

Insectary Wildlife Habitat Trial California Mixed Vegetable Farm

Jessa Kay Cruz, Senior Pollinator Conservation Specialist The Xerces Society, Dec, 2019

Objective: Analyze the multiple natural resource benefits of pollinator habitat features in different cropping systems and identify some of the motivations for, and barriers to, adoption. Use simple protocols to assess habitat establishment and effects of habitat plantings on water-holding capacity, soil carbon sequestration, and populations of beneficial insects.

County: San Benito, CA

Average Annual Precipitation: 15"

MLRA: 14

Practice: Insectary Wildlife Habitat; small acreage (420)

Dominant Soil Type: Sorrento silty clay loam

Slope: 0 - 2%

Aspect: NA

Elevation: 260'

Site Preparation: Disked and bedded prior to planting

Planting Method: Hand planting of transplant plugs

Plant Spacing: 2' centers

Planting Date: 11/8/2017

Acres Planted: 0.2

Previous Site History: Fallow field edge

Fertilizer: None (compost used at time of planting)

Irrigation: Drip, every 7-10 days during dry season

Grazing: NA



Figure 1: Blooming plants such as yarrow (*Achillea millefolium*) and California poppy (*Eschscholzia californica*) provide good insectary habitat.

Introduction

This field trial was part of a larger project which involved designing and implementing specific insectary habitat features, such as field borders or cover crops, and measuring some of the resource benefits of these features. We worked with seven different growers at nine different sites as part of this project. This project encompassed multiple cropping systems including almonds, walnuts, apples, winegrapes and mixed vegetables.

Selecting appropriate plant materials and/ or engineering appropriate seed mixes was a key component of the project. All species used for this specific site were native to the region, and known to be attractive to pollinators and other beneficial insects. As water use of non-crop species (e.g. habitat) is always a concern in this region, the selected plants were also drought-tolerant. Finally, an effort was made to utilize approximately equal numbers of early-, mid- and late-season blooming species in order to provide floral resources for beneficial insects throughout their varied emergence times and life stages.

This field trial was planted on a 22-acre organic farm growing a diversity of mixed vegetables including tomatoes, greens, broccoli, beans, squash, melons, and strawberries. The areas chosen for insectary

habitat planting were unusable as cropped areas due to the placement of existing irrigation valves. These areas border existing fields or blocks, and were fallow prior to implementing this project. Management of these fallow areas posed a constant challenge to the farmer, with weeds managed through repeated tillage. The planting areas are approximately 5' in width, and vary from 330 – 350' in length, totaling approximately 0.2 acres.

As site preparation is critical to successful habitat establishment, and as the areas to be planted had high weed pressure, we recommended eradicating weeds through sheet mulching for a full year prior to planting. Although the grower did manage weeds in the area prior to planting, she was unable to complete the sheet mulching, and continued disking the area instead. This may have resulted in less than adequate site preparation, as repeated disking tends to exacerbate weed problems in the long term.

The habitat areas were plug-planted by hand in the fall using dibble sticks. After planting, we top-mulched with a thick layer of cardboard and a thick layer of hay to keep weeds down and moisture in. Drip irrigation was also installed at the time of planting.

We used simple protocols to track the establishment of the habitat areas overall, as well as the establishment of individual species, to help inform seed mix and plant list recommendations. We also used Xerces' '[Beneficial Insect Scouting Guide](https://xerces.org/publications/scouting-guides/beneficial-insect-scouting-guide)' (xerces.org/publications/scouting-guides/beneficial-insect-scouting-guide), to monitor the habitat areas and a paired control site for eight different beneficial insect groups. Over the course of two years, we conducted this scouting four to five times at each site between March and September. At the end of the project period, we also conducted field soil assessments and soil testing at the project sites and a paired control site, in order to assess the effect of the habitat planting on soil health. Finally, we conducted exit interviews with participating growers to assess some of the reasons that growers adopt these habitat features, as well as some of the barriers and challenges growers face throughout the process.

Results

This site was visited on 4/17/18, 7/11/18, 8/30/18, 3/19/19/ and 4/25/19. During each visit, we assessed establishment success and completed the beneficial insect scouting protocol. At the end of the project, we administered the grower survey and conducted the soil health assessment, the results of which are below.

Establishment Success: All of the species selected for this project established successfully and provided consistent bloom from March through October. The site established well overall, with weed management activities conducted 2 -3 times throughout each growing season, mostly in the spring and early summer.

Insect Scouting: Using both floral monitoring and sweep netting, we assessed and recorded populations of the following insect groups: native bee, honey bee, syrphid fly, predatory wasp, spider, minute pirate bug ('MPB'), ladybeetle and lacewing. The project area was paired with a control site on the same property, which consisted of typical resident vegetation growing along a field border in a different part of the farm (Figures 5 and 6). Below are the results of the insect scouting for this site. The results of the insect scouting for all groups of beneficial insects combined is shown in Figure 2, while Figures 3 and 4 contains the results with only natural enemies and only pollinators, respectively. As syrphid flies can be both pollinators (as adults) and natural enemies (as larva), they are included in both tables.

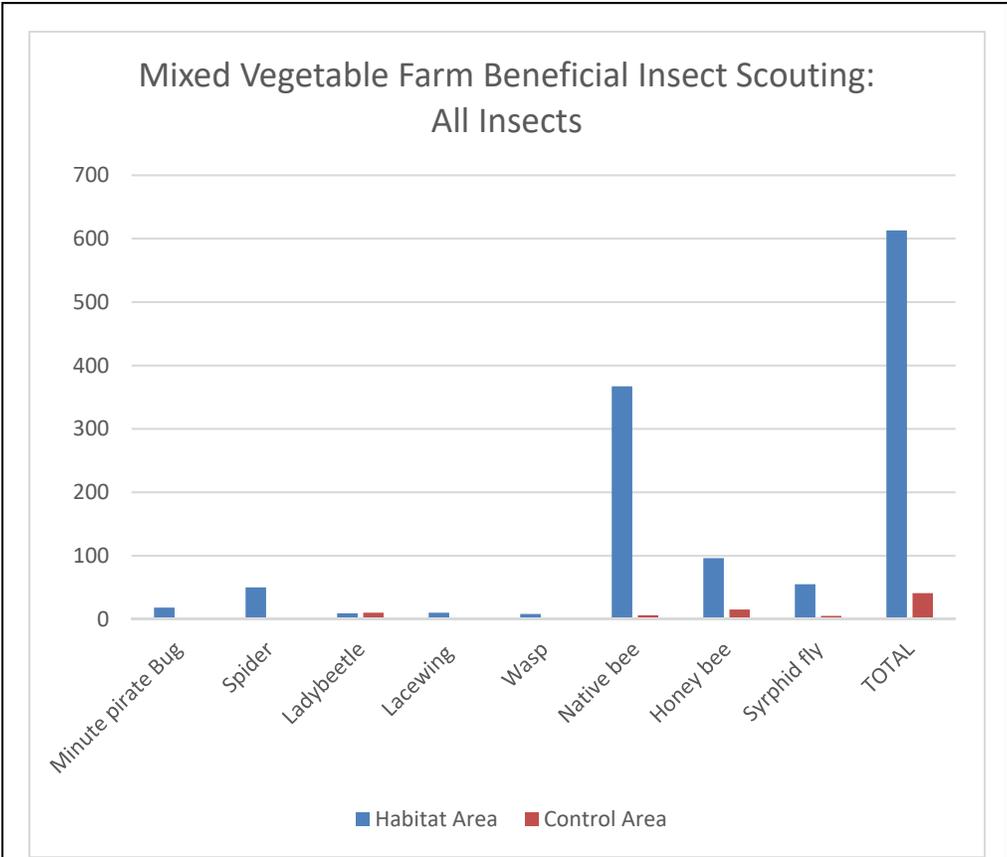


Figure 2: Beneficial insect scouting data from this organic mixed vegetable farm.

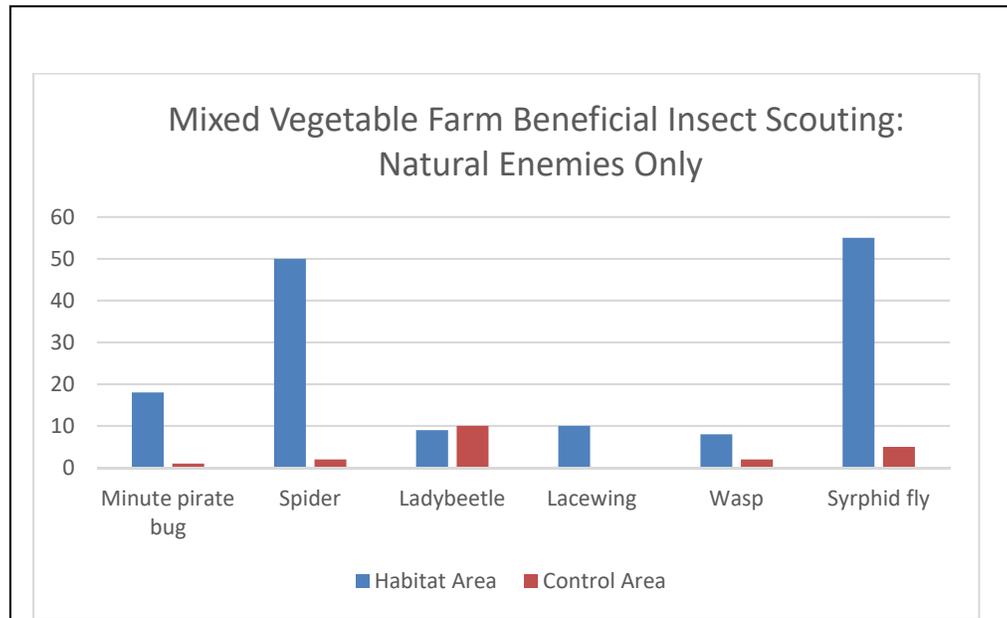
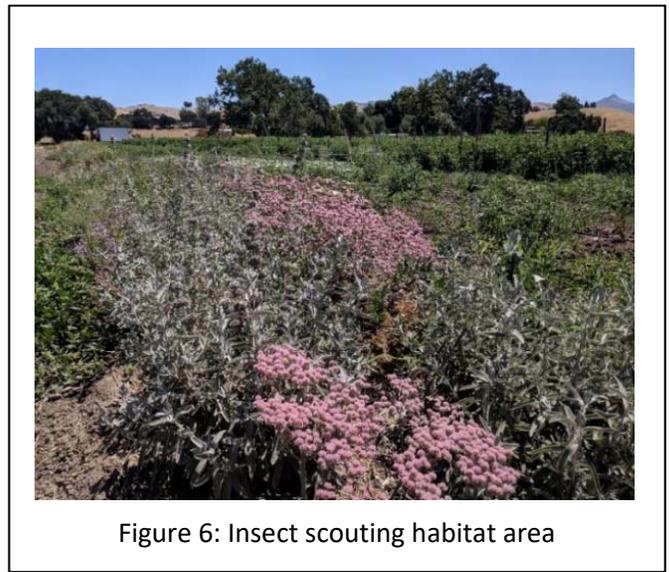
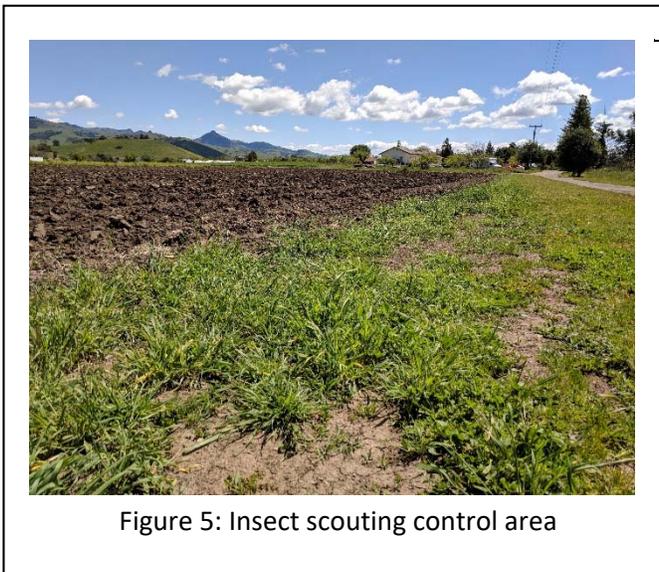
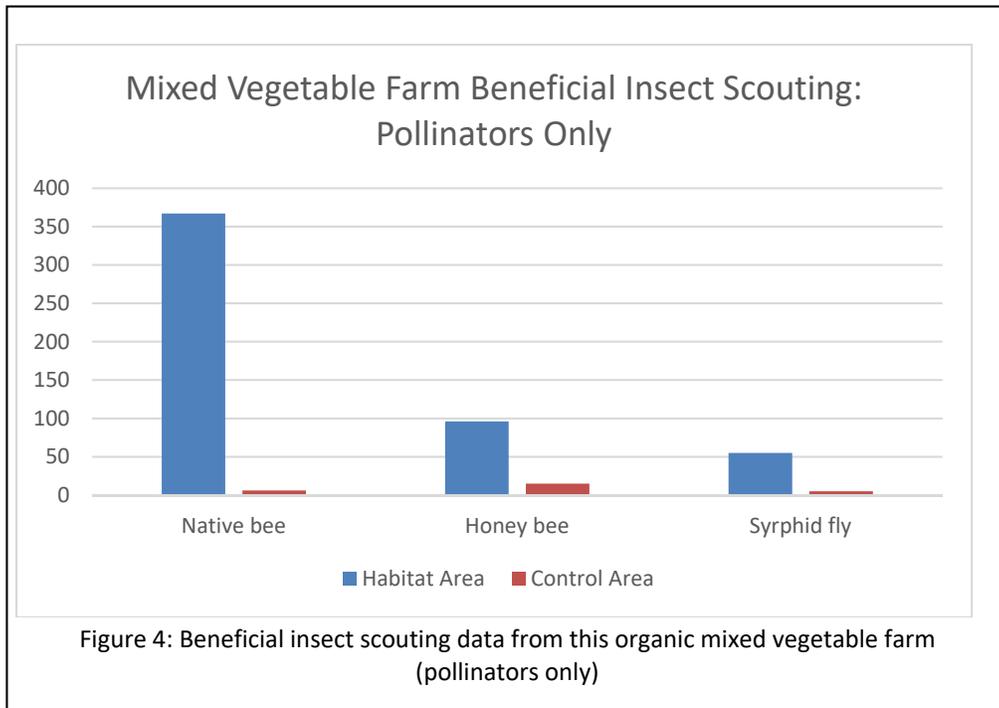


Figure 3: Beneficial insect scouting data from this organic mixed vegetable farm (natural enemies only)



Soil Health Monitoring: Monitoring took place in a tomato field (which served as the control area) and in an adjacent perennial habitat feature. At both fields we assessed ten different soil attributes using the [NRCS soil health field assessment](#). We also submitted soil samples for two different laboratory tests. The first test measured water holding capacity (performed by A&L Western Agricultural Laboratories of Modesto CA). The other was the [Haney test](#) (performed by Ward Laboratories of Kearney NE), which measured microbial activity and nutrients to provide a general soil health score.

Table 1: Case Study Soil Test Results: Below are the results from the three different soil tests conducted at the case study farm.

		Habitat area	Control
Water Holding	Water holding capacity	41%	43%
	Available water (in/ft)	1.23	1.29
Haney Test	pH	7.4	7.3
	Organic matter (%LOI)	2.1	2.2
	Respiration (ppm CO ₂ /24 hr)	45.7	29.3
	Organic N (ppm)	46.5	42.4
	Organic C (ppm)	229	205
	OC : ON	4.9	4.8
	Soil Health	9.62	7.46
Field Assessment	Compaction	3	3
	Structure	3	1
	Crusts	3	3
	Residue	3	1
	Roots	2.5	1
	Pores	2.5	1
	Earthworms	2	1
	Biological activity	2	1
	Smell	2	2
	Aggregate stability	3	2.5
	Mean field score (max = 3)	2.6	1.7

Summary and Discussion

Establishment Success: All individual species established well, as did the field borders overall. The greatest challenge to field border establishment was weed management, followed by irrigation issues (hooking up the drip irrigation, making repairs to cut lines, etc). Over the course of the three-year project, the farmer spent approximately 160 labor hours on the basic upkeep of the field borders. This is a little more time than is typical for this type of project, which is likely due to the somewhat inadequate site preparation.

Plant species and seed mix recommendations: The plants selected for this project produced good results, (see Table 1 below) and are appropriate for similar projects in the same geographic region. The establishment data from all projects together helped inform seed mix specifications for insectary cover crops, including species selection, relative percentage of each species in the seed mix, and overall

recommended seeding rates. This larger project resulted in the creation of three different seed mixes: one for almond orchards or other scenarios where producers want early maturing annuals that that leave little residue into the summer; one for vineyards or apple orchards, where permanent cover is desired; and one for walnut orchards where shade and leaf duff are factors. More information and specifications for these different [cover crop seed mixes](https://xerces.org/pollinator-conservation-resources/California) can be found at xerces.org/pollinator-conservation-resources/California.

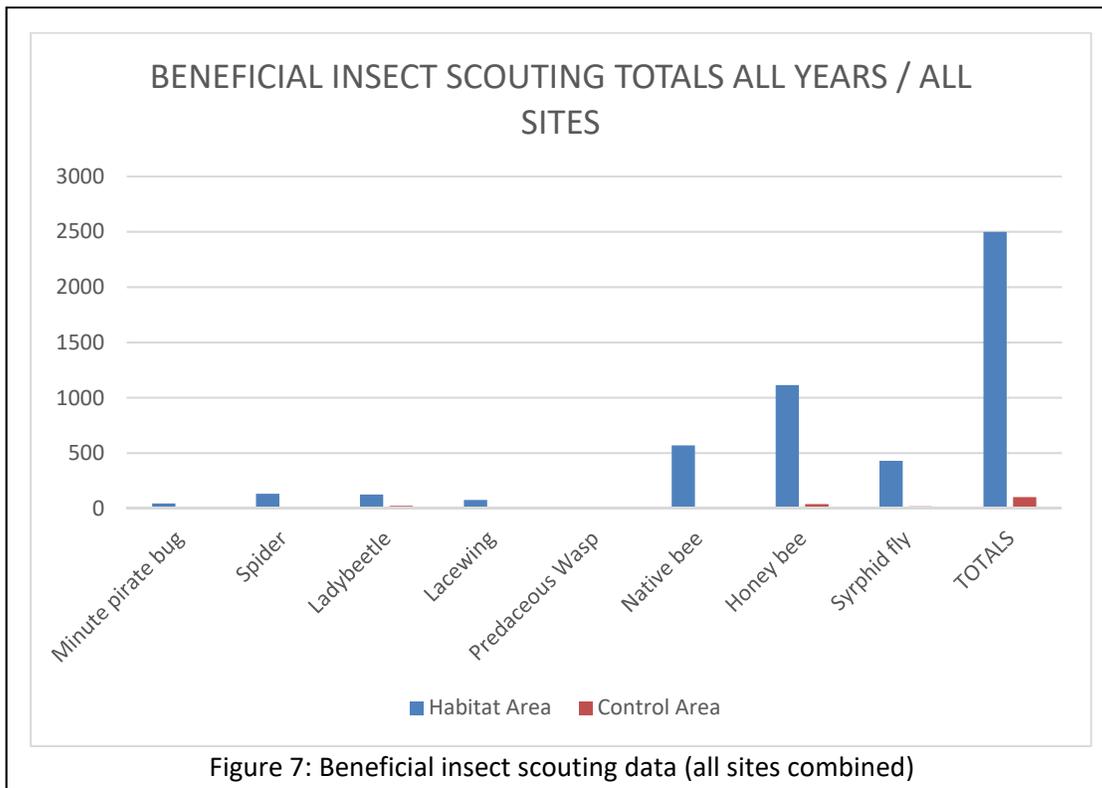
Table 2: Species and Quantity: Below are the plant species used in this project.

Scientific Name	Common Name	*Bloom Period	Native y/n	Annual / Perennial	Number of plants
<i>Achillea millefolium</i>	Yarrow	Early through late	Yes	P	212
<i>Asclepias fascicularis</i>	Narrow leaf milkweed	Mid	Yes	P	212
<i>Eriogonum grande rubescens</i>	Red buckwheat	Early through late	Yes	P	180
<i>Eriogonum parvifolium</i>	Seacliff buckwheat	Early through late	Yes	P	180
<i>Eriophyllum lanatum</i>	Wooly sunflower	Mid	Yes	P	50
<i>Eschscholzia californica</i>	CA Poppy	Early through late	Yes	A / P	212
<i>Grindelia camporum</i>	Gumplant	Mid through late	Yes	P	212
<i>Monardella villosa</i>	Coyote mint	Mid	Yes	P	212
<i>Penstemon heterophyllus</i>	Foothill penstemon	Early / mid	Yes	P	180
<i>Phacelia californica</i>	California phacelia	Early / mid	Yes	P	150
<i>Salvia leucophylla</i>	Purple sage	Mid	Yes	P	180
<i>Salvia melifera</i>	Black sage	Mid	Yes	P	180
<i>Stipa cernua</i>	Nodding needle grass	NA	Yes	P	240
<i>Stipa lepida</i>	Foothill needle grass	NA	Yes	P	240
<i>Stipa pulchra</i>	Purple needle grass	NA	Yes	P	250
TOTAL:					2,880

*Bloom Times: Early = Feb through April; Mid = May through July; Late = Aug through Oct

Insect Scouting: Overall, fifteen times the number of beneficial insects were found in the field borders as compared to the control site. These results differ slightly from the aggregated results from all sites combined, where there were approximately twenty four times the number of beneficial insects in the habitat areas as compared to the control site. This slight difference could be due to the fact that there were fewer honey bees at this site overall as compared to other sites in the study, as well as the fact that there were slightly larger populations of beneficial insects found in the control area at this site compared to other sites. Native bees were the most abundant insect monitored at this site, and their populations were significantly higher than at any other site monitored for this project. The next most abundant beneficial insect found scouting at this site were honey bees, followed by syrphid flies and spiders. Honey bees were the most abundant insect found in all sites combined, followed by native bees, syrphid flies and spiders. Below (Figures 7 – 9) are the aggregate results of the insect scouting at all of the sites for this project.

This farm scored relatively high on the Xerces/NRCS California [Pollinator Habitat Assessment Guide \(https://efotg.sc.egov.usda.gov/references/public/CA/CA_PollHabAssessment_Orchard_FieldCrops_8-18.pdf\)](https://efotg.sc.egov.usda.gov/references/public/CA/CA_PollHabAssessment_Orchard_FieldCrops_8-18.pdf), so it is likely that the features and practices supporting pollinators that were identified during the assessment contributed to the high numbers of native bees. In particular, proximity to surrounding natural or semi-natural habitat, a diverse cropping system, and minimal pesticide use all likely contributed to high native bee populations. This farm also had several permanent habitat features (in addition to temporary or ephemeral features) and a higher percentage of habitat overall when compared to other farms included in this study, which likely contributed to high beneficial insect counts overall.



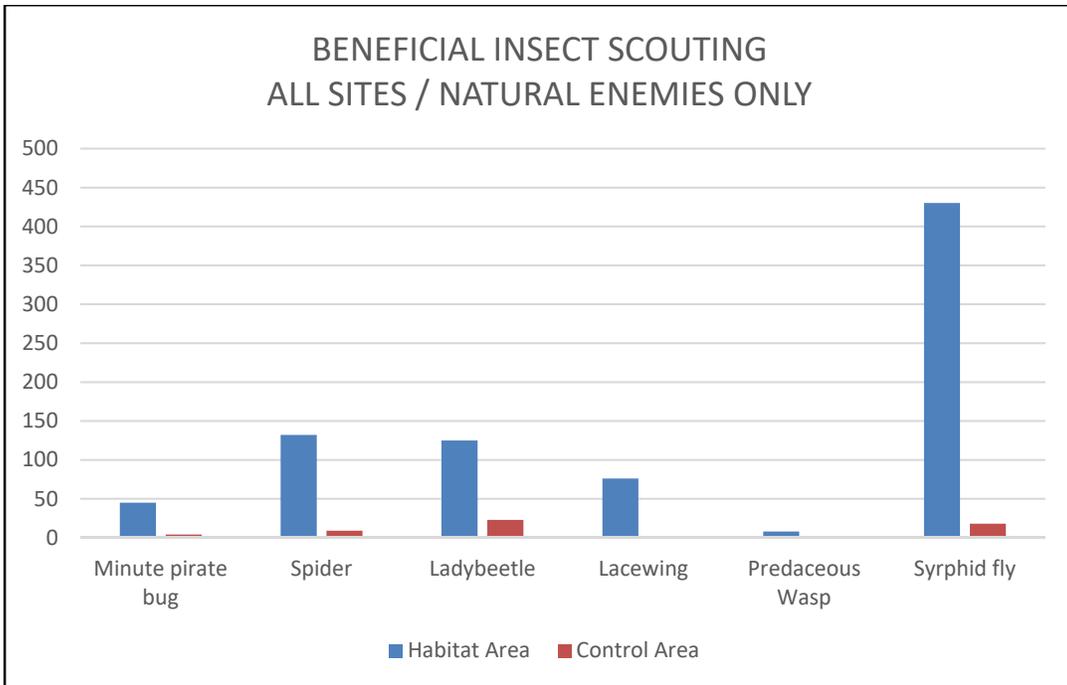


Figure 8: Beneficial insect scouting data (all sites combined, natural enemies only)

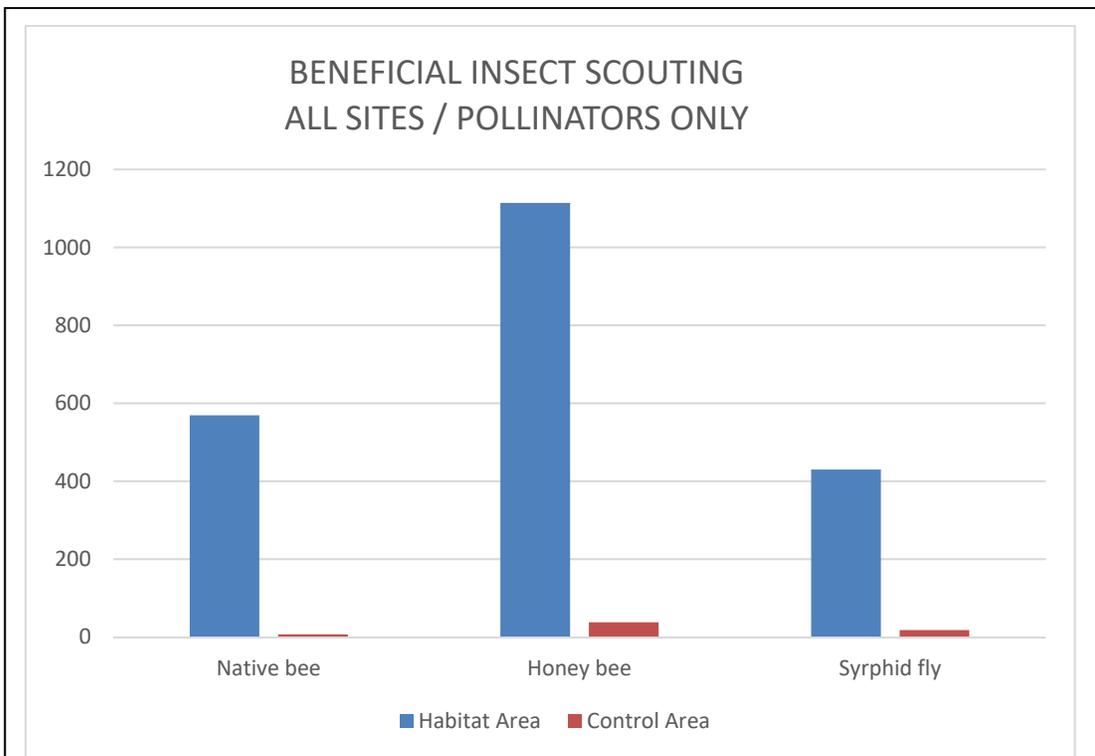


Figure 9: Beneficial insect scouting data (all sites combined, pollinators only)

Soil Health Monitoring:

Case study habitat area vs. case study control area: Some anecdotal differences can be observed between the permanent habitat area and the control area on the case study farm. For example, the habitat area scored as healthier than the control area in nearly every criterion of the field assessment. These differences were most noticeable for soil structure, residue cover, and the presence of roots and pores. The soil health scores and soil respiration values reported by the Haney test were also somewhat higher in the habitat area as compared to the control. A higher soil respiration value indicates a greater abundance of microbial life in the soil. The soil health rating generates a score based on this respiration rate, as well as the soil's carbon and nitrogen balance, with a general goal for a score of >7.

These differences in soil health and structure in the habitat planting may be due in part to the permanent presence of living roots that were missing in the control field. As living plants take in carbon dioxide from the atmosphere, the roots also pass carbon into the soil. Some of this plant-supplied soil carbon serves as fodder to build up populations of soil organisms. As roots, soil organisms, and organic matter increase they bind the soil together, creating air pockets and aggregates that sequester carbon.

Case study site vs. all other sampled sites: This site's soil results can be compared to the aggregate data of all the farm sites surveyed to gain a better understanding in the context of Central California farming. In addition to this case study (an organic-certified vegetable farm), we surveyed three cover-cropped almond fields paired with three control fields that did not receive cover crops. These farms were all conventional almond orchards, with soil types ranging from sand to clay loam.

This case study's habitat planting had a noticeably lower respiration rate than the cover cropped almond sites, indicating a lower level of microbial activity. Microbe populations swell in the presence of increased soil carbon, but the carbon concentrations in both of this case study's fields was very similar to the average concentration in all the almond fields. The diminished presence of microbes on this case study farm, then, might be accounted for by the almond sites' lower nitrogen concentration and subsequently higher, more favorable C:N ratios. Soil microbes prefer a C:N ratio of about 24:1. At very low C:N ratios, like those found in both the case study's habitat and control areas, carbon is consumed quickly and microbe population growth may be inhibited.

Conclusion: Building soil health is a process that can take many years. As such, measurable changes in soil health will take longer than the duration of this project. If the case study's habitat feature is maintained, in future years the differences between the habitat area and adjacent cropped fields may become more noticeable.

Table 3: Aggregated Soil Test Results: Below are the results from the three different soil tests conducted at the case study farm alongside the mean results of these same tests from three additional almond orchard sites.

		CASE STUDY FARM		ALL OTHER SITES	
		Habitat area	Control	Cover Crop (n = 3)	Control (n = 3)
Water Holding	Water holding capacity	41%	43%	44%	40%
	Available water (in/ft)	1.23	1.29	1.3	1.2
Haney Test	pH	7.4	7.3	7.0	7.0
	Organic matter (%LOI)	2.1	2.2	2.6	1.8
	Respiration (ppm CO ₂ /24 hr)	45.7	29.3	76.2	42.5
	Organic N (ppm)	46.5	42.4	9.8	10.4
	Organic C (ppm)	229	205	219	167
	OC : ON	4.9	4.8	23.4	16.1
	Soil Health	9.62	7.46	12.0	8.7
Field Assessment	Compaction	3	3	2.7	2.3
	Structure	3	1	2.2	1.5
	Crusts	3	3	3	3
	Residue	3	1	N/A*	N/A*
	Roots	2.5	1	1.3	1
	Pores	2.5	1	2	1.2
	Earthworms	2	1	1.5	1.7
	Biological activity	2	1	1.5	1.2
	Smell	2	2	2.2	1.5
	Aggregate stability	3	2.5	2.2	2.3
	Mean field score (max = 3)	2.6	1.7	2.1	1.7

* All other sites are almond orchards, which scrape to remove residue before harvesting the crop

Grower Feedback: Below are the aggregated results of the survey, which was completed by five participating growers at the end of the project. In parenthesis is the percentage of growers surveyed that included that particular answer in their response. The feedback from the grower partner at this site generally matched the combined feedback from all growers.

1) Top five objectives for cover-cropping / planting field borders

- a. Increase soil organic matter (100%)
- b. Attract pollinators and beneficial insects (80%)
- c. Improve water infiltration (60%)
- d. Reduce compaction (60%)
- e. Improve soil health (40%)

- 2) **Top three concerns / barriers prior to project**
 - a. Increased workload to manage cover crop (80%)
 - b. Uncertainty about which species to plant (60%)
 - c. Fitting into crop management or crop rotation practices (60%)
- 3) **Top three concerns/ barriers now that project is complete**
 - a. Fitting into crop management practices (40%)
 - b. Increased workload to manage cover crop (40%)
 - c. Increased risk of frost in adjacent crops (40%)
 - d. Cost / unknown cost benefit (40%)
 - e. Access to equipment for planting or managing cover crops (40%)
- 4) **Have you planted cover crops / habitat planted prior to this project?**
 - a. No (60%) / Yes (40%)
- 5) **How likely are you to continue planting cover crops / habitat**
 - a. Very likely (100%)
- 6) **What would be most helpful to support you in continuing to plant or maintain cover crops on your farm (top three)?**
 - a. Continued technical support on what species to plant (100%)
 - b. Financial support for cost of seed / plants (80%)
 - c. Financial / physical support with planting or managing habitat (60%)
- 7) **What benefits did you experience from planting cover crops?**
 - a. Increase in beneficial insect populations (80%)
 - b. Benefits to managed honey bee hives (40%)
 - c. Soil health benefits (40%)
 - d. Reduction in insecticide applications (20%)
- 8) **What challenges / unwanted outcomes did you experience from planting cover crops?**
 - a. Increased workload (60%)
 - b. Managing weeds (40%)
 - c. Clearing away debris (40%)
 - d. Planting equipment and timing (40%)

Additional Feedback: A series of outreach events related to insectary cover-cropping were conducted as part of this project. A survey was sent out to participants from several workshops to get additional feedback on goals, objectives and hurdles related specifically to cover-cropping. Twenty-one people responded, which represents a 46% response rate. Below are the results, which are similar to the results of the individual grower surveys.

- 1) **How would you describe yourself?**
 - a. NRCS or RCD staff (66.7%)
 - b. Educator or student (23%)
 - c. Farmer / rancher (9.6%)
 - d. Conservation non-profit staff (9.6%)
- 2) **Which FIVE objectives or potential benefits of cover-cropping are most important to you or the growers you work with? Please select only your top five choices.**
 - a. Increase soil organic matter (61.9%)
 - b. Improve water infiltration (61.9%)
 - c. Suppress weeds (47.6%)
 - d. Attract pollinators / beneficial insects (47.6%)
 - e. Improve soil health (47.6%)

- 3) **Several barriers to planting cover crops have been identified. Of these barriers, which THREE most concern you or the growers you work with? *Please select only three options.***
 - a. Fitting into crop rotation or crop management practices (90.4%)
 - b. Increased workload to manage cover crop (52.4%)
 - c. Cost / unknown cost benefit (52.4%)
- 4) **Did this workshop make you more likely to plant a cover crop, or encourage those you work with to plant a cover crop, in the near future?**
 - a. Yes (85.7%) / No (14.3%)
- 5) **Did this workshop address any of the barriers to cover crop planting you have, or have heard expressed by growers you work with?**
 - a. Yes (81%) / No (19%)
- 6) **Did this workshop expose you to new ideas about cover cropping?**
 - a. Yes (90.5%) / No (9.5%)

*Special thanks to Evan Olivas from the NRCS for assistance with the survey

Acknowledgements

PHOTO CREDITS: All photos by The Xerces Society / Jessa Kay Cruz

FUNDING PROVIDED BY: California Natural Resources Conservation Service / USDA.

Award number 69-9104-17-537

AUTHORS: Jessa Kay Cruz, Mace Vaughan, Kitty Bolte and Kathryn Prince of The Xerces Society for Invertebrate Conservation