*Western SARE Competitive Grants: Graduate Student*

***Strategies to manage understories for ecological value in sustainable hazelnut orchards and matrix oak woodland habitat***

Principal Investigator: Dr. Lauren Hallett.

Graduate Student*:* Alejandro Brambila

Producer cooperators:

* Taylor Larson: Co-owner of “My Brothers Farm”. A diversified organic farm that includes riparian forest and oak woodland. Among other things, Taylor produces hazelnuts, apples, pork and bison.
* Lynnea Lane and Paul Massee: Managers of “Lane-Massee Farm”. Conventional, large scale hazelnut producers. The Lane-Massees have been growing hazelnuts for over 60 years.
* Linda Perrine: Owner of “Honor Earth Farm”. Has been producing hazelnuts organically and monitoring filbertworm populations on her farm since 2008 and is interested in participating in alternative methods.

*Relevance to Sustainable Agriculture (800 words - currently 973)*

Hazelnuts are a booming industry in Oregon’s Willamette Valley, where 99% of the US crop is produced (Honea 2016, Perkowski 2017).Hazelnuts are a challenging crop, as they are sensitive to pests and harvesting nuts requires the ground to be bare. Traditionally, conventional farms have used intensive spraying, flailing, and scraping to eliminate pests and understory vegetation in orchards (and increasingly throughout their properties). Interest is growing in developing more sustainable hazelnut farming practices, for example, the Oregon Organic Hazelnut Cooperative (OOHC) was formed in 2016 to promote sustainable farming through educational outreach, nut processing and marketing (Hall 2017). Reducing pesticide and herbicide use is important for long-term sustainability, but before these practices can be widely adopted it is critical to develop alternative strategies to control pests and promote beneficial species while maintaining yields. **Here, we propose a set of strategies to promote sustainable, multifunctional hazelnut farms in the Willamette Valley**. Specifically, we test the use of pig grazing to reduce pest loads and native cover crops in orchards to promote beneficial species. We suggest that the hazelnut boom poses a unique opportunity to develop novel approaches to understory management across the farm-wildland matrix.

**Reducing pests**

The filbertworm (FBW), *Cydia laiferreana,* is a native moth that burrows into nuts and renders them inedible (Chambers et al. 2011). **We propose using pig grazing as a sustainable form of physical or “cultural” pest control that removes nuts that harbor the immature FBW.** Pesticide use is common in conventional agriculture to control FBW, whereas more sustainable practices include pheromone mating disrupters and post-harvest nut removal (Wiman et al. 2018, Hedstrom et al. 2014, Olsen 2002). Because the larva burrows in nuts, removing all nuts from the ground at the end of the growing season breaks the month’s lifecycle and curtails its population size. This approach to FBW management can be effective at the local level, but can be confounded by dynamics over the larger farm-wildland matrix. Specifically, the FBW native host is the Oregon white oak (*Quercus garryana*), a major component of important oak-prairie ecosystems of the Willamette Valley (Lewis 1992). Oaks near orchards serve as source pools of pests to re-invade hazelnuts. As a consequence, there is pressure on growers to remove oaks from their lands (Larson *pers comm)*. This represents a potentially large clash between environmental and production aims.

Our focus is to develop a solution that protects farms against FBW infestation while conserving rare oak habitat. **We will co-manage oak and hazelnut understories by grazing for acorn and hazelnut removal**. Pigs have a preference for acorns, and acorn-fed pig is an increasingly popular food type in the US (Rodriguez-Esteves et al. 2012, Shattuck 2013). We hypothesize that in addition to direct grazing in orchards, pigs can be used to indirectly reduce pest pressure by removing acorns that would otherwise host the moth larvae. This type of cultural control has successfully been employed in other systems such as the use of chickens for blueberry pest management (Caruso 1995, Walters 2009). This project is relevant to the components of sustainable agriculture through adding a revenue stream (pork), increasing the value of nuts, preserving native oak habitats, and reducing the exposure of farmers and farming communities to pesticides.

**Promoting beneficial species**

Hazelnut farmers need a clear level ground at the time of harvest to efficiently harvest their crop. Traditionally, orchard floors have been maintained bare through spraying, flailing and scraping, which results in a sterile understory (Olsen 2013). This type of management has proven to be unsustainable, with associated ecological costs to soil health as well as plant and animal communities. Practically, bare orchard floors have also led to serious erosion and drought stress in orchards, and Oregon State University now advises hazelnut farmers to plant cover crops which help alleviate these conditions (Olsen 2013, Mennan 2012). **We will test the potential for using native grassland plants to further improve upon traditional cover crop services through added ecological values.** Using native plants in the hazelnut understory provides an opportunity to support sustainable farming through the promotion of beneficial species including pollinators and pest predators, and through further aligning production and conservation goals through increased orchard habitat value.

Pest management through biological control has been a successful strategy for many hazelnut pests, and a large number of highly effective pest predators and parasites are already found in hazelnut orchards (Messing 1995, AliNiazee 1998). Cover crops can support populations of Coccinellidae, Syrphidae, and Chrysopidae predatory larva, which rely on pollen and nectar as adults, as well as maintain a prey population to support beneficials when pest populations are low (Haidari 1959, Messing 1983)*.* Cover crops can also support beneficial native pollinators, which are essential to the success of many regionally important crops including blueberries, apples and marionberries, often present on a diversified farm. Specifically, we expect native plants to promote the abundance and diversity of beneficial species, while providing the same soil benefits as conventional crops.

A major limitation to the use of native plants as a cover crop is their cost. To be economically feasible, prairie plants must create-self sustaining populations and not require reseeding year after year (potentially resulting in long-term economic savings). To create sustainable populations, these plants must survive (perennials) or reach maturity and produce seeds in the context of orchard management activities. We will test the compatibility of selected prairie plants with different management activities and canopy structure. Specifically, we will examine the effects of summer flailing and scraping. Since a newly established hazelnut orchard has a much more open canopy than a mature orchard, we will include species with different shade tolerances. Fortunately, native prairie plants, like typical cover crops, are quick to establish, small in stature and senesce by fall harvest. We will also evaluate factors relevant to sustainable farming including soil moisture, amount of exposed soil, and pollinator presence.

*Objectives (300 words – currently at 427)*

Our **overarching goal** is to develop novel strategies of understory management on hazelnut farms to increase farm multi-functionality and facilitate sustainable agriculture.

**Objective 1: Reduce filbertworm pressure in oak and hazelnut stands using pig grazing.** We predict that pigs will preferentially graze acorns and hazelnuts when confined in areas where these are available. When infected acorns and hazelnuts are removed, the FBW lifecycle will be interrupted and their population sizes should decrease. AB, LH, LP and TL will collaboratively design and install pig grazing plots and exclosures on My Brothers Farm and Honor Earth Farm. TL will implement grazing treatments. AB and an undergraduate assistant (UA) will measure rates of infected acorns (Fall 2020, 2021) and filbertworm densities in both before and after pig grazing (Spring 2020, 2021, 2022). We will measure filbertworm populations using emergence and aerial traps. Our hypothesis will be supported if grazing reduces the proportion of infested acorns and FBW populations in subsequent years.

**Objective 2: Promote beneficial pollinator and predator diversity through native cover cropping.**  We predict that robust native species will be able to establish and persist in hazelnut understory. AB and LH developed the plot design which will be installed by AB and Marissa Lane-Massee (MLM) at Lane-Massee Farms in Fall 2020. We will compare the survival and reproduction native species with that of traditional cover crops (Table 1). At peak flowering in Spring 2021 AB, MLM and UA will monitor plant species survival and beneficial insect diversity. This will be repeated in 2022 to identify species with long-term survival potential. Our objective will be achieved if we identify key natives that survive or reproduce, and support elevated populations of beneficials.

**Objective 3: Grazing and cover crops do not compromise other sustainable farm goals.** Specifically, FBW grazing should not come at the expense of pre-existing native vegetation or oak seedling recruitment (in oak stands) or orchard floor disturbance that could lead to erosion or an inefficient harvest. To address oak understory AB and UA will establish vegetation transects in Fall 2020. These will be monitored concurrently with plots in the orchard before and after grazing to quantify understory disturbance. Native cover crops should provide comparable or increased benefits to traditional cover crops including soil shading/moisture, erosion control and soil building. To assess potential compromises to these functions, we will use percent bare ground as a proxy for shading and erosion control and peak standing biomass to represent potential carbon inputs to the soil (concurrently with monitoring for objective 2). MLM will lead soil moisture monitoring Feb-June 2021 and 2022.

*Research Materials and Methods (1500 words – currently 1638)*

**Objective 1: Silvopasture FBW management**

We will test the effectiveness of pig grazing to reduce filbertworm pest pressure in hazelnut stands embedded in an oak woodland-agricultural matrix. We are testing this approach at two farms. My Brothers’ Farm, is a 320-acre OOHC member farm in Creswell, OR has over 2000 young hazelnut trees, and also produces cider apples, bison and pork on a property with several old oak stands. Here, we will test pigs’ ability to clear acorns in oak stands, reducing overall farm pest pressure. A seed grant through the University of Oregon allowed us to collect baseline measurements and implement experimental treatments in summer 2018 and 2019. With this grant, we hope not only to collect filbertworm population response data, but to expand our pest management experiment to another OOCH member farm. Honor Earth Farm has a more established 25 year old orchard that has been monitored for FBW since 2018. Here, we will test pigs’ ability to reduce pest pressure directly in a productive orchard with a known level of pest pressure. Measuring treatment response is labor intensive but essential to understanding the viability of our approach. Below we outline the proposed treatments and response variables to be implemented and recorded with this grant.

In the summer of 2018 we established paired control and treatment plots in oak stands at My Brothers Farm, and propose to do the same at Honor Earth farm in the orchards in 2020. In one plot, we implemented a pig grazing program, while restricting grazing in the other. Plot size is five acres, reflecting potential radius of a filbertworm flight path. We used movable electric fences to implement the treatments, grazing each plot in four rotating pastures for a total of two weeks. Grazing (performed by 20 heritage pigs) was timed to correspond with initial acorn release (Sept-Oct) to target infected acorns as they are aborted and dropped early. The grazing treatment was and will be implemented by Taylor Larson, co-owner of My Brothers’ Farm. We have designed measurements using a Before-After Impact-Control (BACI) design to allow contrasts in the same plot before and after treatment as well as contrasts between the grazed plots and paired control.

To track success **O1**, pig grazing in oak and hazelnut stands will reduce filbertworm pressure, we will sample nuts and count infected and healthy totals. At My Brothers’ Farm we will select five large oaks within each plot (grazed/ungrazed) that are known to produce many acorns. At Honor Earth Farm, five healthy hazelnut trees will be selected at random. Below each tree, two 2m x 2m plots will be established on opposite sides of the tree and cleared of vegetation. Plots will be spaced from the trunk of the tree a distance of 0.5 times the width of the canopy. Immediately before and after pig grazing in 2020 and 2021, nuts from grazed and control plots will be counted and checked for any signs of filbertworm infestation (entry/exit holes). We will use paired t-tests to compare infected nut densities between grazed and ungrazed sites before and after grazing.

In the spring and summer following each grazing event, we will directly measure the effect of nut removal on FBW population density. To do this, we will construct twenty 0.5 m x 0.5 m emergence traps by building wooden frames covered in netting, with a pheromone trap at the top of the top to lure and capture any emerging FWM moths. We will use 10 traps per plot and monitored them weekly during filbertworm emergence (May-July 2021-2022). In addition we will install 4 aerial pheromone traps per plot to measure moth densities over the course of the summer. These methods have been previously successful in capturing moths and establishing initial densities.

**Objective 2: Inter-row natives for beneficial species**

We will establish native understory plantings at two orchards in the Willamette Valley managed by Lane-Massee Farms.The first orchard (Keizer, OR) is 60 years old, and the other (North Howell, OR) is mostly 40 years old, but has a section (two rows) on the edge of the orchard with 15 year old trees. The fifteen year old trees have the most open canopy, followed by the 60 year old, whose canopy has opened due to pruning and dropping of diseased limbs. In full leaf, the 40 year orchard has an almost completely closed canopy. Orchard age will be taken into account as a factor that may affect native cover success.

Within each age of orchard, we have already established six blocks (total 24 blocks) approximately 6 m x 18 m for MLM’s thesis project on soil moisture. Each block consists of three management-level plots: “no management”, “flailed”, and “flailed + scraped”. These plots are adjacent to each other between two rows of trees, and are bounded by trees at each corner (see attached figure). They represent different levels of orchard floor management intensity from the typical flailing (large-scale mowing/ branch chipping) and scraping (a tractor attachment that floats at a predetermined height and is pulled, leveling and mechanically disturbing the soil) to “no management” where only occasional tractor traffic and harvest sweeping disturb the plot. Management plots are included to test the compatibility of native cover crops with typical farming activities.

Within each plot, we will establish four 2.5 m x 2.5 m subplots seeded with different mixes of 19 native and four conventional cover crop species in Fall 2020 (see attached figure, Table 1). Multiple commercially-available species have been selected to identify best options for native cover crop. These species are common and persist in remnant natural grasslands, perform well in prairie restorations, establish quickly and reproduce profusely. We selected species that perform well from full sun to partial shade. We developed four seed mixes: annuals, perennials, unmanaged natives, and industry control (see Table 1, and attached figure). Clockwise from the northwestern subplot, the seed mixes applied are annuals, perennials, true control (no seeds applied), and industry control. We did not seed an industry control in the “no management” plot. Instead, we seeded the “unmanaged natives” mix, which contains all of the annual and perennial forbs, as well as the three graminoids. This was primarily to limit the amount of grasses used (a concern of our farming partners) and to test for competitive/facilitative interactions between annuals and perennials. Each subplot will be seeded at 8g/m2, regardless of the number of species in the seed mix. Each species in a mix will be seeded at the same rate by weight (i.e. 1g/m2 in annual and perennial mixes).

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| --- | --- | --- | --- |
| Species | Native | Functional group | Seed Mixes |
| Collomia grandiflora | Yes | Annual forb | Annuals, unmanaged natives |
| *Amzinckia menziesii* | Yes | Annual forb | Annuals, unmanaged natives |
| *Clarkia purpurea* | Yes | Annual forb | Annuals, unmanaged natives |
| *Epilobium densiflorum* | Yes | Annual forb | Annuals, unmanaged natives |
| *Gilia capitata* | Yes | Annual forb | Annuals, unmanaged natives |
| *Lotus purshianus* | Yes | Annual forb (legume) | Annuals, unmanaged natives |
| *Plectritis congesta* | Yes | Annual forb | Annuals, unmanaged natives |
| *Sanguisorba annua* | Yes | Annual forb | Annuals, unmanaged natives |
| *Achillea millefolium* | Yes | Perennial forb | Perennials, unmanaged natives |
| *Agoseris grandiflora* | Yes | Perennial forb | Perennials, unmanaged natives |
| *Lomatium nudicaule* | Yes | Perennial forb | Perennials, unmanaged natives |
| *Potentilla gracilis* | Yes | Perennial forb | Perennials, unmanaged natives |
| *Prunella vulgaris* | Yes | Perennial forb | Perennials, unmanaged natives |
| *Viola praemorsa* | Yes | Perennial forb | Perennials, unmanaged natives |
| *Geum macrophyllum* | Yes | Perennial forb | Perennials, unmanaged natives |
| *Eriophyllum lanatum* | Yes | Perennial forb | Perennials, unmanaged natives |
| *Danthonia californica* | Yes | Perennial graminoid | Unmanaged natives |
| *Festuca roemeri* | Yes | Perennial graminoid | Unmanaged natives |
| *Carex tumulicola* | Yes | Perennial graminoid | Unmanaged natives |
| Winter barley | No | Annual graminoid | Industry control |
| Common oats | No | Annual graminoid | Industry control |
| Common vetch | No | Annual forb (legume) | Industry control |
| Climbing pea | No | Annual forb (legume) | Industry control |

Table 1: Selected species, characteristics and seed mixes.

To evaluate **O2**, whether native grassland species can survive and increase beneficial diversity, the cover of each species will be measured at peak biomass in 2021. We will sample across each subplot with two line-point intercept transects of twenty points each, crossing diagonally in the center of the plot. Each transect will be four meters long with measurements taken every 20cm. At each point a pin will be dropped, and each plant it touches will be recorded. From this, we will estimate percent cover of each species, representing its level of success in establishing and surviving the growing season. By comparing percent cover of each species with the initial amount of seed added in each mix, we will identify which species performed best in each context.Without the addition of more seeds, this process will be repeated in 2022 to evaluate the ability of each species to successfully reproduce, resist invasion by weeds, and maintain a viable population over time.

We will measure beneficial pollinator and pest predators concurrently with line-point intercept monitoring. We will collect insects in subplots planted with different seed mixes in the spring of 2021. We will send samples to be identified by expert taxonomists at OSU. We will assess actual pollination by bagging the emerging flower buds of 10 individuals within each treatment (to assess seed production in the known absence of pollinators) and second by hand pollinating 10 marked individuals within each treatment (to assess seed production in the presence of complete pollination). The natural pollination rate will therefore be calculated as (seeds produced in open – seeds produced in bagged)/seeds produced in hand pollinated flowers (Kearns and Inouye 1993).

**Objective 3: Tradeoff avoidance**

To be successful in increasing farm sustainability, the success of objectives 1 and 2 should not come at the expense of other metrics of sustainability. To evaluate our impact on broader mutifunctinonality we will measure pig disturbance, and compare soil effects of our native cover crops with traditional cover crops and bare ground practices. These include soil stabilization and building, shading and moisture retention.

To address potential pig disturbance in oaks, we will establish four 100 meter vegetation transects per plot in Fall 2020. Immediately before and after pig grazing, we will estimate percent cover of bare ground, litter, herbaceous cover, and shrubs in 2m x 2m plots each twenty meters along these transects . Any oak seedlings will be flagged before grazing to quantify losses. This process will be replicated in hazelnut orchards to address the potential for rutting that reduces harvest efficiency. Instead of vegetation classes we will estimate percent ground disturbance and measure the deepest rut in each plot. We will be successful if pig grazing causes minimal losses to oaks and other native vegetation, and minimal disturbance in the orchards.

To test whether we are successfully minimizing erosion risks, we will estimate the amount of bare ground exposed throughout the wet/growing season (February to June 2021-2022). Each native seed mix will be analyzed against the industry control and true control (no seeds added). Hazelnuts (especially young trees) rely on soil moisture being available as long as possible into the spring. In the Willamette Valley, nearly all precipitation falls between October and May, with the majority falling from December to March. By mid-summer, orchard soils can get very dry, prompting farmers to water trees weekly (often by hand). We will install soil moisture probes to test whether native cover crops increase soil moisture in the spring through shading the soil. We will measure soil moisture concurrently with estimating exposed bare ground. Cover cropping can also have long term benefits for the soil, primarily through the incorporation of organic matter containing carbon and nitrogen to the soil. This organic matter increases soil fertility, water holding capacity, and can help resist compaction. We will use standing biomass as an indicator of the level of soil building provided by our cover crops. At peak standing biomass (in June 2021-2022), we will clip all aboveground biomass in a predetermined .25 m x .25m square portion of each subplot. Biomass will be dried in a 60 \*C oven for 48 hours and weighed. We will be successful if the above soil quality metrics are equal to or better than those found in industry and true controls.

*Educational Outreach Plan (500 words - currently 545)*

Our educational outreach philosophy is based on the principles of “translational” science where we collaboratively design a project with stakeholders taking an active role (Hallett 2017). Key stakeholders in this project are our producer-cooperators, who will not only participate in the implementation of this project, but have been working with us iteratively over two years to define problems, questions and potential solutions.

Involving producers from the outset will lead to relevant and directly applicable results. This implicitly facilitates broader outreach as we are working to answer questions that growers are interested in rather than providing external solutions. Our close working relationship with our producers uniquely positions us in local networks to disseminate our research to the sustainable hazelnut farming community and other interested parties. For example, producer-cooperator Taylor Larson is a local leader in the sustainable hazelnut farming community. Primarily, as vice-president of the OOHC, we have a direct line of contact with hazelnut producers who have already demonstrated an interest in sustainable farming. As director of the Coast Fork Willamette watershed council, a community environmental organization that works to “enhance the.. watershed through restoration, monitoring, education and stewardship”, we have connections to a network of landowners who are environmentally minded. Finally, Taylor leads Rogue Farm Corps, an educational apprentice program for young farmers. This broad range of relevant parties are prime candidates for participants in field days.

Field days will be focused during periods of engaging research activity on the farms. Annually, there are two highly active seasons: May/June, when soil moisture, plant and beneficial insect monitoring take place; and September/October, when pig grazing and associated monitoring take place. We will host one field day corresponding to each of these time periods in both 2020 and 2021. In 2020 we will focus on our objectives and research process, and in 2021 we will focus on disseminating lessons learned.

In addition to educational outreach to practitioners, we will use our research as a model of translational science in undergraduate education. Through our collaboration with My Brothers Farm, we have already hosted class field trips and had three undergraduates develop research for honors theses associated with this project. With support from SARE, we will continue this work as our project expands in scope. We have also collaborated with Dr. Betsey Miller, at Oregon State University, to develop our FBW monitoring methods. Dr. Miller will serve as a link to OSU students and researchers who may also be interested in this work.

To reach a broader public we will participate in conferences and reach out to media outlets for press. Specific habitat/ecology focused conferences include: the annual ESA meeting (August), Society for Ecological Restoration NW meeting (Eugene, OR: 2021), the National Conference on Ecosystem Restoration (Portland, OR: August 2, 2020), the annual Willamette Valley Habitat Meeting (Albany, OR: February) and the Cascade Prairie-Oak Partnership Conference (Vancouver, WA: October 2020). Farmer conferences include the Nut Growers Society Annual Winter Meeting (Corvallis, OR: January), Nut Growers Society Summer Tour (potentially on site, August), North American Agroforestry Conference (2021). We will also work with university public relations to promote our work in university publications and to the hazelnut industry. Finally, we will coordinate with Dr. Stephanie Frischie at the Xerces society to share our work promoting beneficial species.

*Scholarly Publications & Educational Materials (500 words)*

All results of this project will be published in peer-reviewed scientific journals. The following are potential avenues of publication:

* Frontiers in Ecology and Environment (ESA), Renewable Agriculture and Food Systems (Cambridge University), Agroecology and Sustainable Food Systems (Taylor & Francis), Agriculture, Ecosystems and Environment (Elsevier)
  + General sustainable agriculture publications.
* Journal of Agroforestry Systems (Springer)
  + Publications related to pig silvopasture in oaks.
* Journal of Integrated Pest Management (Oxford Academic)
  + FBW cultural control through grazing and promotion of predatory insects.
* Environmental Entomology
* Restoration Ecology (Society for Ecological Restoration), Ecological Restoration (University of Wisconsin)
  + Restoration journals focusing on creating native grassland understory in hazelnuts that supports native pollinator populations.

For each of the conferences listed in the educational outreach plan, posters or oral presentations with slideshows will be developed. These, along with published papers will be available at the Hallett Lab website: [www.halletlab.netlify.com](http://www.halletlab.netlify.com).

General outreach versions of posters will be developed into handouts for field days. These will contain general project overview (cover crop or pig grazing depending on season), basic results, and benefits to producers - along with contact information for further inquiries.

*Evaluation of Producer Adoption (300 words)*

Changes in producers’ knowledge, awareness and attitudes will be primarily evaluated by providing the WSARE Survey at field days. Longer term indicators of producer adoption will include broader incorporation of sustainable practices to hazelnut farming in the Willamette Valley. We plan to develop a native hazelnut understory seed mix with Heritage Seedlings, the largest local supplier of native seeds for restoration projects in the valley. This would parallel a partnership in California between academia, the Xerces society and Hedgerow Farms to develop an annual wildflower seed mix to be used in almond orchards. Sales of this seed mix will be a useful indicator of producer adoption of native cover cropping.

*Innovations and Contributions to Sustainable Agriculture (500 words - currently 610)*

This project has the potential to increase hazelnut farm multifunctionality and support local and regional ecosystems while providing benefits to farmers and farm communities.

Farm productivity will be increased through reduced pest pressure, increased nut yields, and increased usable land. If pig grazing is shown to reduce FBW population sizes, fewer nuts will be infected and can be sold. Currently, it is common to lose 10% of crops to FBW infestation. Native cover cropping can also reduce FBW and other pest populations through providing habitat and forage for predatory insects. If cover cropping increases soil moisture, less trees will be lost to drought stress, and the trees that survive will grow more quickly and produce more than if they had been water stressed. Grazing pigs in oak woodlands expands the productive acreage of the farm. Finally, for multi-crop farms like My Brothers Farm that also produces apples, increased native pollinator populations can increase productivity of these crops.

Farm profits will be positively affected by the above mentioned increases in productivity, but also through efficiencies and abilities to reduce costs in other ways. For example, cultural control of FBW can reduce the need to spray (typically $200/acre/year). This can help reduce the barriers to organic certification, which allows growers to increase their revenues substantially (conventional ~ $2/lb, organic ~9$/lb). These prices are also more stable, as conventional hazelnuts have typically been sold overseas and are affected by international politics. Some growers have felt compelled to remove oak stands from their property to reduce FBW, a substantial cost that could be avoided through grazing. The main cost in raising pigs is feeding them, and by allowing pigs to graze for nuts and acorns, the profit margin on pork can be increased for free. Finally, these sustainable practices provide a compelling story for farmers to engage customers with in selling their products.

Orchard soil health will be improved as integrating livestock into the orchard brings in important soil nutrients that will help fertilize hazelnut trees. Replacing a bare orchard floor with a diverse cover crop will help prevent erosion, a potentially expensive problem in hazelnut orchards. It will also increase soil carbon and help structure the soil, providing habitat for a diversity of soil organisms. Improved soil health will benefit water quality as less erosion finds it was into waterways. Along with this, reduced pesticide and fertilizer use on farms will also benefit water quality.

A major innovation of this project is the aligning of sustainable agriculture and conservation goals. Before widespread land conversion, much of the Willamette Valley was dominated by diverse oak-savannah, woodlands and grasslands. These habitats, collectively referred to as “oak-prairie” have been reduced to less than 5% of their original extent. Of these remnants, over 80% are on private, often agricultural, lands. Oak-prairie habitats are therefore among the most endangered ecosystems in the Pacific Northwest, and working with farmers for their protection is essential for their conservation. Accordingly, the Oregon Department of Fish and Wildlife has recognized these as “priority” habitats for conservation and work is ongoing to restore and manage them. They also have cultural value, native people, resources, supporting native pollinator base for western Oregon. Through increasing the ecological value of farms, sustainable hazelnut farming can play a role in supporting and preserving and these systems. More multifunctional farms reduce the risk of local species extinctions where populations are trapped on islands of habitat in unusable agricultural land. These populations will be able to more easily forage and move through agricultural landscapes. Expanding grasslands under hazelnuts and grazing in oak woodlands will lead to a closer integration of oak-prairie conservation efforts with sustainable agriculture.