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Cultural and Ecological Restoration of School Creek at Blue Lake Rancheria, Humboldt County, CA

Cecilia C. French
Cal Poly Humboldt, ccf33@humboldt.edu

Michelle Mendoza
Cal Poly Humboldt, mm952@humboldt.edu

Roots Galindo
Cal Poly Humboldt, rg271@humboldt.edu

August O'Neil
Cal Poly Humboldt, apo10@humboldt.edu

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Cecilia French, Roots Galindo, Michelle Mendoza, August O'Neil

Community Partner Jacob Pounds

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Department of Environmental Science & Management

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ABSTRACT

The School Creek Cultural Revegetation and Riparian Restoration Project site is a low elevation riparian forest surrounding the seasonal creek channel approximately a mile from its confluence with the Baduwa't (Mad River). The site was originally restored in 2021, with recontouring of the channel and revegetation, however mortality occurred for many planted species which prompted this 2023 project. The School Creek site has been severely degraded over the last hundred years from land use practices, industrialization, and colonization. Streams that have been damaged by heavy logging have created high sedimentation levels within the Baduwa't, which is listed as "impaired" on the U.S Environmental Protection Agency's 303(d) list for excessive siltation/sedimentation and temperature (State of CA North Coast Regional Water Quality Control Board, 2018). Additionally, the industrialization of the town of Blue Lake has altered the natural course of the School Creek channel and landscape by building a school, railroad grade, mill, and housing. The forcible separation of the Wiyot people from their ancestral land halted native management practices, further pushing the degradation of the watershed. The lower Baduwa't riparian area was converted to pasture for grazing sheep and cows. However, since 1983, Blue Lake Rancheria has worked to buy land back in the watershed and restore it (Wiyot Tribe, 2023). This project is on Blue Lake Rancheria land, and seeks to restore the riparian area by utilizing native and culturally significant plants which have been cultivated for specific purposes since time immemorial by the Wiyot people. Revegetation of culturally significant plants will allow for both cultural and ecological resilience, enhancement of biodiversity, and reinforcement of ecosystem services.

INTRODUCTION

Low elevation riparian forests located in and around agricultural systems represent a small percentage of the total available areas for this at-risk habitat type, however, these few pockets offer great opportunities to boost biodiversity. The biodiversity supported by these low elevation riparian areas is directly correlated with and contributes to the supply of ecological services they provide. Riparian forests and associated wetlands are a highly threatened ecosystem in California, where up to 90% of these critical wetland areas have been lost due to development and water extraction (*How Much Wetland Area Has California Lost?*, 2016). It is critically important to restore these ecosystems due to their disproportionate positive impact on the ecological services and resilience of surrounding ecosystems (Castellano et al. 2022). A healthy watershed relies on riparian vegetation to avert erosion, irrigate aquifers, ameliorate water quality by removing excess nutrients, and create habitats for wildlife (Craig et al., 2008; Nilsson & Svedmark, 2002; Zhang et al., 2022).

Tribal and Watershed History

The Mad River watershed is the ancestral home of the Lassik, Nongatl, Whilkut, and Wiyot Tribes (Blue Lake Rancheria, 2021). The watershed stretches nearly 500 square miles from Trinity County to Humboldt County (Figure 1).

Figure 1. Tribal Territories In and Around the Mad River Watershed (*Native Land Digital*, 2021).

The lower portion of the Mad River is ancestral Wiyot land, known to the Wiyot people as the Baduwa't. The surrounding towns Arcata, Blue Lake, Eureka, and McKinleyville all rely on the Baduwa't for drinking water (Blue Lake Rancheria, 2021). It is important to note that the Baduwa't is listed as impaired by the EPA for high temperatures and excessive turbidity (Blue Lake Rancheria, 2021).

The Blue Lake Rancheria is on the ancestral territory of the Wiyot people and was originally founded in 1908 to be a safe place for homeless native peoples (Blue Lake Rancheria).

However, in the 1950s, the tribe was wrongfully terminated under Public Law and their trust lands were taken (Stillwater Sciences, 2010). The Tillie-Hardwick Lawsuit, in 1983, reinstated the Blue Lake Rancheria as a federally recognized tribe along with 76 acres of land (*Blue Lake Rancheria Tribal Court*, 2023). Today, the tribe is reconnecting with the land and improving ecosystem function through restoration efforts within the Baduwa't watershed as they monitor water quality, conduct salmonid surveys, implement stream restoration, and replant native plant communities (Blue Lake Rancheria, 2023).

Cultural Revegetation and Implementation

The recognition and cultivation of culturally significant species are necessary to meet international biodiversity goals. Traditional management, guided by the relationship and knowledge of the place, promotes a holistic and integrated approach to ecosystem health, conservation, and management which allows for greater biodiversity and ecosystem resilience (Goolmeer et al. 2022). Anderson 2013, describes land management by the Indigenous peoples of California as processes that began as long as twelve thousand years ago. Anderson explains how riparian communities contain culturally significant plants that were tended by Indigenous peoples using traditional techniques including prescribed burning, irrigation, pruning, sowing, tilling, and weeding. Cultural land management practices are highly effective and technical bodies of knowledge that have been practiced and thus optimized for centuries. Many of these techniques have specific cultural outcomes that provide goods and services to Indigenous communities and the surrounding ecosystem. This includes the production of culturally significant materials such as hazel shoots for basket weaving. Post-colonization, these cultural outcomes have not been reached due to differing target objectives of Western land management methods of agriculture, grazing, fire suppression and resource extraction such as mining and timber. For example, a study done by Marks-Block in 2021 looked at the effect of cultural burning and wildfires on California hazelnut *(Corylus cornuta var. californica)* stem production for basket weaving materials is extremely beneficial. This was conducted in northwest California and shows a dramatic, 13fold increase in stem production following cultural fire. Additionally, the article analyzes effects of landscape and slope position on plant success and survival.

The species selected for the revegetation of the School Creek site were chosen for their importance to the function of the riparian ecosystem and for traditional uses. These species are native to riparian zones in California and have evolved to meet environmental needs and allow for channel resilience and stability (Singh et al., 2018). Such species are culturally significant for basket weaving, arrow and paddle making and more. The Wiyot tribe would regularly burn useful plants such as California hazelnut to stimulate regrowth and propagate new young shoots that were ideal for basket making. According to anthropologist Harold Driver, the Wiyot tribe burned hazel to create sticks for “better basketry warps” which is a basket twining term where the vertical foundation sticks are more flexible due to new growth after a burn (Anderson, 2013). Marks-Block et al., 2021 describes how burning can redistribute soil nutrients and promote straight growth of young shoots that grow more vigorously. Not only do the shoots grow straight at a significantly increased rate, they are also more flexible and resistant to fracturing (Marks-Block et al., 2021). Once harvested these shoots are relied on for structural support within the basket. In the same twining process, coast Redwood, Sitka spruce, and red alders are used for the horizontal lacing sticks, or weft (*QR Basket Making Process*, 2018).

Project Objectives

The objective of the School Creek Riparian Cultural Revegetation Project is to integrate Traditional Ecological Knowledge with Western Science to guide ecological restoration of the surrounding riparian stands of the seasonal School Creek channel. School Creek is a tributary to the Baduwa't. The Blue Lake Rancheria is working to restore the land adjacent to School Creek by revegetating with native riparian species. This site was stripped of its native species that are significant to ecosystem function and cultural practices (Blue Lake Rancheria, 2021). Replanting native riparian species will create accessible gathering areas for cultural foods and materials as well as provide an area for the tribe to be able to practice cultural burns. Additionally, it will provide riparian habitat for wildlife while slowing sedimentation and runoff in School Creek. Unfortunately, prior replanting efforts have not been highly successful. The Cultural and Ecological Restoration of School Creek at Blue Lake Rancheria project objectives are to record an inventory of plants on site and to revegetate with native species.

METHODS

Site Description

Blue Lake Rancheria is located along the Baduwa't, adjacent to Highway 299, in the town of Blue Lake. Our project was located within the partially restored School Creek site (Figure 2). This site has been heavily degraded by sheep grazing, construction of Highway 299, damming, and water conversions (Stillwater Sciences, 2010). Two sites were identified within the project to focus our efforts, these sites are listed as Site 1 at 40°52'08.9"N 124°04'20.8"W and Site 2 at 40°52'08.9"N 124°04'20.8"W. Sections that were replanted are highlighted on the map– Site 1 is highlighted in yellow; Site 2 is highlighted in green, and an additional area near site 1 is highlighted in purple (Figure 3). Both sites are oriented along a seasonal stream called School Creek, which is not officially recognized by the US Geological Survey.

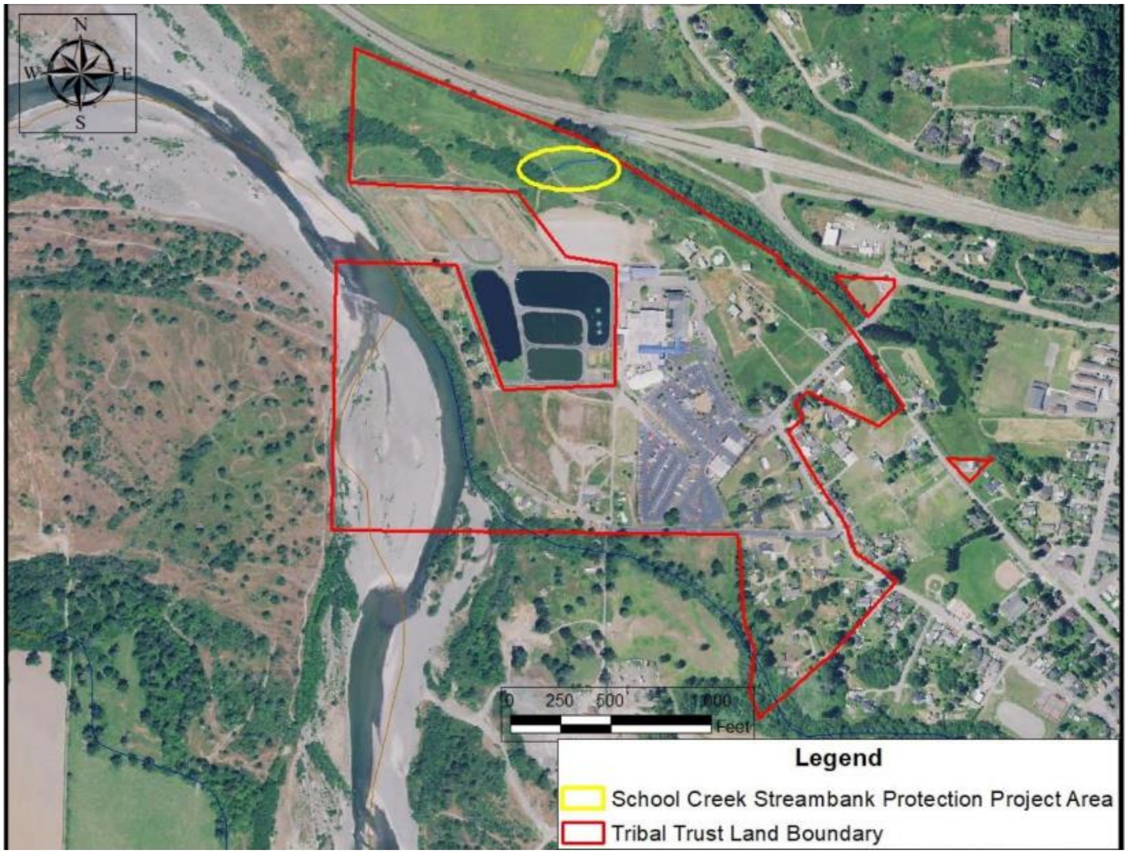

Figure 2. Blue Lake Rancheria Riparian Zone Project Site Map (Blue Lake Rancheria Environmental Program Staff, 2021).

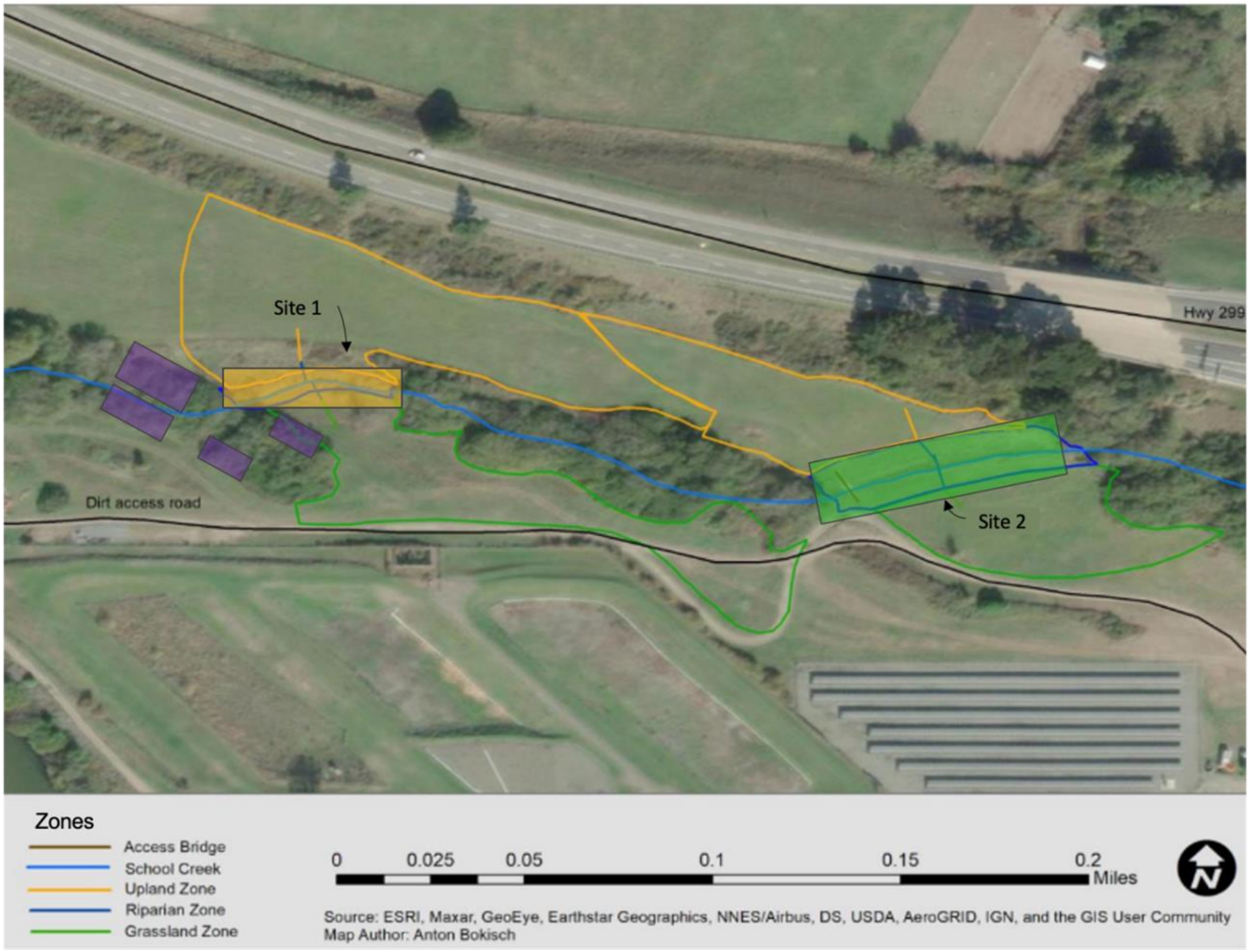

Figure 3. Site Map: Site 1 highlighted in yellow, Site 2 highlighted in green, additional plantings highlighted in purple (Blue Lake Rancheria Environmental Program Staff, 2021).

Site 1 is separated by a willow hummock, contains 74 trees with tree guards from the previous restoration project, and is located down the School Creek channel from Site 2 nearer to Baduwa't (Figure 4). Site 2 is closest to Hwy 299 and contained 115 trees with tree guards (Figure 5). The soil of the sites lacks significant amounts of organic matter, causing the soil to be prone to drying out. Additionally, coastal winds from the west move through each site, causing notable wind disturbance to the plants. Similarly, there is very little shade on site causing intensive heat stress in July-September. Full sun exposure posed a significant challenge, as irrigation was not an option at either site. To date, there have been small-scale projects on both sites to restore aspects of the riparian zone. Site 2 was originally replanted in the fall 2021, as a small project with U.S EPA 319 funds for nonpoint source pollution prevention. Along with the tree and wetland species planted, beaver dam analogs were incorporated to slow water currents and store fine sediment on the floodplain. Planting of native species to create a riparian buffer zone followed in order to increase stream bank stability, lessen nonpoint source pollution, and provide culturally significant gathering materials for the Wiyot tribe. Site 1 was planted the subsequent year, during the fall of 2022, following the initial plantings at Site 2. These consecutive projects indicate that our data collection for Site 1 is one year old, while our data for Site 2 is two years old.

While multiple diverse species were planted on these sites, high mortality rates occurred, primarily leaving madrone and big leaf maple as surviving species. This was unexpected, as red alder is typically very resilient, and thrives in riparian zones.

Figure 4. Site 1 located closest to Baduwa't.

Figure 4a. Aerial photo of Site 1.

Figure 5. Site 2 located closest to highway 299.

Figure 5a. Aerial photo of Site 2.

Field Methods

In 2021, revegetation efforts in the riparian zone of the School Creek restoration project were conducted by Blue Lake Rancheria staff members (Figure 3). Plants were planted in cages, many of which experienced mortality. We inventoried both sites to better understand which species survived replanting in the riparian zone. Our inventory included walking the site and counting how many of the replanted species died and recording the species name of the remaining surviving species. We first walked through both sites and flagged the tree cages that had surviving plants in them. We mapped the location of each live plant by assigning each one a point using Gaia GPS, along with their species name. A weed whacker was used around all the tree guards to encourage plant growth, lessen competition by invasive species, and increase access to holes that needed replanting. We began removal of dead planted species and the excavation of holes with shovels for the subsequent planting of native species.

Planting Techniques

A native plant species list was pre-decided by our community partner, consisting of 160 trees of 10 different species (Figure 6). We replanted 63 tree saplings on Site 1 and 42 tree saplings on Site 2.

ACTIVITY	DESCRIPTION	QTY
Cercis occidentalis	Western redbud - 1 gallon	5
Physocarpus capitatus	Pacific ninebark - 1 gallon	5
Sambucus nigra	Black elderberry - 1 gallon	10
Corylus cornuta	California hazlenut - 1 gallon	10
Prunus virginiana	Western chokecherry - 1 gallon	10
Cornus sericea	Red osier dogwood - 1 gallon	10
Picea sitchensis	Sitka spruce - TP4	50
Arbutus menzeisii	Pacific madrone - 1 gallon	20
Acer macrophyllum	Bigleaf maple - 1 gallon	30
Malus fusca	Oregon Crabapple - 1 gallon	10

Plants will be picked up at Samara Restoration Nursery in October of 2023.

Figure 6 . List of the native culturally significant species planted within this project, curated by Jacob Pounds.

Species layout was organized to mimic nature and to appear less row crop-like. Planting locations were in low, mid, and high elevation banks directly next to School Creek, based on their need for proximity to water and plant associations. Those trees that required more water, such as Oregon crabapple and Red osier dogwood, were planted closer to the stream channel. Similarly, trees that would grow to eventually provide shade, like Pacific madrone, were intentionally kept at a distance from species that do not thrive in shaded conditions.

Our species list was informed by mortality of previous planting efforts. For example, alders planted on site 2 had very low survivability in 2021, thus no alders were re-planed on either site. Site 1 was dominated by overstory species. As a result, adjacent willow hummock to the southwest provided excellent shade which appeared to be preferred by conifers at the site already. We determined that Site 2 should stay an open prairie, therefore we planted primarily hardwoods instead of conifers.

After the removal of the dead riparian species, planting could begin. We dug 1.5 ft / 1.5 ft holes for each plant. The edges of each hole were scored to aid in root dispersal as well as increase natural drainage. We placed a small pile of soil and organic matter to form a small mound within the hole before planting. Then, each plant's roots were loosened before placing its corresponding hole (Figure 7).

Figure 7. Sitka spruce's roots being detangled prior to planting.

We draped each plants' roots over each mound. This technique prevented water from pooling at the bottom of the hole and drowning the plant. This small mound also aided in directing the plant's roots outward and down from the plant's center. A dish of soil was formed around the perimeter of the hole to keep water that was intercepted by the plant in a focused area to increase infiltration. This feature was prominent in areas where the slope was steeper and soil and surface water runoff was more of a factor. Untangling the plant's roots, along with creating the mounds within the holes, aimed to give the plants healthy lateral growth and the best chance of establishing themselves. The plant cages from Site 1 and Site 2 were reused to protect each newly planted species.

By the time we finished Site 1 and 2, we found ourselves with 55 extra trees to plant. We chose to plant them among the willow stand by Site 1, indicated in purple on the map (Figure 3). These trees—Sitka spruce, Oregon crabapple and Red Osier Dogwood—were planted without cages. Instead they were strategically placed underneath surrounding blackberry or other bushes to conceal them from browsing.

Soil Amendments

After the plants were planted, the soil was amended using compost tea and mulch. A compost tea was made in house by adding untreated groundwater, rich in iron and magnesium, into a big water container. Then, a mesh bag containing a forest compost supplement, worm castings, crab powder, top feed, and liquified fish was added to the water container. The bag of nutrients remained in the container for a total of 72 hours. The mulch used on site was made from fine sawdust and manure. After planting, mulch was added to the base of each plant (Figure 8), and compost tea was watered in.

Figure 8. A mulched, newly planted Madrone.

Garry Oaks Collection and Planting

Seed collection of Garry Oaks (*Quercus garryana*) from nearby oak groves provided seed stock to enhance this and other planting projects at Blue Lake Rancheria. A majority of those acorns were then planted on Site 2 alongside the hazels for the purpose of eventually providing partial shade, an optimal condition for the hazels.

RESULTS

Prior to planting, we collected data from both sites to establish a baseline for comparison. Plant survival rates were significantly lower at Site 1 in comparison to Site 2. At Site 1, a total of 11 trees out of 74 survived (14.9%), while at Site 2, 73 out of 115 trees survived (63.5%) (Table 1, 2). This could be due to the incised channel and lessened groundwater availability at Site 1. With a young restoration project like this one, there are often very few objective metrics that are even available to measure, let alone be able to compare and form solid conclusions from. Some factors such as encroachment were very apparent as every cage had a foot or more of European pasture grass encircling the cage. Others, like differences in levels of wind disturbance, were observed to be higher in site 1 than site 2; being most likely due to the site 1's orientation and slope.

With the plant species themselves, we observed that Pacific madrone and Bigleaf maple had higher survivability of any species from the original revegetation project (Figure 9, 10). This led us to planting more madrones and maples at our sites, as well as placing them in areas where disturbance was higher to reduce possible mortality within more sensitive species. Madrones were planted on the western edge of the project where the soil was the driest and the wind disturbance was the most prevalent. Adversely, we observed that the conifers planted in the open suffered significant mortality while the one planted in canopy covered areas survived at a higher rate (Paquette et al. 2006). This resulted in a majority of conifers being planted in shaded areas. Our intermediate species, Oregon Ash, Black Elderberry, and Western Chokecherry were planted randomly within the midslope of our project area and our Bigleaf Maples, as per their natural requirements, were planted closest to the stream channel to provide adequate water supply. The idea behind this planting method is to create a buffer perimeter around the more sensitive species on our site. By planting more resilient species on the edge of our site we reduce the long-term edge-effect on the restored ecosystem from the surrounding development. Going into the future, we hope that the site will be set up in a way that gives it the greatest likelihood of survival with the least amount of human intervention.

As part of the project, we also filmed aerial footage from a drone of our team working on the site. This footage will be used by the Wiyot tribe for informational purposes as well as to raise awareness for the restoration work the Wiyot Tribe is doing. This was taken by our community partner Jacob Pounds.

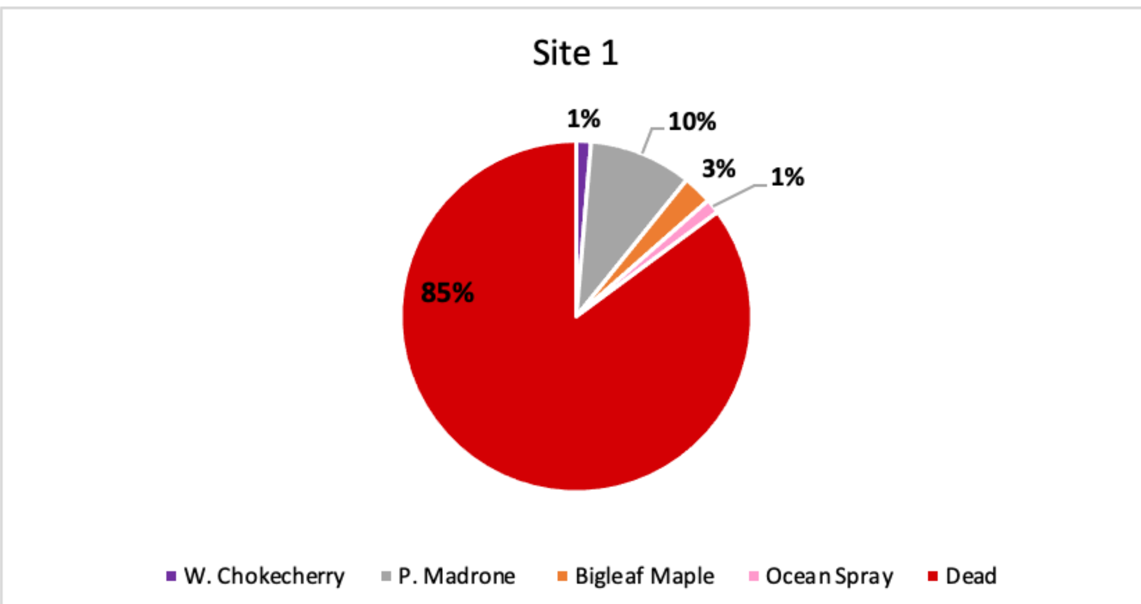

Figure 9. Site 1 survival composition prior to planting.

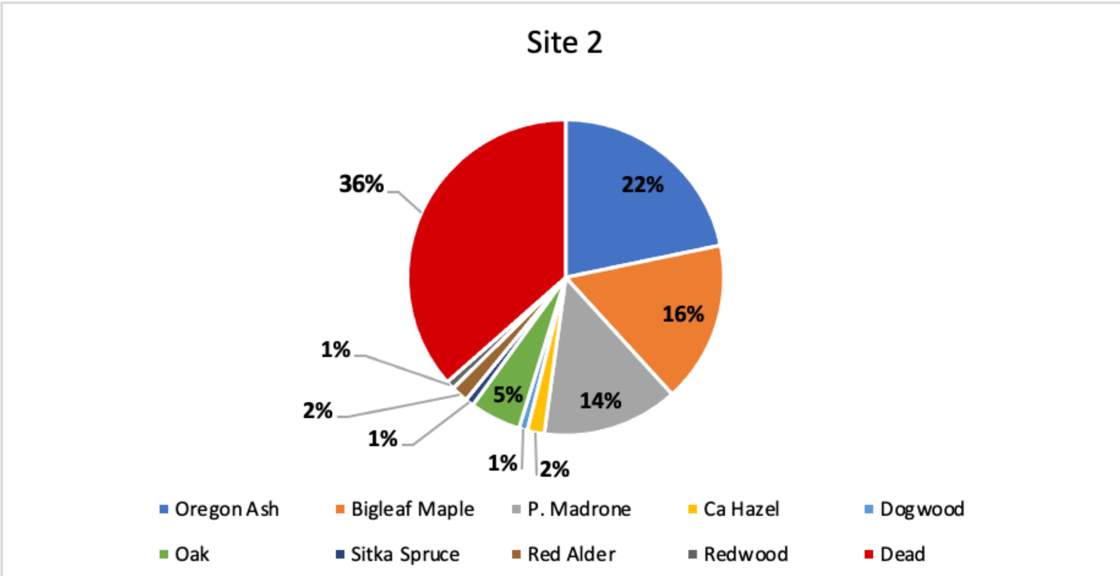

Figure 10. Site 2 survival composition prior to planting.

DISCUSSION

The restoration of the School Creek site aimed to improve plant survivability informed through previous years of planting. Many of the planted species that died were shaded out by surrounding grasses that grew into the cages. We hope that the mulching around the base of the cages of the recently planted seedlings will smother the competition from grass in their direct vicinity and retain moisture later into the dry season. However, it is advised that planting sites be monitored, and in the case of substantial grass growth, a string trimmer and hand weeding tools should be used to cut the grass. This year is projected to be an El Nino weather pattern; therefore, it will likely be wetter than years prior (Ropelewski & Halpert, 1886). We expect that this increased precipitation will encourage and increase plant survivability (Sitters et al., 2012).

Water infiltration and retention were major issues at our site due to the soil type present and the agricultural degradation that had occurred. With species like red alder (*Alnus rubra*) we saw near complete mortality despite being planted near the stream channel. We hypothesized this to be due to the high levels of clay present in the soil and the lack of other, established plants with deep penetrating roots that aerate the soil. This essentially suffocates the plant's roots and is most likely one of the strongest contributors to mortality at the site next to competition from grass and other species (Meyer & Barrs, 1991).

Ungulate browsing is another factor which must be considered to ensure plant survivability at both sites. A majority of the planted species were caged; however, some Oregon crabapple and Red Osier Dogwood were planted without cages among existing shrubs and beneath the riparian overstory. We hope that these plants will be hidden enough under blackberry and other shrubs to not be directly targeted for browsing, however we did observe extensive browsing on uncaged plants.

The main goal at this stage of the project is to allow for the establishment and succession of the riparian forest with cultural benefit. Once vegetation reaches a size where mortality would be unlikely during a fire, it is the plan of the Blue Lake Rancheria to perform cultural burning on the site. This will stimulate growth and allow for the sustainable harvest of basketry materials and other culturally relevant goods. Once the forest reaches this stage, restoration of the site will then be considered a success, and the newly restored track will allow for perpetuation of ecological services at the Blue Lake Rancheria. Additionally, it will create a community space for local tribal members and other interested parties that allows for connections with the land, community, practice of cultural tending and harvesting. Areas which are tended using cultural methods, are often more resilient to extreme weather events, conserve and retain significant amounts of biodiversity, and yield a significantly larger harvest of cultural goods in comparison to non-managed areas (Echeverria & Thornton, 2019; Goolmeer et al. 2022; Marks-Block et al., 2021).

RECOMMENDATIONS

To ensure plant survival and a successful revegetation project, we recommend the use of irrigation for this iteration of planting, considering low rates of survival in previous years. Irrigation should be considered in dry seasons until plants become well established. The use of shade cloths draped over cages is also an effective method in reducing drought and heat related mortality. Additionally, it may be necessary to trim grass at and around the cages to decrease competition and shading to planted species. Currently, Site 1 and Site 2 only have running water in the stream during the rainy months. These sites are heavily altered from construction of railroad grade and from previous agriculture. The soil is dry and clayey and the sites are now more similar to a grassland rather than a stream bed or true riparian zone. Because of this, we would recommend fewer riparian species to be planted here in the future as the climate continues to warm. Additionally, amendments of compost tea should be added, when possible, to bolster nutrient uptake and plant growth. While some of our conifer species were planted without cages due to not being favored by ungulates for forage, it is recommended that uncaged species be monitored to gauge the efficacy of these methods.

We were unable to collect and interpret the survivability of species from the previous planted years due to insufficient data recording in 2021 and 2022. For future projects, it would be beneficial to use the documented data of how many species were planted this year and their location, to gather the survivability and success of each species on both sites. Another recommendation would be to plant native understory species for the purpose of gathering. Some examples are *Achillea millefolium, Gaultheria shallon,* and *Rubus parviflorus* (Table 3).

ACKNOWLEDGEMENTS

We acknowledge that our work was conducted on the ancestral land of the Wiyot Indigenous people, who have been the historical stewards of this land for generations. We thank the Blue Lake Rancheria for allowing us to contribute to the cultural and ecological restoration efforts on their property. We thank Jacob Pounds, Blue Lake Rancheria Tribal EPA, for providing area and plant expertise, equipment, access to the sites, and guidance throughout this project. We lastly thank our professor Daniel Lipe “Bubba” for providing insightful feedback, meticulous edits and reviews, and supporting us throughout the entire process of this project.

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TABLES

Table 1. Surviving species count on Site 1.

Site 1	
W. Chokecherry	1
P. Madrone	7
Bigleaf Maple	2
Ocean spray	7
Dead	63
Total Survived	11
Percent total survived	14.9%

Table 2. Surviving species count on Site 2.

Site 2	
Oregon Ash	25
Bigleaf Maple	19
P. Madrone	16
Ca Hazel	2
Dogwood	1
Oak	6
Sitka Spruce	1
Red Alder	2
Redwood	1
Dead	42
Total survived	73
Percent total survived	63.5%

Table 3. Some examples of native plant gathering species (Anderson, 2013).

Species Name	**Common Name**	**Uses**
Achillea millefolium	Yarrow	Flower, leaves= medicinal
Fragaria vesca	Wild Strawberry	Edible fruits
Gaultheria shallon	Salal	Berries, young leaves= edible, Berries= medicinal
Heracleum maximum	Cow Parsnip	Stalk, leaves= edible, Roots= medicinal
Ribes triste	Wild Currant	Fruit= medicinal
Rubus parviflorus	Thimbleberry	Fruits= edible, Young shoots, roots, leaves= medicinal Leaves= supplementary sanitary product
Urtica dioica	Stinging Nettle	Leaves= medicinal
Xerophyllum tenax	Bear-grass	Grass= basketry material