# ASSESSING THE ECOLOGICAL CONSEQUENCES OF DOMESTIC PIG GRAZING ON THE UNDERSTORY VEGETATION OF AN OAK WOODLAND

By
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Approved: ___ _____

Lauren Hallett


**Abstract**

This study addresses the effects of domestic pig (*Sus scrofa domestica)* grazing on understory vegetation of an oak woodland adjacent to a hazelnut orchard. Oregon white oaks (*Quercus garryana*) are associated with filbertworms (*Cydia laiferreana*), a native lepidopteran pest that uses the acorns as its primary food source during its larval stage. Filbertworms also affect agriculture, infecting hazelnuts and rendering the nuts inedible and unmarketable. Oregon white oak habitats are already under constant threat from land use change due to urbanization and agriculture, and this conflict exacerbates the problem. Pig grazing of infected acorns after they drop in the fall could offer a disincentive of removing oak habitats. It is common for hazelnut farmers to spray pesticides intensively or remove oak stands entirely to mitigate against pests. Pig grazing may (1) be an effective organic alternative and a potentially profitable scenario that could enhance the sustainability of agricultural practices while (2) promoting conservation of a rare ecosystem and (3) facilitating pig farming. Even with this potential win-win-win scenario, any management activity in an ecosystem could impose unintended consequences and introducing an uprooting mammal can be risky. **I tested whether grazing domestic pigs in Oregon white oak stands has any negative effects on understory vegetative cover.** I hypothesized that the pigs will (1) reduce percent cover of the herbaceous understory, (2) increase percent cover of bare ground, and (3) eliminate certain preferred herbaceous species from the site. I also hypothesize that (4) more accessible/less obstructed areas within the plots will have even lower levels of herbaceous/litter percent cover and even higher levels of bare ground percent cover. I visually estimated percent cover of bare ground and herbaceous/litter in quadrats along three transects using a Before-after Control-impact (BACI) design before and after grazing treatments in grazed and un-grazed woodland plots. Domestic pig grazing showed no significant effects on the percent cover of herbaceous/litter and bare ground. There was no loss of specific herbaceous species/litter. This suggests domestic pigs pose a relatively low threat to the understory vegetation of a native oak woodland when regulated through minimal time in the area. Pigs can then provide the win-win-win scenario without harming the understory of an already stressed habitat.

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## Introduction

Oregon's Willamette Valley has been dominated by Oregon white oak habitats, including savannas and woodlands, for thousands of years (Figure 1; Fischer 2008). Oak woodlands are defined as having a high cover of overstory trees (up to 80%) with understory communities composed of grasses, forbs, and woody plants (Peterson 2001). These habitats were historically maintained by humans through active management. Native societies maintained the woodland-savanna by burning them for food production, safety, resource development, transportation, and aesthetics (Ulrich 2010). Over 200 plant and animal species, 45 of which are at-risk, are associated with Oregon white oak, making it one of the most biologically diverse habitat types in Oregon (Fischer 2008). Western grey squirrels, who's native habitat is Oregon white oak woodlands, are just one example of a species experiencing decline (listed as sensitive in Oregon and threatened in Washington) dependent on this habitat (Allen 2019). Since the 1800's, when the first European settlers arrived, these habitats have been greatly reduced. These nutrient-rich, well-drained soils in valley bottoms that support the best oak habitat were also the most valuable farmland (Thomas 2007). Urban development, tree plantations, vineyards, and other human land use change has reduced oak habitats to 24,921- 69,684 ha in the Willamette Valley, just 10% of its historical cover before settlement (Figure 1; Fischer 2008).

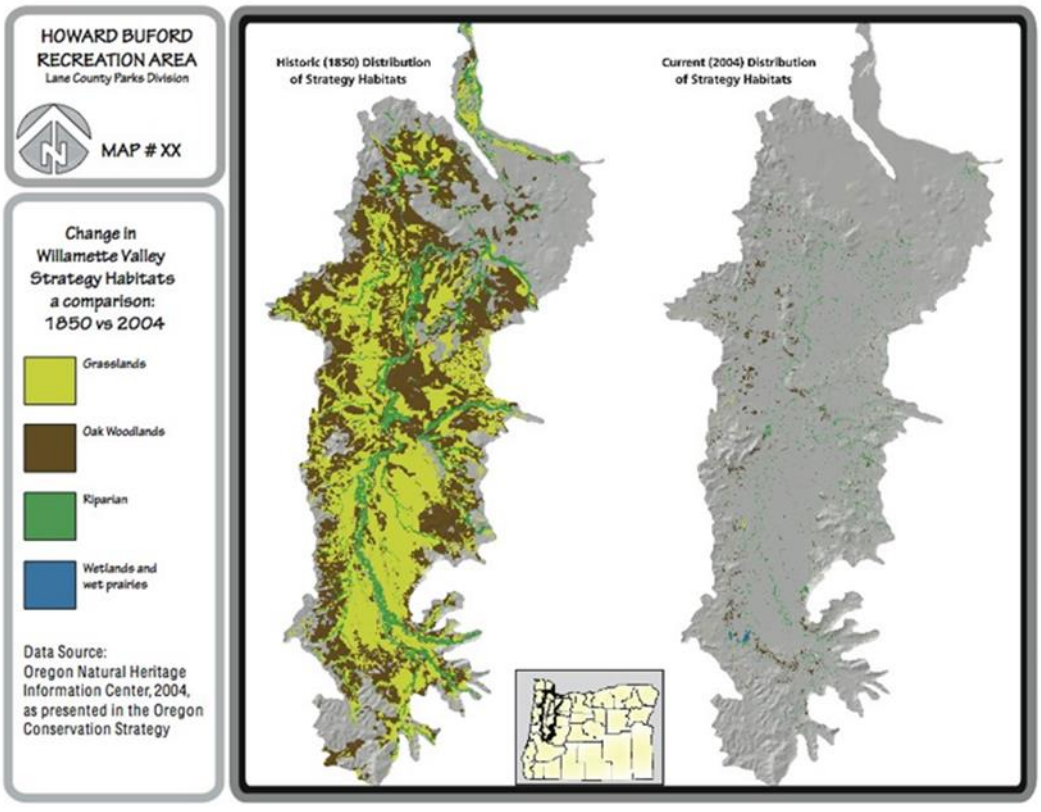


Figure 1: Oregon white oak habitat decline in the Willamette Valley from 1850 to 2004.

Rapid decline in oak habitat is alarming and many private landowners in Oregon are starting to consider preserving what is left. About 96% of the Willamette Valley is privately owned, with 4 of 5 threatened habitat types in Oregon occurring on private land (Fischer 2008).

Private landowners face considerable financial and social pressure to keep their land economically productive and, often, oak habitats directly compete with their production (Ulrich 2010). Too often landowners make the choice to completely remove stands of Oregon white oak because they are threatening agricultural production with pests and competition for resources. Approximately half of earth's habitable land has been modified to some degree for agricultural purposes. Current trends suggest that the global agricultural footprint could increase by a further 18% by 2050 (Demars 2008). Therefore, we must seek collaboration with landowners to increase and maintain biodiversity.

Currently, hazelnut farming is a popular industry in the Willamette Valley, with Oregon producing 99 percent of US hazelnuts and 5 percent of the world's production (Honea; Walton et al. 2007). Oregon hazelnut production has doubled in the last decade and is expected to double again by 2025 (Teel 2018). Hazelnuts (locally known as filberts), just like any agricultural production, is consistently threatened with pests. Hazelnut farms are currently battling the filbertworm(Figure 2a), a native pest that burrows into nuts and renders them inedible. Filbertworms can cause between 20 and 50 percent damage on nut kernels if untreated (Walton et al. 2007)(Figure 2b). The filbertworm over winter is an inactive larva and, eventually, pupa in a silken cocoon that loosely incorporates twigs and leaf material from the orchard floor. Larvae pupate in the cocoon in the spring and begin emerging as adults about 2–5 weeks later. This emergence usually begins around mid-June and continues through October. When the adults emerge, they look for mate s and the day after mating, egg laying starts. Eggs are laid one by one on leaves within 6 inches of nut clusters and hatch within 8–10 days, depending on temperatures. The newly hatched larvae then move to find a nut to feed in. They will feed in the nut for about 2–4 weeks, then they either enlarge their entry hole to exit the nut, or bore a new exit hole (Olsen et al. 2013). While most farmers spray pesticides, another common strategy to reduce filbertworm populations is to remove all nuts from the ground at the end of the season. Because the moth larvae burrow in nuts, removing the nuts breaks the moth's life cycle and curtails its population size without the use of pesticides (Hall 2017). The moths' native host are Oregon white oak acorns and often nearby oak stands act as a source for re-invasion of hazelnut orchards (Lewis 1992). Consequently, farmers often remove their nearby oak stands. However, progressive farmers are starting to grow organic hazelnuts and are seeking alternatives to spraying herbicides and removing oak habitats.

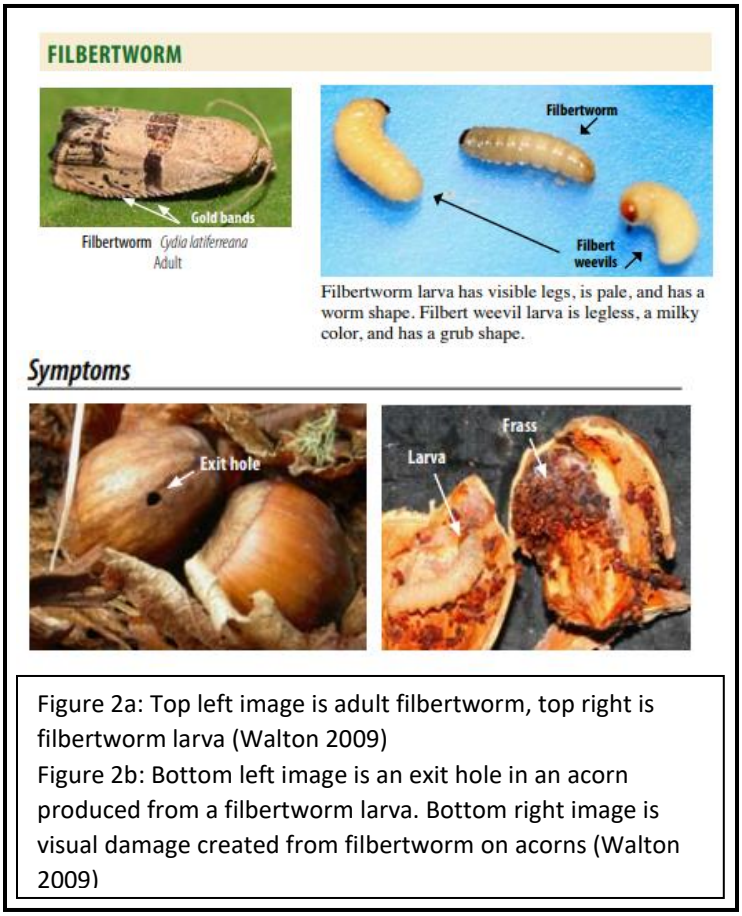


Figure 2a: Top left image is adult filbertworm, top right is filbertworm larva (Walton 2009)
Figure 2b: Bottom left image is an exit hole in an acorn produced from a filbertworm larva. Bottom right image is visual damage created from filbertworm on acorns (Walton 2009)

Pig grazing is a "cultural control" that has successfully been employed in other systems, such as removing apples from the ground of an organic apple orchard (Nunn 2007). Pigs have a preference for acorns, and it is hypothesized that pigs can be used to reduce pest pressure by removing acorns that would otherwise host the moth larvae (Hallett 2018). Pigs are an omnivorous species and their diets vary greatly among habitats and geographic locations (Ickes 2001). They are in the uprooting mammal category, such as wild boar and pocket gophers, which turn over areas of soil to eat foliage, seeds, and roots (Wang 2017). These behaviors may negatively impact understory vegetation (Ickes 2001). Rooting can damage ecosystems by removing entire plants and leading to the spread of certain plant species (such as unwanted invasive species) into bare soils (Wang 2017). Uprooting mammals can also displace and kill seedlings by altering physical properties of the soil, changing nutrient dynamics, or facilitating the spread of exotic vegetation (Ickes 2001). Pigs are curious by nature and some of their disturbance is from investigation rather than foraging. A study found that domestic pigs living in a semi-natural environment spent 52% of the daylight period foraging (rooting and grazing) and another 23% in locomotion and direct investigation of environmental features, which can cause soil compaction (Studnitz 2007). Domestic pigs, however, are less destructive than feral pigs because they are more efficient foragers (Wang 2017). Domestic pig uprooting is of great interest because of their less destructive nature and yet is less studied than feral pig uprooting. This suggests that domestic pigs could be problematic, however, under an optimum level of disturbance, beneficial species richness could be increased, especially when a stable or predictable disturbance regime has evolved together with the local ecosystem. This level of disturbance also facilitates nutrient cycling in soils by increasing the available nitrogen for plant growth (Wang 2017).

I carried out my research at My Brothers' Farm, an organic hazelnut farm. Taylor Larson, owner of My Brothers' Farm, is trying to replicate the process of nut removal in the orchards by grazing the nearby oak woodland with domestic pigs. In a related study, our research group found that pigs successfully reduce the number of acorns on the ground that would otherwise host the moth larvae (Calvin Penkauskas, UO Undergraduate Thesis). While this is promising, we have to do some due diligence as pigs are often associated with the destruction of habitats. While grazing domestic pigs is an attractive alternative to complete removal of Oregon white Oak habitat, my project examines the potential that grazing pigs have to negatively affect the oak understory. Specifically, I hypothesize that the pigs will: **(1) reduce percent cover of the herbaceous understory, (2) increase percent cover of bare ground, and (3) eliminate certain preferred herbaceous species from the site. I also hypothesize that (4) more accessible/less obstructed areas within the plots will have even lower levels of herbaceous/litter percent cover and even higher levels of bare ground percent cover.**

**Study Area**

My Brothers' Farm sits on 320 acres in Creswell Oregon in the southern Willamette Valley, OR (Figure 3). This farm is currently in the process of transitioning from annual grass seed production to a diversified orchard and ranch. Currently, they are producing organic hazelnuts, bison, pork, hops, apples, and pumpkins. There are currently 660 hazelnut trees on the property. Their mission is to be stewards of the land by growing a variety of crops that build soil health, increase water quality, and strengthen the local community.

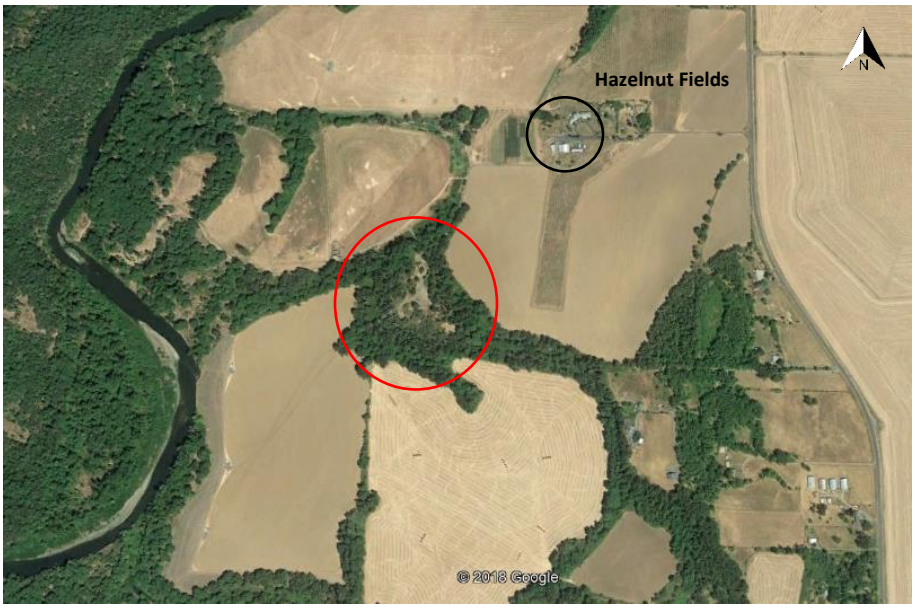


Figure 3: My Brothers' Farm, Creswell Oregon. Coast fork of the Willamette river is located to the west. Red circle indicates study site. Black circle indicates farm's main building. Hazelnut fields labeled.

This study was conducted in a twenty-acre oak woodland southwest of the farm's main buildings (Figure 3). It is part of a landscape matrix and is connected to numerous other woodland patches that run from property to property. The oak woodland is nestled between four agricultural fields and is approximately 1,870 ft from the hazelnut fields. This woodland is approximately 1000 ft east of the coast fork of the Willamette river. This area is in a Mediterranean climate with cool wet winters and warm dry summers. Chehalis silty clay loam composes a majority of the soil in the small oak woodland patch (Soil survey staff, USDA). A gravel road that adjoins the main farm and the four fields runs through the stand and divides it into two sections.

Aerial photos dating from as early as 1934 show this oak woodland mostly unaffected by the changing landscape surrounding it (Figure 4). The site is a remnant riparian habitat (ex-oxbow lake) that consists of Oregon white oaks, Oregon ashes, and big leaf maples with standing water and ephemeral streams in the winter. The oak woodland was left untouched for almost 100 years by farmers because of the saturated ground during the winter.

The understory of the oak woodland at My Brothers' Farm is incredibly diverse and includes multiple plant species. The oak woodland is particularly over run with invasive species such as Himalayan blackberry (*Rubus armeniacus*)(Cover photo). Himalayan blackberry can form much denser thickets than Oregon's native blackberry, Trailing blackberry (*Rubus ursinus*), and its growth in oak savannas can speed conversion to shrub-dominated ecosystems, preventing the establishment of new oaks, and inviting non-native animals that prefer the new species (Dennehy 2011).

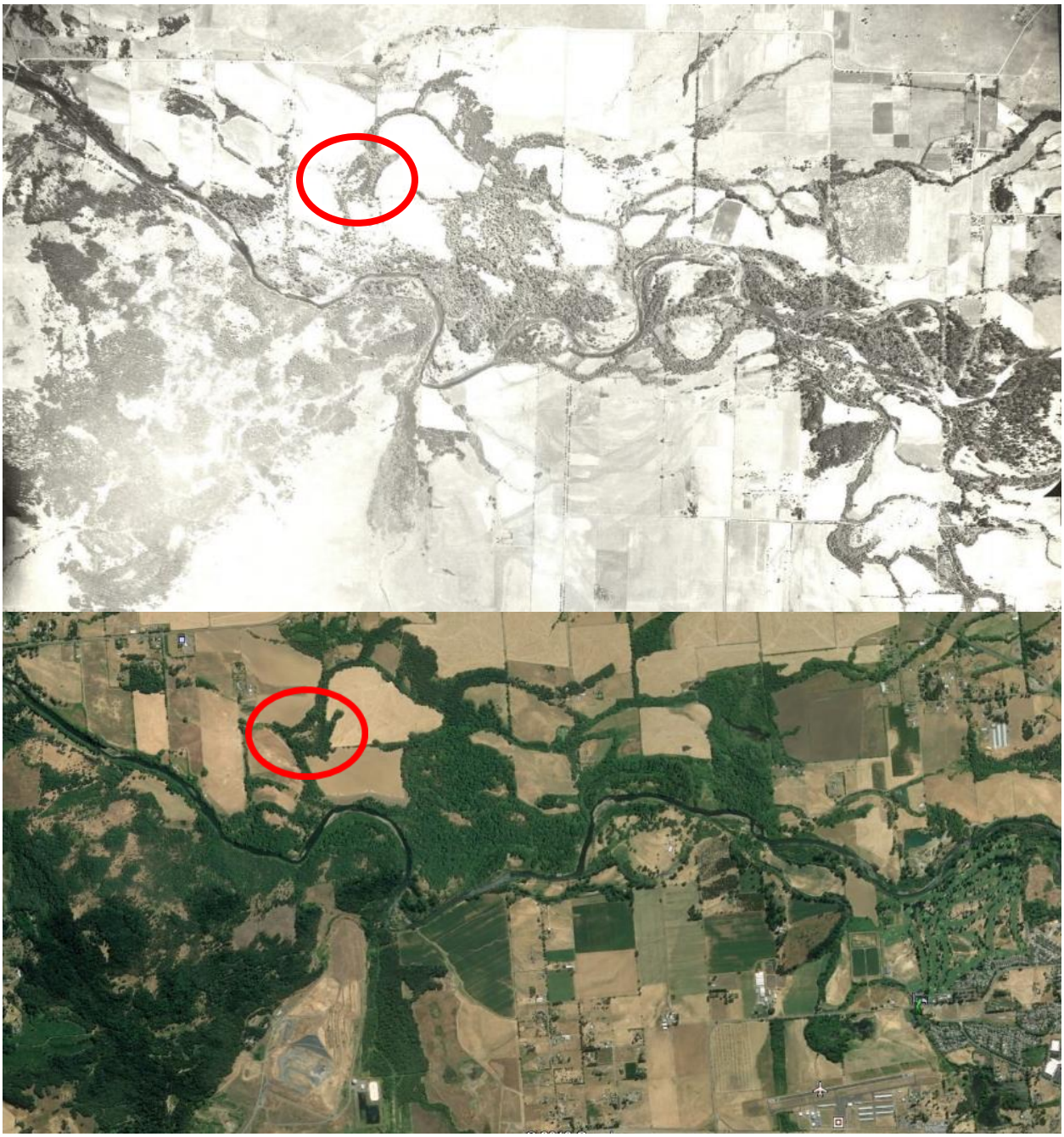

Figure 4: Top: Aerial photo taken from 1934 of Coast fork Willamette river in Creswell Oregon. Circle in red indicates study site.
Bottom: Google Earth image taken from 2018 of Coast fork Willamette river in Creswell Oregon. Circle in red indicates study site.

Before starting the pig grazing study, a rapid vegetation assessment was conducted in July 2018 to determine the most common plant species and areas of interest. Common shrub species that were found in the understory were snowberry (*Symphoricarpus albus*), Indian-plum (*Oemleria cerasiformis*), and Pacific poison oak (*Toxicodendron diversilobum*). The native vines consisted mostly of man root (*Marah oreganus*) and trailing blackberry (*Rubus ursinus*). The invasive vines that dominated the area consisted of Himalayan blackberry (*Rubus armeniacus*) and evergreen blackberry (*R. laciniatus*). Common tree saplings included Oregon white oak (*Quercus garryana*) and Oregon ash (*Fraxinus latifolia*). Remnant, dried stream beds were found running throughout the site and the most common species found there were yerba buena (*Clinopodium douglasii),* pennyroyal (*Mentha pulegium*), Douglas spriaea (*Spiraea douglasii*), and a variety of rushes. Other common herbaceous plants included sheep sorrel (*Rumex acetosella*), Robert's geranium (*geranium robertianum*), and a variety of native and non-native grasses.

The preliminary data before the grazing treatment was applied shows that both the control plot and treatment plot are relatively similar in terms of understory vegetation (Figure 5).

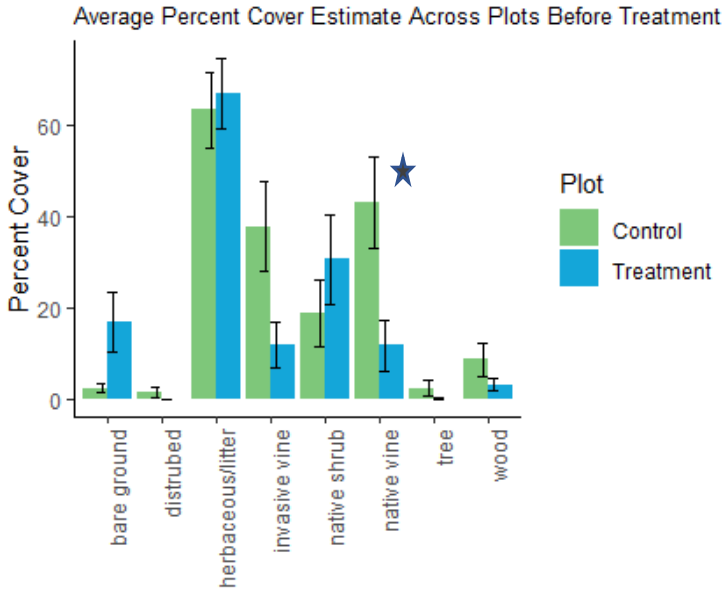


Figure 5: Average percent cover estimate across plots before treatment shows generally similar cover between categories. Green bars are the control plot and blue bars are the treatment plot. Star shows the only category that showed significance: native vine (P=0.018).

## Experimental Design

I divided the oak woodland study site at My Brothers' Farm into two plots, the treatment plot which received pig grazing, and a control plot (Figure 6). The control plot is 7 ½ acres and the treatment plot is 6 ½ acres. The two plots are separated by a gravel road that runs from the north. The control plot has seven percent more canopy cover compared to the experimental plot, with generally less understory vegetation potentially due to less sunlight (Calvin Penkauskas, UO Undergraduate Thesis).

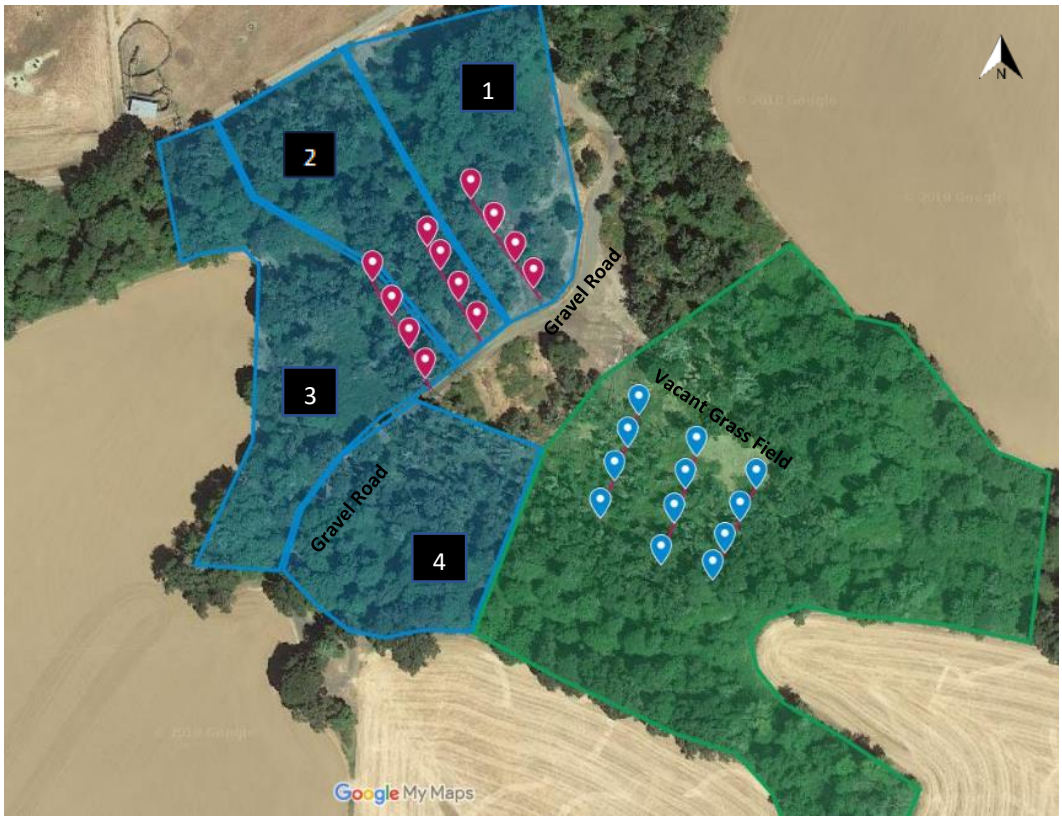


Figure 6: Oak woodland study site at My Brothers' Farm. Green area represents the control plot and the blue area is the treatment plot. Red lines represent the transects. Blue markers are quadrats in the control plot and the red markers are the quadrats in the treatment plot. The pastures are labeled one through four. Gravel road and vacant grass field labeled accordingly.

The experimental plot is further divided into four pastures, an average of 1.6 acres each, to evenly distribute pig grazing pressure across the plot. Pastures are separated by mown strips and electric fencing to secure the pigs' mobility. Baseline vegetation cover was estimated in mid-September 2018. The pigs were released two weeks later into the first pasture. The pigs were rotated through the pastures starting on the eastern side and stayed in each pasture for approximately four days to allow time for acorn consumption while minimizing disturbance. The third pasture was slightly bigger and received five days of treatment. Pasture two experienced pigs that had escaped for a small period of time and received an extra day of treatment to compensate. The fourth pasture received five days because only sixteen of the twenty pigs went into that pasture because four were scheduled for slaughter. The pigs were removed from the

treatment plot mid-November 2018 and post-treatment percent cover was collected at the beginning of December 2018.

To determine the effects of pig grazing on the understory of the oak woodland, I collected data on vegetative percent cover using 24 quadrats along six transects (Figure 6). The treatment plot and control plot each had three 50 m transects. Transects in the experimental plot ran at 315 degrees, perpendicular to the gravel road. Transects in the control plot ran at 195 degrees, perpendicular to the vacant grass field. Transects were separated by 30 m, measured perpendicular to transect direction. Percent cover was visually estimated in four 2 x 2 m quadrats along each transect, at the 5, 20, 35, and 50 m marks, respectively. Each quadrat started on the bottom left corner of the meter mark facing the 50 m point. The quadrats were marked by a 2 x 2 m PVC pipe square that had half meter-tall legs attached at the points to compensate for tall understory vegetation when needed (Figure 7). Quadrats were marked with stake chasers for repeat assessment. Three to four data collectors assessed each plot. We estimated the total percent cover of the following categories: invasive vine, native vine, native shrub, herbaceous/litter, bare ground, wood, disturbed, and tree. These categories were made based on the previous rapid vegetation assessment. Only the bare ground and herbaceous/litter categories were used for assessment. The other categories were recorded for future use since it was expected that these categories would not show effects in the first round of data. These categories were also used to determine the ease of access scale in the fourth hypothesis. The disturbed category was added half way through the first round of data collection due to the fact that some plots were partially mowed or had part of a trail running through it. Each observer independently estimated percent cover and then the most agreed upon estimate was recorded for each category. The individual species were also identified for each vegetative category. Each quadrat was also rated easy or hard to access based on proximity to a clearing and/or presence of heavy vegetation cover. A photo was taken of each quadrat to visually support vegetation cover estimates (Figure 7). Photos were taken facing towards the 50 m quadrat at the end of the transect. Pig grazing effects were evaluated using Analysis of Variance (ANOVA) and Tukey post hoc pair wise comparison. Factors are pig grazing treatment and timing, and their interaction. Software used for statistical analysis was R-Studio. Alpha value of 0.05.

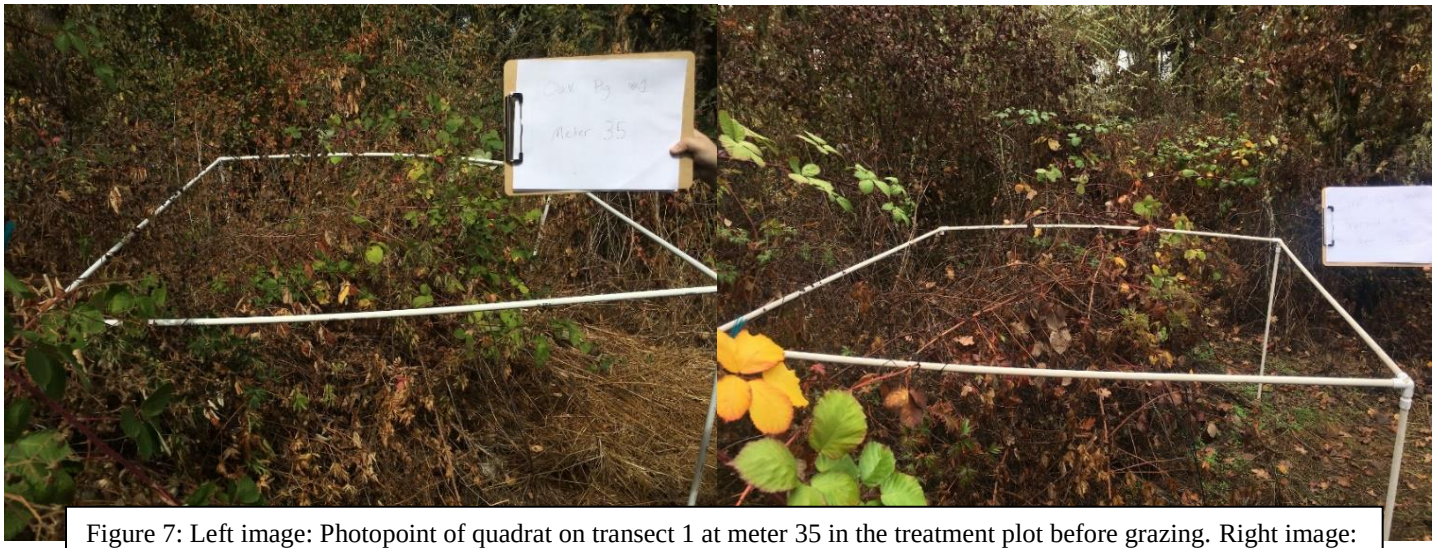


Figure 7: Left image: Photopoint of quadrat on transect 1 at meter 35 in the treatment plot before grazing. Right image: Photopoint of quadrat on transect 1 at meter 35 in the treatment plot after grazing.

## Results

No changes were seen in herbaceous/litter percent cover between time periods at either site. Neither the main effects of timing (p=0.65), or pig treatment (p=0.49) was significant, and there was no significant interaction effect (p=0.79). There was a slight decrease in mean cover in both plots. The control plot decreased from 63.42% to 57.58% and the treatment plot decreased from 66.92% to 65.42%. (Figure 8).

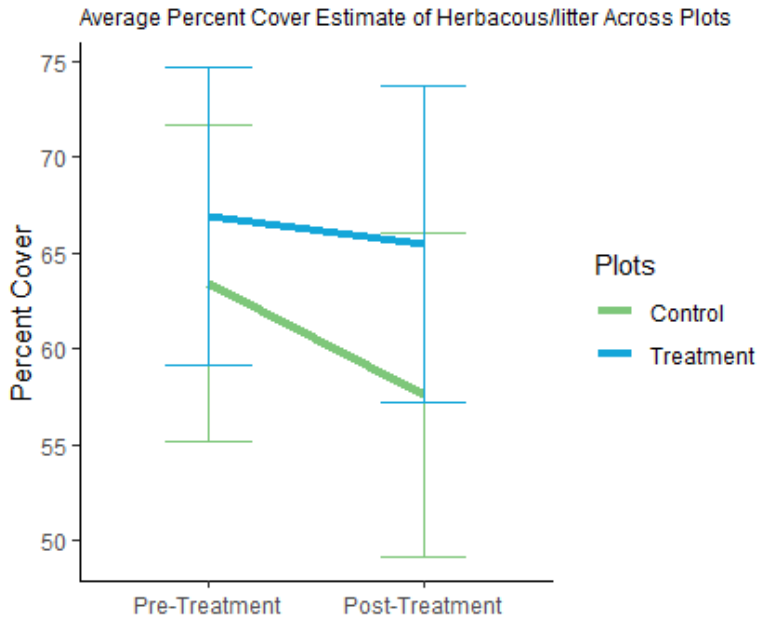


Figure 8: No treatment effects on percent cover of herbaceous/litter category across plots pre and post treatment. The green line is the control plot and the blue line is the treatment plot. The whiskers are error bars from the mean.

No changes were seen in bare ground between time periods at either site. There was a significant difference between plots before pigs were grazed (p=0.008). The main effect of timing (p=0.15) was not significant, and there was no significant interaction effect (p=0.21). To further analyze the significance in the plots a Tukey test was used to compare specific points. The pre-treatment point in the treatment plot is significantly different from the other points. Comparison of pre-treatment in the treatment plot and post-treatment in the control plot was significant (p=0. 02). Comparison in pre-treatment in the treatment plot and pre-treatment in the control plot was significant (p=0.03). There was a decrease in mean percent cover in both plots. The control plot dropped from 2.5% to 1.83% and the treatment plot dropped from 16.83% to 7.08%. (Figure 9).

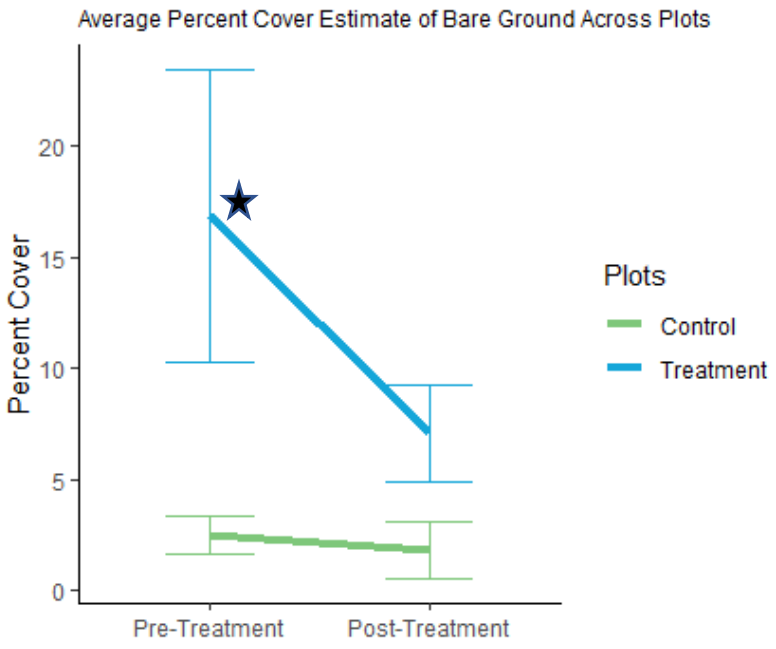


Figure 9: No treatment effects on percent cover of bare ground category across plots pre and post treatment. The green line is the control plot and the blue line is the treatment plot. The whiskers are error bars from the mean. Star represents significant point.

No individual species/litter were eliminated in the treatment plot after receiving grazing treatment (Figure 10). Species that were affected the most in the control plot were moss increasing from presence in two quadrats to nine quadrats, and *Heracleum maximum* decreasing from presence in three quadrats to presence in zero quadrats. Species/litter that were affected the most in the treatment plot are dead leaves increasing from presence in eight quadrats to twelve quadrats, *Geranium robertianum* increasing from presence in seven quadrats to ten quadrats, and lichen increasing from presence in zero quadrats to presence in five quadrats.

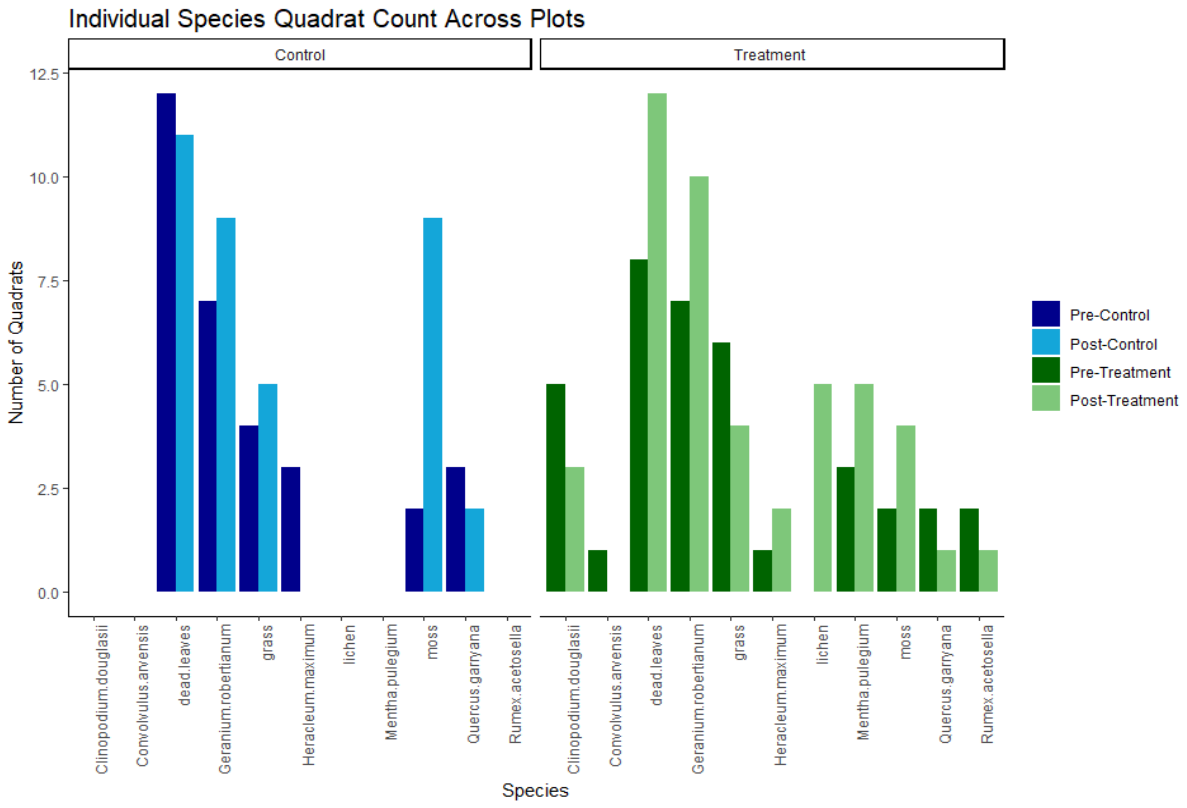


Figure 10: The count of quadrats with individual species presence across plots pre-treatment and post-treatment.

Pig grazing did not have any significant effects on the percent cover of herbaceous/litter in accessible or obstructed quadrats within quadrats (P=0.89) and across quadrats (P=0.43). There was also no significant interaction between quadrats (P=0.47) (Figure 11a). Pig grazing did not have any significant effects on the percent cover of bare ground in accessible/obstructed quadrats within quadrats (P=0.18) and across quadrats (P=0.73). There was also no significant interaction between quadrats (P=0.34) (Figure 11b).

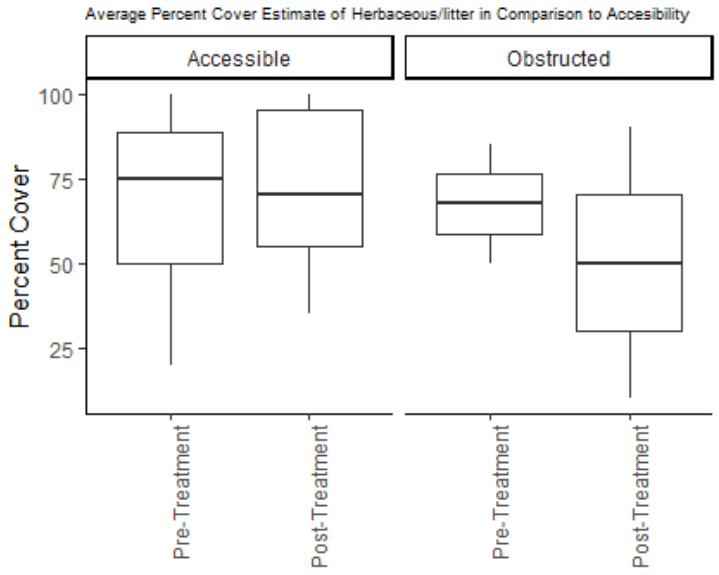


Figure 11a: Average percent cover estimate of herbaceous/litter in the treatment plot in relation to accessibility pre and post treatment

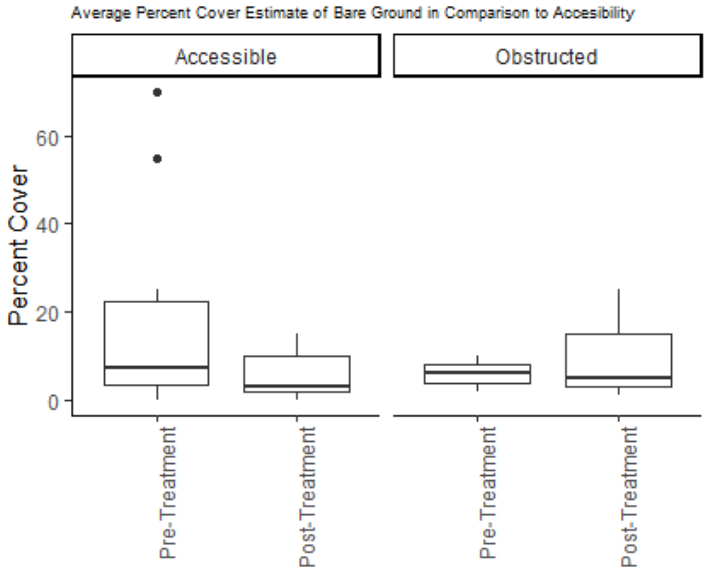


Figure 11b: Average percent cover estimate of bare ground in the treatment plot in relation to accessibility pre and post treatment

**Discussion**

My results show that domestic pigs pose a relatively low threat to the understory vegetation of a native oak woodland when regulated through minimal time in the area.

I hypothesized that the herbaceous/litter layer would decrease with pig grazing, this was not supported by the data. The decrease in herbaceous/litter percent cover was small and ultimately not significant. This slight drop in mean herbaceous/litter layer for both control and treatment plots was most likely due to the natural decline of "greenness" that occur during the winter. Normalised Difference Vegetation Index (NDVI) measurements, in general, shows a decline in the phenology of North American vegetation after late August. Seasonal NDVI measurements in a deciduous forest in New Haven, Connecticut dropped from approximately 0.6 in mid-September to approximately 0.3 in early November (Goward et al. 1985). This can be visually seen in the photopoints taken during data collection in the oak woodland study site (Figure 7).

I also hypothesized that bare ground would increase after pig grazing, showing a trade off with the herbaceous/litter layer. This was not supported by the data and instead decreased. Pigs are often associated with destructive behavior because they uproot plants. I predicted that bare ground would increase because of their presence, but the results showed the opposite effect. Due to the timing of seasonality in the experiment, the decrease in bare ground is likely from the leaves dropping from the canopy layer above. If pigs did increase the percent cover of bare ground, then the timing of leaf fall may have hidden this effect.

When individual species were taken into account there was no significant change in their presence/absence after grazing treatment. This is the opposing direction of my third hypothesis as it was hypothesized that pigs would prefer certain species/litter and this favorability could

eliminate certain species/litter. In the treatment plot there was little decrease in species and instead there was a noticeable increase in *Geranium robertianum*, dead leaves, and lichen. The increase in Robert's geranium is likely due to it being a low growing winter and spring annual. Robert's geranium primarily inhabits forestlands on the west side of the Cascade Range and is becoming one of the most common woodland invaders in Western Oregon (B Rated Weeds, Oregon Department of Agriculture). As stated earlier, the increase in dead leaves is due to the change in seasons and dropping of Oregon white oak and other trees leaves. The increase in lichen is also due to seasonality. Lichens prefer cool, cloudy, wet weather that Oregon undergoes in the winter creating an ideal environment (Pacific Northwest Pest Management Handbooks, 2016).

I predicted in the fourth hypothesis that quadrats with easier accessibility would show a more significant decrease in herbaceous/litter percent cover and more significant increase in bare ground percent cover compared to obstructed quadrats because the site had a dense understory making certain quadrats inaccessible or uncomfortable to reach. This was not shown in the data and both categories were found insignificant in terms of quadrats being accessible or obstructed. This is thought to have occurred because of the limited amount of time in each pasture and the possibility of leaf fall covering up bare ground. Another possibility is that pigs accessed both accessible and obstructed quadrats easily, but still showed no signs of effects on bare ground percent cover and herbaceous/litter percent cover.

This project offers promising results for an alternative pest management strategy, as this study's beginning data shows that domestic pigs cause little harm to the understory vegetation of the oak woodland. Due to this project's early stages, there is many future directions that it could take. The timing of data collection proved to be the most influential since leaf fall and seasonal variation had affected the outcome. It is suggested that the data that is collected after the pig grazing treatment be done before the first frost, earlier in the fall. The timing between the pigs being released and data being collected could be lessened. Another suggestion is to take percent cover at different times of the year to account for loss due to seasons. In order to analyze the full effects of the pigs on the understory I believe it is important to see the long-term effects. This can also be benefitted from adding more quadrats to the study site for additional data. Due to the data's insignificance, more plots may be beneficial for future results. Permanent stem plots may also be beneficial to the experiment to see long term effects on woody vegetation since this study focused mainly on the herbaceous/litter layer. This study focused mainly on broad categories of vegetation and it would be of interest to see the pig's effect on oak seedlings specifically. Leaf litter can influence seedling establishment and possibly prevent new growth of oak trees (Molofsky 1992). Oaks are also shade intolerant and can be affected by the dense thickets of blackberry looming overhead and/or thick canopy layers, so with these seedlings already under pressure it would be of interest to study them further. Oak saplings of different ages could be planted to see which the pigs prefer and how many they consume.

Overall, this organic pest management strategy is a promising alternative to removing stands of Oregon white oak as the pigs impose little ecological consequences on the already stressed habitat. Preliminary results show that pigs are effective at removing the infected acorns off the ground that could possibly infect nearby hazelnut stands (Calvin Penkauskas, UO Undergraduate Thesis). These studies are beginning to obtain the win-win-win strategy of offering relief to Oregon white oak habitats, reducing the pressure of pests on nearby agriculture, and contributing to the local pig industry. I suggest continuing this study and testing this method at various sites.

**Acknowledgments**

I would like to thank my community partner, Taylor Larson, one of the owners of My Brothers' Farm, for giving me the opportunity to work on this incredible project. This project could not have been started without his contributed knowledge and essential participation in its setup.

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