2021 Soil Arthropod Biology Report: Wolf Farms

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 affects soil arthropod biodiversity and functioning relative to conventional crops, like spring planted wheat or legumes. Assessing if and how cover crops support soil arthropod biodiversity and promote soil processes will help inform cover crop use in the inland Pacific Northwest. Ultimately, we 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 Frank Wolf of Wolf Farms, a family owned and operated farm in dryland cereal-based production, located near Uniontown and Colton, Washington. It summarizes the 2021 findings of our study evaluating how cover cropping on large-scale commercial farms impacts soil arthropod biodiversity relative to conventional crops.

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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 within agricultural fields.

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.

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 measured the effects of cover crops and conventional crops on soil health as indicated by the Soil Biological Quality index (QBS-ar), which 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. The QBS-ar scores for each field pair sampled on your farm are included in this report.

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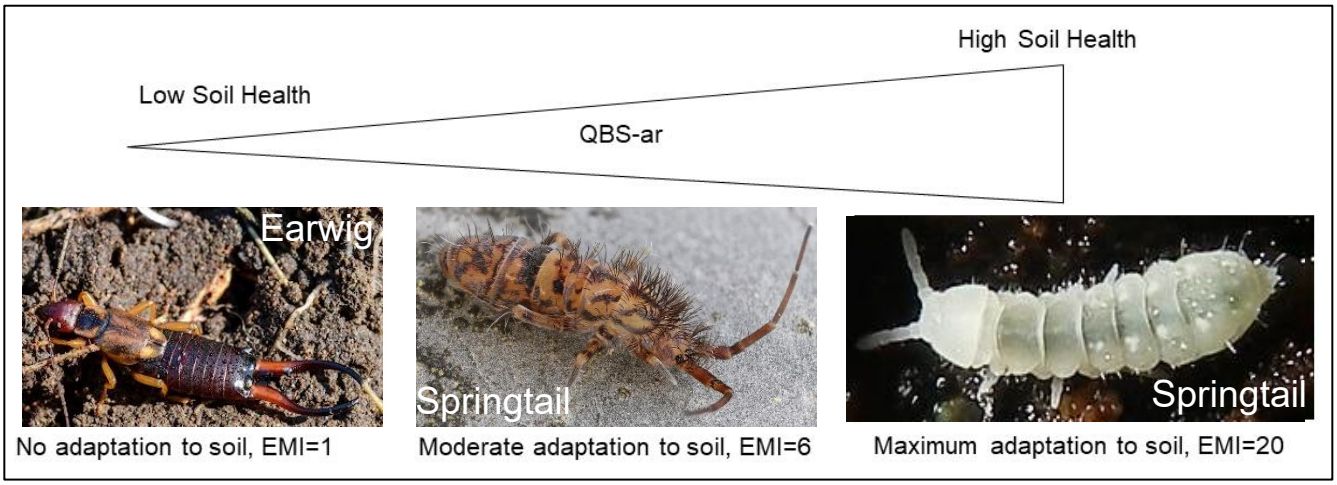

Determination of QBS-ar score. Examples of soil arthropod taxa with different levels of adaptation to soil and different EMI scores. Soils with high soil health are expected to harbor more soil arthropods that are highly adapted to soil, and vice versa. QBS-ar is the sum of EMI scores for a soil arthropod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

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 total soil arthropod community present across all the fields sampled on your farm. Subsequent sections compare soil arthropod biodiversity and soil health (measured using the QBS-ar) in fields planted with either cover crops or conventional crops. We identified three such pairs for comparison on your farm.

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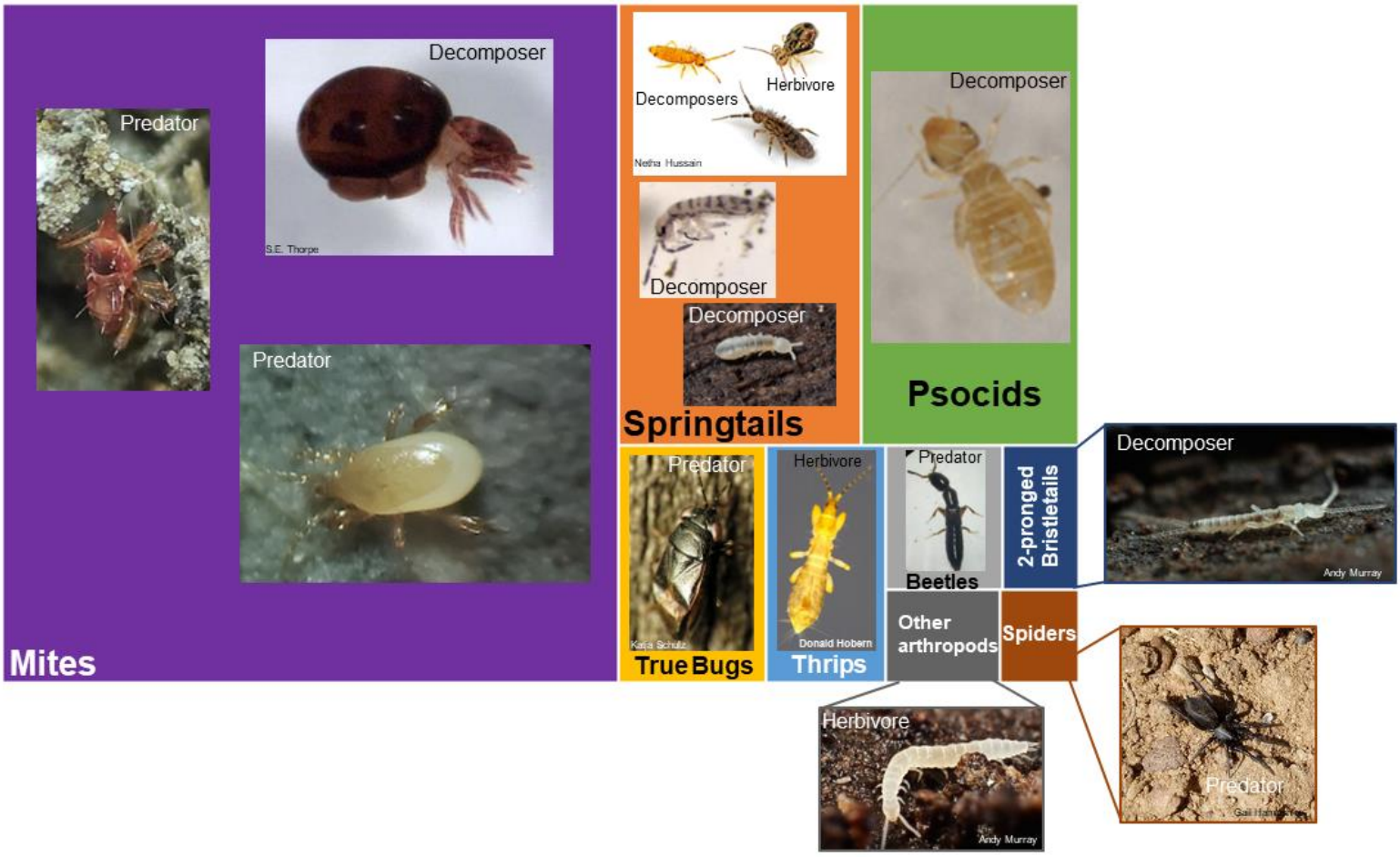
Who is there and what are they doing?

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 agroecosystems. Who is there? What are they doing?



Graph 1. Who is there? This graph shows the soil arthropod community composition across all fields sampled on your farm in 2021. The size of the tiles is proportional to the abundance of each group collected. Like in most soils, mites are the dominant arthropod group, followed by springtails and psocids (also known as book lice). 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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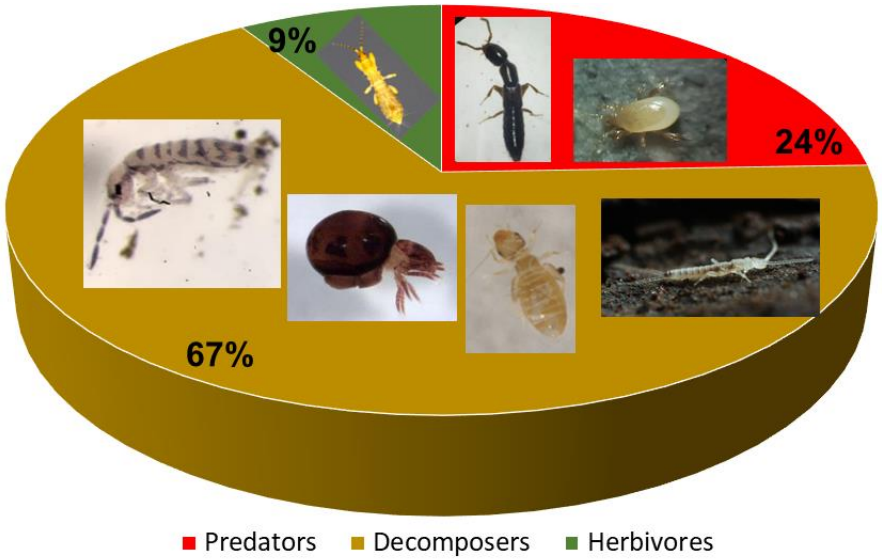
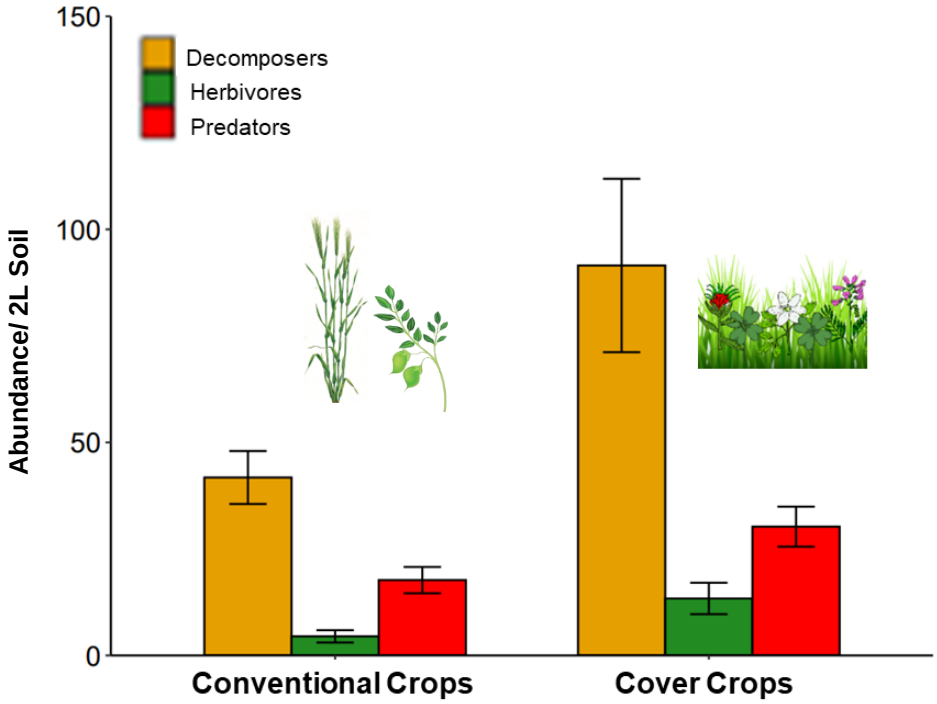


Graph 2. What are they doing? This graph breaks down the soil arthropod community by functional group. Predators, often referred to as natural enemies, eat nematodes and other arthropods and provide valuable biocontrol services. Decomposers break down plant litter and other organic matter, stimulate 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 (conventional spring crop vs. cover crop). The colored bars represent the average abundance of each functional group, and the error bars show the variation around the average. Compared to conventional crops, cover crops increase the abundance of beneficial predators and decomposers, but also herbivores. The data shown here are averaged across sampled fields on your farm.

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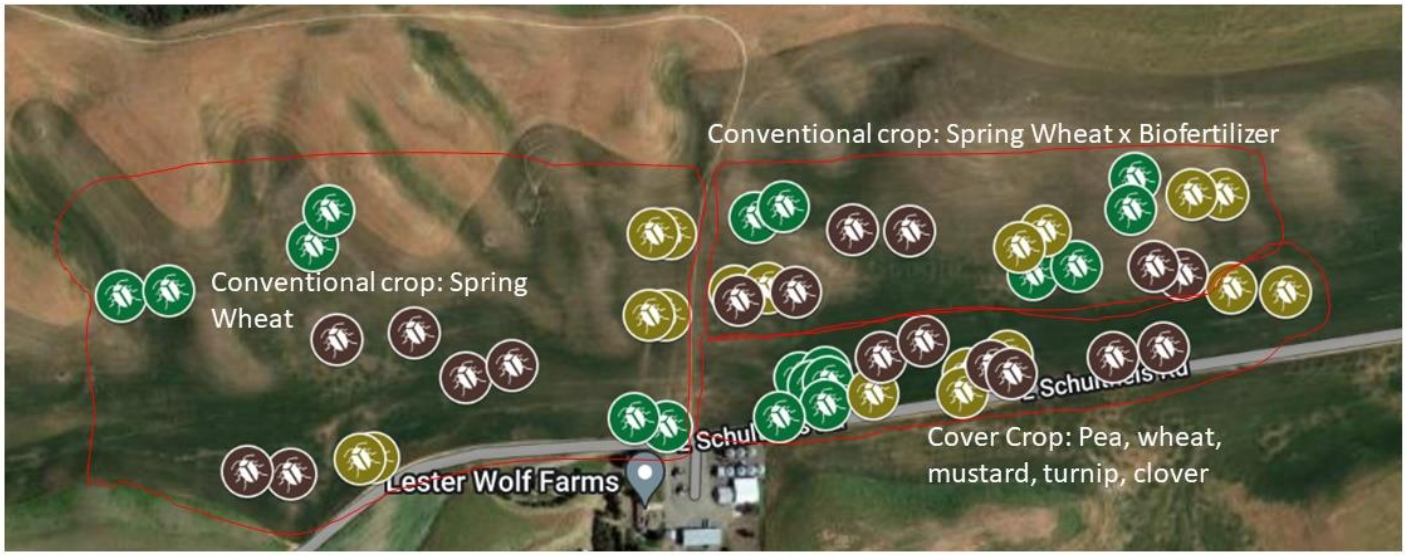
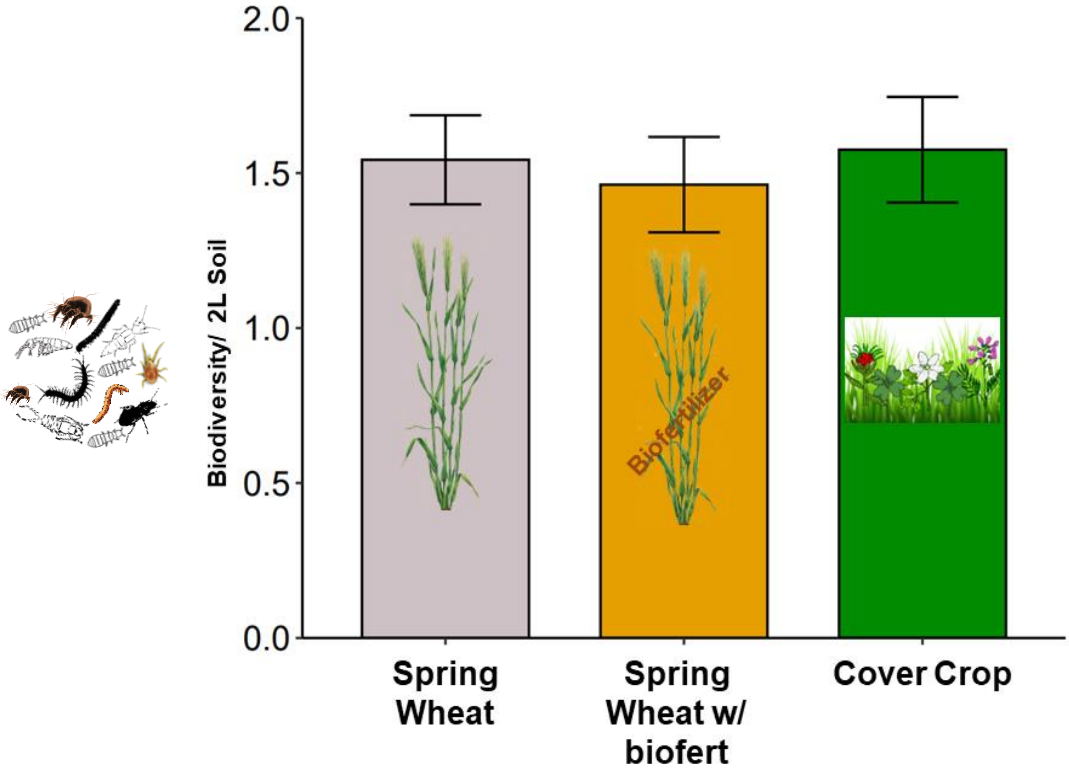
Wolf Farms Field Pair 1:



Field Pair 1 Map (Uniontown, WA). Dots represent in-field sampling locations and months.

June sampling July sampling August sampling



Graph 4. Field Pair 1 Biodiversity. Shannon diversity index of soil arthropods in spring wheat, spring wheat w/ biofertilizer, and cover crop fields. Shannon 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 under each crop, and the error bars show the variation around the average. There was no difference in soil arthropod Shannon diversity between crop types. Data were pooled across sampling months.

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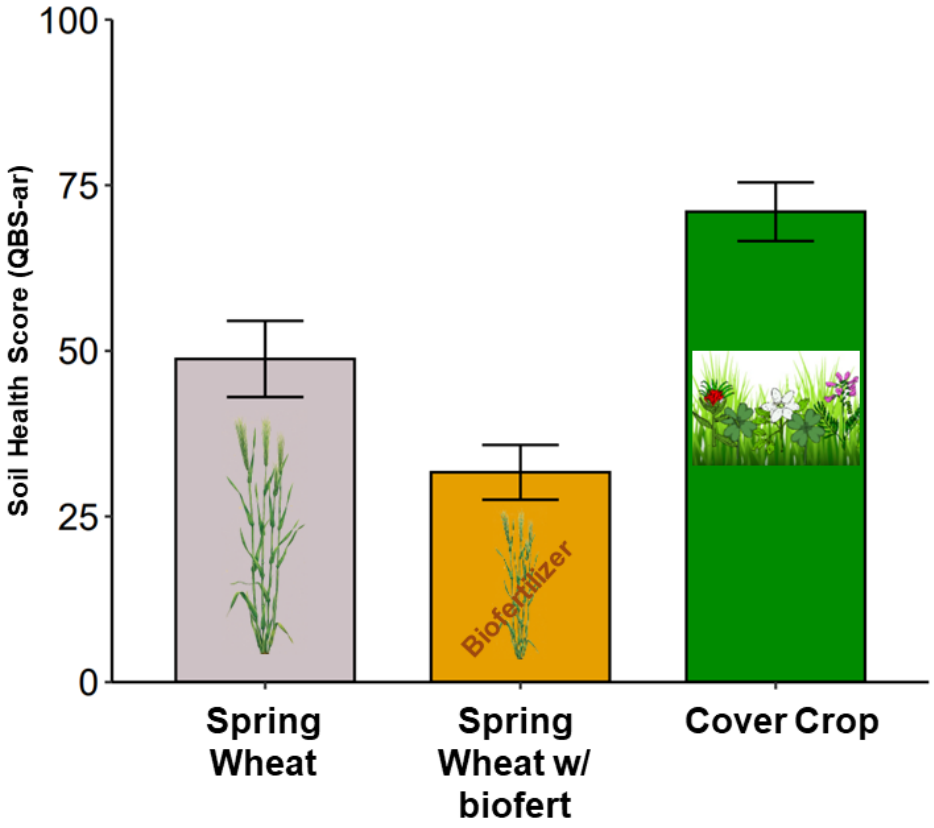

Graph 5. Field Pair 1 Soil Health Score. Soil health, as measured using QBS-ar, of spring wheat, spring wheat w/ biofertilizer, and cover crop fields. The colored bars represent the average QBS-ar score under each crop, and the error bars show the variation around the average. Cover crops had a greater soil health score relative to spring wheat and spring wheat w/biofertilizer. Spring wheat w/ biofertilizer had a lower soil health score, as measured using QBS-ar, than conventional spring wheat. Data were pooled across sampling months.

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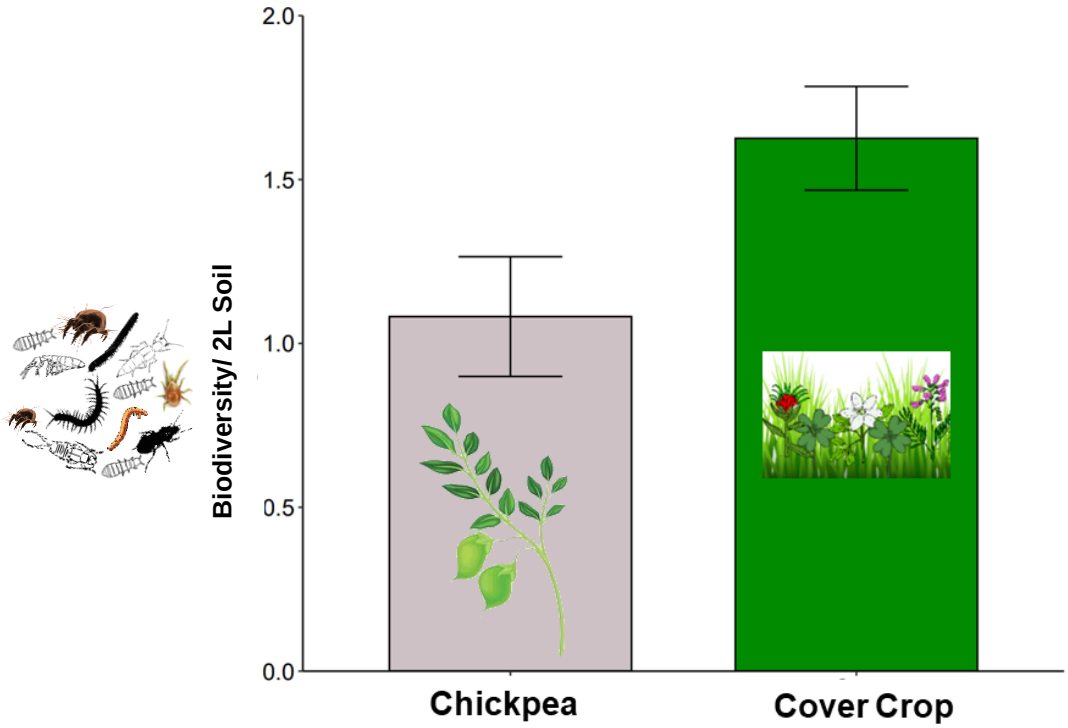
Wolf Farm Field Pair 2:

Field Pair 2 Map (Uniontown, WA). Dots represent in-field sampling locations and months.

June sampling July sampling August sampling



Graph 6. Field Pair 2 Biodiversity. Shannon diversity index of soil arthropods in chickpea and cover crop fields. Shannon 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 under each crop, and the error bars show the variation around the average. Shannon diversity was greater in cover crops than in chickpea. Data were pooled across sampling months.

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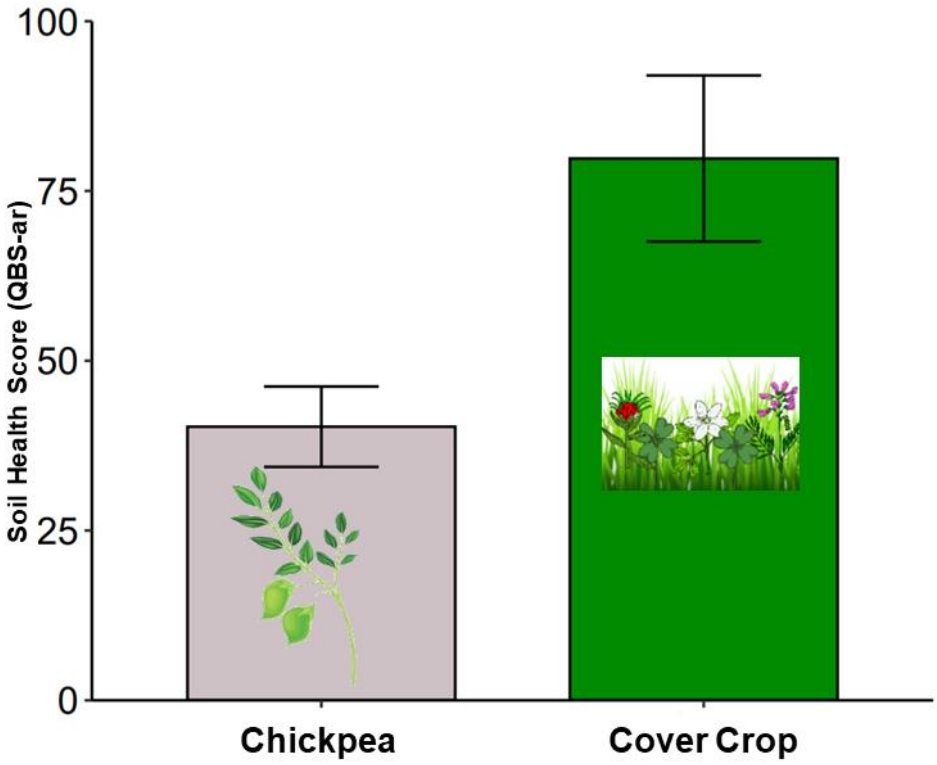

Graph 7. Field Pair 2 Soil Health Score. Soil health, as measured using QBS-ar, of cover crop and chickpea fields. The colored bars represent the average QBS-ar score under each crop, and the error bars show the variation around the average. Cover crops had greater soil health than did chickpea. Data were pooled across sampling months.

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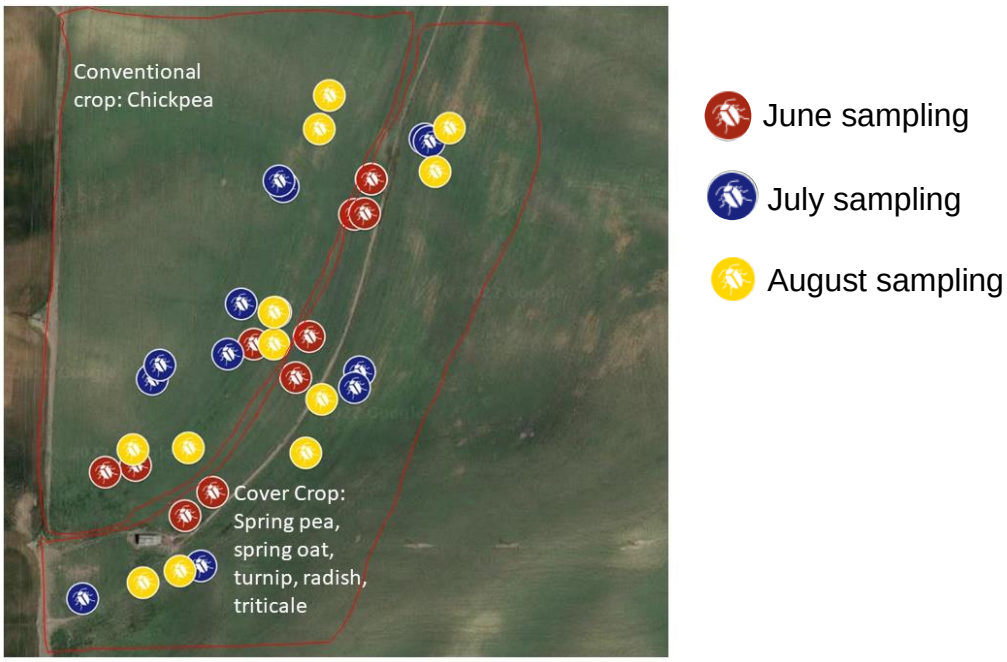
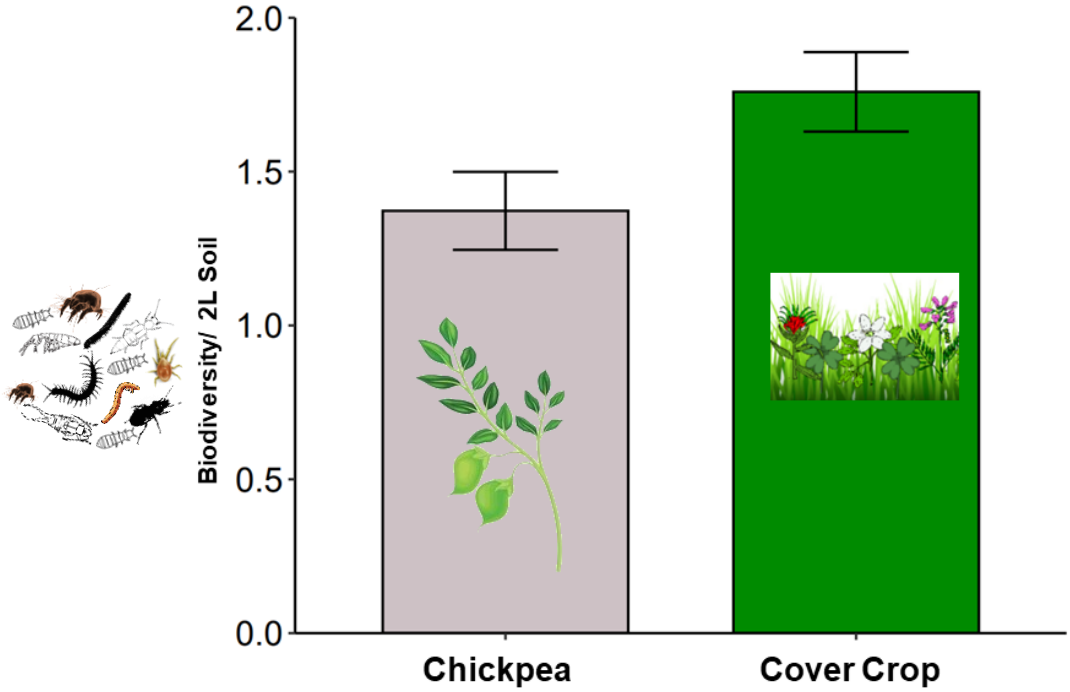
Wolf Farm Field Pair 3:



Field Pair 3 Map (Colton, WA). Dots represent in-field sampling locations and months.



Graph 8. Field Pair 3 Biodiversity. Shannon diversity index of soil arthropods in chickpea and cover crop fields. 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 under each crop, and the error bars show the variation around the average. Consistent with observations in field pair 2, cover crops support a more diverse soil arthropod community relative to chickpea. Data were pooled across sampling months.

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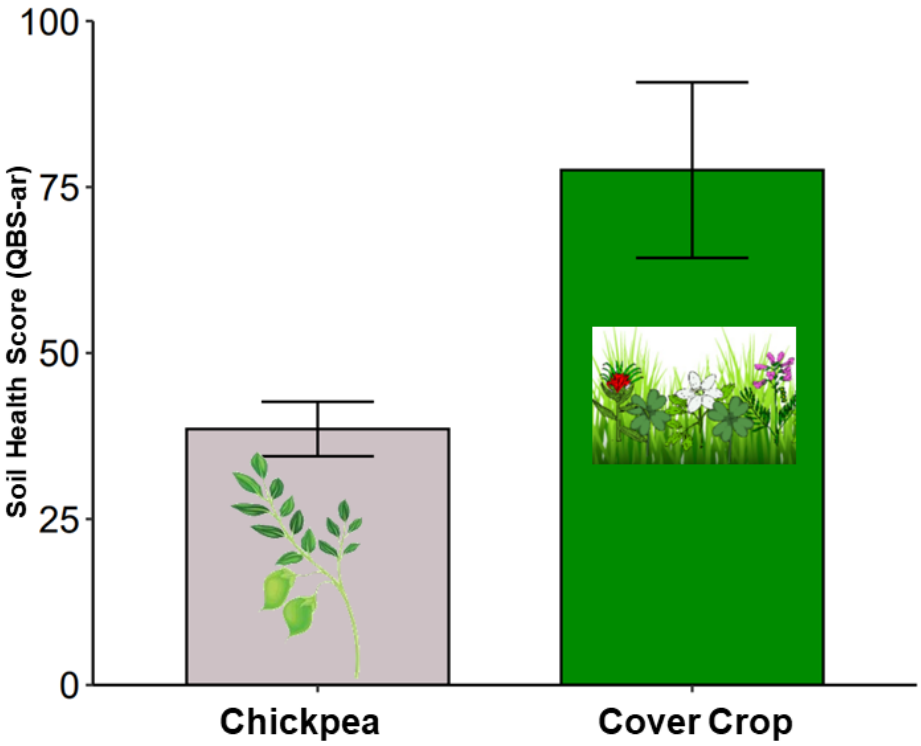

Graph 9. Field Pair 3 Soil Health Score. Soil health, as measured using QBS-ar, of cover crop and chickpea fields. The colored bars represent the average QBS-ar score under each crop, and the error bars show the variation around the average. Consistent with observations in field pair 2, cover crops increased soil health relative to chickpea. Data were pooled across sampling months.

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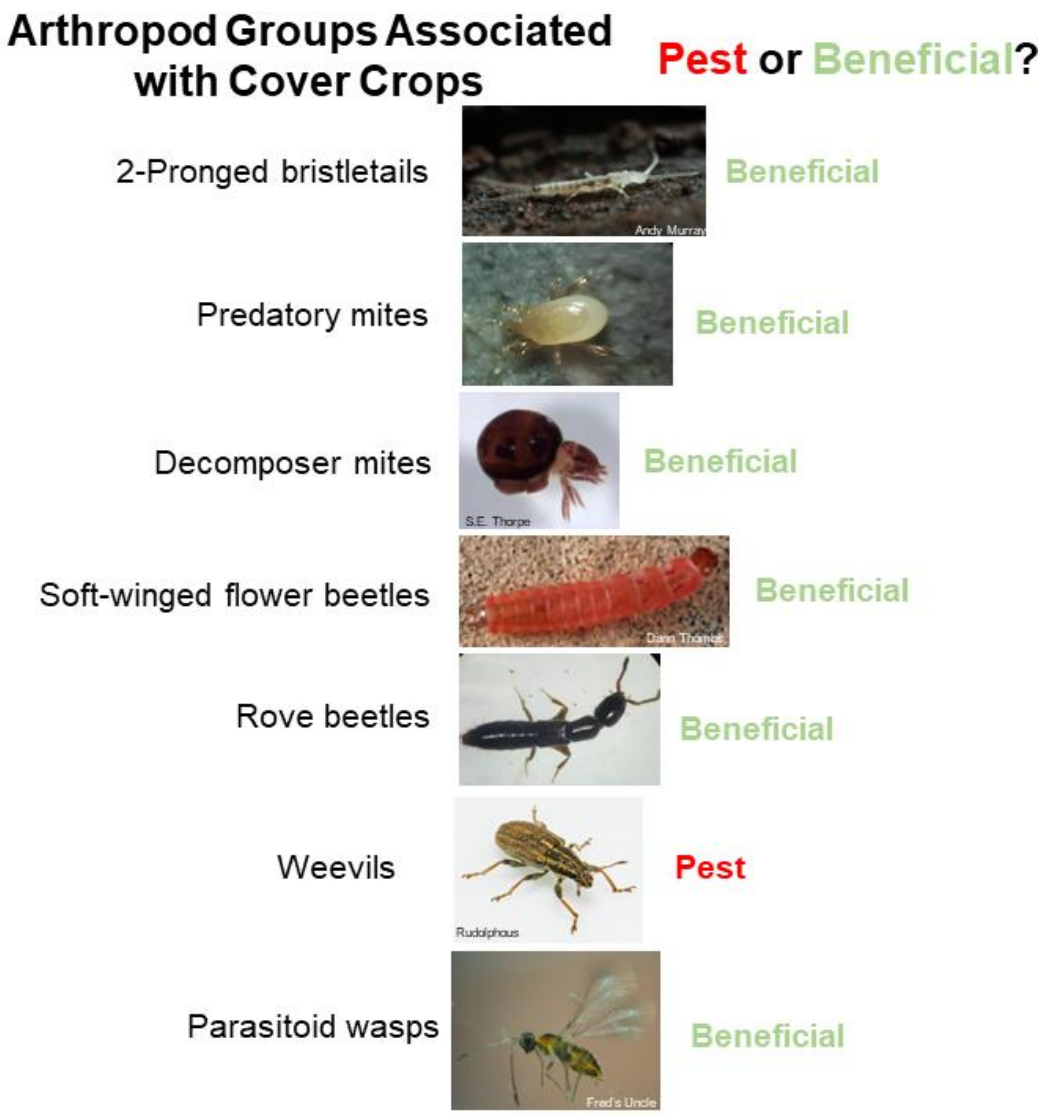

Graph 10. Indicator species. Using a statistical technique called indicator species analysis, we measured if specific arthropod groups were significantly associated with a certain crop type (conventional or cover crop). We conducted this analysis for your farm and found that 7 different groups of soil arthropods were collected more often in cover crops than in conventional crops. 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 conventional crops. 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 promote soil arthropod communities by increasing their abundance and diversity compared to conventional crops. This effect was especially noticeable when comparing cover crop fields to conventional chickpea fields. We did not observe a difference in soil arthropod biodiversity when comparing cover crops to spring wheat.

2. The QBS-ar soil health score was highest in cover crop fields relative to fields planted with conventional crops. This effect was consistent across all the field pairs we sampled.

3. Spring wheat planted with a biofertilizer amendment had a lower QBS-ar soil health score compared to spring wheat planted without biofertilizer.

4. One major impact of planting cover crops was the increase in soil arthropod decomposers. The increase in decomposers is significant for agroecosystems that practice no-till or conservation tillage because decomposers break down organic matter and plant litter that remains on the soil. Increasing the abundance of decomposers could increase the incorporation of organic matter into soil.

5. Cover crops promote the abundance of beneficial soil arthropod functional groups, like predators and decomposers. The soil arthropod groups most responsible for the differences in soil arthropod community composition between crop types are, for the most part, desirable due to the ecosystem services they provide.

6. Comprehensive sampling of single fields like we conducted in this study is uncommon and will allow for future assessments of how soil arthropod communities vary within agricultural fields.

7. Cover crops did not significantly reduce the volumetric water content of the soil relative to conventional crops.

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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.

Field Pair	Sample Date	Crop	pH	VWC (%)	Temperature (°F)
1	18 June 2021	Cover crop	5.24	13.7	62
		Spring wheat	4.82	12.1	61
		Spring wheat w/ biofertilizer	4.79	12.5	67
	13 July 2021	Cover crop	5.1	4.5	72
		Spring wheat	5.02	3.3	73
		Spring wheat w/ biofertilizer	5.03	2.4	82
	9 August 2021	Cover crop	4.98	2.2	79
		Spring wheat	4.79	3.0	73
		Spring wheat w/ biofertilizer	5.11	3.3	81
2	18 June 2021	Cover Crop	4.91	13.5	73
		Chickpea	4.86	15.5	70
	13 July 2021	Cover Crop	4.73	4.4	81
		Chickpea	5.32	3.4	76
	9 August 2021	Cover Crop	4.74	4.1	79
		Chickpea	5.07	4.2	72
3	18 June 2021	Cover Crop	5.16	14.5	71
		Chickpea	4.90	19.7	70
	13 July 2021	Cover Crop	4.89	5.3	81
		Chickpea	4.96	4.9	79
	9 August 2021	Cover Crop	5.73	4.1	69
		Chickpea	5.05	1.5	66

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