Pollinator Monitoring and Riparian Restoration at Whitewater Ranch

Restoration and Research Environmental Leadership Program
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Abstract

Riparian habitats support terrestrial and aquatic ecosystems as they provide water filtration services, water temperature regulation, and habitats for numerous organisms. These ecologically complex riparian systems are sensitive to changes in climate, invasive species, and degradation of soil and vegetation. We monitored plant health which was determined by height, vigor, water temperature, survival rates, and competition levels within active riparian restoration areas. Intense ecosystem changes also adversely affect nearby pollinator populations, threatening the ecosystem services they provide. We studied native pollinators to gain insight into the mechanisms driving biodiversity and agricultural productivity, and contributed to the ongoing restoration project that began on Whitewater Ranch in 2014. We worked with Dr. Lauren Ponisio and Rose McDonald from the Ponisio Lab to assess and monitor native floral species in post-burn timberlands, from the 2020 Holiday Farm Fire, and understand their implementations in ecosystem resilience. After data compilation, we compared our findings to previous ELP data and analyzed the success of restoration efforts. Our research on pollinator conservation, riparian restoration, and sustainable land management practices will aid in informing policymakers, farmers, and ecologists in making decisions and developing plans that promote the integrity of interdependent ecosystems and further agricultural sustainability.

<u>Introduction</u>

Riparian Restoration

Riparian zones, the interface between terrestrial and aquatic ecosystems, provide numerous ecological functions and services, such as filtering pollutants, regulating flow, transporting nutrients, stabilizing riverbanks, and providing habitat for wildlife (Grabau et al., 2011). Riparian areas, including streambanks, riverbanks, and floodplains, support nearly 70% of wildlife species in the Pacific Northwest, despite comprising less than 2% of the western U.S. landscape (Kauffman et al., 2022). Thus, riparian areas are essential environments for many terrestrial and aquatic plants and animals. However, riparian habitats face increasing threats from agricultural activities and the spread of non-native species, which pose significant challenges to their ecological health and function (Shafroth et al., 2008).

Agricultural practices like land clearing, cattle grazing, and irrigation can significantly degrade riparian areas by causing soil erosion, sedimentation, loss of vegetation, and the depletion of freshwater sources (Kauffman et al. 2022). Additionally, non-native plants alter habitats and outcompete native species for resources (Dennehy et al., 2011). The impact of these combined threats is extensive, undermining the ability of riparian ecosystems to provide vital nutrients and habitats for their biotic communities. (Funk et al., 2014). These consequences were evident at Whitewater Ranch, a certified organic blueberry farm in the McKenzie River Valley. This is primarily due to historic cattle ranching by previous owners having degraded Goose Creek, a tributary within the McKenzie River Watershed located on their property, through the overgrazing of vegetation. Recognizing the impact and seeking to improve the creek's ecological health, the current owners have collaborated with the University of Oregon's Environmental Leadership Program (ELP) to actively restore the riparian zone.

The ongoing project involves planting native species along a series of plots throughout the length of Goose Creek, to stabilize the streambank, improve water quality, increase biodiversity, and suppress non-native species. This revegetation replenishes the riparian zone with native trees and shrubs that are vital for reestablishing native plant communities and restoring the ecosystem to a healthy state (Schuster-Wragg et al 2018). Chosen species provided critical resources for pollinators, controlled erosion, and shaded the stream. This shading should lower water temperature, which is a key determinant of water quality, as higher temperatures negatively affect dissolved oxygen levels and aquatic life (Ghermandi et al., 2009). To monitor these changes, our team conducted growth surveys of native plantings, recording their status, vigor, and growth, while also measuring water temperature at four different sites along the creek. This allowed us to identify the most successful native species and gauge the restored zones' effectiveness at reestablishing the ecological functions of healthy riparian zones.

By strategically planting native species along Goose Creek, our project with Whitewater Ranch demonstrated a critical approach to riparian restoration, aiming to not only restore the streambank and improve water quality, but also create a flourishing habitat for diverse life. Together, we enhanced the ecological health of Whitewater Ranch, identified the most effective restoration methods, and contributed valuable knowledge to the conservation of riparian areas in the Pacific Northwest.

Pollinators

Intensive agricultural practices contribute to the decline of the quantity and variety of resources for pollinators by limiting plant diversity, occupying large plots of land, and decreasing bloom durations (Williams et al., 2015). Pollinator populations have experienced significant declines as a result of habitat loss, improper agricultural practices, and shifts in flower phenology. The loss of pollinators holds great significance, as pollination is a key ecosystem service with 90% of flowering plants dependent on pollination via mutualism, and 37% of the food humans consume is derived from processes involving pollination (Geppert et al., 2020). The continued decrease in pollinator populations and significant reduction in diversity and abundance of native plants, severely impacts ecosystems and agricultural production. Promoting local pollinators requires diverse plant communities, which support bee populations and enhance crop pollination. Supporting native pollinator populations in agricultural landscapes benefits crop yields because it increases the diversity of pollinator species. (Blaauw and Rufus 2014). Native pollinator enhancement is vital to ecosystems because it reduces the reliance on European Honeybees, a non-native and invasive pollinator species.

In our partnership with Whitewater Ranch, we conducted pollinator counts in a designated blueberry field. This study aimed to assess pollinator presence during agricultural production and evaluate the efficacy of an ongoing riparian restoration project. In 2020, the Holiday Farm Fire devastated over 100,000 acres in Oregon, destroying homes and businesses and affecting 1,200 acres of the property. The ranch had been dedicated to the sustainable cultivation of blueberries, and the aftermath of the fire allowed for an opportunity to study the ecosystem's resiliency and the potential for recovery. Our team worked with Dr. Lauren Ponisio, and her lab from the University of Oregon, to observe and examine the resilience of pollinators and the effectiveness of habitat restoration. The Ponisio lab is studying the effects and role of fire in shaping the health and biodiversity of ecosystems. To do so, we tracked the growth and progress of native plant seedlings and the activity of pollinators as these areas began to flourish with new life. In our study, and in conjunction with the Ponisio Lab, we monitored native wildflower seedlings to determine the success of pollinator plantings.

The ELP Restoration and Research team worked with our community partners to monitor variation in abundance of native pollinator populations, and established native wildflower plantings in timberlands impacted by wildfire. Through our collaboration, the Poniso lab will identify the most successful native wildflower plantings and their effect on pollinator populations. Whitewater Ranch will be able to enhance pollinator populations on its property, as well as continue the goal of being environmental stewards of the McKenzie River. Furthermore, implementing sustainable practices on Whitewater Ranch can provide a blueprint for other land managers who are pursuing sustainable agriculture practices on their property.

Study Area

Whitewater Ranch is located in Leaburg, OR along the McKenzie River, and resides approximately thirty miles east of Eugene at an elevation of 213 meters (Leaburg 1 SW, n.d.). The site encompasses diverse habitats including agricultural, riparian, upland, and forested areas supported by the McKenzie River watershed and Goose Creek. A significant portion of the ranch's upland region was damaged in 2020, in which 1,200 acres of forest on the property was burned during the Holiday Farm Fire (Russell, personal communication). The site consists of 90 acres of organic blueberry crops, growing Liberty, Draper, Cargo, and Top Shelf varieties for wholesale. Goose Creek, a tributary of the McKenzie River, flows directly through the two crop areas and is the primary site of our riparian restoration project (Figure 1). The Ranch is owned by Jim and Jane Russell and managed by Seth Morgan using low-impact sustainable farming methods (Whitewater Ranch, n.d.). Management on the farm is multi-faceted, with goals to sustainably support agricultural productivity while also supporting pollinator health, ecological diversity, and riparian restoration (Russell, personal communication).

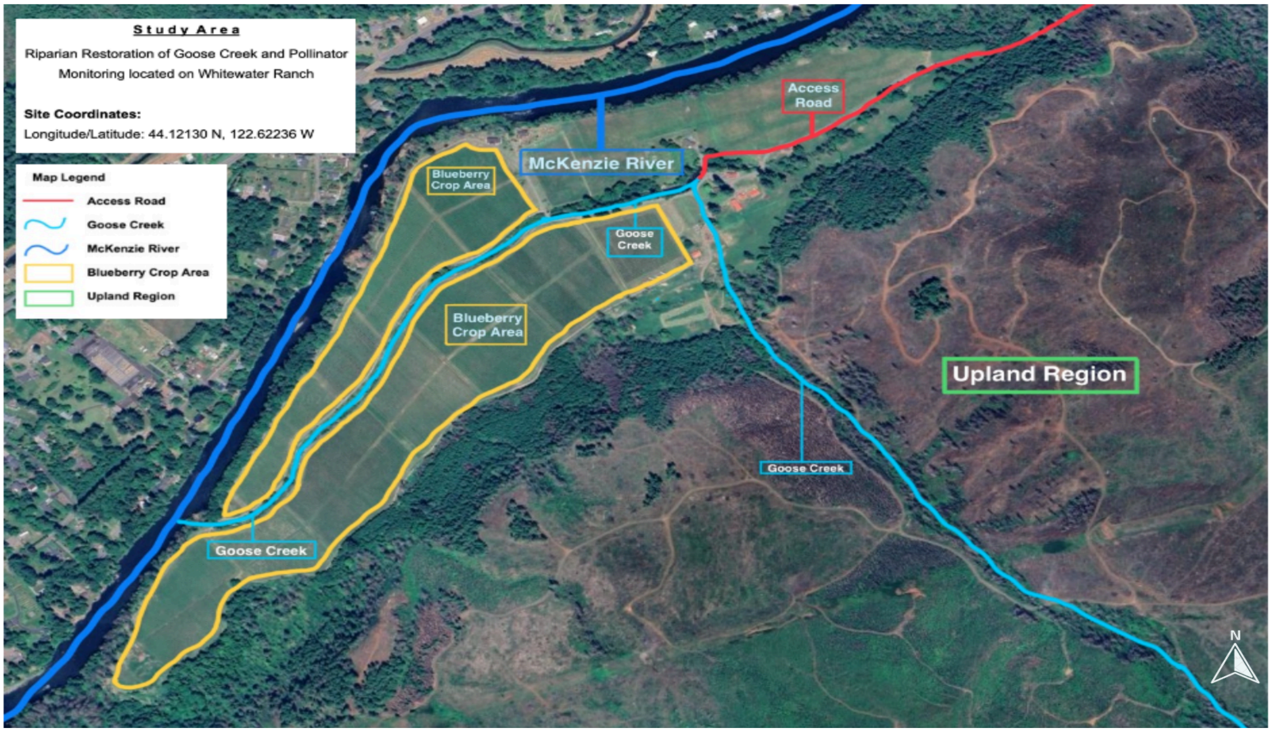

Figure 1: This map presents an aerial view of Whitewater Ranch along the McKenzie River. Labels include Goose Creek, the McKenzie River, Blueberry Crop Areas, Upland Region, and Access Roads (Google Earth, 2024).

Methods

Riparian Restoration Maintenance

For the restoration and maintenance of Goose Creek, we focused on monitoring the growth and survivability of the restoration plantings that were planted by the previous ELP Restoration and Research teams. We started with removing highly competitive, non-native species such as; Himalayan blackberry (*Rubus armeniacus*) and Reed Canary Grass (*Phalaris arundinacea*). Removal of the Himalayan Blackberry was executed by hand using gloves, clippers, and loppers. In compliance with Whitewater Ranch's organic certification, no herbicides were used throughout the restoration process. To control Reed Canary Grass (*Phalaris arundinacea*), we utilized a weed wacker to cut down individuals at their base, and maintenance was performed weekly due to the fast-growing nature of the species. Along the edge of the riparian zone, a majority of the long metal fencing was removed for easier management of the pollinator patches and the removal of the non-native species. Weed mats were placed as a preventative measure for non-native species growth. Additionally, weed mats surrounding plants that have reached free-to-grow status, the point at which plants are able to grow without support, were removed. Most of the iron stakes and fencing materials, as well as weed mats that had been removed, will be reused at a further point in the restoration process to implement sustainable practices.

Riparian Plantings

We continued the monitoring of previous plantings' health, and based on their survival, we planted additional plants in the riparian and pollinator areas. Plant health was determined by tracking the growth height of plants from previous years and comparing it to the base information collected by the 2023 team. To determine the plant's survival rate, we looked for signs of disease, animal grazing, and competition from other species. We recorded the status of the plant (dead or alive), growth of the plant, and damage characteristics of the plant (location, type, quantity) if there was any damage present. We also noted any competitors to our riparian plants, such as the presence of tall Reed Canary Grass. We used the photo point method to observe the change over time of Goose Creek and record the progression of the plant growth. We measured the heights of the plantings during the restoration process to provide baseline information for future projects to monitor. Along the transition zones of Goose Creek, we prepared sites for our team and the 2025 ELP team, where we pulled weeds and removed other invasive plant species. Once completed, we planted patches of native plants to provide habitat for pollinators. These plants included California Poppy (*Eschscholzia californica*), Oregon Sunshine

(*Eriophyllum lanatum*), Yarrow (*Achillea millefolium*), Oregon Phacelia (*Phacelia nemoralis ssp. oregonensis),* and Common Self Heal (*Prunella vulgaris)* from a local native plant nursery, along with Milkweed Strawberries (*Asclepias syriaca L. X Fragaria virginiana)* that were transplants from ELP Director Peg Boulay's garden (Appendix C).

Pollinator Surveys on Blueberry Hedgerows

The blueberry pollinator protocol was designed to measure the activity and number of individual pollinators actively pollinating the blueberry reproductive organs, or blooms. We performed two surveys over 10 weeks to study the native pollinators in Whitewater Ranch's blueberry fields. The surveys were conducted under ideal conditions of temperatures over 59ºF, wind speeds of less than 2.5 m/s, and sunny or partly cloudy to overcast conditions. The surveys were conducted between the hours of 9:00 am and 4:00 pm. Our team of twelve broke into four teams of three, with each team having one member who recorded data, one member who kept pace and timing, and one member who counted the number of pollinators. Four transects of sixty meters each were randomly selected along the blueberry hedgerows at the beginning of the Restoration and Research project in 2014. The transects have been maintained in those same rows to continue standardization and to eliminate observer bias. Environmental conditions such as temperature, wind speed, and weather circumstances at each plot were recorded before beginning the protocol. The teams randomly selected which side of the hedgerow the data would be collected on, and each team took care to avoid their shadows hovering over the rows, as this could have disturbed the pollinators.

To begin the survey process, a stopwatch was set for twenty minutes by the pace counter. The pace was set at three meters per minute down the sixty-meter transect to complete the survey in twenty minutes. Once the survey started, the pollinator counter began recording every individual pollinator that was actively pollinating the blueberry blooms . Any pollinators who were not actively pollinating, or were only touching the reproductive systems, were not included in the data sets. The numbers, species, and confidence in the identification of pollinators were noted and recorded by the data collector. The types of pollinators that were counted include European honeybees, bumblebees, carpenter bees, orchard mason bees, bees (other bees), flies (flies or bee-flies), unknown identification, and others (hummingbirds, beetles, wasps, ants, etc). At the end of the survey, pollinator counts were finalized and added to our data sets. We compared this data to previous data sets and evaluated the success of the restoration efforts.

Pollinator Plant Survey on Burn Piles

The pollinator enhancement study design protocol, created by the Ponisio Lab, was created to measure the percent cover, the number of individuals, and how many plants had buds or blooms within the selected plots. Observation sites were marked with flags before our team's arrival by the Ponisio Lab to standardize past and future data collection. Groups were split up into six teams of two for efficiency. We conducted presence-absence surveys to see which and how many plants returned from last year and recorded the plants' percent cover using quadrats. Additionally, we recorded the number of blooms or buds present on each plant. Illustrated field guides created by our team and plant identification handouts were provided as in-field references to aid students when identifying the plants. Additionally, members from the Ponisio Lab were present to ensure quality assurance of the plant identification. Once each plot was counted and finished, our team consolidated all data.

Water Monitoring

The water monitoring protocols have been in place for the past nine years. Our team collected data twice over the eight weeks in early and late spring between 12:00 pm and 3:00 pm.

Time was set to maintain standardization and accuracy between data taken from the previous years. Two teams of three used satellite imagery and coordinates to identify the exact four locations along the creek where water temperature data was collected from the previous year, where each team split off to monitor two locations each. Using a meter measuring stick, the teams found the center of the creek at their respective sites, and then recorded the depth of the water at that point. For exactly sixty seconds, a digital thermometer was held underwater at that location and the temperature was recorded. The weather was also recorded for the 48 hours leading up to the test and the current conditions to account for any anomalies.

Results

Riparian Planting Monitoring

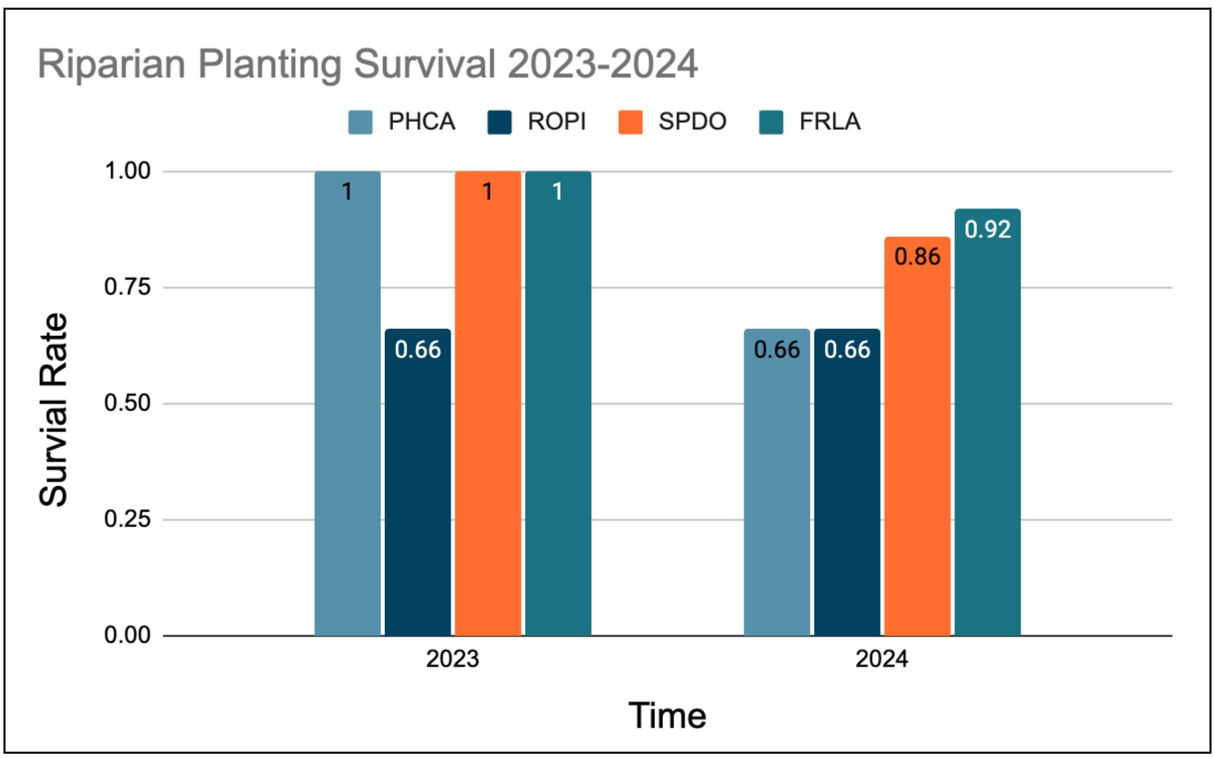

Figure 2: The survival of four planted species within the riparian zone located on Goose Creek (see Appendix A).

Amongst the four species, Oregon Ash (FRLA), Pacific Ninebark (PHCA), Douglas Spiraea (SPDO), and Clustered Rose (ROPI), all species except Clustered Rose exhibited a decrease in survival rate from 2023 to 2024. Oregon Ash experienced the highest survival rate at 92%.

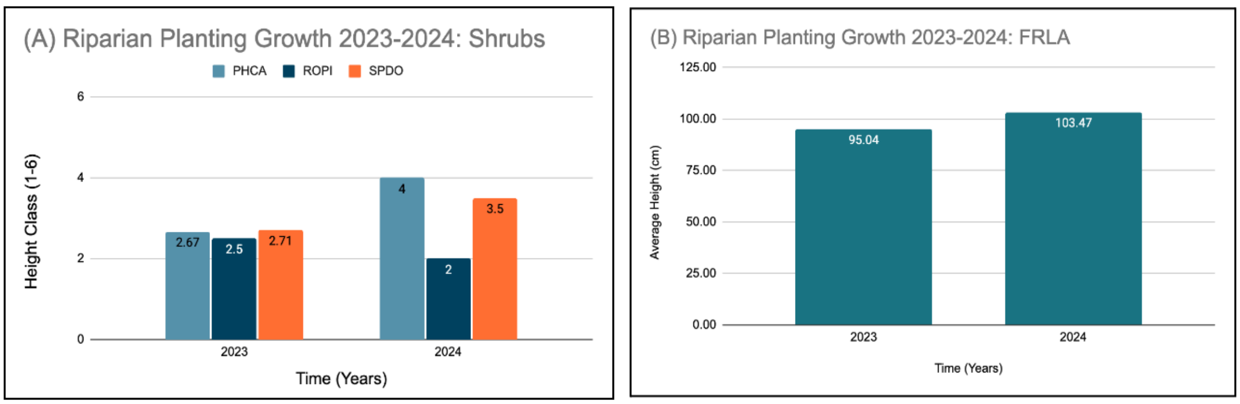

Figure 3A: Plant growth from 2023 to 2024 for three shrubs using average height class. Height classes include: 1 (0.3 m); 2 (0.3-0.6 m); 3 (0.6-1.2 m); 4 (1.2-1.8 m); 5 (1.8-2.4 m); 6 (2.4+ m). *Figure 3B*: The average plant growth in 2023 and 2024 for the Oregon Ash (FRLA) tree using average height in cm.

The three shrubs graphed above include Pacific Ninebark, Douglas Spiraea, and Clustered Rose. Of these three species, the most significant increase in height class is Pacific Ninebark (PHCA) which grew from 2.67 in 2023 to 4.0 in 2024. Douglas Spiraea (SPDO) showed a slight increase from height class 2.71 in 2023 to 3.5 in 2024. However, Clustered Rose (ROPI) showed a decrease in height class from 2.5 in 2023 to 2.0 in 2024. The average height (cm) of the Oregon Ash tree located in the riparian zones of Goose Creek increased from 95.04 cm in 2023 to 103.47 cm in 2024.

Water Quality Monitoring

When restoring riparian areas, water quality is vital to monitoring the effectiveness of riparian restoration. Water temperature was the metric used to assess water quality quantitatively. The water temperatures between the sites were close to one another throughout the years observed with a slow increase in later years. In 2016, all sites have a water temperature between 48 ℉ and 53℉, and in 2024, all sites have a temperature between 58 ℉ and 60 ℉ (*Fig. 4*).

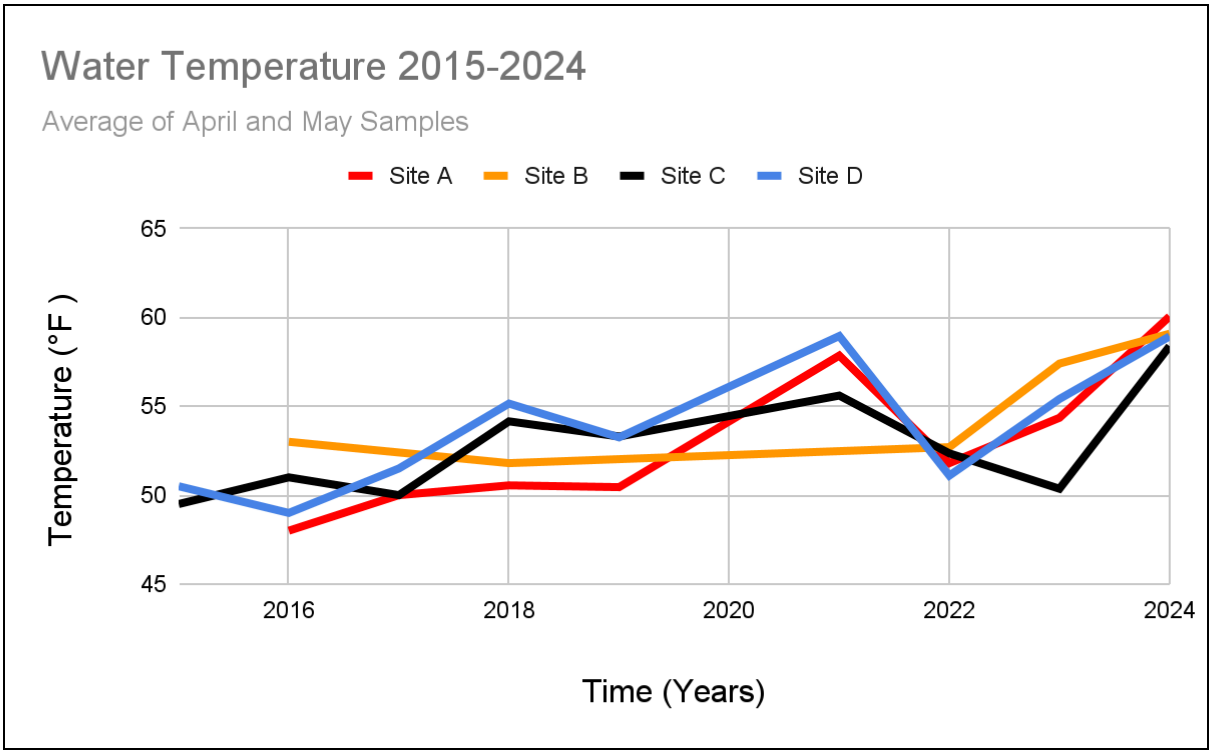

Figure 4. Trend lines of average water temperatures from April and May at four sites (A-D) at Whitewater Ranch from 2015-2024. Missing data points from before 2016 are due to variations in protocol throughout the years.

Photo Points

To assess qualitative changes in the riparian area surrounding Goose Creek and other areas of Whitewater Ranch, photo points were taken each spring starting in 2015. The photo points indicate changes in vegetation over the course of nine years, highlighting 2015, 2019, and 2024.

Photopoint 10A: Photopoint 4:

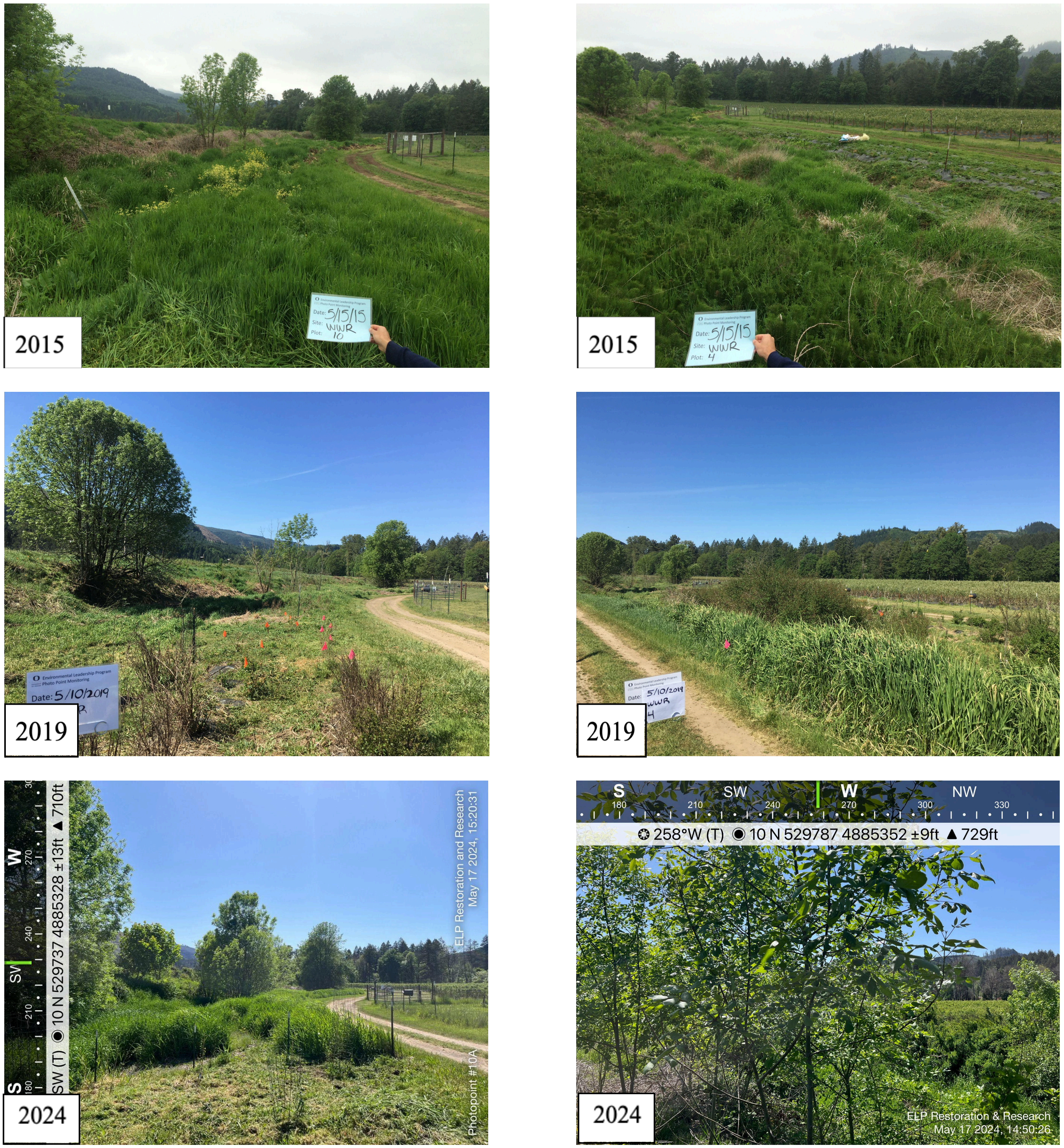

Figure 5. Photo points 10A and 4 taken along Goose Creek exhibiting changes in vegetation in 2015, 2019, and 2024 (See Appendix E).

Pollinator Enhancement

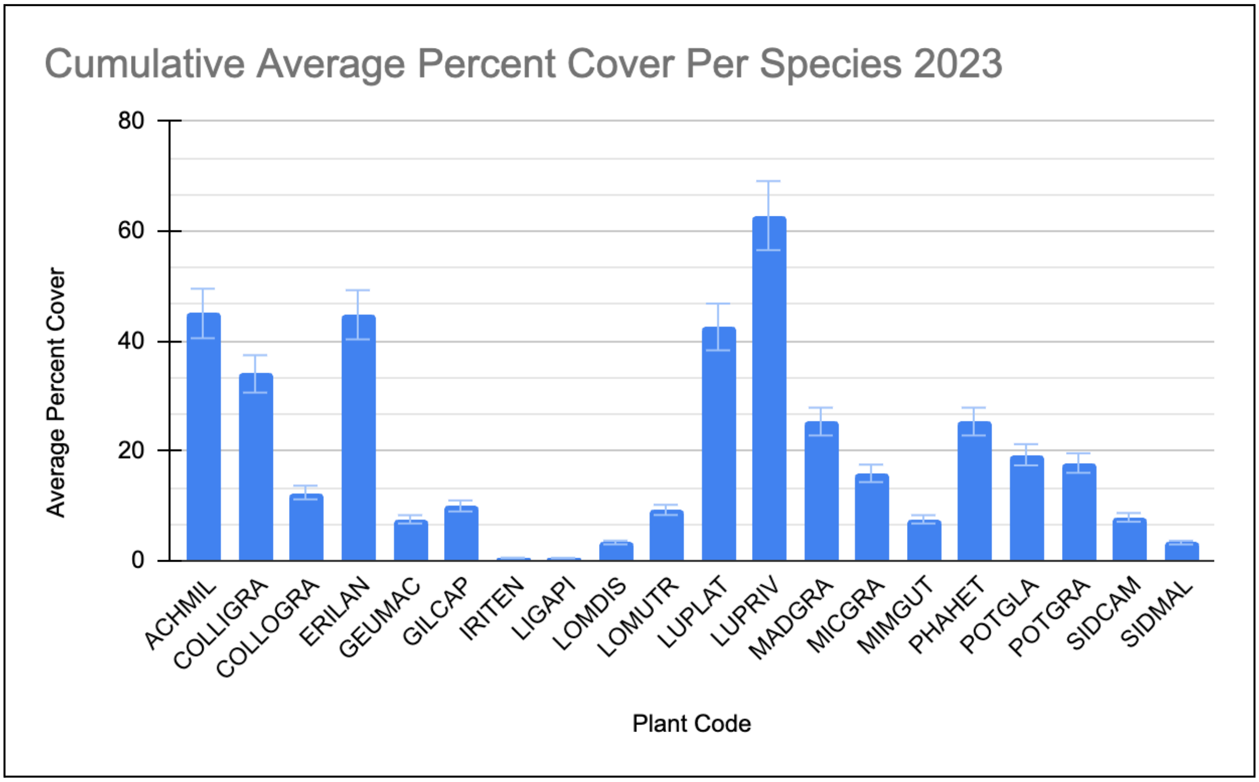

Figure 6. Average percent cover of 20 species (see Appendix B) for all observed burn plots in 2023

Measurements of percent cover of planted native flowering species in burn plots were collected and analyzed in Dr. Ponisio's pollinator enhancement study. Only four of the twenty species exhibited vegetation cover greater than 40%. These four species were: Common Yarrow (ACHMIL), Oregon Sunshine (ERILAN), Broadleaf Lupine (LUPLAT), and Riverbank Lupine (LUPRIV). Riverbank Lupine had the highest percent cover with an average of 62.85%. Of the twenty, four species exhibited an average percent cover under 5%, and two species under 1%: Tough Leaf Iris (IRITEN: 0.52%) and Celery Leaf Lovage (LIGAPI: 0.49%).

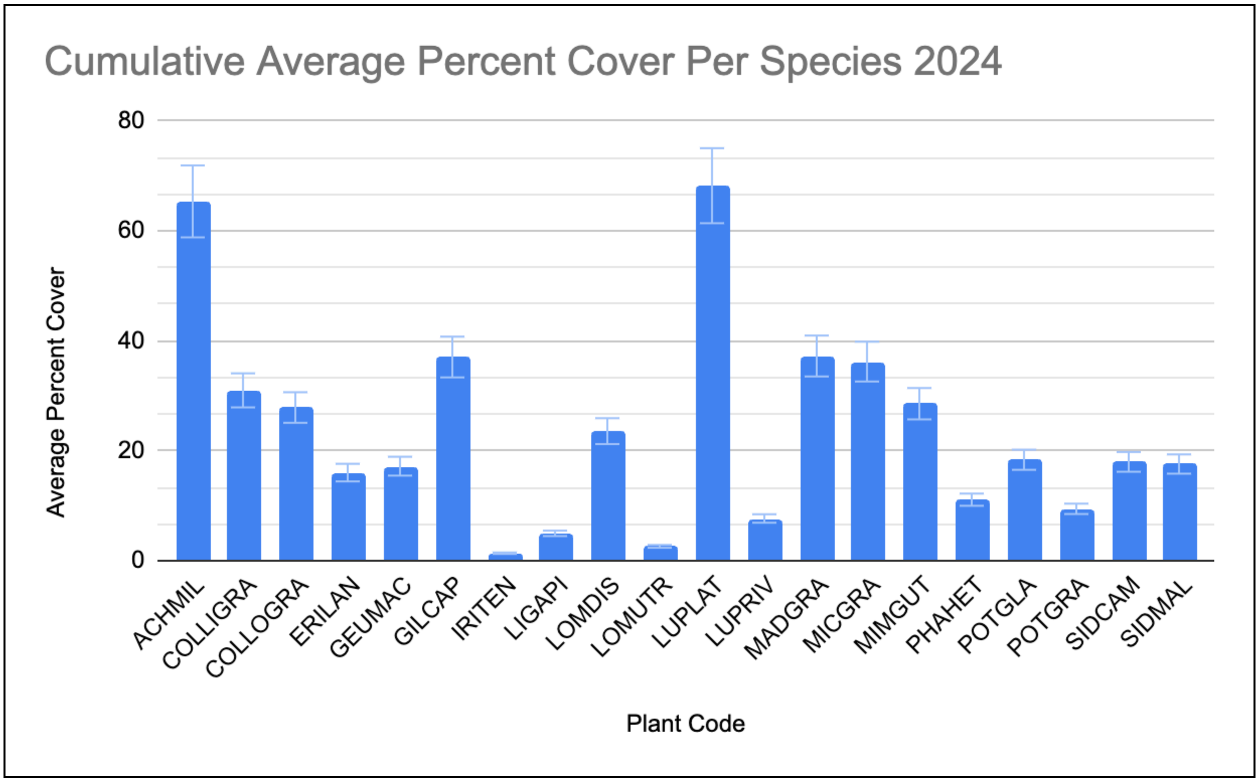

Figure 7. Average percent cover of 20 species for all observed burn plots in 2024

In 2024, only two of twenty species exhibited an average percent cover of over 40%, both increased from averages in 2023 to above 60%. These two species were the Common Yarrow (ACHMIL) and the Broadleaf Lupine (LUPLAT). Unlike the 2023 surveys, Broadleaf Lupine (LUPLAT) had the highest average percent cover at 68.2%. Most species exhibited greater average percent cover in 2024 than in 2023, with 9 species reaching over 20% cover (ACHMIL, MADGRA, POTGRA, LUPLAT, COLLIGRA, ERILAN, MICGRA, POTGLA, and LUPRIV) compared to 7 species in 2023. Percent cover of 4 species (IRITEN, LIGAPI, LUPRIV, and POTGRA) decreased in 2024 compared to 2023.

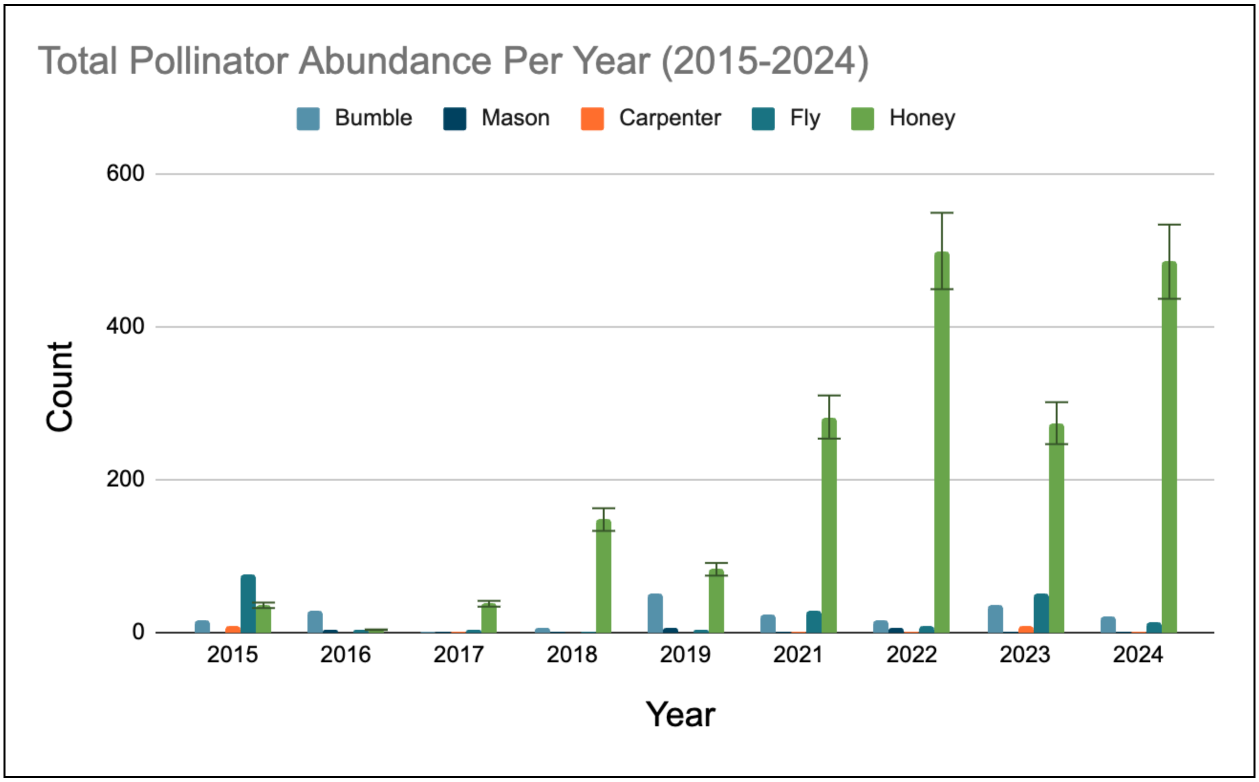

Figure 8. Abundance of pollinators for two surveys (2015-2023). Graph of all pollinators native (bumblebees, mason bees, carpenter bees, and flies) and non-native (European honeybees).

Patterns of pollinator abundance between 2015 and 2023 indicated flies were the most abundant pollinator in 2015 followed by bumblebees in 2016. Non-native honeybees have been the most abundant pollinators from 2017 to the present (Fig. 7). Over the past half-decade, honeybee abundance has seen a general increase with a decline in 2023 similar to that of 2021, but the population has rebounded in 2024 (Fig. 7). Due to the large number of honeybees relative to native pollinators, to analyze native pollinator abundance results have been separated from those of honeybees (Fig. 8).

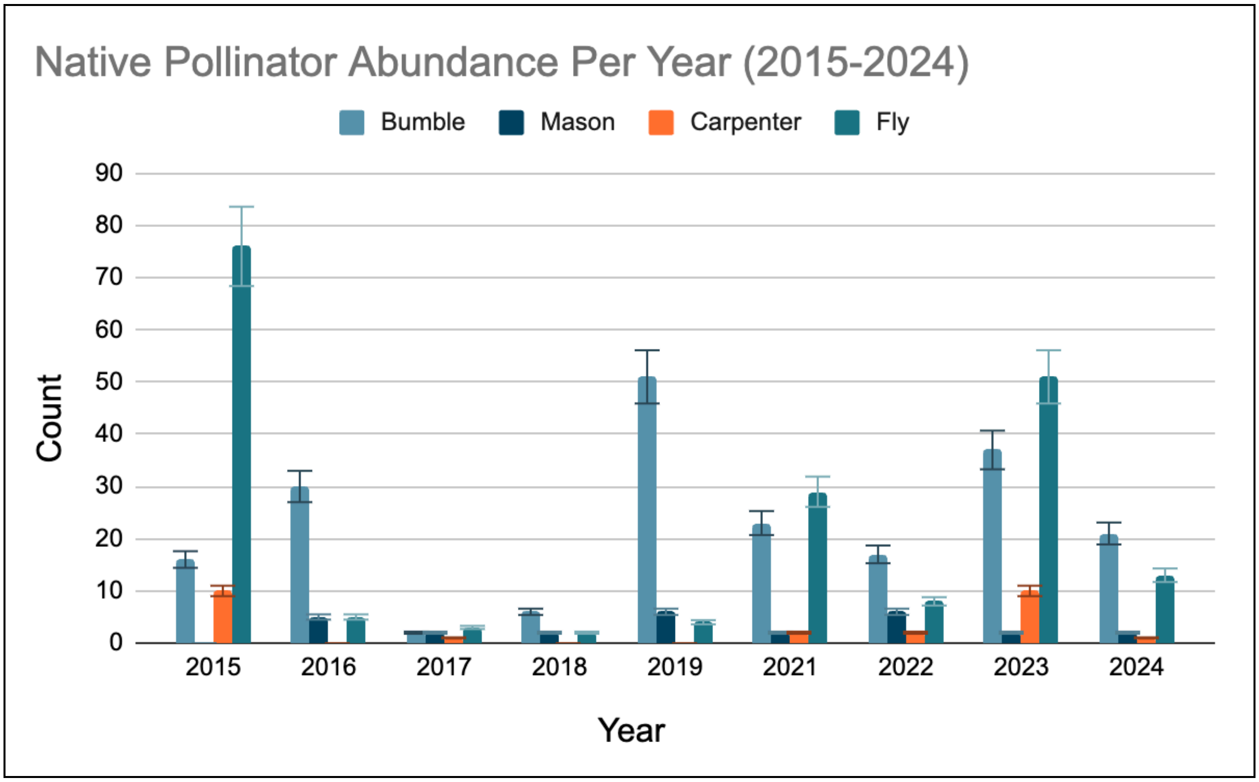

Figure 9. Abundance of native pollinators for two surveys 2015-2023.

Bumblebees and flies have been the most abundant native pollinator every year that has been surveyed from 2015-2024, with the greatest fly count in this time frame being 76 in 2015 and bumblebees reaching 51 in 2019 (Fig. 8). Surveys from 2017 and 2018 observed atypical low abundances for native pollinators with no more than 10 individuals for any of the groups surveyed.

Discussion

Riparian Planting Monitoring

The 2024 team contributed to the ongoing restoration of Goose Creek and the 10-year study of ecological resilience over time. The riparian plant monitoring results indicated how invasive species competition significantly impacted the survivability of young plantings. Non-native species outcompeted riparian plantings for space and light availability, preventing plantings from achieving free-to-grow status. Himalayan Blackberry and Reed Canary Grass were overgrown in the riparian zone this year, and the survival rates of native plantings decreased significantly from the 2023 data. Other than competition, variability in survivability and growth rates could be due to browsing wildlife and varying weather patterns. Additionally, data collection was repeated several times due to misinterpretation of protocol and miscommunication between sub-teams. We speculated that there could have been a mislabeling of plantings from previous years, as two of last year's recorded plants were not found. We recommend that future teams plant further downstream to expand pollinator habitat and increase creek health within unshaded spaces.

Water Quality Monitoring

Previous teams planted trees and shrubs along Goose Creek to stabilize the riverbank and provide shade to decrease water temperature. Teams from 2015, 2017, 2019, and 2021 had incomplete data from Site B which led to inaccurate interpretations of that site in Figure 4. The increasing temperature trend seen in Figure 4 implied that the warming climate may be affecting Goose Creek's water source, and localized riparian efforts did not influence temperature as initially hypothesized. To improve consistency throughout the project, future teams should prioritize accurately completing data collection from all sites. It is unclear how many variables collectively affect Goose Creek, thus, we recommend future teams analyze how the depth of different sites impacts the extent of warming water temperatures and other potential sources of variability.

Photo Points

The photo points demonstrated a significant increase in biomass from previous plantings and natural fauna across all sites. The framing of certain photo points has been zoomed in from using the app Solocator, so it is recommended that future teams step back a few feet after lining up the photo points to capture the site more accurately. Documenting Goose Creek and Whitewater Ranch annually allows teams to use the context and protocols of documented years to determine what environmental stressors the riparian zone is responding to. Doing so allows for further interpretation of which methods improve ecological resistance, health, and status. This year's team was surprised by the amount of time it took to complete the photopoints and next year's team should plan to split into groups to complete them all in a timely manner. Some photo points are overgrown or difficult to reach, so groups may need to adjust the framing of the photo.

Blueberry Pollinator Survey

The pollinator counts illustrated that the European honeybees prevailed as the dominant pollinator for the blueberry plants. After isolating the native pollinators, bumblebees and flies continued to be the most prominent blueberry pollinators, consistent with previous years' data. Whitewater Ranch rents supers, stacked box hives, placed at the end of the blueberry fields to supplement pollination to increase crop yield. After the Holiday Farm Fire, Jim and Jane Russell needed to import European honey bees post-burn, due to the loss of native pollinator habitats and populations. They collaborated with ELP to reinstate native pollinator species, as the goal of the pollinator enhancement is to reduce future reliance on European honeybees. The variability seen in Figures 8 and 9 is likely due to habitat availability. Bumblebees make underground hives and ideal nesting areas are widely available near the blueberry fields. However, mason bees require hollow stems, a limited resource near the blueberry fields, to nest. Variability could also be due to the timing of taking pollinator counts because temperature, wind speed, cloud cover, and seasonality determine pollinator activity.

Pollinator Enhancement

Native floral species were planted in the burn plots to study which species perform well in post-burn timberlands. Sloping terrain, soil quality, and a hotter microclimate could contribute to the survivability of the plantings. It is important to note that Iris Tenax, while not prominently observed within the burn plots, is abundant in the surrounding areas. This year's team observed decreased vegetation cover in the early season but a significant increase in cover in the late season as seen in Figure 7.

We observed that the flowers in the burn plots bloomed earlier than the traditional season. We assumed that pollinators would also come out earlier to take advantage of the increased availability of resources; however, pollinator behavior indicated that they followed a normal season timeframe. In future data collection, it is important to observe the changing seasonality and the pollinators' behavioral responses. We recorded a shift in seasonality for the burn plots and the blueberry fields after examining early and late-stage blooms, and we hope future teams study the response of pollinators for both protocols.

Next Steps

We hope future management teams introduce more artificial hives for native pollinators to increase their populations and overall native bee diversity. As mentioned before, mason bees are rare in the blueberry rows because of the few places they can build their hives. In order to increase their population, it would be beneficial to create more of these hives to further promote habitat availability. This would promote pollination for the multitude of different plant species found on the Whitewater ranch property, especially the blueberry plants and the native plant species found in the timberlands. With the increase of native pollinators, this would slowly reduce the amount of non-native honey bees required each year to pollinate the blueberry flowers and would promote pollinator diversity.

Identifying which species of native plants increases the presence of pollinators, and establishing them quickly, is important for future implementation of this research. Professor Boulay and Dr. Ponisio hope to continue this project to study how increasing native pollinator resources can improve post-fire ecological succession and the role of pollinators in sustainable agriculture (Boulay and Ponisio, personal communication). This information is becoming increasingly important as climate change and global warming lead to longer and more intense fire seasons, which pose a substantial threat to sensitive ecosystems similar to Goose Creek.

Acknowledgments

The 2024 Restoration and Research team would like to thank all affiliates of the Environmental Leadership Program, as your work, dedication, and knowledge has allowed us to attain both a better understanding of ecological monitoring and the skills to design and implement an ecological monitoring plan. Being an ELP student has allowed us to significantly expand our knowledge, skills, and interests, and it wouldn’t have been possible without you! We would like to give a special thank you to Jim and Jane Russell, who allowed us the opportunity to work and learn on their property, shared local and agricultural knowledge with us, and provided us with a sublime resting place accompanied by baked goods. We would also like to thank the manager of the farm, Seth Morgan, for helping us to both better understand sustainable agricultural management and maintain a safe working environment. We would also like to thank Lauren Ponisio and Rose McDonald of the University of Oregon’s Ponisio Lab, for allowing us to be research participants in their ongoing study regarding pollinators. We must also acknowledge the work, commitment, and diligence of the past ELP teams working at Whitewater

Ranch since 2014–The research and restoration of previous ELP teams has served as the basis of our restoration project, and the attentiveness and dedication of their work has been greatly appreciated. Lastly, we would like to thank Peg Boulay (ELP Co-Director and Instructor) and Lydia Lapporte (GE Project Manager) for their continued guidance, support, and feedback within our work. Thank you for giving us the knowledge and tools to design and implement a restorative monitoring program, evaluate the efficacy of our work and the work of past ELP teams, and grow into restorative land stewards.

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Appendices

Appendix A: Riparian Zone Plant Species Identification

Monitored Riparian Plantings Species List

Common Name	Scientific Name	Species Code	Type	Native/Invasive
Oregon ash	*Fraxinus latifolia*	FRLA	Tree	Native
Clustered rose	*Rosa pisocarpa*	ROPI	Shrub	Native
Pacific ninebark	*Physocarpus capitatus*	PHCA	Shrub	Native
Douglas spiraea	*Spiraea douglasii*	SPDO	Shrub	Native

Targeted Invasive Species

Common Name	Scientific Name	Species Code	Type	Native/Invasive
Himalayan Blackberry	*Rubus armeniacus*	RUAR/ RUDI	Shrub	Invasive
Reed canarygrass	*Phalaris arundinacea*	PHAR	Grass	Invasive

Appendix B: Plant Species Identification (Ponisio Plots)

Ponisio Plots Species List

Common Name	Scientific Name	Code	Growth Form
Yarrow	*Achillea millefolium*	ACHMIL	Perennial
Large-flowered Blue-eyed Mary	*Collinsia grandiflora*	COLGRA1	Annual
Large-flowered Collomia	*Collomia grandiflora*	COLGRA2	Annual

Oregon Sunshine	*Eriophyllum lanatum*	ERILAN	Perennial
Large-leaved Avens	*Geum macrophyllum*	GEUMAC	Perennial
Globe Gilia	*Gilia capitata*	GILCAP	Annual
Pacific Iris	*Iris tenax*	IRITEN	Perennial
Celery-leaved Lovage	*Ligusticum apiifolium*	LIGAPI	Perennial
Fernleaf Biscuitroot	*Lomatium dissectum*	LOMDIS	Perennial
Spring Gold	*Lomatium utriculatum*	LOMUTR	Perennial
Broadleaf Lupine	*Lupinus latifolius*	LUPLAT	Perennial
Riverbank Lupine	*Lupinus rivularis*	LUPRIV	Perennial
Slender Tarweed	*Madia gracilis*	MADGRA	Annual
Slender Phlox	*Microsteris gracilis*	MICGRA	Annual
Yellow Monkeyflower	*Mimulus (Erythranthe) guttatus*	MIMGUT	Annual*
Varileaf Phacelia	*Phacelia heterophylla*	PHAHET	Perennial
Sticky Cinquefoil	*Phacelia heterophylla*	POTGLA	Perennial
Slender Cinquefoil	*Potentilla gracilis var. gracilis*	POTGRA	Perennial

Meadow Checkermallow	*Sidalcea campestris*	SIDCAM	Perennial
Rosy Checkermallow	*Sidalcea malviflora*	SIDMAL	Perennial

Appendix C: Pollinator Enhancement Plantings

To promote pollinators in the riparian zone while simultaneously rebuilding natural ecological relationships and diversity, we planted a variety of container stock plants. All species planted are proven to attract pollinators but different species of plants require various growing conditions (ex: shade-loving, full sun exposure, half sun exposure, etc.). The overall success of the plantings will be essential to making decisions regarding future restorative plantings within the riparian zone.

Common Name	**Scientific Name**	**Tag Number**
Common Yarrow	*Achillea millefolium*	485, 487, 489
Milkweed Strawberry	*Asclepias syriaca L. X Fragaria virginiana*	83
Self Heal	*Prunella vulgaris*	493. 494, 495
Oregon Phacelia	*Phacelia nemoralis ssp. oregonensis*	500, 541, 544
Oregon Sunshine	*Eriophyllum lanatum*	466, 467, 468
California Poppy	*Eschscholzia californica*	453, 455, 456

Appendix D: Water Monitoring Site Descriptions

Site	UTM	Description/Comments
A	10N 53104961E 488595075N	Trout Creek; 10m upstream of the bridge.
B	10N 530134E 4885516N	Goose Creek; immediately upstream of Duck Pond, ~1m upstream of the inflow culvert.
C	10N 52984399E 488540536N	Goose Creek; at the beginning (NE end) of the restoration area, ~1m downstream of the culvert next to the toolshed.
D	10N 528941.18E 4884373.91N	Goose Creek; ~20m upstream from the confluence with McKenzie River, 10m downstream from the final culvert on Goose Creek before confluence.

Figure 10. Water monitoring sites A-D along Goose and Trout creek.

Appendix E: Photo Point Log

Photo Point	UTM	Description/ Comments	Years Observed
4	10N 529789 E 488356 N	Phase 1: On the south bank (river left), looks downstream.	2014, 2015, 2016, 2017, 2018, 2019, 2021, 2022, 2023, 2024
10A	10N 529742 E 4885328 N	Phase 1/2: On the north bank (river right), looks downstream.	2015, 2016, 2017, 2018, 2019, 2021, 2022, 2023, 2024

Appendix F: Map of Burn Plots

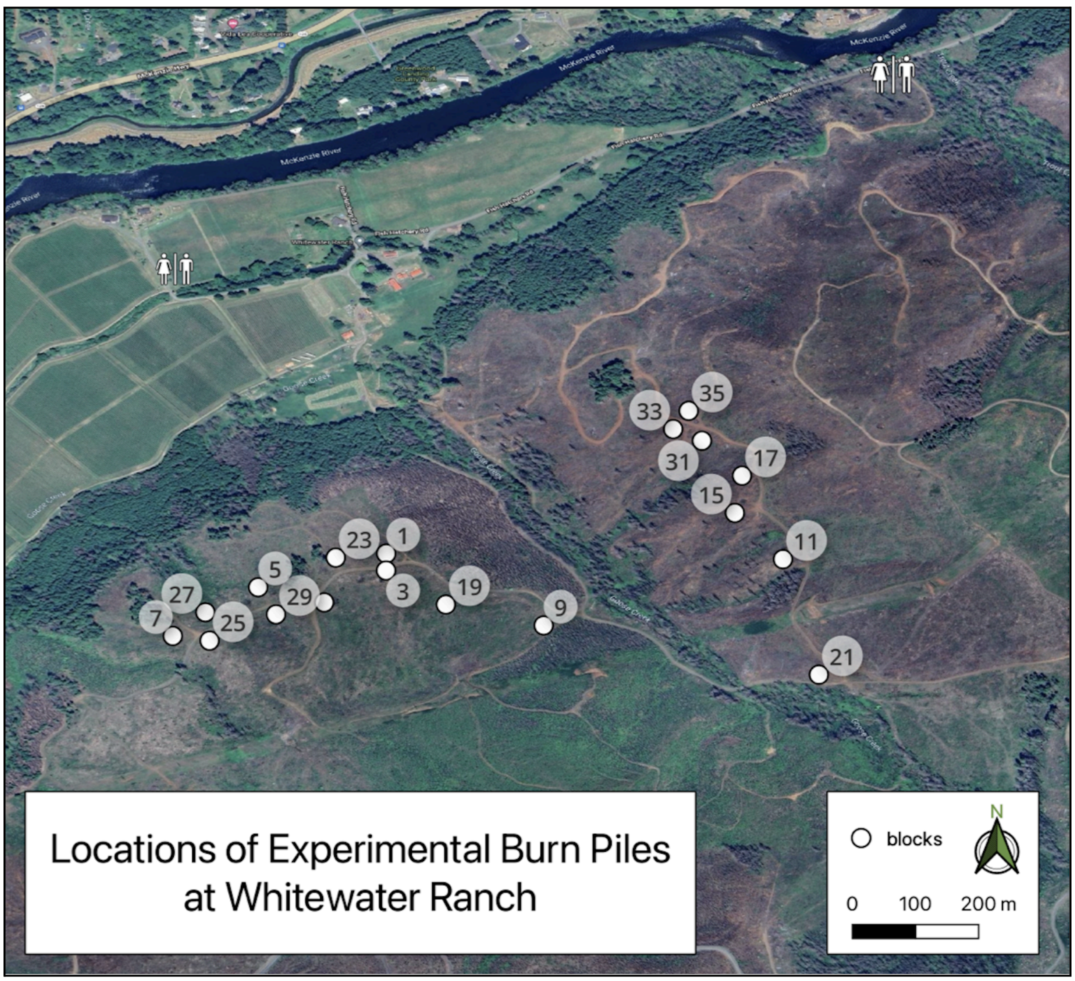

Figure 11. The locations of 17 burn piles in the headlands of Whitewater Ranch used by the Ponisio lab to perform pollinator plant surveys.

Appendix G: Map of Pollinator Transects

Figure 12. Map of transects for blueberry field pollinator survey.