2021 Soil Arthropod Biology Report: Soil Stewards Farm

Proposal GW20-217: The effects of cover crops on soil arthropod communities in the Inland Pacific Northwest

This project investigates how cover crop use and cover crop diversity on a small-scale organic farm affects soil arthropod biodiversity and functioning relative to standard crops, like potatoes. Assessing if and how cover crops support soil arthropod biodiversity and promote soil processes will help inform cover crop use in organic systems in the inland Pacific Northwest. Ultimately, our goal is to identify agricultural practices that boost belowground biodiversity to support the internal regulation of soil ecosystem services.

This report has been prepared for producer-collaborator Alison Detjens and the Soil Stewards Farm, a small-scale organic vegetable farm located in Moscow, Idaho. It summarizes the 2021 findings of our study evaluating how cover cropping on a small-scale organic farm impacts soil arthropod biodiversity relative to potatoes. The cover crops mix was oats and pea.

Prepared by: Dane Elmquist

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University of Idaho
Department of Entomology, Plant Pathology and Nematology

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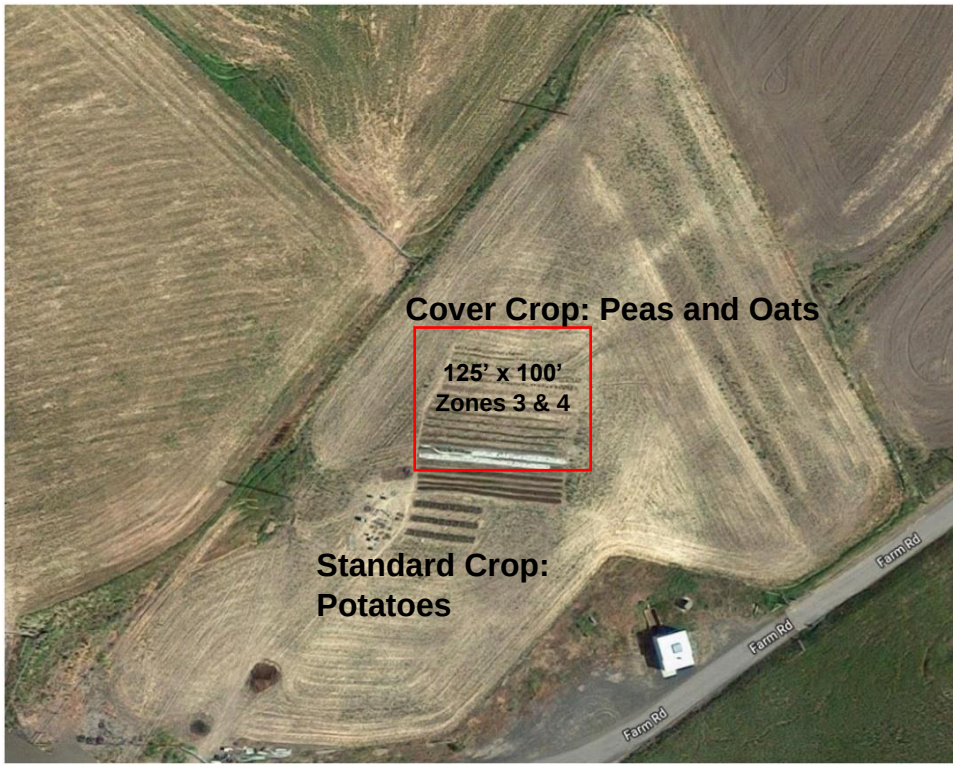
How do we study soil arthropods?

Arthropods are the most diverse group of animals on the planet. Many familiar groups of animals are arthropods: insects, spiders, mites, springtails, millipedes, centipedes, crabs, woodlice, etc. Soil arthropods include the arthropods that live on the soil surface, in the litter, and those that live lower within the soil profile. In agroecosystems, most soil arthropods are found in the top 5 inches of soil.

We sampled arthropod communities in your fields during June, July, and August of 2021. Soil arthropod populations can vary greatly over time and space. Therefore, our sampling protocol involved sampling throughout the growing season and sampling in many locations within your fields. This way we can account for the patchy distributions of soil arthropods.

Communities were sampled at a depth of 5 inches. We took multiple soil samples, mixed them in the field, and took 2L of this soil mixture from which to extract and characterize the soil arthropod community. Soil arthropods were extracted from soil samples with Berlese-Tullgren funnels in which heat drives the arthropods from the soil into collecting vials. This technique relies on the arthropods natural behavior of moving downwards through the soil to avoid drying out or getting too hot.

Berlese-Tullgren funnel



Map of Soil Stewards Farm. We sampled arthropod communities in Zone 3 and 4 at the farm during June, July, and August. Communities were sampled at a depth of 5 inches. Both crops were under irrigation throughout the growing season.

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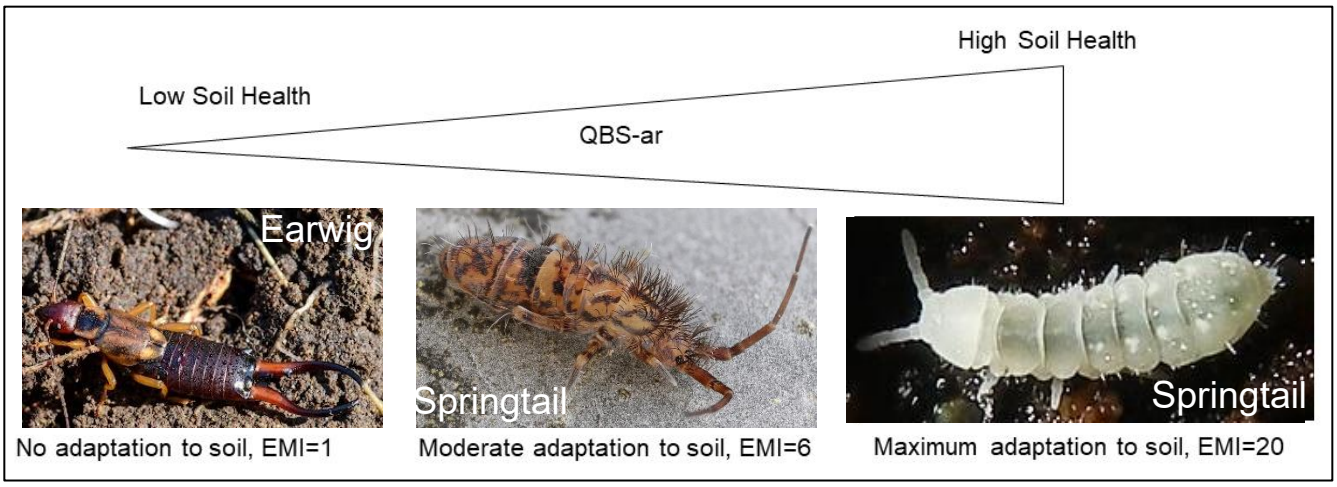
Soil arthropods as bioindicators of soil health

Implicit in the concept of soil health is that soil is a living ecosystem. Despite the known influence of soil arthropods on soil processes, they are not often included in soil biological community assessments. Common frameworks for soil health tests incorporate physical and chemical parameters, microorganisms (bacteria and fungi) and earthworms, but overlooking the critical arthropod community.

Understanding how to measure soil health is a front line in agroecosystem management. We utilized the Soil Biological Quality index (QBS-ar) to measure the effects of cover crops and potatoes on soil health. The QBS-ar is a soil health index that uses soil arthropods as biological indicators. QBS-ar is based on the concept that soil arthropods morphologically well-adapted to soil are more abundant in healthy soils. Arthropods from soil samples are assigned a score based on their adaptation to the soil, which is determined using morphological characteristics (e.g., presence of eyes, pigmentation, appendage modifications, etc.). The scores range from 1 (no adaptation to soil) to 20 (maximum adaptation to soil). When we process the arthropod samples, we assign scores to each group and then sum the scores for each community to obtain the QBS-ar score.



Determination of QBS-ar score. Examples of soil arthropod taxa with different levels of adaptation to soil and different EMI scores. Soils with high soil health are expected to harbor more soil arthropods that are highly adapted to soil, and vice versa. QBS-ar is the sum of EMI scores for a soil arthropod community.

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The importance of soil biodiversity

Biological diversity can be measured by accounting for both richness (number of groups) and evenness (abundance of each group). Biologically rich soil arthropod communities are more likely to have groups that give resilience to agroecosystem soils, since as a community with more groups is more likely to include groups with features or functions that allow them to adapt to a changing environment increases. If one group in the community experiences change, other groups may be able to adjust and maintain the regulation of soil processes. Biologically even soil arthropod communities are not overly dominated by just a few groups. Greater biodiversity (richer and more even communities) gives ecological systems a better chance of adapting to environmental variation that is becoming more frequent. Our program seeks to identify agricultural practices that promote soil biodiversity, and we focus for this study on how crop type affects soil arthropod biodiversity.

This report begins with a summary of the soil arthropod community collected at the Soil Stewards Farm. The following section compares soil arthropod biodiversity and soil health (measured using the QBS-ar) in soils planted with cover crops or potatoes.

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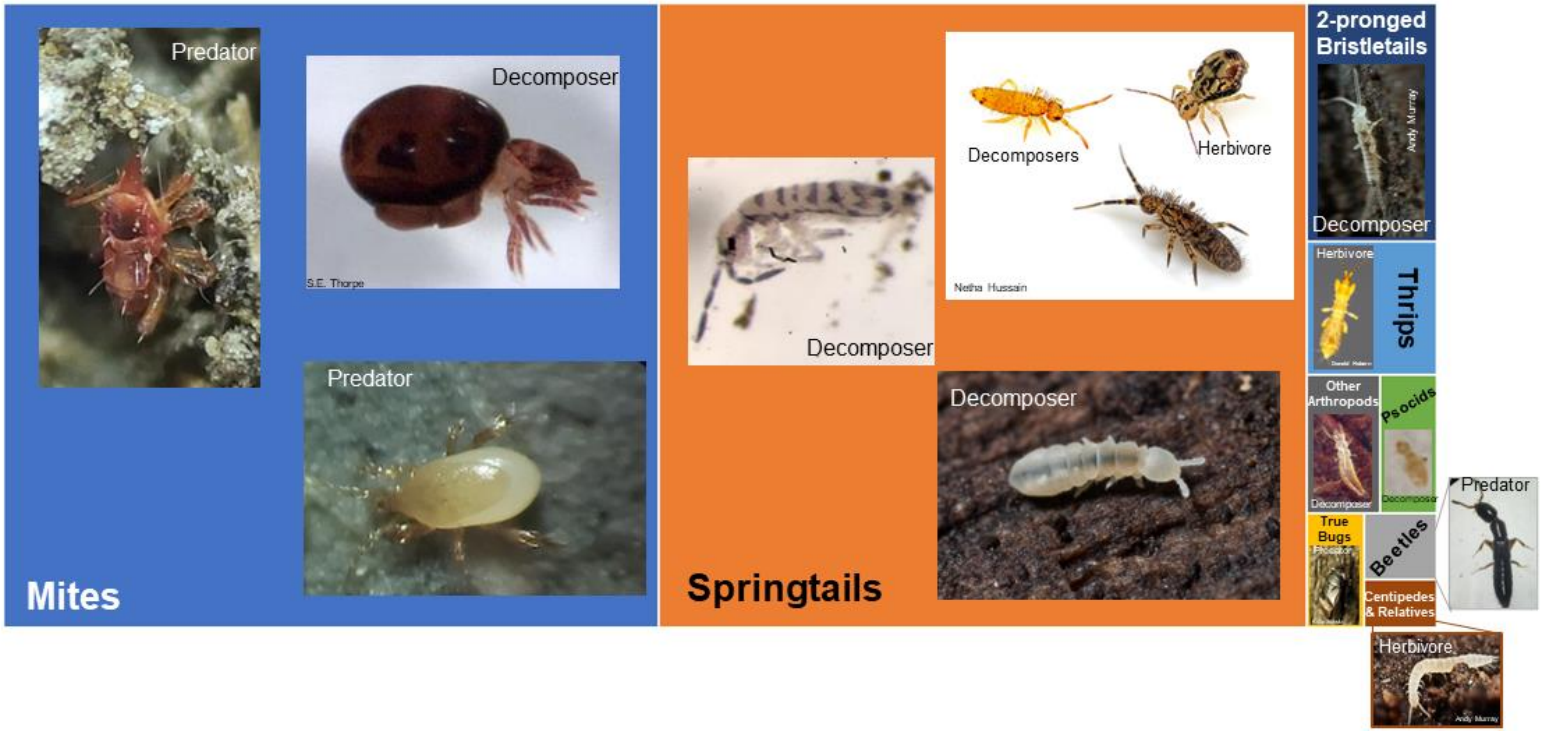
Who is there and what are they doing?

Many arthropods spend at least part of their lives in the soil and are major regulators of soil processes. Despite their role in maintaining healthy soils, we don't know much about the soil arthropod communities in Palouse organic agroecosystems. Who is there? What are they doing?



Graph 1. Who is there? This graph shows the soil arthropod community composition at the Soil Stewards Farm in 2021. The size of the tiles is proportional to the abundance of each group collected. Like in most soils, mites and springtails are the dominant arthropod groups, followed 2-pronged bristletails (Order: Diplura). Arthropod pictures show representative organisms in each group and are labeled with their functional group (i.e., what they are eating).

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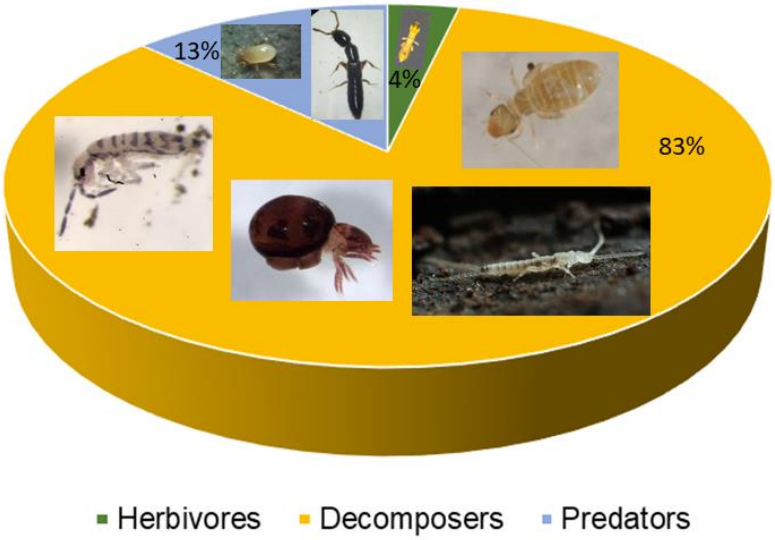
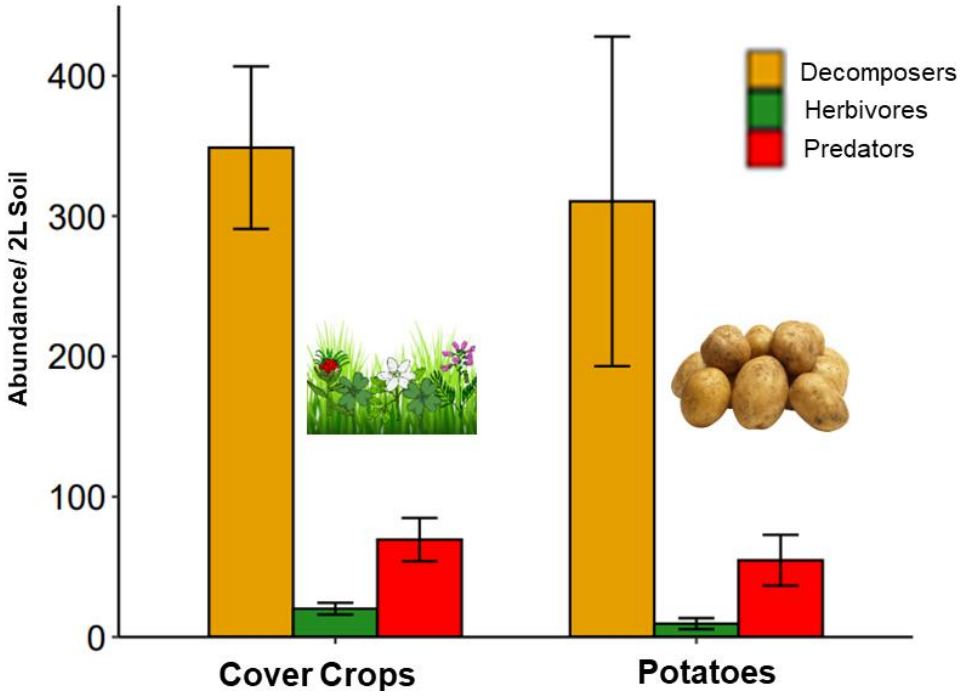


Graph 2. What are they doing? This graph breaks down the soil arthropod community composition by functional group. Predators, often referred to as natural enemies, eat nematodes and other arthropods and provide valuable biocontrol services. Decomposers break down plant litter and other organic matter, stimulate microbial processes, and improve nutrient cycling. Herbivores feed on plants and are generally considered pests in agroecosystems.



Graph 3. What are they doing? This graph shows the abundance (# of individuals in 2L of soil) of different functional groups in each crop type (cover crop vs. potatoes). The colored bars represent the average abundance of each functional group, and the error bars show the variation around the average. There were no differences in abundance of soil arthropod functional groups between potatoes and cover crops.

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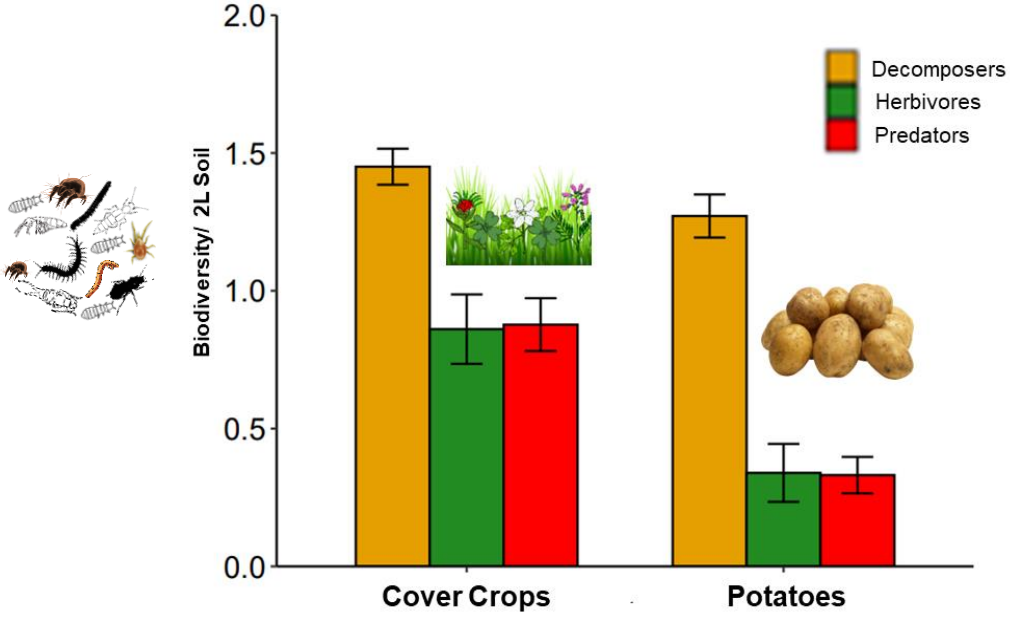
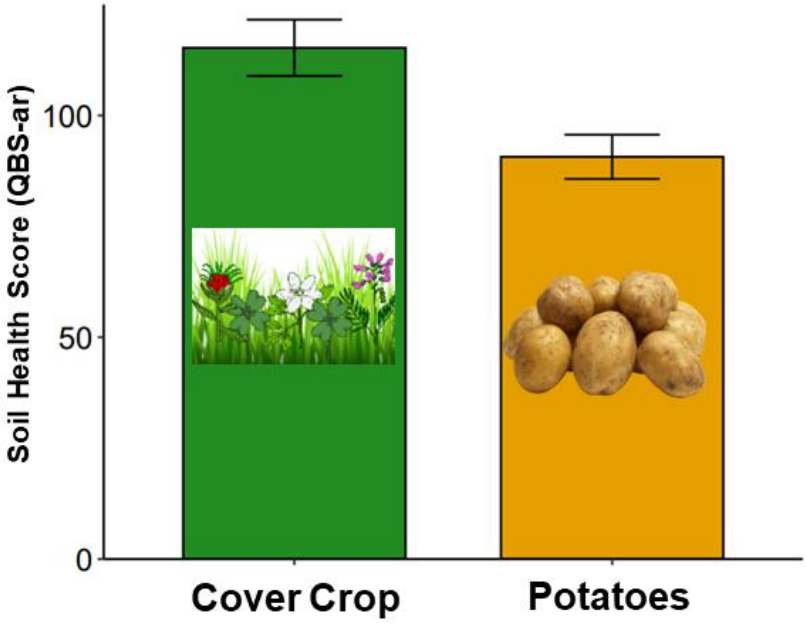


Graph 4. What are they doing? This graph shows the Shannon diversity index of different functional groups in cover crop vs. potatoes. Diversity is a metric that accounts for both richness (number of groups) and evenness (abundance of each group). The colored bars represent the average diversity of each functional group, and the error bars show the variation around the average. Contrary to the results we observed for abundance, cover crops increased the biodiversity of each functional group compared to potatoes.



Graph 5. Soil Health Score. Soil health, as measured using QBS-ar, for cover crop and potatoes. The colored bars represent the average QBS-ar score under each crop, and the error bars show the variation around the average. Cover crops had greater soil health than did potatoes.

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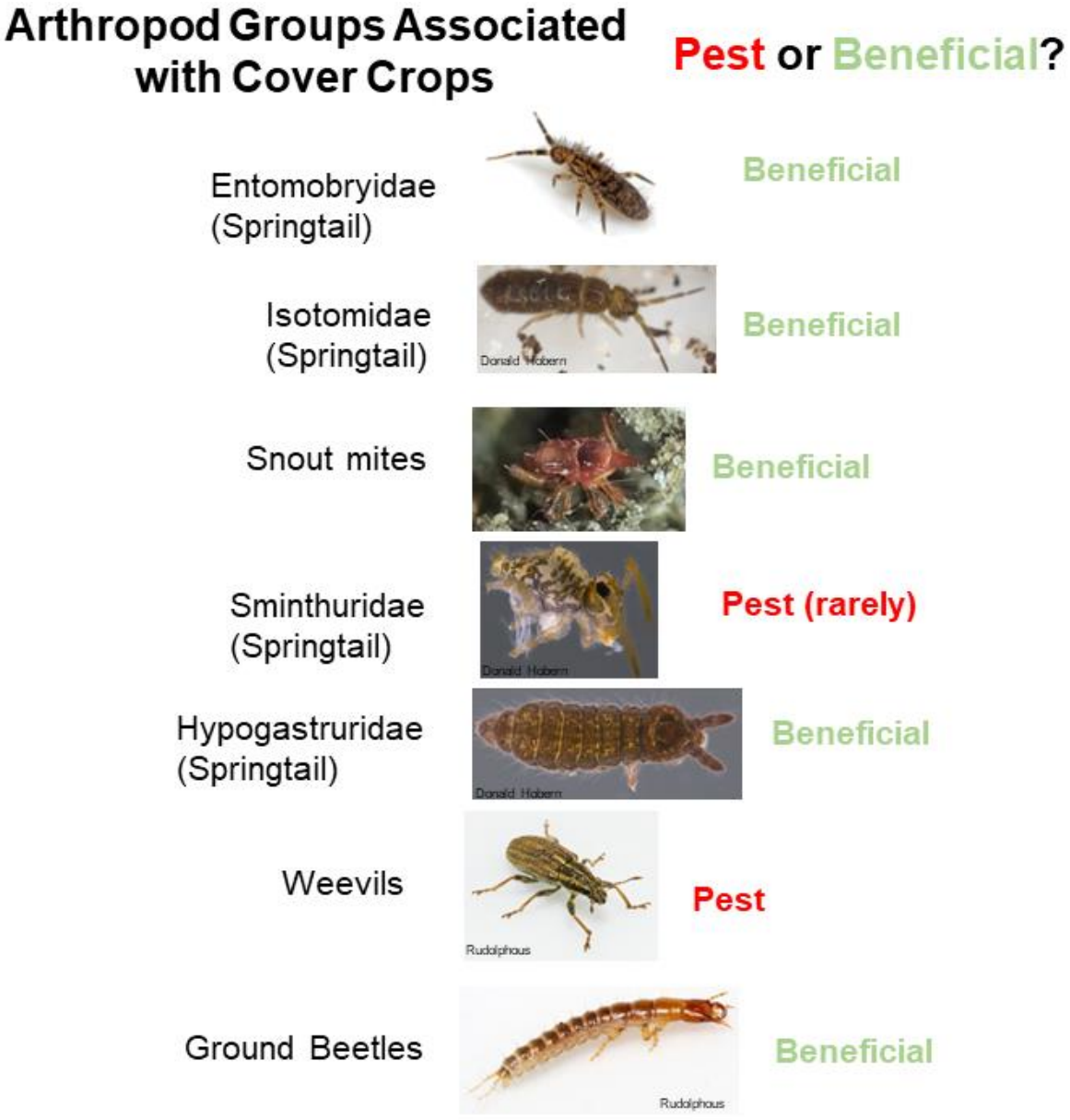

Graph 6. Indicator species. Using a statistical technique called indicator species analysis, we measured if specific arthropod groups were significantly associated with a certain crop type (potatoes or cover crop). We conducted this analysis for your farm and found that 7 different groups of soil arthropods were collected more often in cover crops than in potatoes. These are the groups most responsible for the differences in soil arthropod community composition between crop types. Most groups associated with cover crops are beneficial, but the weevil association should be considered when determining what crops to plant next in rotation. Many of these weevils were pea leaf weevil (*Sitona lineata),* which are pulse crop specialists. No soil arthropods were collected more often in potatoes. This result suggests that cover crops can be used to promote beneficial soil arthropod groups that provide valuable ecosystem services like biocontrol and decomposition.

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Summary

1. Cover crops increased the diversity, but not the abundance, of different soil arthropod functional groups compared to potatoes.

2. The QBS-ar soil health score was highest in cover crop relative to potatoes, perhaps reflecting the benefits of a multi-species crop.

3. Several springtail groups are significantly associated with cover crops. These springtail groups are beneficial decomposers and nutrient cyclers. Our results suggest that cover crops could be used to cultivate a diverse springtail community.

4. Observed differences between cover crop and potatoes related to soil biology and we did not observe any cover crop effects on soil pH, temperature, or volumetric water content.

5. Overall, increasing the number of management practices which reduce fallow and soil disturbance, and provide consistent resources that feed the soil's arthropod food web results in more diverse soil arthropod communities that support the natural regulation of soil processes.

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When collecting soil samples, we also measured soil pH, volumetric water content (VWC) (5” depth), and temperature (°F) (5” depth). The average values from 3 samples are presented in the table below for each collection date and crop type.

Sample Date	Crop	pH	VWC (%)	Temperature (°F)
23 June 2021	Cover crop	6.65	14.5	67
	Potatoes	6.88	20.6	72
8 July 2021	Cover crop	7.04	8.6	62
	Potatoes	6.94	14.5	63
6 August 2021	Cover crop	6.85	11.0	75
	Potatoes	6.64	11.6	78

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