Briefing Note

Bugged Out: How DNA Metabarcoding Can Protect Canadian Agriculture

Insect impact on Canadian agriculture

Canada's agricultural sector is a vital aspect of the Canadian economy, employing 2.3 million people and generating $150 billion dollars towards Canada's gross domestic product in 2023 alone[1].

The sector is continuously threatened by the presence of pest species and the decline of beneficial insects (e.g. insect pollinators, beetles and spiders). Traditional surveillance methods are not sufficient.

DNA metabarcoding adoption can revolutionize pest surveillance and management, fostering sustainable agriculture and climate resilience.

Canadian Insects and Agricultural Impacts

Agricultural systems host both beneficial and pest insects which can alter agriculture productivity. Beneficial insects (especially pollinators and spiders from the phylum Arthropoda) are integral to the agriculture industry as they provide essential services such as pollination, soil remediation, and natural pest control - ultimately leading to increased agricultural yields and overall ecosystem health [1,2].

Monitoring of beneficial insects in Canada is largely overlooked aside from academic groups. Meanwhile, human-caused climate change is expected to substantially reduce the diversity, abundance, and distribution of these vital insects[3]. This will leave the agriculture industry more prone to pest damage and reduce productivity.

In 2023, North American pests were responsible for the loss of ~ 21 million kg of corn from farmers alone – a financial loss of about 10 million CAD[4].

We need a new way to track insects

Economics and Scale: Canada has a vast expanse of farmland, with 93.5 million acres dedicated solely to crop production[5]. Traditional pest surveillance using visual or trapping surveys is time consuming and costly, can only monitor a small area and requires highly trained surveyors for effective monitoring[2,6,7].

Knowledge: Successful pest management requires early identification of pests to limit their spread and the chance of yield loss[8]. Small, cryptic, or novel pest species require insect experts to identify them[9]. As experts are far and few between, false identifications, rising consultation costs, and delayed identification make traditional monitoring less reliable[10,11].

Missing Pests and Beneficial Insects: Existing pest surveillance is heavily focused on already established regulated plant pests[6] but overlooks newly emerging pests. Furthermore, even established, beneficial species are not systematically tracked throughout Canada[12,13].

Recommendation details on pg 2

DNA metabarcoding: the future of insect monitoring

Cost effective and scalable: Requires minimal expertise from field workers – but instead just sample collection capabilities. Consequently, the high labor costs associated with employing skilled experts in-field would be drastically reduced[14].

Comprehensive surveillance: The CFIA and AAFC are focused on the surveillance of both pests and beneficial insects[15]. DNA metabarcoding has broad identification capabilities and could increase the surveillance of both beneficial and pest species – as the processing of one sample can test for both simultaneously.

Fast and environmentally friendly: From the time of traditional surveillance to treatment, aggressive pest species can rapidly reproduce and larger pesticide use is required[16]. With DNA metabarcoding, species identification can be completed as soon as 24 to 48 hours after collection[17], ultimately treating and curbing outbreaks earlier.

1. Develop pilot programs, focusing on training programs

Conduct region-specific pilot programs to validate DNA metabarcoding approach in diverse agricultural settings.

This approach should support applied research grants and collaborate with local current research groups. We recommend the CFIA collaborate with local research groups specializing in DNA metabarcoding or insect monitoring to design and conduct studies on methodology verification, local environmental suitability, and cost monitoring.
Alongside the principal investigators of these studies, training programs for a subset of current CFIA pest management and Agri-Food Canadas "Wildlife Habitat Capacity on Farmland Indicator" employees/contractors should be implemented to learn on-field and laboratory work surrounding sampling techniques, equipment operation, and data interpretation.

2. Expand DNA reference libraries

Collaborate with academic institutions and research organizations to achieve comprehensive species coverage for all Canadian pests of interest.

Expanding DNA reference libraries will enable the Canadian agriculture sector to mitigate damage from current and potential future insect pests, facilitating timely monitoring and response to crop pest issue. We recommend the government provide grants, similar to The Invasive Species Action Fund, to researchers and private research groups so that current DNA reference libraries can be expanded for insect monitoring[18]. Many Canadian institutions specialize in DNA metabarcoding and the curation of reference libraries, such as The Center for Biodiversity Genomics (University of Guelph).

3. Integrate with national programs

Incorporate DNA metabarcoding within CFIA's existing pest monitoring frameworks.

Once pilot programs have confirmed the efficacy of DNA metabarcoding for wider use throughout Canadian agricultural settings, the CFIA should seize the opportunity to lower pest monitoring costs and expand their monitoring capabilities.
We recommend that DNA metabarcoding data, particularly that of positive pest sampling results, be regularly integrated within surveying applications already supported and used by the CFIA, such as ArcGIS[19]. Integration of this monitoring data into existing frameworks would allow for the accurate spatial mapping of insects of interest, in the form that the data will be readily available for risk analysis and informed interventions.

DNA metabarcoding: the future of insect monitoring

DNA metabarcoding is a transformative approach, offering enhanced accuracy, scalability, and the expansion of insect monitoring for Canada.

This surveillance tool also allows expansion into beneficial insects, supporting Canada's commitment to sustainable agriculture and biodiversity conservation.

Research Highlights Effectiveness

DNA metabarcoding is a type of genetic analyses that allows for the rapid identification of species from genetic material.

Paul Hebert and Dr. Dirk Steinke from the University of Guelph explored the use of DNA metabarcoding to identify insect and pest diversity within an agriculture setting. Collecting samples from two farms in Ontario for a season, they found over 7,000 insect species by DNA metabarcoding. 231 were identified as registered pests, with the others being beneficial or unregistered. After some analysis, the results also showed which crops were most prone to pests.

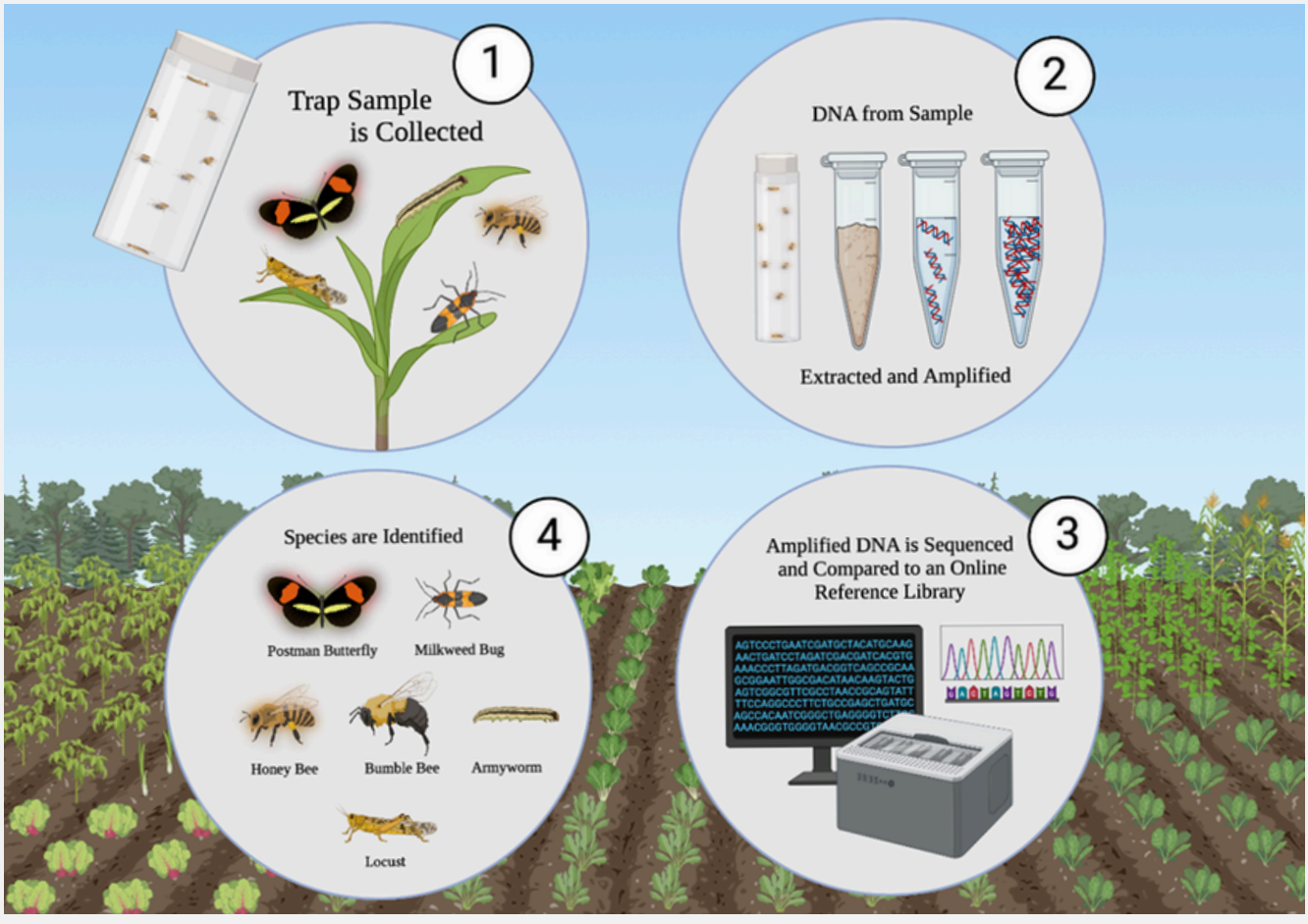

Figure 1: How it works - Understand the process of DNA metabarcoding from sample collection, DNA extraction, identification and comparison to reference libraries

Contributions & Partners

This policy brief was developed through the CARE program, in partnership with Food from Thought and the Arrell Food Institute.

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