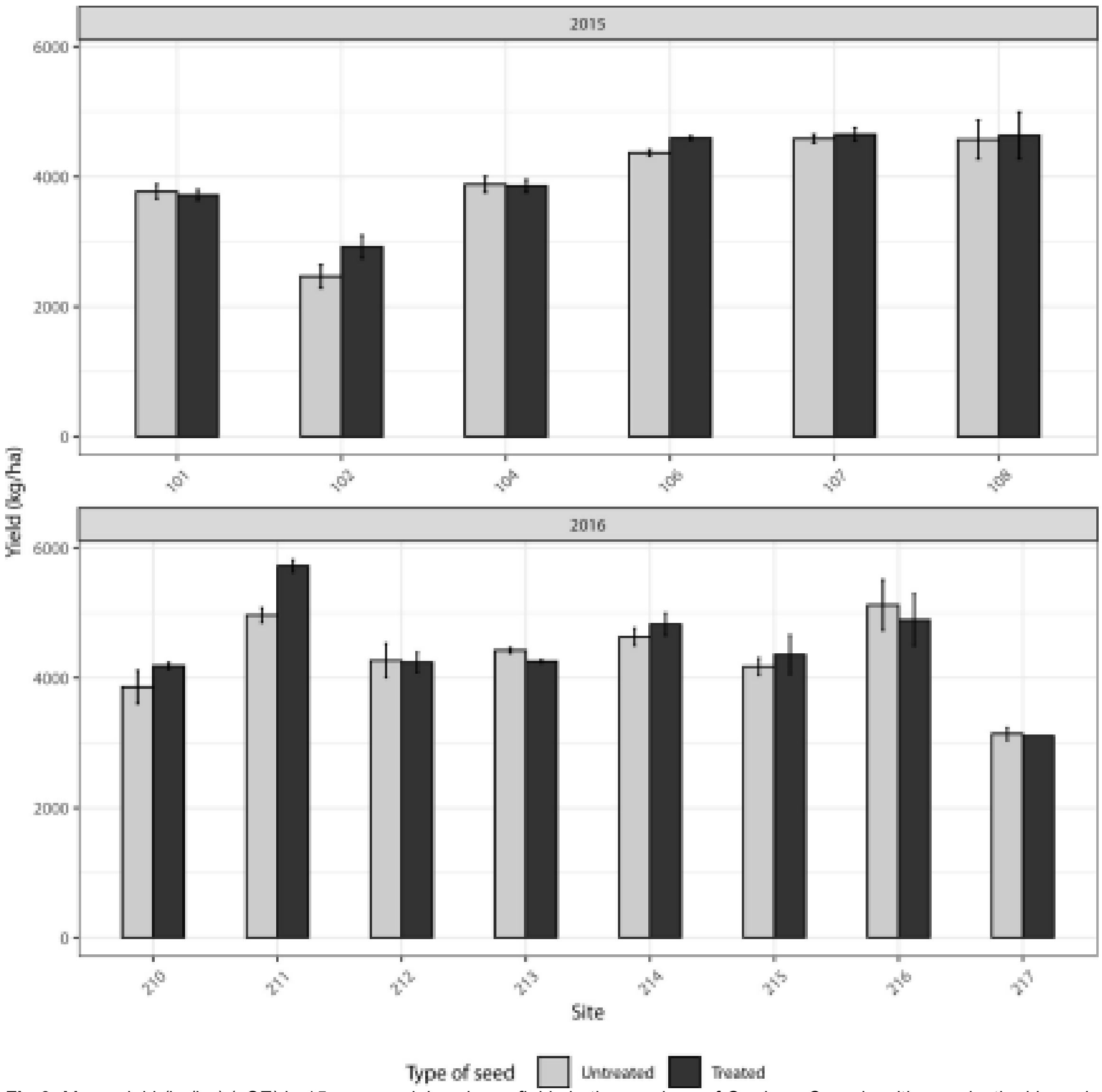

Fig 6. Mean yield (kg/ha) (±SE) in 15 commercial soybean fields in the province of Quebec, Canada with neonicotinoid seed treatments or without (control strips) in 2015 (A) and 2016 (B).

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first observed in organic soil in raspberry fields in Quebec [79, 80, 81, 82], but no information was available on the type and intensity of damage it causes in corn or soybean. We observed higher proportions of damaged corn seedlings in untreated corn plots in 8, 17 and 19 fields in 2013, 2014, and 2015, respectively. In Europe, the presence of 5 to 10 larvae per m^2 caused 30% mortality of maize seedlings [83]. Furlan [78] observed that a loss of 1 corn plant per m^2 could cause significant yield losses. In our study, we observed more than 10 larvae per m^2 in 11 (58%) and 10 (42%) fields in 2014 and 2015, respectively, but no differences in plant stand or grain yield were observed. The main damage that was observed in the seedlings was a hole in the grain, which can cause growth delay and sometimes no growth at all. However, the conse quences were generally limited to irregular plant heights in different portions of the field. This kind of damage, less intense than that caused by larger wireworm species such as *Agriotes* spp.

[84] or *Melanotus* spp. [85, 86], could explain the lack of differences in corn plant stand or grain yield between treated and untreated strips.

These results call into question the threshold of 1 wireworm per bait trap [83] commonly used for our main wireworm species, *H. abbreviatus*. This threshold was developed for *Agriotes* spp. found in northern France. Furlan [78] demonstrated that thresholds could differ with wire worm species and the type of damage they are causing. He identified thresholds varying between 1 and 5 wireworms per bait trap for species with a length between 40 mm and 12 mm. In our case, *H. abbreviatus* measured 12 mm at the last larval stage [36] and did not cause signif icant damage to corn plants. A study conducted in 2016 at 162 sites in Quebec showed that 5% seedling damage was observed when more than three wireworms/bait traps were found in the fields [87]. This suggests that the threshold for *H. abbreviatus* could be closer to three wire worms per bait trap, but this remains to be validated [87]. This low pest pressure, due in part to the prevalence of *H. abbreviatus*, a different wireworm species than the ones observed in other parts of Canada or the USA [88, 89, 90], could explain the lack of yield differences in our study.

In soybean, although high wireworm populations were observed in some fields, almost no damaged grains or plants were observed. Wireworms feed mainly on cereals [37, 84]; hence, soybean, a legume species, may not be an adequate food source for larvae. Although other soil insect pests could pose a threat to soybean, such as white grubs or seedcorn maggot, very small populations of those pests have been observed in monitored fields. However, they could become a problem in some years, sporadically, when harsh weather conditions are experienced [47, 48, 91, 92]. The wet springs that sometimes occur in Quebec can increase the damage caused by those pests, and insecticide seed treatments could be useful in such conditions. Soy bean aphid, *Aphis glycines* (Matsumura), is one of the pest species targeted by neonicotinoid seed treatments. In one study [93], observations of soybean aphid populations showed that the threshold was not reached in all fields in either year. Aphids emerged too late in fields to be controlled by insecticide seed treatments, a finding also reported in other studies in the United States and Quebec [93, 94]. Overall, very low pressure associated with soil insect pests were observed in soybean in both years of the study.

Effects of neonicotinoids on corn and soybean yields

Overall, our study did not show any differences in grain yield between treated and untreated corn or soybean seed. Several factors may help explain these results, such as low pest pressure, compensatory growth, rapid decrease in neonicotinoid concentrations within the plants, or the absence of other non-abiotic stresses.

Some studies have reported an increase in yield associated with insecticide seed treatment when wireworms were present in high abundance [61] or when more than two pest species were present [51]. For example, Wilde et al. [61] evaluated the effect of seed treatments on wireworms in corn and found that this approach increased plant stands and grain yield almost 50% of the time, mainly when insects were present in high numbers. The same conclusion emerged from an overall analysis of soybean yield increases across the USA [51, 56], in which insecticide seed treatment was found to be useful only when three foliar-feeding pest species were present at the beginning of the summer. Cox and Cherney [48] showed, however, that there is high variability in soybean yield for the same varieties and seed densities at different locations in North America, and that the use of insecticide seed treatments did not provide benefits to all growers. In corn, a meta-analysis combining 15 years of U.S. data revealed that even at the highest dose used against corn rootworm, there was no significant benefit of using seed treated corn [30]. However, North et al. [59] found the opposite results in an analysis of 91 trials on 14 years in mid-south USA, with global yield gain of 700 kg/ha in corn treated with neonicotinoids. Such a high level of variability between studies could be explained by climatic conditions, which varied between sites and years, by the abundance of pest species and by the efficiency of the insecticides. Alford and Krupke [95] reported that less than 1.5% of clothianidin applied to the seeds translocate through the roots and shoots of corn plants under field conditions and that this treatment did not cover the entire window of activity of all soil insect pests. This temporally limited protection from insecticide within the plant could in part explain the variability in yield differences between treated and untreated plants in many field studies [57, 58, 61].

Overall, insect pest pressure was low in the five years of the study. Wireworm populations were below the threshold of 1 wireworm/bait trap in 69% of the soybean fields and in 92% of the corn fields. If we consider a threshold of 3 wireworms/bait traps, the threshold was reached in only 2 corn fields. White grub and seedcorn maggot numbers were also very low in all our fields. Even though some damage to seedlings was observed in corn fields and plant stands were greater in treated soybean plots, no overall differences in yield were observed.

A "stress shield" or growth facilitation effect has been observed with neonicotinoid treated seedlings in a few studies on corn, sorghum and wheat [96, 97, 98, 99]. Increased growth has been observed for neonicotinoid treated seeds compared to untreated seeds when exposed to different stresses [96, 97, 98, 99]. This "stress shield" may be observed mainly in response to drought stress or weed pressure. In our study, however, no such effect has been observed, which could be explained by compensatory growth. Compensatory growth is the increase that occurs in plant growth rate following a period of stress, such as drought, or increased plant population density [100, 101]. This compensatory growth is well documented in corn [30, 96, 100, 101, 102] and soybean [52, 103]. The stress caused by soil insect pests feeding on young seedlings could have triggered this phenomenon of compensatory growth, which would explain the lack of difference in yield.

Various IPM strategies have been developed in recent years for soil insect pests with the aim of reducing the use of insecticide seed treatment. Pest management of wireworms does not require the prophylactic use of neonicotinoids and in cases where pest densities are high, alternatives to insecticides exist. Some approaches are still being tested, such as mass trapping of adult wireworms with light traps [104], crop rotations with brown mustard or buckwheat [105], attraction to insecticide-treated wheat grown between untreated potato rows [106]; they represent alternative control measures that are under development in Canada. Other methods, such as trap crops using pea and lentil [107] or the use of entomopathogenic fungi such as *Metarhizium anisopliae* [108, 109, 110] could be tested on a large scale against wireworms.

Furlan et al. [111] proposed a mutual funds approach covering the risk of implementing IPM programs for Italian producers, which increased farmer profits while reducing the use of pesticides. In Quebec, a decision support tool was developed based on a boosted regression analysis of all physical and landscape parameters that favour the presence of the main wireworm species in the province, *H. abbreviatus*. This tool is freely available online (VFF Qc, available at www.cerom.qc.ca/vffqc), and allows producers to predict the risk of encountering a high abundance of this wireworm species [87].

Our study clearly demonstrates that neonicotinoid seed treatments in corn and soybean are not justified in about 95% of the field crop acreage in the province of Quebec, which represents 500,000 ha of fields (corn, soybean and cereals). While the use of neonicotinoids is to be phased out completely in Canada by 2021 [112], other insecticide treatments are replacing them; they are based on the same marketing strategy of insurance against the risk of pest attack. With these new products, the same limited availability of untreated seed is observed as is the case for neonicotinoids. The widespread use of insecticides as seed treatments—even if the new products are potentially less harmful to the environment and human health—will not be sustainable over the long term, and will increase risk of the insects developing resistance [2, 30] along with contamination of the environment. An exponential increase has been observed in the levels of these new insecticides in rivers in Quebec since they were registered as seed treatments; they are already reaching the maximum allowable concentrations for aquatic life in some places [17]. IPM strategies based on pest densities and risk factors represent a more sustainable solution for protecting field crop from threats and for preserving the environment and human health.

Supporting information

S1 Table. Characteristics of the 84 experimental sites followed between 2012 and 2016 in corn and soybean in Quebec, Canada. Fertilization: Organic fertilization involves the use of manure, but unspecified.
(CSV)

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Author Contributions

Conceptualization: Geneviève Labrie, Annie-Ève Gagnon, Anne Vanasse, Gilles Tremblay.

Data curation: Geneviève Labrie.

Formal analysis: Geneviève Labrie, Alexis Latraverse.

Funding acquisition: Geneviève Labrie, Annie-Ève Gagnon.

Investigation: Geneviève Labrie.

Methodology: Geneviève Labrie, Annie-Ève Gagnon, Alexis Latraverse, Gilles Tremblay.

Project administration: Geneviève Labrie.

Supervision: Geneviève Labrie.

Validation: Geneviève Labrie, Annie-Ève Gagnon, Anne Vanasse, Alexis Latraverse, Gilles Tremblay.

Labrie.

Writing – original draft: Geneviève

Writing – review & editing: Annie-Ève Gagnon, Anne Vanasse, Alexis Latraverse, Gilles Tremblay.

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Cornell CALS

College of Agriculture and Life Sciences

Entomology

February 20, 2026

Dr. Scott McArt
Department of Entomology
Cornell University

Hi folks, my name is Scott McArt and I'm an associate professor of entomology at Cornell University.

In June 2018, my group was commissioned by the Cuomo administration in New York to conduct a risk-benefit analysis for neonicotinoid insecticides. Over two years, we comprehensively synthesized all peer-reviewed literature and land-grant university extension publications on risk to pollinators and economic benefits to farmers & applicators for each context in which neonicotinoid insecticides are used. We published our 432-page report in 2020, ultimately informing the Birds and Bees Protection Act, which was passed in New York in December 2023. A similar bill was signed into law in Vermont about a year later. And you folks in Colorado are presently considering a similar bill.

For risk to pollinators, our report's most important finding is that in and near corn and soybean fields that are planted with neonicotinoid-treated seeds, exposures are likely to impair or stop honey bee reproduction 37% of the time.

This high risk to honey bees from neonicotinoid-treated corn & soybean seeds is paired with a strikingly small proportion of fields that benefit economically from using neonicotinoid-treated seeds. Specifically, the data show that only 2-7% of corn & soybean fields improve yield and experience an economic benefit. In other words, between 93-98% of farms are losing money from using neonicotinoid-treated corn and soybean seeds.

IPM-based pest control options are readily available for field crops farmers. Thank you for making an informed evidence-based decision on this topic.

Sincerely,

Scott McArt

Link to our full 432-page risk-benefit analysis for neonicotinoid insecticides:
https://cornell.app.box.com/v/2020-neonicotinoid-report

Scott McArt, PhD
Associate Professor

Department of Entomology
4132 Comstock Hall

Ithaca, NY 14850
Office: 607-255-1377

blogs/cornell.edu/mcartlab
pollinator.cals.cornell.edu

My name is Cory Kreft and I have been a commercial migratory beekeeper since 2001. I was born and raised in Southeast Colorado. My heart is in this valley, and I've worked in agriculture here my entire life. I first started taking care of bees in 1996 when I was 15 years old, where I worked for a honey farm during summer break in high school and junior college.

From 2008 to 2013, I raised healthy bees that produced healthy honey crops. I was producing 200 barrels of honey from 1,400 colonies. My business was so successful that I was able to purchase the honey farm that I grew up working for in the 90's. Losses were minimal and my hives were strong.

All of that changed in the mid-2010's, around when use of neonicotinoid as seed coatings for field crops really took off. What started as a few lost hives turned into devastating losses. I went from losing 15-20% of my hives to losing anywhere from 65-85% of my hives. Year after year, I would return to a small fistful of bees with the queen in the middle. The rest of my bees had all disappeared.

Last year was one of my worst years. I went from 2900 hives to 432 hives. That's over 85% loss.

Rebuilding hives is a laborious and costly exercise. For each healthy hive, I can expect to profit approximately $200 annually, but a dead hive will cost you $450. This is because of all the work that goes into replacing a dead hive: you have to stack and store the hives in shipping containers, maintain them while they're in storage, and keep the containers clean. **Losing 85% of my hives cost me over $1,100,000 last year.**

Even for the bees that do survive, they are weak. I used to produce 200 barrels of honey from 1,400 colonies. **I now produce 16 barrels of honey from 2,400 colonies.** I am struggling to maintain 15% of what I used to produce in 2008. Things are so bad I expect 65% annual loss each year, which was never a sustainable goal to begin with, but now I can't even maintain those losses.

I am certain it is neonicotinoids that are killing and weakening my bees. I grew up learning about neonicotinoids. I remember listening to conversations my boss would have with scientists and legislators about how they impair a bee's navigation system and make it harder to keep a healthy hive. Neonicotinoids take away a hive's field force, and that's exactly what happened with mine. I learned that the EU banned neonics and that they had been experiencing similar losses that I was, but after the ban, their bees went from failing to flourishing.

My bees and I are surrounded by conventional corn and sorghum. There has always been corn in Southeast Colorado, but there is more corn in this valley than I have ever seen before, and nearly all corn seed is coated with a neonicotinoid.

I have spoken to decisionmakers and shared my story. The most common question I get in response is, "what about the losses that farmers could face?" But I am a farmer. What about the losses I am already experiencing? Why did I deserve to lose a million dollars last year?

My grandfather was a successful farmer from the 1960's to 1990's, and he never relied on a neonicotinoid treated seed. Most farmers don't need neonicotinoids on their seed, but they purchase it because untreated seeds are harder to find. The SEED Act would give farmers better options while also protecting my bees and my livelihood. Please stand up for me and everyone else in farm country who is hurting because of these dangerous chemicals.

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Dru Spinuzzi – Drubeez Honey

Good afternoon,

My name is Dru Spinuzzi. I am the owner of Drubeez Honey, and I have been keeping bees in Colorado for 12 years.

I started with one hive that my children gave me for my birthday. What began as curiosity grew into passion. Over the years I expanded from a hobbyist into what we call a sideliner operation, sometimes managing 75 or more hives.

In beekeeping, there are three general levels:

- Hobbyists
- Sideliners
- Commercial operators

And it's important to understand that hobbyist beekeepers make up over 90% of beekeepers in the United States. They are environmental stewards in neighborhoods, towns, and rural communities. They pollinate gardens and small farms. They educate the public. They share local honey and wax within their communities. They are the grassroots of pollinator health.

When they experience discouraging losses, many leave beekeeping altogether — and that weakens the entire pollination network.

Two years ago, I doubled my hive numbers. They were strong. Honey supers were stacked. It was harvest time. I went to one yard south of town that had 50 hives. Two weeks earlier they were full of bees. When I returned, the yard was silent. No piles of dead bees. No clear robbing. Just empty boxes and a few struggling queens. Nationally, annual colony losses average around 30–40% according to USDA and university surveys. Beekeepers plan for loss. This was 100% loss in that yard. That is collapse.

After that loss, I spent the winter researching and speaking with other beekeepers and growers.

Neonicotinoids are systemic insecticides widely used as seed treatments in crops like corn and sorghum. Because they are systemic, they move into pollen and nectar. Research shows they can persist in soil for multiple years depending on conditions. Studies have detected residues in surface waters in agricultural areas.

Laboratory research has demonstrated lethal and sublethal impacts on honey bees, including impaired navigation and foraging behavior. Field research continues to evolve, but concerns remain.

A significant portion of corn seed in the United States is sold pre-treated with neonic coatings. In some cases, untreated alternatives are not readily available unless specifically requested.

This is not about blame. It is about stewardship.

Farmers face real pest pressures and tight margins. Bees and agriculture are not enemies. Bees are agriculture.

But coexistence requires balance.

It requires transparency about seed treatments.
It requires access to untreated seed options.
It requires continued evaluation of long-term environmental persistence.
It requires communication between growers and beekeepers.

Bees do not recognize fence lines. Water does not stop at property lines. What enters the soil can move into water systems. What persists in the environment becomes part of the broader landscape we all share.

I am deeply concerned about the future of my children and my grandchildren. This is not just about bees anymore. When research shows that certain chemicals can persist in soil for years and are detectable in water systems, it raises questions about long-term environmental accumulation. It raises questions about cumulative exposure — not just for pollinators, but for wildlife and for people.

I am not standing here claiming to be a toxicologist. I am standing here as a mother and a grandmother who believes it is time for everyone in the state of Colorado to pause, look around, use common sense, and protect what we have.

We all drink the same water. We all depend on the same soil. We all eat food grown in this state. Stewardship should not be controversial.

Honey bees contribute approximately $15 billion annually in added crop value to U.S. agriculture. They support fruits, vegetables, nuts, forage crops, and seed production.

In the last six years, I have doubled my hive numbers — yet my honey production has declined from what should average 40 pounds per super to closer to 12–15 pounds per hive.

Queens cost around $40 each. Replacement bees are expensive. Varroa mites require constant treatment. Drought stresses forage. Beekeeping is already difficult. Large unexplained losses make it unsustainable — especially for hobbyists, who make up over 90% of beekeepers.

If hobbyists walk away, we lose education, advocacy, and local pollination support.

I am not asking for extreme action.

I am asking for:

- Continued science-based review of systemic insecticides

- Transparency and clarity regarding treated seed
- Meaningful access to untreated seed options
- Ongoing collaboration between agricultural and pollinator communities
- Policy decisions grounded in long-term stewardship

Please read the bill carefully. Listen to agricultural producers. Listen to beekeepers. And most importantly, consider the long-term health of Colorado’s land, water, agriculture, and families.

I stood in a yard of 50 silent hives. That moment stays with you. I am still here. Still keeping bees. Still working alongside farmers. And still asking that we protect the land and resources that sustain all of us — not just for today, but for our children and grandchildren. Because stewardship is not political. It is generational.

Thank you.

Dru Spinuzzi

Senate Agriculture & Natural Resources

02/26/2026 01:30 PM

SB26-065 Systemic Insecticide Use Limitations

Typed Text of Testimony Submitted

Name, Position, Representing	**Typed Text of Testimony**
Nic Korte For Grand Valley Audubon	Declining populations of birds are obvious to us from year-to-year. We see it in our annual census, the Christmas Bird Count, and in our normal trips to the field. Neonicotinoids (neonics) kill indiscriminately, exterminating not only â€œpestsâ€� but also beneficial insects. They work their way up the food chain, killing birds and harming human health. Research has demonstrated that exposed birds can quit eating, fail to reproduce, become unable to migrate, become paralyzed or experience seizures (as this insecticide targets the nervous system). Neonics are often used to pretreat seeds before planting but they are also sprayed on leaves. Less than 5% of the neonic gets absorbed in the plant; the remaining 95% persists in the soil, water, and air. We support this bill because it would reduce unnecessary use of â€œneonicsâ€�. Nonetheless, it would allow field crop seeds to be treated with systemic insecticides when theyâ€™ll be determined to actually help farmers. It would improve farmer access to seed without unnecessary insecticide coatings. It would protect crops that depend on pollinators and reduce pollution across Coloradoâ€™s lands and waters.
Brent Johannes For themself	The European Union has banned the same chemicals considered in this legislation. If their farmers can do without it, I think our farmers can also. Wildlife populations are suffering and we need to make changes. Please pass this bill.
Patrick Hume For themself	My name is Patrick Hume. I am a small grains farmer and beekeeper located in Springfield, Colorado and I am writing to you today to express my support for SB26-065 - Systemic Insecticide Use Limitation Bill. For close to 10 years, I have attempted unsuccessfully to procure non neonicotinoid treated Corn, Milo, and Sunflower Seed for use in my 6000 acre operation from a multitude of seed providers unsuccessfully. I object to ubiquitous application of these seed treatments because I don't believe these insecticides are necessary for the high plains desert region in Baca County that I farm. In my region we typically do not have soil derived insect pests, even under irrigation. I find it a direct violation of my Integrated Pest Management plan to be effectively forced to apply broad spectrum insecticides without first demonstrating a presence of a pest and then ensuring pest populations meet an economic threshold before application. By violating my IPM plan I risk inadvertently poisoning natural beneficial predator insect populations that could by themselves keep pest insect population

	below economic threshold levels, causing unnecessary economic and pesticide burden to my operation. Since I started bee keeping, I have not had a year where my mortality rate for colony losses was at or below USDA established normal level of 25%. Originally, I believed my loss rate was due to Verona mite infestation and frigid artic vortex conditions, but as my mite treatment plans have improved and winter conditions have warmed, I question if these unwanted seed treatments are to blame. I base this assumption primarily on research articles detailing neonicotinoid sublethal effects, specifically navigation impairment, and my direct observation of absconded hives lacking all bees in hives full of honey in the spring. I feel that if SB26-065 passes I will finally be able to opt out of unnecessary seed treatment that in my opinion has caused more economic harm than good to my and my partnersâ€™ operations. And in the event a soil derived pest does establish itself the ability to opt in on these then justified treatment options, maintaining my IPM plan.
Alejandro Calixto For themself	My name is Alejandro Calixto, and I serve as the Director of the Cornell Integrated Pest Management Program. I am here to highlight key findings from Cornell Universityâ€™s extensive research evaluating alternatives to neonicotinoid insecticide seed treatments and assessing both their risks and their real world benefits. Cornellâ€™s studies make several points clear. Firstâ€”while neonicotinoids can provide benefits to some crops, they also carry significant ecological risks when used as seed treatments, particularly to pollinators and beneficial insects. Federal assessments further confirm that neonicotinoids used in this manner may jeopardize the survival of more than 200 threatened and endangered species. To better support growers, reduce reliance on these insecticides, and return to foundational Integrated Pest Management practicesâ€”including assessing pest risk before selecting a management toolâ€”Cornell has conducted the largest multi farm, multi year field studies to date, spanning 2022 to the present. These studies, carried out on nearly 80 farms across New York State, evaluated both actual pest pressures and the performance of neonicotinoid seed treatments compared to alternative products, including the option of no insecticide seed treatment, with a strong emphasis on determining pest risk. One of the most important findings is that the risk of pest damage is less than 1% in field corn, sweet corn, and soybean. Several IPM tacticsâ€”including using no seed treatment at allâ€”provided benefits equivalent to those of neonicotinoid treatments. This demonstrates that effective pest management begins with evaluating pest risk, which in many cases is extremely low. Taken together, Cornellâ€™s research shows that the ecological risks of neonicotinoid seed treatments are high, while their practical benefits are inconsistent

	and often limited in real world agricultural settings. At the same time, effective alternativesâ€"including risk based decision making and, when appropriate, no seed treatment at allâ€"demonstrate that agriculture can reduce reliance on these insecticides while maintaining productive, resilient farming systems. Thank you. Alejandro Calixto, Ph.D. Director, Cornell Integrated Pest Management
Ingrid Moore For themself	I strongly support this bill. Please vote YES to pass it out of this committee. The importance of this bill cannot be overstated! We must re-think the wasteful and unnecessary default use of neonicotinoids to pre-treat crop seeds. Fun fact: one treated corn seed contains enough active ingredient to kill 250,000 bees! It is also lethal to other wildlife, such as birds, and even large mammals! (We are large mammalsâ€¦) We live in an environment awash in chemical poisons. Research shows Neonicotinoids are present in our ground water, surface water, tap water, and our bodies! In one study a high percentage of pregnant women tested showed high levels of this poison. Hardly any water treatment systems remove these chemicals. Arguments from agriculture that these poisons are necessary for profitable crop yields have been DISPROVEN BY RESEARCH showing that there is NO ADVANTAGE TO CROP YIELDS USING COATED SEEDS. Another argument is that untreated seeds are not widely available. Passing this bill will start a movement to create a DEMAND for untreated seeds and the producers will respond. The sponsors of this bill can provide references to the research mentioned above. I am so grateful to Senators Kipp and Wallace, and Reps Brown and Velasco for sponsoring this bill. Please vote YES.
Simone Colburn	Please vote yes on bill SB26-065 to put in place far-overdue regulations on systemic insecticide use. Coloradans deserve to live in a clean environment with healthy water,

For themself	soil, and food. Systemic insecticides release poison into the body of plants. The chemicals then seep into the soil and can last for years. While the toxins are not sprayed into the air, they are designed to last within the plantsâ€™ over 80% water content. The non-persistent compounds of the insecticide are quickly degraded in soil and water, lasting as rain washes the chemicals into nearby streams or as it seeps through the soil into groundwater reserves. The ecosystem as a whole suffers from systemic pesticides. The nectar and pollen hold the toxins and endanger pollinators which have declined 72% in Colorado since 1998. For thousands of years, we have worked with rather than against nature. Only in the last century did we move away from natural methods of growing healthy food to place poison inside of plants. If this rhetoric around nature and health comes off as a snobby intellectual concern, bare with me. Iâ€™ve been involved in environmental and climate justice work since I was in high school, but until recently I had fallen for the narrative that â€œhealthy, sustainableâ€� food is only a concern of wealthy residents who are hyper-sensitive to wanting reusable straws and pretty greenery. Really, the food we eat dramatically affects our health and our ecosystems and the impacts are not equally distributed. Pesticide use is linked to neurological disorders, cancers, diabetes, and respiratory illnesses. Those living closest to polluted soil and waterways are often the same communities that reside in food deserts without access to organic foods. It is unjust to make individuals, who already have to balance concerns about grocery bills, childcare, and a roof over their heads, figure out which foods are so toxic that the chemicals canâ€™t be cleaned off by merely washing them. The Environmental Protection Agency, unlike other countriesâ€™ regulating bodies, uses the approach that each chemical is â€œinnocent until proven guilty.â€� Big corporations that prioritize their wealth over consumers make sure to defend themselves against a guilty sentence. As our elected officials, you have the knowledge and the means to pass policy that protects Coloradans right to live in a healthy environment and access to safe food.
Amanda Martinez For themself	Hello, My name is Amanda Martinez, and I am a bird and native plant advocate representing myself who works for Audubon Rockies. I also care deeply about the health and safety of our food supply and the people who grow it. Iâ€™m located in Loveland, CO, and I am very concerned about neonicotinoid or â€œneonicâ€� pesticide pollution in Colorado, especially from treated seed. These systemic and toxic chemicals are in our water and bodies, and theyâ€™re driving pollinator and bird losses. One treated seed can kill a songbird or 250,000 bees! Neonics kill insects indiscriminately, meaning we are losing important insect populations at unprecedented levels, including predator insects that would protect crops. I remember seeing many more insects, butterflies, and bees in my youth, when on trips with family or out enjoying nature. Now, seeing a butterfly feels like a special occasion. That shouldn't be the case.

	For decades now, research has shown that the use of neonics on corn rarely results in higher yields. This prescriptive use of pesticides is like taking antibiotics when you don't have an infection. Additionally, we know that a large portion of the pesticide ends up in the soil and water causing runoff pollution that can affect people and can cause neurological damage. This is not only dangerous but a waste of money and resources for farmers. Our farmers deserve better, safer seed choices, and we should return their autonomy to make their own choices about what is best for them, and many farmers want that freedom. I strongly urge the Legislature to support SB26-065, the SEED Act, to help farmers make safer choices. Best, Amanda Martinez

Thank you for the opportunity to provide testimony in support of SB26-065 Systemic Insecticide Use Limitations. I am a professor at Michigan State University who has worked for three decades on pollinators, pollinator declines, causes of decline, and opportunities for recovery. This includes for common as well as US Endangered Species. Further, I lead a long-term research program that has, for nearly four decades, studied how we can use ecology rather than chemistry to manage sustainable agricultural systems.

The latest research shows that pollinators are declining, and neonicotinoids are the leading cause of decline

In 2024, my lab showed that insecticides, especially neonicotinoids, rose above other threats as a leading cause of insect decline (Van Deynze, et al. 2024). Working in the Midwestern US, we assembled decades-long data on butterfly abundances, temperature, precipitation, land cover, and all classes of pesticides. We then compared the effects of global changes. We found that insecticides were a consistent, long-term cause of decline. Further, on a year-to-year basis, neonicotinoids had the strongest, negative effects on butterfly abundance. Other recent studies have also found pesticides, including neonicotinoids, as critical factors causing pollinator decline (Guzman, et al. 2024).

In 2025, my lab published the definitive study showing that butterflies have declined across the United States (Edwards, et al. 2025). We have lost a quarter of all butterflies in the last two decades. Butterfly abundances in Colorado and neighboring states are declining even faster than the national average. Of 342 different butterfly species assessed, 245 species declined in abundance by more than 10%; the median species declined by 42%.

Butterflies are a critical indicator for insect and pollinator decline more generally. Butterflies are the only insect group for which we can collect detailed data to understand long term, large scale decline. There is no reason to believe that other insect groups, especially herbivorous insects like bees, are not declining as fast as butterflies. Other global analyses support rapid insect decline, including for butterflies and moths (Dirzo, et al. 2014), and for all insects on land that have declined in abundance by 9%/decade (Van Klink, et al. 2020). In Germany, insect biomass, a measure of the significance of insects in ecological systems, declined 75% in 27 years. One-third of North American bumble bees have declined in the last century (Guzman, et al. 2021).

Insecticides and endangered species

At the leading edge of insect decline are those species threatened with extinction. Of the 29 butterfly species currently listed on the US Endangered Species List, three, the St. Francis' Satyr, the Miami Blue, and Lange's Metalmark, have not been seen in recent years and could be extinct. One endangered species, Poweshiek Skipperling, has experienced precipitous decline across its range from eastern Michigan to Manitoba, with a leading cause being new classes of insecticides that arrived simultaneous to the time of the butterfly's loss.

Conclusions

Insects are declining in Colorado, and more widely. Change is needed to arrest, and even reverse insect declines. Systemic insecticides are applied to seed coatings, and most often without demonstrated need. Other approaches to insect control, including genetic modification of crop plants, insecticide application after pest outbreak, and broader integrated pest management, are usually sufficient to manage pest populations. SB26-065 is a strong framework to halt and, ideally, reverse insect decline. The law would reduce the stress that insecticides impose on beneficial insects. At the same time, it will permit individuals to use systemic insecticides when there is demonstrated need, and when other means of control fall short.

Sincerely,

Nick Haddad

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Feb 26, 2026

RE: Testimony of the Natural Resources Defense Council in Support of SB26-065

Chair Roberts and Members of the Committee:

We submit the following testimony on behalf of the Natural Resources Defense Council (NRDC), and our over 26,000 Colorado members and activists, in support of SB26-065, the SEED Act. This bill will provide urgently needed reductions in use of harmful and unnecessary insecticide seed treatments, while preserving flexibility for farmers to address real pest problems.

Neonicotinoid insecticides (neonics) are the most commonly used insecticides nationwide, particularly as coatings for field crop seeds.[1] Neonic-coated seeds may now represent the largest annual deployment of insecticides in U.S. history,[2] with pollution building up in Colorado's environment year after year.

The harms to Colorado's agriculture, wildlife, and people from widespread, prophylactic use of systemic insecticide seed coatings far outweigh their limited benefits to field crop farmers.

Systemic insecticide seed coatings threaten health, agricultural sustainability, and wildlife. Widespread use of neonic and other systemic insecticide seed treatments drive massive contamination of land, water, wildlife, and our communities, with serious consequences:

- **Neonics pose risks to Coloradans' health.** Neonics appear in the bodies of half the U.S. population at any given time. They have been detected in more than 95% of pregnant women tested across the country,[3] with levels steadily rising, indicating worsening, widespread exposure. Research links neonic exposure to birth defects of the heart and brain and cognitive impairment in prenatally exposed children,[4] as well as lower testosterone, sperm count, and sperm quality in adults.[5]
- **Neonics jeopardize access to healthy and affordable food.** Neonic contamination is a leading cause of dramatic losses of bees and other pollinators that cut into farmers' bottom lines.[6] One neonic-treated corn seed contains enough active ingredient to kill 250,000 bees.[7] They also harm beneficial insects that naturally control pests, and they degrade soil health.[8] Ultimately, they threaten the viability of our food systems.
- **Neonics contribute to mass losses of wildlife that support billions of dollars of economic activity in Colorado.** Neonics wipe out insects and other invertebrates that countless species, including birds and fish, rely on for food. These impacts travel up the food chain, jeopardizing the natural landscapes and wildlife that make Colorado unique.

Systemic insecticide seed coatings benefit multinational corporations, not farmers. Neonic seed treatments are applied to certain field crop seeds by default, not based on actual pest pressure, padding the pockets of multinational seed and agrichemical companies at Colorado's expense. Research shows that these seed treatments rarely improve yields in corn, and even if they do, it is not at levels that would allow farmers to recoup the costs of purchasing the seed treatment.[9] In some cases, they actually harm yields, by undermining soil health and killing beneficial insects that help control pests.

The SEED Act builds on successful models for reducing unnecessary seed treatment. Since 2019, Quebec, Canada, has operated a need-based use program for neonic seed coatings for field crop seeds.[10] The program has successfully and dramatically reduced use of neonic seed coatings and the resulting runoff,[11] without impacting yield.[12] As a result of this success, the province recently expanded the program to include all insecticide seed coatings. New York and Vermont have passed similar laws,[13] which go into effect in 2029– the SEED Act aligns with this timeline.

In sum, the SEED Act adapts common-sense, proven solutions from other jurisdictions to fit Colorado's needs. It would protect Coloradans and our environment by reining in the state's number one source of neonic pollution. With more damage done every day, Colorado's legislature must act now. **We urge you to advance this important legislation.**

The Science Supporting the SEED Act Is Strong and Clear: Detailed Analysis

The body of scientific evidence supporting the SEED Act is robust and growing. We provide a detailed summary of the harms, pollution, and inefficiencies resulting from widespread use of neonic-treated seed below.

I. Neonics Are Toxic, Persistent, and Everywhere

Neonics are the most widely used insecticides nationwide. They cause widespread ecological destruction and pose risk of harm to children's health. There are three factors that make neonics especially problematic for the environment and public health.

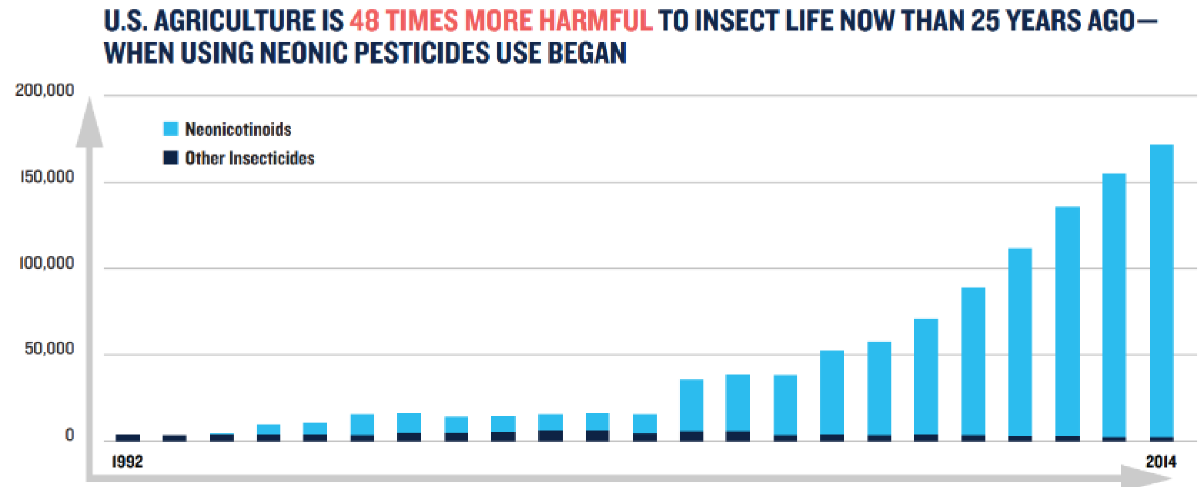
First, neonics are extremely toxic to insects and other invertebrates. For example, just one corn seed treated with a neonic product at EPA-approved rates can contain enough pesticide to kill over 250,000 bees.[14]

Second, neonics are exceptionally good at contaminating the environment. Unlike older, conventional insecticides, neonics are "systemic," meaning they are absorbed by plant tissues in order to make the plant itself—including its nectar, pollen, and fruit—toxic. To achieve this result, neonics dissolve easily in water and persist for long periods in soil. Because neonics build up in areas of year-after-year use[15] and spread out with each rainfall or watering, their extensive and continual use has caused ubiquitous contamination of large portions of the country's soil, water, and plant life.

Third, neonics are the most widely used insecticides in the United States. Nearly all conventional corn,[16] meaning neonics are likely used on nearly 1.5 million acres in Colorado on just that crop.[17] The five major neonic chemicals approved for outdoor use—acetamiprid, clothianidin, dinotefuran, imidacloprid, and thiamethoxam—are also widely approved as seed treatments on other crops.

Neonics' toxicity, persistence, and widespread use have massively increased harm to insect populations. One study estimates that since neonics were first introduced, U.S. agriculture has become 48-times more harmful to insect life.[18] Ninety-eight percent of this increase was attributable to neonics, the number one use of which is on treated seeds (see figure below).

TOTAL ACUTE ORAL INSECT-TOXICITY LOAD OF INSECTICIDES IN U.S. AGRICULTURE BY YEAR (IN LD_{50}-DAYS)



Data from Michael DiBartolomeis et al., "An Assessment of Acute Insecticide Toxicity Loading (AITL) of Chemical Pesticides Used on Agricultural Land in the United States," *PLoS One* (August 6, 2019).

II. Neonic Contamination Is Widespread

Neonics broadly contaminate land, water, wildlife, and even people's bodies nationwide. The U.S. Geological Survey (USGS) has detected neonics in a about half of stream samples nationwide.[19] A recent analysis by Dr. Pierre Mineau suggests that Colorado is no exception to widespread contamination.[20] Despite infrequent and sporadic sampling of surface waters—which makes it less likely to detect neonic contamination—USGS detected imidacloprid at more than one third of surface water sampling sites in Colorado.

USGS did not test at all for clothianidin and thiamethoxam, the neonics most commonly used as seed treatments. But groundwater testing has found clothianidin and thiamethoxam most frequently, suggesting a gaping hole in surface water quality testing for neonics in Colorado. In tested wells, clothianidin in particular was found at alarming levels—more than 100 times higher than U.S. EPA's benchmarks for chronic harm to aquatic invertebrates. While neonic detections in groundwater were relatively infrequent at 6.5%, serious shortcomings in sampling methods mean this is almost certainly a vast underestimate of the scope of contamination. The Agricultural Water Quality Program used reporting thresholds of 100 and 200 ng/L, 10 and 20 times higher than U.S. EPA's chronic benchmark for harms to aquatic ecosystems. In USGS surface water testing, nearly all detections were below these reporting limits. In other words, the groundwater testing results likely ignore the vast majority of contamination that occurs at low, yet ecologically significant, levels.

Using available groundwater and surface water data and taking into account the limitations of the data available—all of which bias the dataset *against* detecting neonics—Dr. Mineau concludes that "neonic contamination levels documented in Colorado samples indicate a significant and widespread threat to aquatic and terrestrial life."

Across the country, neonic contamination extends far beyond water. Studies by the Minnesota Department of Natural Resources documented neonics in 61% of white-tailed deer in 2019, and in 94% of deer in 2021.[21] In Texas between 2020 and 2022, over one third of birds tested positive for imidacloprid.[22] And a 2026 study in North Dakota detected neonics in 13%, 15%, and 35% of bobcats, fishers, and river otters, respectively.[23]

In 2019, the Centers for Disease Control and Prevention (CDC) published the updated results of its national biomonitoring program, which measures pesticides in the urine of thousands of Americans age three and older.[24] The update included data from 2015-16, and was the first to include neonics. The results showed that roughly half of the U.S. general population is exposed to neonics on a regular basis, with children having higher levels than adults.[25]

More recent data suggests that neonic exposures have grown significantly in recent years, with risks of exposure especially acute for pregnant women and young children. A 2022 multistate study of 171 pregnant women found that over 95% had neonics or neonic degradates in their bodies.[26] Detection levels generally exceeded previous CDC findings and, alarmingly, detection also steadily increased over the course of the four-year study period (2017-2020) – both in frequency and in magnitude – with the highest levels in Hispanic women.

Together, these studies show that neonic contamination is widespread and getting worse.

III. Neonics Threaten the Health of Colorado's Residents, Especially Children

Neonics are chemically similar to nicotine. They attack nerve sites that insects and humans share, which play a central role in the operations of our brain and nervous systems.[27] More specifically, critical parts of the brain are densely populated with nerves containing the particular nACh receptor area targeted by neonics (the α4β2 subunit), including: the cortex (responsible for planning, judgment, creativity, inhibition, attention, memory, language); the thalamus (emotion, memory); and the cerebellum (posture, balance, coordination, speech).[28]

Health experts have long been concerned about the impact of nicotine-like substances on the brain—a reason they have long warned pregnant women to avoid nicotine.[29] A growing body of research now links neonic exposures to elevated risk of developmental or neurological damage in humans, particularly in infants and young children.[30] These include malformations of the developing heart and brain, autism spectrum disorder, cognitive impairment, memory loss, and tremors.[31] Research also finds associations between higher neonic exposure and impairments to metabolic processes like insulin regulation and fat metabolism.[32]

Animal testing shows an even broader range of concerning injuries with implications for human health, including: multiple birth defects and increased rates of death for the fawns of white-tailed deer fed "field realistic" (i.e., "real world") levels of neonics in water;[33] reduced thyroid functioning in deer;[34] and in prenatally exposed rodents, deficits such as thinner brain cortexes and other brain abnormalities, altered behavioral reflexes, and decreased sperm and testosterone levels.[35] New research also shows neonics can target mammalian ovaries, resulting in significantly fewer egg follicles, and more unhealthy ones.[36] All of these studies have implications for similar risks to people.

Information and studies collected by EPA reaffirm the risks posed by neonics, yet these risks are often undercounted and ignored in regulatory decision-making. EPA poisoning reports reveal that hundreds of people have been poisoned with neonics, with some fatalities reported.[37] A recent analysis of pesticide manufacturer-submitted toxicity studies also concluded that EPA is ignoring statistically significant harms in those studies, meaning EPA's regulatory standards are likely inadequate to protect Americans from widespread exposure.[38]

These widespread and growing exposures are a considerable concern for childhood neurological development. A 2022 study shows that neonics flow through the placenta, and then to all the fetal tissues including the developing brain and nervous system.[39] Previously, Japanese researchers had identified neonics in the urine of newborn babies, further supporting the idea that neonics pass from a pregnant mother to her developing fetus.[40] This is highly concerning given the multitude of studies suggesting developmental risks from neonic exposure.

People are commonly exposed to neonics through food and water.[41] Conventional chlorination alone, without carbon filtration treatment, generally fails to remove neonics from drinking water.[42] More concerning still, neonics break down in water, forming chemicals that can be several hundred times more toxic to people than the original neonic chemical, which then may be made more toxic still through the chlorination process.[43]

IV. Neonics Drive Losses of Pollinators and Other Beneficial Insects, Threatening Farmers' Bottom Lines and Our Food Systems

More than two decades of research identifies neonic contamination as a driving factor behind mass losses of bees and other crucial pollinators. Since the mid-2000s—when annual losses of honey bee colonies skyrocketed—beekeepers nationwide have consistently lost more than 30% of their colonies each year.[44] Last year, Colorado beekeepers lost an estimated 43% of their colonies. And while honey bees are important to agriculture in their own right, they also serve as a canary in the coalmine for disappearing populations of Colorado's nearly 1,000 wild bee species, as well as other pollinators that are crucial to agriculture and ecosystems.

Among all the stressors affecting bees, only the dramatic uptick in the use of neonicotinoid pesticides in the mid-2000s—mainly from increased use on corn and soybean seeds[45]—matches the dramatic uptick in bee losses witnessed at precisely that time.[46] Since that time, a large and growing body of research confirms neonics are a leading cause of bee and other pollinator declines, including several comprehensive global literature reviews[47] and the largest neonic field study to date—actually funded by the pesticide industry itself.[48] In 2020, Cornell University published its own review of over 1,100 studies finding substantial harms from a broad variety of neonic uses, [most notably from treated corn, soybean, and wheat seeds as well as] non-agricultural turf and ornamental uses.[49] In 2024, researchers identified increase neonics use as "a major driver of changes in occupancy across hundreds of wild bee species."[50] Neonic use is also linked to significant declines in butterflies,[51] particularly monarchs,[52] which can encounter harmful or deadly levels of neonics in farm fields or nearby wild plants that can absorb neonics and stay toxic for years. In fact, neonic treated seeds were recently identified as the number one factor correlated with monarch butterfly declines in the Midwest, including the monarch butterfly.[53]

Pollinator losses are already harming farmers. A 2023 study estimates that inadequate pollinator populations are reducing production of fruits, vegetables, and nuts by 3-5% worldwide.[54] Reduced production of these healthy foods is, in turn, leading to an estimated 427,000 additional preventable deaths annually.[55] And these deaths are disproportionately in wealthier countries like the United States, where reduced access to healthy foods is more likely to shift people's diets to cheaper, unhealthy alternatives. Another major study shows that many top fruit crops are "pollinator limited" across the U.S., meaning that a lack of bees and other pollinators is currently lowering crop yields.[56]

These findings are of particular concern to Colorado, where a report from leading experts across the state concluded that although "[t]he value of native pollinating insects to Colorado's natural resources is difficult to estimate . . . , [it] is likely in the billions of dollars."[57]

Beyond pollination, neonics harm other beneficial insects essential for farming—such as nematodes,[58] earthworms,[59] and pest predators[60]—and can disrupt other key components of soil health. Pest predators are especially at risk from eating contaminated insects, as the harmful neonic levels can remain in insect prey,[61] leading to decreased yields as the beneficial predator populations die out.[62] Research from Penn State found that in no-till systems, neonics can indirectly increase slug damage and lower crop yields by poisoning insects that eat slugs.[63] A study of northern Great Plains farms found that fields using neonics and other conventional insecticide treatments had 10 times the insect pressure and fewer profits compared with those employing regenerative farming methods, likely due to lower input costs, more "good bugs" that keep pest populations under control, and better crop marketability.[64] Research also shows that neonics may harm soil health directly by changing the composition of soil microbial communities—harming beneficial bacteria crucial for plant growth and health and soil fertility and quality.[65]

V. Neonics Contribute to Mass Losses of Birds and Fish that Help Drive Colorado's Economy

As losses of insects multiply, insect-eating animals suffer too. Birds appear particularly vulnerable—96% of land-based birds feed insects to their young, with many species also relying on insect food sources as adults.[66] In North America, 30% of birds have disappeared in the past fifty years,[67] with research linking neonics to annual losses of up to 12% in grassland species and 5% in insect-eating species.[68] Likewise in Europe, Dutch researchers have linked declining populations of insect-eating birds to the introduction of neonics—even in areas with exceptionally low neonic levels (20 parts per *trillion* in water)[69]—and the pesticides are also believed to play a key role in declines of French farmland birds.[70]

Neonics harm birds directly, too. Eating just one neonic-treated crop seed is enough to kill some songbirds.[71] And at nonlethal doses, neonics can damage birds' immune and reproductive systems, cause rapid weight loss, and impair navigation and migration ability—all reducing the likelihood of their surviving and reproducing in the wild.[72] With hundreds of millions of acres of U.S. farmland sown with neonic-treated seeds every year, birds are broadly at risk—particularly when, as commonly occurs, piles of seed are left out in the open or planted shallowly enough for birds to eat.[73] At least one assessment has made the case that bats can also be harmed directly or indirectly.[74]

Neonics are also devastating for aquatic ecosystems because they are highly toxic to aquatic invertebrates that fish and other species rely on for food. One study in Japan found that the introduction of the neonic imidacloprid to the area surrounding a longstanding fishery caused the collapse of that fishery in just one year.[75] Researchers found that after neonics contaminated the water, plankton populations plummeted, starving the fish that fed on that plankton.

While birds and fish are ecologically critical in their own right, they also help to support a $65 billion outdoor industry in Colorado.[76] Recreational fishing alone generates $2-3 billion in economic activity each year.[77] And birding and other wildlife viewing are estimated to generate another $1.7 billion annually.[78] Large-scale diminishment of Colorado's wildlife is something the state simply cannot afford.

VI. The Most Widespread Neonic Uses Are Wasteful and Provide Little or No Economic Benefits to Farmers

Neonics are often applied to crop seeds prior to planting. The mixture of chemicals applied to the seed is commonly called a "seed treatment" and the resulting product is a "treated seed." The idea behind these treatments is simple: as a crop begins to grow, it absorbs the neonic seed coating, making the whole plant toxic to pests. This use pattern began in the mid-2000s and drove a massive increase in neonic use nationwide. Today, neonic seed treatments are used on hundreds of millions of acres nationwide—including nearly 100% of conventional corn acres—and likely upwards of 2 million acres of Colorado farmland.

There are three fundamental problems with neonic-treated seeds. First, they target a pest problem that almost never exists, meaning farmers rarely see economic returns. Second, instead of replacing other insecticide applications, seed treatments have become a massive *additional* use of insecticides. Third, the vast majority of neonics applied as seed treatments do not enter the target plant as intended, making them incredibly wasteful.

A. Neonic-treated seeds rarely benefit the farmers using them

Research concludes that farmers rarely benefit from using neonic-treated seeds. An analysis of 1,100+ peer-reviewed studies across North America shows that the most common uses of neonic-treated seeds—i.e., for corn and soybean—typically provide *no economic benefit for farmers*.[79] Research finds that neonic seed treatments have no impact on yield in most cases,[80] and even if they do, those improvements are only minor and still do not allow farmers to recoup the costs associated from having to purchase the seed treatment.[81] This is because most farms generally have only a "low level of pest-associated pressure and damage," if at all.[82] These research findings conclude that due to these low risks, neonic seed treatments "should not be used prophylactically"[83] and that "[they] are not warranted for grain production outside of specific instances of high pest pressure."[84]

Research in Quebec, Canada, suggests that *any* insecticide seed treatment is unnecessary in the vast majority of circumstances. Labrie et al. (2020) demonstrated that although targeted pests (like wireworm) were more prevalent in fields without neonic seed treatments, yield was unchanged.[85] In other words, the presence of pests targeted by seed treatments did not reduce crop yields. Insecticide seed treatments were simply not necessary.

Though seed prices vary, farmers are likely paying a premium for seeds that ultimately do not provide an economic return. Using prices provided by Bayer CropScience, a 2020 literature review found that untreated corn seeds cost $20.15 less per acre than neonic-treated seeds, and fungicide-only seeds cost $6.80 less.[86] For soybeans, untreated seeds cost $20.70 less than neonic-treated seeds, and fungicide-only seeds cost $5.10 less based upon farm-level data from independent research.[87] Conversations with Colorado farmers and seed dealers indicate the premium for a neonic treatment today is about $8 an acre, but even applying the most conservative assumptions, Colorado farmers are paying millions of dollars per year for seed treatments that are not increasing their yields.

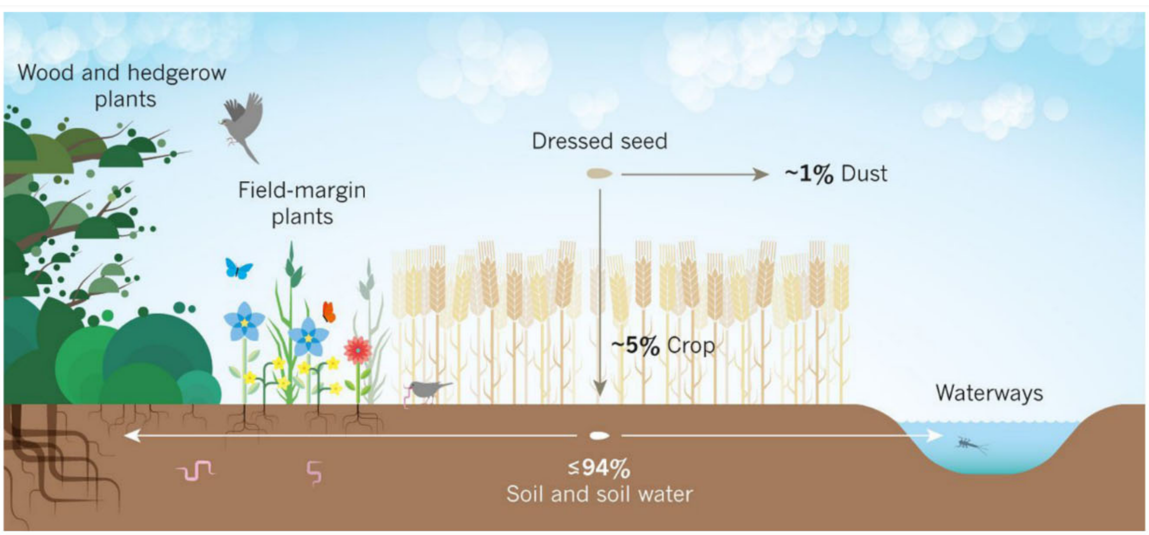
B. Neonic seed treatments have not replaced alternative insecticide uses

The amount of insecticides applied through methods other than seed treatment has remained constant or increased since widespread adoption of neonic seed treatments.[88] Prior to widespread use of neonic-treated seeds, only 35% of corn and 5% of soybean acreage was treated with an insecticide *all season*, versus 100% and over 50% today *just for seed treatments*.[89] This strongly suggests that neonic seed treatments have not replaced alternative pesticide uses; they are an *additional*, unnecessary use.

Neonic seed treatments provide a short window of protection against soil-borne pests—typically just 2-3 weeks.[90] As research and field trials repeatedly demonstrate, pests are not at economically damaging levels during this period. If insect pests become problematic after this early window of protection, farmers typically use spray-applied insecticides—just as they did before insecticide seed treatments became popular. In all, little has changed. The only difference is that many farmers are *adding* insecticide seed treatments to their pest control regimen—whether they benefit financially or not.

C. Neonic seed treatments are wasteful

Treated seed applications are remarkably inefficient and likely to lead to widespread pollution. Of the typical neonic treatment on a corn or soybean seed, only 2-5% of the active ingredient is absorbed into the target plant—leaving the other 95+% in the soil,[91] where the chemicals persist for years.[92] Once in the soil, neonics are easily carried considerable distances by rain or irrigation water to contaminate new soil, the plants in that soil (as they absorb the chemicals and also become toxic), and water supplies.[93]



Reprinted by permission from Springer Nature: Dave Goulson, "Pesticides Linked to Bird Declines," *Nature* 511, no. 7509 (July 2014): 295-96, https://go.nature.com/2rNOZcK.

VII. Widespread Seed Treatment Use Is Driven by Corporate Power

As demonstrated above, farmers rarely see economic returns from the use of neonic seed treatments. Nevertheless, their use is extremely widespread. This surprising result is explained largely by massive consolidation of the agrichemical industry. From 2018-2020, just two massive companies—Bayer Crop Science and Corteva Agriscience—supplied about 72% of corn seed nationwide.[94] Those same companies manufacture neonics and other insecticides.[95] So they take corn seeds with the most advanced traits that many farmers want, and they package them with insecticide seed treatments—and then charge farmers a premium for this added 'protection.' As a result, many farmers have little choice but to purchase and use corn seeds pre-treated with neonics and other insecticides.

Even for crop seeds that are more commonly available untreated, pesticide manufacturers exert outsized influence over farmer decisionmaking. According to a 2023 study analyzing the sources of information farmers use to learn about agronomic practices and stewardship issues, "[t]he two most frequently reported information sources were agricultural retail suppliers, specifically chemical dealers and seed dealers, utilized by nearly all farmers in our sample (96% for each one)."[96] For example, Pioneer—a leading seed supply company owned by Corteva Agriscience—has "local Pioneer teams" across the country with "territory managers" and agronomists available to provide information to farmers.[97]

Despite common engagement with pesticide companies with seed dealers, farmers encounter limited transparency about the content of their seed treatments. A 2020 study found that whereas 97-99% of surveyed farmers could "name the field-applied pesticide(s) used on their cotton, corn, wheat, or soybean crops," only 65% of corn growers and 57% of winter wheat growers were able to name the seed treatment product used on their crop.[98]

VIII. The SEED Act Follows Successful Models for Reducing Unnecessary Neonic Seed Coatings

If the SEED Act is enacted, Colorado will not be alone in tackling the neonic problem. Quebec, Canada, provides a highly successful model for eliminating the needless use of neonicotinoid seed coatings in field crops. In 2019, Quebec required farmers to obtain an agronomic justification—basically, a prescription—before purchasing neonic-treated corn and soybean seeds. Within just two years, neonic-treated corn and soybean use was virtually eliminated and neonic contamination plummeted. Crucially, crop yields have remained constant or increased since the new restrictions.[99] In 2025, Quebec expanded the program to all insecticide seed treatments,[100] consistent with the research showing that insecticide seed treatments in corn and soybeans generally do not benefit farmers.

In 2024, New York and Vermont became the first states to pass bills to limit neonic-treated seed use, following the success in Quebec. The provisions of those bills regarding restrictions on neonic field crop seed coatings will take effect on January 1, 2029.[101]

IX. A Yes Vote on SB26-065, the SEED Act, Protects Colorado – Now and in the Future

SB26-065 is a carefully tailored bill that limits neonic uses that are both harmful and unnecessary, while preserving flexibility for farmers to use seed treatments that will address real pest problems. It's a win for pollinators, pollinator-dependent farmers and beekeepers, Colorado's environment, and all Coloradans who value clean water, local produce, and a healthy environment. **For these reasons, NRDC strongly supports SB26-065 and urges you to advance this bill.**

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My name is Perry Welch. I live in El Paso County and have been keeping bees for about 25 years. Five years ago I became a commercial beekeeper, where I send my bees to California to pollinate almond crops. When my bees aren't pollinating almonds, they are with me in Colorado, where they pollinate and make honey from alfalfa.

I lost 373 colonies last year because of neonics. That is over 72% of my colonies. Each colony has about 60,000 bees, which means I lost over 20 million bees last year to these pesticides. I started with 517 colonies, then by mid-November, they dropped to 380. By mid-January, I only had 144 colonies to send to California. After my bees finished pollinating the almonds, I received 132 colonies back.

I'm not concerned about the 12 colonies I lost in California. I am devastated by 373 colonies I lost while my bees were pollinating alfalfa in Colorado. Normal losses used to be around 10%, now we are seeing die offs closer to 60%-75%.

Week after week while I was having these losses, I looked for answers. I didn't find any piles of dead bees. My bees simply disappeared. They never made it home. I know from being in this business for decades that bees are excellent navigators, so if they don't make it home, something happened to their GPS system. In my experience, the only thing that does that to a bee is pesticides.

When I looked further into the cause of my losses, I learned that alfalfa commonly comes with neonicotinoid insecticides on the seeds. These insecticides make the whole plant toxic, and when they spread through soil and water, they can make nearby plants toxic too. My bees were getting sick and dying by simply trying to feed.

Neonics were introduced over 20 years ago. In 2006, we had devastating losses all across the country. The EU imposed significant restrictions on neonics in 2013. After 8 years, their bee populations and soil health were back to normal.

Last year, I spent $12,000 buying 400 queens trying to increase my hive count, but only 20 colonies ended up strong enough to go to California. Buying queens is a significant expense, and after I ended up with fewer colonies than I started, I realized it was not sustainable for me to continue doing business the way I was in Colorado. I made a decision to find fresh bees in a state that uses very little pesticides and those hives had very minimal losses (~10%) between the end of their season and getting into the Almonds

I can no longer trust that Colorado is a safe environment for my bees. I spent some of my retirement money--$165,000—to purchase 816 colonies from New Mexico. If I didn't buy bees last year, I wouldn't have bees. I found a seller in New Mexico who assured me that there are no pesticides used near his apiary. I cannot find anyone with that guarantee in Colorado because it is so hard to find seed without these insecticide coatings.

We need the SEED Act to send a signal to seed companies that there's a market in Colorado for seed without chemicals that kill millions of my bees. If the farmers knew that 87% of the pesticides were being leached into the ground water and that they are affecting not just plants downstream but also the water that a lot of us drink they would take the time to find alternatives that work and are less toxic

February 25, 2026

Senate Agricultural and Natural Resources Committee

RE: Support for SB 26-065 – Systemic Insecticide Use Limitations

Dear Chairman Roberts, Vice-Chair Danielson and Members of the Committee:

My name is Mark Fuller and I am a resident of Carbondale, Colorado. I am submitting this testimony in favor of SB 26-065

Since neonicotinoids (neonics) were developed in the 1980s they have become the most widely used class of insecticides in the world and are very common in Colorado. There is a growing body of evidence showing the harmful and persistent effects of widespread neonic usage. It accumulates in the soil and is carried by water where it kills insects important to ecosystem health. Although not all of the documented declines in native bird and insect populations can be attributed to neonics, these pesticides have proven toxic effects throughout the environment and are almost certainly a contributing factor to losses of important insect species such as domestic and wild bee populations. Limiting their use and providing farmers with the opportunity to use untreated seeds is a 'win-win', in that it will reduce toxins in the environment while providing farmers with more and better choices for their crops.

As both a home gardener and a birder, I have first-hand experience with both the limited choices available for crop seeds and the drastic and obvious declines in both insect and bird diversity and numbers over the 45 years I have been on my property. Without bees and other beneficial insects and without the birds that can also be a victim of neonic poisoning, it is becoming increasingly difficult to maintain a healthy and thriving garden. I recognize that there are instances where treated seeds may be the only answer for farmers and this bill provides for responsible use of neonics. It is not a ban but a reasonable means of minimizing the use of toxic chemicals when not needed. The absence of alternatives to treated seeds means that most of us can only choose between giving up a treasured and important food source or adding harmful chemicals to our environment. This is an unacceptable choice – support for SB 26-065 will ensure that both large and small food producers will have more options and the environment will benefit in the process.

The United States did the right thing by banning DDT in the 1970's. DDT is a similarly harmful chemical insecticide, and, like neonics, its use had massive harmful unintended consequences. Neonics, being water-soluble and systemic, are even more potent, making entire plants toxic to pollinators and beneficial insects. SB 26-065 puts reasonable limitations on the use of neonics and will safeguard environmental quality while giving farmers the tools they need. Given your responsibility to your constituents and to the State of Colorado, I hope you will take this opportunity to support SB 26-065 in the interests of a healthier, more vibrant, more resilient natural world for ourselves and future generations.

Thanks to Senator Kipp for sponsoring this bill and thanks to the Committee for considering my testimony.

Respectfully,

Mark Fuller

fulcon@comcast.net

Carbondale, CO 81623

Bret Turner, MPH – bret.turner@cuanschutz.edu – Aurora, CO 80247

Mister chair and members of the committee, thank you for allowing me the time to speak. My name is Bret Turner and I live in Aurora. I am a Hazardous Materials Specialist at the University of Colorado Anschutz Medical Campus and received my Master of Public Health Degree from the Colorado School of Public Health in Global Environmental and Occupational Health. I support the passage of SB26-065 because there is a growing and extensive body of scientific evidence in public health research that neonicotinoids are incredibly dangerous to human health.

The establishment of these negative health outcomes and the ubiquitous nature of neonics in our food supply, drinking water, and the environment, combined with the dearth of regulatory controls on neonics here in Colorado is deeply concerning. Industry has painted use of neonicotinoid pesticides as "precise" and "targeted," but multiple studies indicate that these compounds are present in the bodies of roughly half of the US population, with levels likely rising[1]. If drift and bioaccumulation of these pesticides were truly controllable with the current methods, then we would not consistently discover dangerous levels of these chemicals in soil[2], water[3], food[4], and the bodies of non-target species[5] (including human beings[1]). Even small levels of neonic exposures are linked to developmental[6] and reproductive toxicity[7], metabolic[8] and endocrine disorders[9], and cancer risks[10].

I urge you to vote "yes" on SB26-065 in order to protect the health of Coloradans from these dangerous substances. Thank you for your time and I am happy to answer any questions that you may have.

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MAD!

Mad Agriculture is a Colorado-based nonprofit working to catalyze a regenerative revolution in agriculture. Our mission is to help farmers, land, and ecosystems thrive together for generations to come. We offer collaborative support in the form of technical and financial assistance to farmers and ranchers to help them meet their goals and to reduce the impact of agriculture on the environment.

We support the SEED Act because it would improve farmer choice in the seed marketplace, reduce environmental harm from prophylactic use of seed-applied pesticides, and align with a regenerative vision for the future of Colorado agriculture.

Producers should have the ability to make context-specific management decisions, including choosing appropriate traits and seed coatings for their local conditions and pest pressure. Yet today, most field crop seed sold in the United States comes pre-treated with insecticides by default, limiting farmers' ability to decide whether that insecticide use is warranted for their fields. When seeds are routinely sold with insecticides already applied, pest management decisions are effectively made upstream in the supply chain rather than by farmers in response to field conditions.

At Mad Agriculture, we are acutely aware of the need to balance financial and conservation decisions. But research shows that prophylactic neonicotinoid seed coatings have little impact on yields and economic returns for farmers, despite the added cost, and that they are rarely necessary except in a narrow set of high risk use cases. Reports from the Canadian province of Quebec, which has implemented a prescription-based model for neonicotinoid seed coating use, confirm that it is possible to dramatically reduce their use with little impact on yield losses.

Given these seed coatings limit farmer choice, add unnecessary costs, and have limited agronomic impact, it's all the more compelling to consider their impact on the environment. Their ubiquitous use has demonstrated negative impacts on pollinators, beneficial insects, and birds. And given they are systemic and persistent in the environment, these impacts could continue to accumulate if no effort is made to curtail their use.

We urge you to advance the bill out of Committee and into the full Senate for further debate. It is the responsible choice for farmers, the environment, and citizens of Colorado. Thank you for your consideration.

Sincerely,
Philip Taylor, **Mad Agriculture**

Beth Conrey Testimony Supporting SB26-065 The SEED Act

My name is Beth Conrey and I am the owner of Bee Squared Apiaries in Berthoud, CO. I manage ~200 colonies between Denver and Wellington. I have been keeping bees for over a quarter century. I am past-president of the Western Apicultural Society as well as the Colorado State Beekeepers Association. I currently serve on the board of the Pollinator Stewardship Council and People and Pollinators Action Network.

Since I began keeping bees, many variables have changed. The average colony production numbers have plummeted from 75 pounds per hive to an average around 30 pounds now. Average colony losses were reported in single digits. The Apiary Inspectors of America's US Beekeeping Survey for 2024-2025 reported nationwide losses of **55.6%**! In CO, annualized losses totaled 43%. Far more disturbing are summer losses which were 33% in CO for the same year. These numbers have not been trending better—they have been trending worse. Commercial beekeeping has become unsustainable.

Why are bees dying in the summer? The primary reason is pesticide exposure. Neonicotinoids are the most common pesticide used in American agriculture due to their ease of use as an unregulated seed coating. Yep, unregulated—due to the "treated article exemption". Because the latest seed technologies are administered as seed coatings, they make the entire plant toxic for ALL insects whether they are beneficial or a pest. They kill bees. They kill native bees. They kill ALL INSECTS that come in contact with the plant. And they do it with chronic sub-lethal poisoning. **The results of these prophylactic seed treatments administered over the past 2 decades on corn and other field crops have been overuse, widespread environmental contamination, well-documented harm to beneficial insects and pollinators and escalated pest resistance.**

Honey bees are expensive. Annualized losses of nearly half of the bees in America make it even more so. One might legitimately ask why I still keep bees at all. My answer: I love keeping bees and it is my livelihood. Many of the smaller beekeepers never keep bees again after successive years of total losses.

Neonicotinoids have also been proven not to increase yield nor have they been found to decrease the use of other pesticides. Those who have blazed this trail report no decline in production numbers—despite industry predictions to the contrary. Treated seed is frequently the ONLY option for farmers and they, and the environment, are paying the price. Requiring farmers to only use pesticides when they are actually needed makes sense.

Colorado has an opportunity to join the European Union, Quebec, Ontario and other forward-thinking states to rein in the ubiquitous and unnecessary use of seed treatments by passing the SEED Act. We are not the first—but we need to be the next! I'm tired of bees "just getting by" due to the sub-lethal effects of these chemicals on colony growth numbers, queen and drone fecundity and overwintering success. Native pollinators, Monarch butterflies and insectivorous bird declines need to be mitigated as well. The timing on the Act will allow un-treated seed to enter the distribution pipeline so farmers will actually have a planting choice. **Please vote yes on SB026-065.**

University of Colorado Boulder

Arts and Sciences/Integrative Physiology
Ramaley N379A
354 UCB
Boulder, Colorado 80309-0354

t 970 946 5909
Jenni.Shearston@colorado.edu
http://www.colorado.edu/lab/ceep

Jenni A Shearston, PhD, MPH
Regarding CO SB26-065: Systemic Insecticide Use Limitations
February 25, 2026

My name is Jenni Shearston, PhD, MPH. I am an environmental epidemiologist and Assistant Professor in the department of Integrative Physiology at the University of Colorado Boulder. I am submitting this testimony on my own behalf as a scientist and expert in public health; I am not representing the University of Colorado Boulder. I have a Master of Public Health from New York University and a PhD in Environmental Health Sciences from Columbia University, and more than a decade of experience in public health. I'm writing to testify in support of limiting use of neonicotinoid coated seeds when they are not needed for agricultural purposes.

As an epidemiologist who measures chemical pollution and studies its effects on health, I was pleased to learn about the introduction of SB26-065 because I believe it has the potential to reduce human exposure to neonicotinoid pesticides. Neonicotinoid pesticides are a concern for human health for the following reasons:

1. The general United States population is ubiquitously exposed to neonicotinoid pesticides.
    a. An analysis of urine samples from an ongoing, nationally administered survey conducted by the Centers for Disease Control and Prevention, called the National Health and Nutrition Examination Survey, found that in the 2015-2016 study cycle, about half of the US population older than 3 years of age had detectable levels of neonicotinoid pesticides in their urine (Ospina et al., 2019).
    b. Neonicotinoid pesticides were again measured in the 2017-2018 study cycle. The CDC found that 81% of urine samples in the survey had measurable levels of 5-hydroxyimidacloprid, and 78% of samples had measurable levels of N-desmethylacetamiprid. These chemicals are metabolites – or breakdown products – of imidacloprid and acetamiprid, two neonicotinoid pesticides (CDC, 2025).

2. Studies suggest that neonicotinoid pesticides likely impact human fetal development even at chronic exposure levels.
    a. A study in California found that prenatal exposure to neonicotinoids is associated with a fetal development problem called tetralogy of fallot, a type of congenital heart condition (Carmichael et al., 2014).
    b. Several studies in China have found evidence that maternal exposure to neonicotinoids during pregnancy can negatively impact fetal growth (Fu et al, 2025; Pan et al, 2023; Pan et al., 2022; Zhang et al., 2024).

3. Neonicotinoid pesticides have been detected in water in Colorado, and in food items across the United States, indicating that water and food may be human exposure routes.
    a. One report analyzing Colorado state's Agricultural Water Quality Program data found neonicotinoid pesticides in groundwater monitoring wells and sites across the state, and especially in the South Platte Basin (Mineau, 2025). It is possible that groundwater is a source of human exposure in Colorado.
    b. A study analyzing fruit, vegetables, and honey available for purchase in Boston, Massachusetts found neonicotinoids in several foods (Chen et al., 2014).

c. The US Department of Agriculture's 2024 Pesticide Data Program Annual Summary report found acetamiprid present in 31% of apples tested, 22-50% of blackberries, and 15% of cucumbers. It also found dinotefuran in 11% of cucumbers, imidacloprid in 13-25% of blackberries and 10% of onions and cucumbers (USDA, 2024). It is possible that food products are a source of human exposure in Colorado.

Results from the CDC's National Health and Nutrition Examination Survey make it clear that the general US population is exposed to neonicotinoid pesticides. Scientific studies suggest these exposures may impact fetal development, and that higher exposures may be worse for health. Given this evidence, it is important to reduce neonicotinoid exposure in Colorado, for example by limiting unnecessary use of neonicotinoid pesticides and therefore reducing the public's exposure through water and food grown in Colorado. Reducing Coloradans' overall exposure to neonicotinoids has the potential to lower overall health risks.

I urge the committee to support policies that reduce unnecessary use of neonicotinoid pesticides and subsequently protect public health and the health of children. I would like to thank the members of the committee for the opportunity to submit this testimony.

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Testimony in Support of Senate Bill 26-065: The SEED Act

To: Senate Agriculture & Natural Resources Committee

From: American Bird Conservancy

Date: February 20, 2026

Dear Chair and Members of the Senate Agriculture & Natural Resources Committee,

On behalf of American Bird Conservancy (ABC), I am submitting this testimony in strong support of Senate Bill 26-065, the Strengthening Economic and Environmental Decisions (SEED) Act. ABC is a national organization dedicated to conserving wild birds and their habitats. We believe SB26-065 represents a balanced, science-based approach to pest management by regulating the use of field crop seeds coated or treated with systemic insecticides. By requiring a certificate of need from an approved third-party verifier before the purchase and application of these seeds starting January 1, 2029, this bill protects our ecosystems while simultaneously empowering farmers.

The Threat to Avian Populations

Systemic insecticides are designed to be absorbed by plants and translocated through plant tissue. The bill correctly identifies a comprehensive list of these chemicals, including neonicotinoids like acetamiprid, clothianidin, dinotefuran, imidacloprid, and thiamethoxam. Because these chemicals are systemic, they are present in the plant's roots, leaves, pollen, as well as the seed itself.

The prophylactic use of treated field crop seeds—such as corn, soybean, wheat, and sunflower—poses an existential threat to bird populations. Scientific consensus is that neonicotinoids are highly toxic to avian species.

- **Lethal Ingestion:** A songbird consuming just a fraction of a single treated seed can experience immediate and catastrophic effects, including severe weight loss, disruption of migratory orientation, reproductive failure, and death.
- **Food Source Depletion:** Because these pesticides are highly effective at indiscriminately killing insects, they decimate the primary food source for insectivorous bird species.
- **Targeted Use:** By ensuring that an approved third-party verifier will only issue a certificate if the treatment is necessary and appropriate to address a demonstrable pest issue, SB26-065 will significantly reduce environmental contamination and protect our vulnerable bird species. Furthermore, the certificate will detail restrictions on seed handling and disposal to specifically minimize harm to bird populations and ecosystems.

Protecting the Soil Biome for Agricultural Success

The impacts of systemic insecticides extend far beneath the surface, threatening the soil biome that is absolutely necessary to grow crops.

- **Microbial Decline:** When treated seeds are planted, only a small fraction of the active ingredient is absorbed by the crop. The remainder leaches into the surrounding soil and water, altering the diversity, structure, and functioning of the soil microbial community.
- **Loss of Beneficial Organisms:** Neonicotinoids harm agriculturally beneficial organisms, including earthworms and plant-growth-promoting rhizobacteria. These organisms are critical for nitrogen cycling, organic matter mineralization, and overall soil fertility.
- **Long-Term Contamination:** These chemicals can persist in the soil for months or even years, leading to a toxic accumulation that weakens soil health and crop resilience over time.
- **Sustainable Verification:** The SEED Act mitigates this damage by requiring an approved third-party verifier to conduct a pest risk assessment before application. This ensures the soil microbiome is only exposed to these chemicals when absolutely required.

Restoring Freedom of Seed Choice for Farmers

Currently, the widespread, prophylactic application of neonicotinoids on major crop seeds has created a consolidated market where farmers have little to no choice. The vast majority of corn and soybean seeds on the market come pre-treated, forcing farmers to buy and plant pesticide-coated seeds whether their specific agricultural property has a pest problem or not.

SB26-065 will restore freedom of seed choice.

- **Incentivizing Untreated Seed:** By prohibiting seed dealers from selling treated seed unless the buyer presents a valid certificate at the point of sale, the market will naturally be incentivized to supply untreated seed. Distributors will stock what farmers are legally permitted to buy without added bureaucratic hurdles.
- **Emergency Protections:** To protect farmers during this market transition, the bill wisely includes a provision authorizing the Department of Agriculture to grant emergency exceptions. If there is an insufficient supply of untreated, commercially available seeds, farmers will not be left empty-handed.

American Bird Conservancy

Paying More for Negligible Benefits

Perhaps the most compelling economic argument for the SEED Act is that farmers are currently paying a premium for a product that frequently offers no return on investment.

- **Lack of Yield Increase:** Extensive research, including comprehensive reviews by the EPA and leading agricultural universities, demonstrates that neonicotinoid seed treatments offer negligible or no crop yield benefits in most planting scenarios.
- **Timing Mismatch:** These treatments offer a narrow window of protection (typically 2-3 weeks after planting), which often does not coincide with the mid-summer arrival of primary economic pests, rendering the early-season treatment useless.
- **Economic Protection:** The SEED Act will save farmers money by preventing the unnecessary purchase of expensive treated seeds. The bill's mandate to implement a program ensuring these seeds are used only when needed and expected to be effective guarantees that farmers are only investing in chemical controls when there is a scientifically verified economic benefit.

Conclusion

Senate Bill 26-065 is a commonsense approach for Colorado’s agricultural economy and its natural heritage. It ensures that the use of highly toxic systemic insecticides as field crop seed coatings or treatments is targeted, scientifically justified, and effectively monitored. We urge the committee to vote in favor of the SEED Act to protect our birds, our soils, and our farmers.

Sincerely,

American Bird Conservancy

Serena Chenery

Advocacy Coordinator

schenery@abcbirds.org

ALBERT LEA SEED
1414 W Main St PO Box 127
Albert Lea, MN 56007 P: 800.352.5247
F: 507.373.7032
seedhouse@alseed.com
alseed.com

February 19, 2026

Sen. Dylan Roberts, Chair
Agriculture & Natural Resources
Colorado State Capitol
200 E. Colfax Ave.
Denver, CO 80203

Sen. Jessie Danielson, Vice Chair
Agriculture & Natural Resources
Colorado State Capitol
200 E. Colfax Ave.
Denver, CO 80203

Dear Chair Roberts, Vice Chair Danielson, and Committee Members:

My name is Mac Ehrhardt, Chairman of Albert Lea Seed, and I support SB26-065, the SEED Act. Our company keeps up with the latest research on efficacy and safety, and we actively market seed options without systemic insecticide coatings that we think are a better fit for many corn and other field crop operations. Based on my first-hand knowledge of the supply chain for pesticide-treated field crop seeds, I believe that, given adequate notice, the seed industry is well-positioned to adapt to the regulatory changes proposed in the SEED Act and supply Colorado farmers with seed without these coatings.

Albert Lea Seed has been supplying farmers with seed since 1923, and we have been in the business of selling both conventional and organic seed for over 30 years. While Albert Lea is headquartered in Minnesota, we ship seeds to farmers across the United States, including Colorado. My company has stayed in business for 100 years by keeping the needs of our customers-farmers-at the front of our minds. This legislation would not jeopardize farmers' ability to access the seed they need to preserve their livelihoods.

Nearly all wheat, oat, barley, and rye seed is sold untreated, or treated by seed dealers and retailers shortly before being delivered to a farmer. For these species, farmers are typically given treatment options at the time they order the seeds. For this reason, I am very confident that Colorado farmers would have no trouble purchasing wheat, oat, barley and rye seeds not treated with neonicotinoids and other systemic insecticides. It is very likely that retailers and seed dealers will instead supply these seeds either untreated, or treated with fungicides, biologicals, and possibly alternative insecticide treatments.

Supplying seed corn not treated with neonicotinoids is currently more logistically challenging because seed corn is treated before being shipped to seed dealers and other agricultural retailers. Nevertheless, seed companies can and will adapt their supply chains to be able to provide these seeds to the farmers of Colorado.

First, Colorado farmers plant close to 1.5 million acres of corn each year, representing a significant market for corn seeds worth over $160 million dollars. It is extremely unlikely that seed companies will walk away from this lucrative market.

Second, other states will be creating need-based use programs on a similar timeframe, further pushing markets to offer seed options without systemic insecticides. Specifically, New York and Vermont will be implementing new programs starting January 1, 2029—in alignment with the SEED Act. Shifting the supply chain to provide seed without neonicotinoids or other systemic insecticides is feasible with that phase-in period, particularly with the regulations targeted for completion by January 1, 2028. And farmers will have close to a full year to assess their pest pressure and reach a determination about their seed needs before placing orders in fall/winter 2028.

While altering their supply chains presents some challenges for seed companies, these are the kinds of issues our industry deals with all the time, and seed companies can and will meet the new demand. Moreover, the bill allows for the Colorado Department of Agriculture to relax restrictions as needed where there is a lack of commercially available non-insecticide-treated seed for a particular crop.

In sum, this regulatory change is not an existential threat to farmers. I would not risk submitting this testimony or putting the farmers that my company has been serving for three generations in jeopardy if I had the slightest doubt that the market for seed will adapt, where necessary, in the timeframe provided by this bill.

Mac Ehrhardt

Mac Ehrhardt, Chairman
Albert Lea Seed House, Inc.
mac@alseed.com

XERCES SOCIETY
for Invertebrate Conservation

Protecting the life that sustains us

Colorado General Assembly
Senate Agriculture and Natural Resources Committee
Written Testimony in Support of
SB26-065, Strengthening Economic and Environmental Decisions (SEED) Act
February 26, 2025

Submitted by:

Jacqueline Buenrostro, M.Sc.
Pesticide Reduction Specialist
The Xerces Society for Invertebrate Conservation
jacqueline.buenrostro@xerces.org

Dear Chair Roberts, Vice Chair Danielson, and all Honorable Members of the Committee:

We submit this testimony on behalf of the **Xerces Society for Invertebrate Conservation**, a national nonprofit dedicated to protecting invertebrate wildlife through research and science-backed policies and practices. Xerces is recognized as a global leader in pollinator conservation by the United Nations Food and Agriculture Organization and USDA–Natural Resources Conservation Service. As part of this work, we partner with Colorado's state agencies, land managers, and local communities to find pest management solutions that work for people and pollinators in the state.

We appreciate the opportunity to submit testimony in **support of the Strengthening Economic and Environmental Decisions or SEED Act, SB65.** This bill would reduce the prophylactic use of seeds treated with systemic insecticides including neonicotinoids and diamides. These represent a large share of insecticide use in the state and are costly for growers, largely ineffective at improving yields, and hazardous to the state's pollinators and natural resources. This bill is supported by evidence in the Colorado Native Pollinating Insects Health Study and by Governor Polis' priority area of protecting pollinators from pesticides, as indicated in his 2026 State of the State Address.[1]

We share our evidence to these points and relevant information below. Please do not hesitate to reach out to us for further information or conversations.

[1] Governor Jared Polis' State of the State Address. 2026. See comments at 1hr, 18min. Available at: https://www.youtube.com/watch?v=P7HabInABSk

Pollinators are important for Colorado, yet are declining.

Managed and wild pollinators are incredibly important for agriculture and natural ecosystems in Colorado. Over 1,000 species of bees and nearly 300 species of butterflies can be found in the state, and our pollinators directly support billions of dollars in Colorado's agricultural production.[2] Indeed, many of our cherished agricultural commodities rely on pollinators including Palisade peaches, apples, Rocky Ford cantaloupe, beans, tomatoes, and squash. Pollinators also sustain our natural ecosystems: over 80% of flowering plants rely on these tiny creatures to reproduce.[3]

Unfortunately, we have witnessed an alarming decline in pollinators in recent decades. While it is not possible to collect data on the status of every pollinating insect in the state, the severity of declines have been quantified for several species of interest, for example:

- Commercial beekeepers are reporting record overwintering losses of honeybees in 2025, with average losses over 50% and many operations reporting 70-100% losses over the last year.[4]
- Nearly 30% of Colorado's native bumble bee species are imperiled and petitioned or under review for protection under the federal Endangered Species Act by the US Fish & Wildlife Service. This includes the western bumble bee (*Bombus occidentalis*), a once widespread species which has declined by 57% from its known range in just over 20 years with projected future declines up to 97% by 2050, driven in part by neonicotinoid insecticides.[5]
- Eastern populations of the monarch butterfly, whose migration passes through Colorado east of the Rocky Mountains, have declined by approximately 80% since the 1980s and 1990s. This species has been proposed for listing as "threatened" under the Endangered Species Act.[6]

Pesticide use, including systemic insecticides such as neonicotinoids and diamides, is a major driver of pollinator declines. Even as overall agricultural insecticide use by volume has gone down since the

[2] Armstead, S. et al. 2024. Colorado Native Pollinating Insects Health Study. Available at: https://dnr.colorado.gov/native-pollinating-insects-health-study

[3] Ollerton, J., Winfree, R. and Tarrant, S. 2011. How many flowering plants are pollinated by animals?. Oikos, 120: 321-326. https://doi.org/10.1111/j.1600-0706.2010.18644.x

[4] Project *Apis m.* 2025. *Severe and Sudden Losses of Managed Honey Bees Across the Nation*. Available at: https://static1.squarespace.com/static/650342507631075013d25a2c/t/67a505a93e1b5b1ba7a4e145/1738868137561/Jan+2025+Colony+Losses+Communication+Final.pdf (Accessed 30 May 2025).

[5] Janousek WM, et al. 2023. Recent and future declines of a historically widespread pollinator linked to climate, land cover, and pesticides. PNAS. 120(17):e2304869120. doi: 10.1073/pnas.2304869120.

[6] The Xerces Society for Invertebrate Conservation. "Monarch butterfly proposed for listing under the US Endangered Species Act". Available at: https://xerces.org/press/monarch-butterfly-proposed-for-listing-under-us-endangered-species-act

1990s, the total toxic load to terrestrial arthropods from insecticides has increased markedly over this timeframe, primarily driven by the high toxicity of neonicotinoid insecticides.[7,8]

Neonicotinoids and other systemic insecticides are a key driver of pollinator declines.

The use of neonicotinoid insecticides has increased dramatically since their introduction in the 1990s. These systemic insecticides have also been joined by newer systemic products on the market, including diamides (e.g. chlorantraniliprole) and butenolides (e.g. flupyradifurone). These products are used extensively and prophylactically in agriculture in the form of seeds coated with systemic insecticides before sale. Since their appearance on the market, an accumulation of independent, peer-reviewed scientific evidence has shown that systemic insecticides and particularly neonicotinoids are directly linked to the widespread decline of bees and other pollinators.[9,10,11,12,13,14]

Neonicotinoids and other systemic insecticides have several characteristics that make them uniquely dangerous for Colorado's pollinators, other wildlife, and ecosystems. First, they are toxic to bees and other beneficial insects at very small doses. **For example, the lethal dose of the neonic thiamethoxam, which is commonly applied as a seed coating, for an adult honeybee is 15,000 times smaller than a grain of salt. This makes it more than 90 times more toxic to a bee than chlorpyrifos, a highly toxic organophosphate insecticide.** While diamides including chlorantraniliprole are generally less acutely toxic to adult honeybees, they are highly toxic to developing honeybee larvae as well as butterfly larvae and adults. In fact, **chlorantraniliprole is the most toxic of all insecticides tested on the monarch**

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[7] Jakob Wolfram *et al.* 2026. Increasing applied pesticide toxicity trends counteract the global reduction target to safeguard biodiversity. *Science.* 391,616-621.DOI:10.1126/science.aea8602

[8] DiBartolomeis M, et al. 2019. An assessment of acute insecticide toxicity loading (AITL) of chemical pesticides used on agricultural land in the United States. PLoS ONE 14(8): e0220029. https://doi.org/10.1371/journal.pone.0220029

[9] Rundlöf, M. et al. 2015. Seed coating with a neonicotinoid insecticide negatively affects wild bees. *Nature.* 521:77-80. https://doi.org/10.1038/nature14420

[10] Forister, M.L. et al. 2016. Increasing neonicotinoid use and the declining butterfly fauna of lowland California. *Biology Letters.* 12:20160475. http://dx.doi.org/10.1098/rsbl.2016.0475

[11] Woodcock, B.A. et al. 2017. Country-specific effects of neonicotinoid pesticides on honey bees and wild bees. *Science*. 356(6345):1393-1395. https://doi.org/10.1126/science.aaa1190

[12] Becher M.A. et al. 2023. Recent and future declines of a historically widespread pollinator linked to climate, land cover, and pesticides. *PNAS.* 120(5).

[13] Guzman, L.M. et al. 2024. Impact of pesticide use on wild bee distributions across the United States. *Nature Sustainability.* 7:1324–1334. https://doi.org/10.1038/s41893-024-01413-8

[14] Van Deynze, B. et al. 2024. Insecticides, more than herbicides, land use, and climate, are associated with declines in butterfly species richness and abundance in the American Midwest. *PLoS ONE.* 19(6):e0304319. https://doi.org/10.1371/journal.pone.0304319

butterfly based on available data.[15] Butenolides including flupyradifurone are also very harmful to bees and butterflies. In a semi-field experiment where wild bees were exposed to label-recommended rates of products containing flupyradifurone, 100% of the population died within three days of exposure.[16] This active ingredient also resulted in 100% chronic exposure mortality for monarch larvae that were exposed to leaves 24 hours after treatment at application rates consistent with the label.[17]

Typical concentrations of these systemic insecticides encountered in the environment also result in a number of effects that do not cause immediate death but can reduce survival and reproduction. Such effects can include reduced foraging, shorter lifespan, lower queen production, and even reduced honey yield.[18] Even trace amounts of neonicotinoids in nectar and pollen can cause harm to bee health, leading to impaired colony function and reduced reproduction.[19] Chronic neonicotinoid exposure can also weaken immune function, resulting in colonies that are more susceptible to *Varroa* mite infestations and other parasites and pathogens. Weakened colonies are also less likely to overwinter successfully. Notably, neonicotinoids can become more toxic to honey bees at lower temperatures, suggesting that residues stored in honey and pollen may pose heightened risks during winter.[20] These non-immediate effects are not isolated to neonicotinoids. For example, significant reproductive effects were observed in bumble bees as a result of chronic exposure to chlorantraniliprole.[21] Wild bees exposed to label rates of flupyradifurone experienced lower nesting success and reduced foraging efficiency.[14] These types of harmful effects are more difficult to observe than immediate mortality, but can cause populations to decline over time.

The systemic nature of these insecticides means they are absorbed by the plant and expressed in tissues throughout the plant, including the pollen and nectar that bees rely on for food. This makes non-target exposure unavoidable to pollinators foraging in a contaminated landscape. Furthermore, systemic insecticides do not stay where they are applied, especially when used as seed treatments. In fact,

[15] Krishnan, N. et al. 2021. Monarch Butterfly (Danaus Plexippus) Life Stage Risks from Foliar and Seed-Treatment Insecticides. *Environmental Toxicology and Chemistry.* 40(6). https://doi.org/10.1002/etc.5016.

[16] Siviter, H. et al. 2024. A novel pesticide has lethal consequences for an important pollinator, *Science of The Total Environment*. 952. https://doi.org/10.1016/j.scitotenv.2024.175935.

[17] Mach, B.M. et al. 2024. Target and non-target effects of insecticide use during ornamental milkweed production. *Environmental Entomology*. 53(4):648-658. https://doi.org/10.1093/ee/nvae056

[18] Chambers, R.G., Chatzimichael, K., and Tzouvelekas, V. 2019. Sub-lethal concentrations of neonicotinoid insecticides at the field level affect negatively honey yield: Evidence from a 6-year survey of Greek apiaries. *PLoS ONE.* 14(4):e0215363. https://doi.org/10.1371/journal.pone.0215363

[19] Wu-Smart, J. and Spivak, M. 2016. Sub-lethal effects of dietary neonicotinoid insecticide exposure on honey bee queen fecundity and colony development. *Nature Scientific Reports*. 6:32108. https://doi.org/10.1038/srep32108

[20] Saleem, M. S., Huang, Z. Y., & Milbrath, M. O. (2020). Neonicotinoid pesticides are more toxic to honey bees at lower temperatures: Implications for overwintering bees. *Frontiers in Ecology and Evolution*, 8(556856). https://doi.org/10.3389/fevo.2020.556856

[21] Smagghe, G. et al. 2013. Dietary Chlorantraniliprole Suppresses Reproduction in Worker Bumblebees. *Pest Management Science* 69 (7): 787–91. https://doi.org/10.1002/ps.3504.

research demonstrates that over 90% of the seed coating does not remain on the seed; most analyses indicate that less than 5% is taken up by the target crop plant. [22,23,24,25] Instead, the majority of the active ingredient is released into the surrounding environment. It may be released as dust during planting, leach into subsurface water, contaminate watersheds, persist in soils, and/or be taken up by non-target plants.

These systemic insecticides are persistent, long-lived chemicals. Neonicotinoids persist in plants and the environment for months and sometimes years after they are used, making them toxic to pollinators even after the growing season. Diamides are also incredibly persistent. For example, dissipation studies with chlorantraniliprole show a half-life **up to 1130 days** on bare ground plots. [26] This means it would take **over 15 years to achieve 97% decay**. Because of this persistence, toxic levels build up and accumulate season after season. These factors make toxic exposure very likely for bees, butterflies, natural enemies, and other insects that are beneficial to growers.

Seeds treated with systemic insecticides provide little to no benefit to growers, with high environmental costs.

Seeds treated with systemic insecticides are often used prophylactically - when there is no pest threat present - on dozens of crops, including alfalfa, corn, sunflower, soy and wheat. Treated seeds account for an estimated 10% or more of all insecticide use, and conservative estimates found that coated seeds are planted on approximately 150 million acres in the United States.[27] These estimates are likely lower than actual use, because the US Environmental Protection Agency (EPA) designates coated seed as "treated articles," essentially exempting them from federal pesticide regulation and reporting requirements (see figure).

[22] Alford, A. and Krupke C.H. 2017. Translocation of the neonicotinoid seed treatment clothianidin in maize. *PLoS ONE.* 12(3): e0173836. https://doi.org/10.1371/journal.pone.0173836

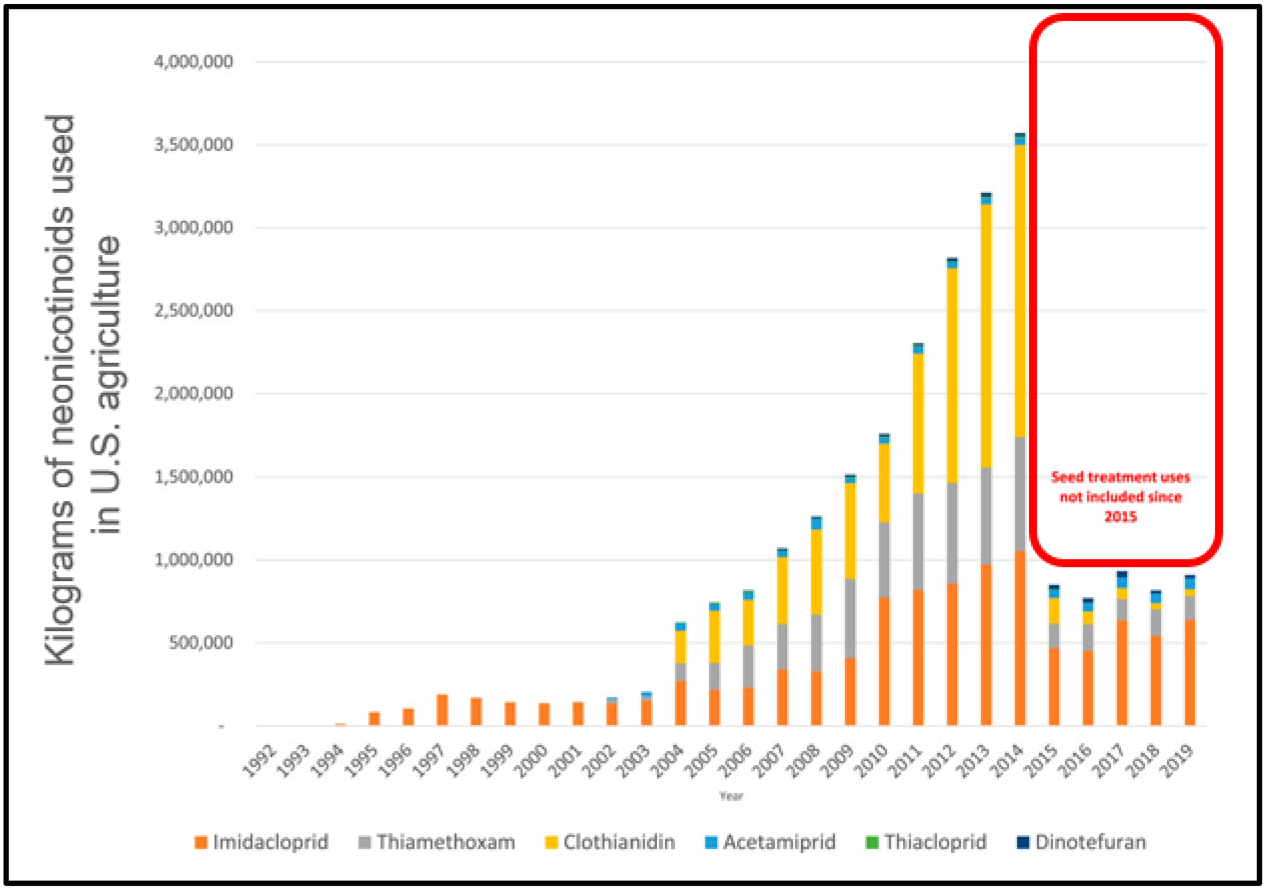
[23] Tooker, J.F., Douglas, M.R. and Krupke, C.H. 2017. Neonicotinoid Seed Treatments: Limitations and Compatibility with Integrated Pest Management. *Agricultural & Environmental Letters*, 2: ael2017.08.0026. https://doi.org/10.2134/ael2017.08.0026

[24] Wood TJ and Goulson D. 2017. The environmental risks of neonicotinoid pesticides: a review of the evidence post 2013. *Environ Sci Pollut Res Int.* 24(21):17285-17325. doi: 10.1007/s11356-017-9240-x.

[25] Morrison, B.A., Xia, K. and Stewart, R.D. 2023. Evaluating neonicotinoid insecticide uptake by plants used as buffers and cover crops. *Chemosphere.* 322. https://doi.org/10.1016/j.chemosphere.2023.138154.

[26] Chlorantraniliprole Pesticide Fact Sheet. 2008. *US Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substances.*

[27] Douglas, M.R. and Tooker, J.F. 2015. Large-Scale Deployment of Seed Treatments Has Driven Rapid Increase in Use of Neonicotinoid Insecticides and Preemptive Pest Management in U.S. Field Crops. *Environmental Science & Technology*. *49*(8):5088-5097. DOI: 10.1021/es506141g



Prophylactic use of neonicotinoid-treated seeds has driven an increase in neonicotinoid usage in the United States. Current data does not reflect usage in treated seeds, since this data has not been included since 2015. Figure adapted from Sass, J. B., Donley, N., & Freese, W. (2024). Neonicotinoid pesticides: evidence of developmental neurotoxicity from regulatory rodent studies. Frontiers in Toxicology, 6, 1438890. https://doi.org/10.3389/ftox.2024.1438890

Despite their widespread use, research demonstrates that **in most cases, these seed treatments do not benefit farmers.** For example, in the case of corn and soy, field trials consistently show limited to no yield benefit of the use of treated seeds.[28,29] Recent research also shows that neonicotinoid seed coatings can reduce weed seed control by insects in corn-soy rotations,[30] and negatively affect

[28] Grout, T. A. et al. 2020. Neonicotinoid Insecticides in New York State: Economic Benefits and Risk to Pollinators. Cornell University. Available: https://cornell.app.box.com/v/2020-neonicotinoid-report

[29] Labrie et al. 2020. Impacts of neonicotinoid seed treatments on soil-dwelling pest populations and agronomic parameters in corn and soybean in Quebec (Canada). PLoS ONE 15(2): e0229136.

[30] Rowen, E. K. et al. 2025. Insecticides may facilitate the escape of weeds from biological control. *PeerJ*. 13:e18597. https://doi.org/10.7717/peerj.

arthropod decomposers that build healthy soils.[31] Overuse of systemic seed treatments have also been linked to losses of insect predators that provide natural pest control, resulting in reduced crop density and yield.[32]

This widespread, unnecessary use is not helpful to growers and is also harmful to pollinators, waterways, and ecosystems. For example, research shows that fields planted with neonicotinoid-treated seeds and their surrounding areas had 50% fewer wild bees compared to a paired control field planted with untreated seeds. Fields planted with treated seeds also experienced a 100% reduction in solitary bee nesting, a 40% reduction in male and worker bumble bees, and a 70% reduction in queen bumble bees, which are the reproductive unit of the colony.[33] Research from northeast Colorado also found that the neonicotinoid thiamethoxam, a common seed coating, was found in 46% of sampled native bees, sometimes at levels linked to lethality.[34] The imperiled monarch butterfly is also at risk from systemic seed treatments: monarch caterpillars reared on milkweed adjacent to diamide-treated corn had a lower growth rate compared to monarchs reared near untreated plants.[35] These effects can have repercussions for fitness and reproduction, leading to species declines over time.

Seed treatments in Colorado are also linked to pollution of the state's valuable water resources, according to a recent report that analyzed data from Colorado's Agricultural Water Quality Program. Wells sampled in the South Platte Basin in Weld, Morgan, Washington, Logan, and Sedgwick Counties contained levels of neonicotinoids used in seed treatments that were **100 times above levels at which adverse effects on aquatic life from chronic exposure are expected**. Because the aquifer in this region is hydrologically connected to the South Platte River and its tributaries, these results have relevance to surface water as well as groundwater. Several samples from the South Platte Basin also **exceeded EPA's worst case scenario concentrations of clothianidin residues from corn seed treatments in groundwater.**[36]

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[31] Pearsons, K. A., & Tooker, J. F. 2021. Preventive insecticide use affects arthropod decomposers and decomposition in field crops. *Applied Soil Ecology.* 157. https://doi.org/10.1016/j.apsoil.2020.103757

[32] Douglas, M.R., Rohr, J.R. and Tooker, J.F. 2015. Neonicotinoid insecticide travels through a soil food chain, disrupting biological control of non-target pests and decreasing soya bean yield. *Journal of Applied Ecology.* 52(1):250-260. https://doi.org/10.1111/1365-2664.12372

[33] Rundlöf, M. et al. 2015. Seed Coating with a Neonicotinoid Insecticide Negatively Affects Wild Bees. *Nature* 521 (7550): 77–80. doi:10.1038/nature14420

[34] Hladik, M.L., Vandever, M. and Smalling, K.L. 2016. Exposure of Native Bees Foraging in an Agricultural Landscape to Current-Use Pesticides. *The Science of the Total Environment* 542 (Pt A): 469–77. https://doi.org/10.1016/j.scitotenv.2015.10.077.

[35] Florez Ruiz, T. 2026. Beyond the Target: Impacts of Agricultural Pesticides and Fungicides on Non-Target Flora and Food Web. (Thesis, University of the Andes / Cornell University). Available: https://repositorio.uniandes.edu.co/server/api/core/bitstreams/744ec252-ca45-4c31-86ae-794907345dc2/content

[36] Mineau, P. 2025. Neonicotinoid Pesticides in Colorado Water: Threats to the State's Aquatic Ecosystems. Available at: https://www.nrdc.org/sites/default/files/2025-07/neonicotinoid-pesticides-in-colorado-water-threats-to-the-states-aquatic-ecosystems.pdf

Despite this documented harm to yields and ecosystems, growers may not currently have the easy access they need to seeds with their desired traits without insecticidal coatings. It is important to note that **the large companies that sell seeds are the same companies that manufacture the pesticides used to coat them.** This market consolidation reduces competition and disincentivizes product diversification - for example, making hybrid corn varieties available without insecticide treatments. This has long been a concern of the U.S. Department of Agriculture.[37] If Colorado enacts legislation that limits cases where treated seeds can be used, it will create a market for seeds without insecticides, making it easier for farmers to purchase them. Other states are moving in the same direction, with New York and Vermont enacting legislation in 2023 and 2024 to phase out prophylactic use of neonicotinoid insecticides on seeds in favor of a justified use model.

Support the SEED Act, SB 65: A commonsense solution for Colorado's growers and pollinators.

The SEED Act (SB 65) offers a practical, science-based solution to Colorado's systemic insecticide problem. This bill would:

- Phase out prophylactic use of seeds treated with systemic insecticides in select crops by 2029, while still allowing their use when there is a documented pest threat.
- Establish an approval process so farmers facing real pest challenges retain access to treated seed if needed.
- Provide a transition period, giving both farmers and seed suppliers time to secure affordable, untreated alternatives.
- Protect Colorado's pollinators, ecosystems, and waterways that are critical to the health of our state.

Importantly, the SEED Act is not a ban on the use of systemic insecticide seed treatments. Rather, it shifts their use to a prescription-like system that prevents needless use and makes options without insecticidal coatings more readily available. New York[38] and Vermont[39] recently passed similar laws on treated seeds, which mirror a program that has been successful in Quebec for years. Experiences in Quebec—where neonic-coated seeds were largely phased out in 2019 and use of seed with no insecticides continues to grow—show that farmers can maintain strong yields while reducing treated

[37] "More and Better Choices for Farmers: Promoting Fair Competition and Innovation in Seeds and Other Agricultural Inputs." 2023. USDA Agricultural Marketing Service. https://www.ams.usda.gov/sites/default/files/media/SeedsReport.pdf
[38] S.1856-A/A.7640 press release, 2023
[39] Xerces press release, 2024

seed use.[40] In fact, no crop failures have been documented in Quebec in response to their restrictions, as farmers continue to see a lack of need for seeds treated with systemic neonicotinoids and diamides.[41]

Colorado has already taken meaningful legislative action to protect pollinators, including the Native Pollinating Insects Health Study[42], Pollinator License Plate program[43], granting Colorado Parks and Wildlife the authority to conserve insects[44], and restricting the unlicensed sale of neonicotinoid insecticides[45]. The SEED Act would honor Colorado's legacy of environmental sustainability and pollinator protection by filling the largest unaddressed gap in regulation that puts the state's pollinators at risk. Support for SB 65 is a vote of support for Colorado's farmers, robust agricultural economy, and the invertebrate wildlife that in turn supports them. For these reasons, we urge you to vote this piece of legislation out of committee favorably.

Sincerely,

Jacqueline Buenrostro, M.Sc.
Pesticide Reduction Specialist
Xerces Society for Invertebrate Conservation
jacqueline.buenrostro@xerces.org

[40] Rosemary Malfi. 2024. What We Can Learn From Québec's Success With Regulating Pesticide-Treated Seed.
[41] Letter to Gov. Hochul from Louis Robert and Dr. Genevieve Labrie. August 7, 2023. Available: https://drive.google.com/file/d/1-XgopE5PJaFFuJyytRi9-F3FFEvRURpS/view
[42] A result of SB22-199: https://leg.colorado.gov/bills/sb22-199
[43] A result of HB21-1145: https://leg.colorado.gov/bills/hb21-1145
[44] A result of HB24-1117: https://leg.colorado.gov/bills/hb24-1117
[45] A result of SB23-266: https://leg.colorado.gov/bills/sb23-266