# Bushy Lake Restoration, Monitoring, and Adaptive Management on the American River, Sacramento, California

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With funding from
Sacramento County Department of Regional Parks

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## EXECUTIVE SUMMARY

The Bushy Lake Restoration Project (Project) is a collaboration between California State University (CSU), Sacramento, faculty, students, and Public Affairs and Advocacy; local community engagement; and environmental groups interested in the lower American River. The Project consists of restoration, monitoring, and adaptive management of wetland and riparian zones near Bushy Lake, adjacent to Cal Expo on the American River Parkway (Parkway) in Sacramento, California.

This restoration experiment began in January 2015, with the Sacramento County Department of Regional Parks (County Parks), which provided Project funding, and with assistance from volunteers from the community and involvement by CSU Sacramento students. For the past two years, monitoring, restoration planting, and experimental design—and adaptive management since then—have created a fire-resilient habitat island in the corner of Bushy Lake, helping to achieve specific policy goals designated in the American River Parkway Plan (Chapter 6). We have also estimated carbon stocks stored in soils in the restoration area (Chapter 3). In 2016, we expanded the experimental restoration efforts, conducted a depressional wetland module of the California Rapid Assessment Method (CRAM) (Chapter 4), and monitored bird populations (Chapter 5). In the process of monitoring, we discovered the site is refugia for western pond turtles, and in March and April, we observed over 26 turtles at one time, when the river was high. We also observed river otters displaying courting and denning behavior, and in August 2016 discovered bear scat in the restoration area. The scat was confirmed by Sage LaPena, Native American traditional knowledge holder, and wildlife biologists at the September 23 Launching Event.

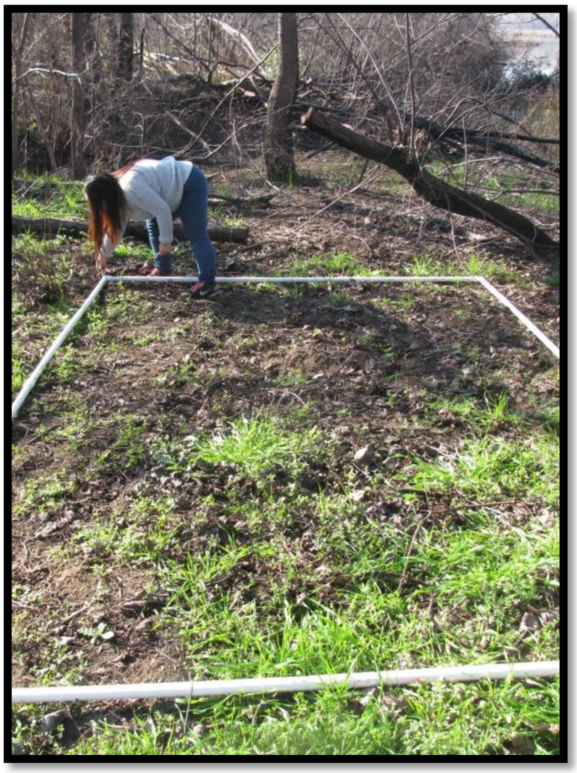
In September 2016, a large fire once again struck the lower American River Parkway in the general area of Bushy Lake. The fire burned the highest quality riparian habitat on the northern side of the lake (as evidenced by CRAM scores). Fortunately, the Project restoration habitat was spared the destruction of wildfire. The remaining habitat island in the midst of a charred and ashy landscape provided habitat for an abundance of local birds, small mammals, and deer. Deer trails are common in the Project area, with signs of browse and bedding in the Santa Barbara sedge and creeping wild rye.

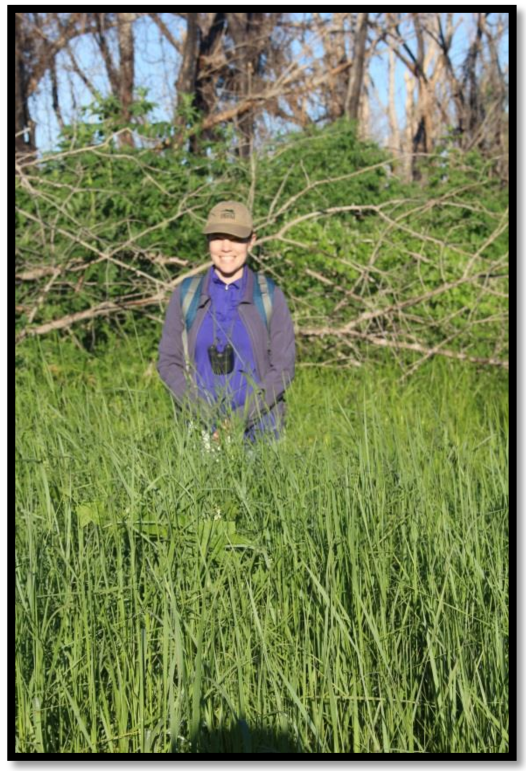
The Project has provided an exceptional opportunity for high-impact student-faculty research; involving students as docents and volunteers at the launching event; and providing community service engagement in implementing restoration experiments, monitoring, and adaptive management. Over the years since its inception, this Project provides third-party validation for the efforts of County Parks through community engagement, environmental education, and enhancing wildlife habitat at Bushy Lake. I plan to continue to involve undergraduates in STEM research and undergraduate science as this Project expands and incorporates additional faculty, classes, and students.

**Acknowledgements**

This project is part of the Earth Stewardship Initiative Post-Burn Vegetation Demonstration Project. We would like to thank Mary Maret and the Sacramento County Department of Regional Parks for funding and support.

In the photos below, Mary Xiong is shown at the inception of the experiment in January 2015 and Kayla Henry in June 2016. I would like to thank both women, who have graduated and moved into professional positions, for their assistance on this project.





Special thanks go to the following individuals who contributed to this document:

- Elizabeth Blue assisted with editing and writing Chapter 1 for this document. I would like to thank her for her work as my research intern in fall 2016 and for helping lead the planning and implementation of the Bushy Lake launching event and the follow-up monitoring and adaptive management at Bushy Lake.
- Dr. Andrew Margenot, UC Davis, wrote and led soils carbon data analysis for Chapter 3 – Physical Resources.
- Kayla Henry wrote the Bird Habitat and Monitoring component of Chapter 4 on the Biological Environmental, coordinated avian monitoring at Bushy Lake, and helped with the Bushy Lake Launching Event.
- Mary Xiong helped write Chapter 6 on the Riparian Habitat Experiment A. She also helped with the Bushy Lake Launching Event.

- Matt Owens completed his Environmental Studies (ENVS) senior thesis, which we used in Chapter 6 concerning the Riparian Habitat Experiment B. He contributed significant numbers of hours helping at the restoration project and completed his ENVS senior thesis at the project.
- Ryan Shaw completed his Environmental Studies (ENVS) senior thesis on western pond turtle monitoring and is assisting with monitoring protocols and spring visual monitoring of the western pond turtles.
- Thank you to students in ENVS 121 Field Methods, ENVS 158 Wetlands Ecology, and ENVS 151 Restoration Ecology for their help on this project. Without you, it would not have been done, and certainly would not have been as much fun!!!

**Student Achievements**

- Ryan Shaw. 2016. An Examination of the Western Pond Turtle (*Actinemys marmorata*), to Improve Monitoring and Habitat Conservation. Sacramento, CA. Capstone Thesis for ENVS Program. f
- Owens, Matt. 2016. Effects of Poison Hemlock (*Conium maculatum*) Treatments on the Success of Understory Plants, Creeping Wild Rye (*Elymus triticoides*) and Santa Barbara Sedge (*Carex barbarae*) at Bushy Lake, Sacramento, CA. Capstone Thesis for ENVS Program.
- Xiong, Mary. 2015. Riparian Understory Restoration of White Root (*Carex barbarae*) and Creeping Wild Rye (*Elymus triticoides*) in Post-Burned Areas at Bushy Lake, Sacramento, CA USA. Completion of ENVS Senior Thesis, Spring 2015.
- Xiong, Mary; and Michelle Stevens. October 2015. Poster Presentation Riparian Understory *Restoration of White Root (Carex barbarae) and Creeping Wild Rye (Elymus triticoides) in Post Burn Areas at Bushy Lake, Sacramento, CA*. Abstract submitted to Bay Delta Science Conference 2015.

Students from Restoration Ecology Class, Spring 2016

- Henry, Kayla; Tom Henry, and Michelle Stevens. October 2015. Poster Presentation: *Monitoring post-fire resiliency in a depressional wetland using California Rapid Assessment Methodology (CRAM) and intensive vegetation and Avian Species Richness to establish long-term monitoring using citizen science.* Abstract submitted to Bay Delta Science Conference 2015.
- Henry, Kayla. 2015. Avian habitat Availability in the Bushy Lake Wetland Restoration Site: A CRAM Based Evaluation. Completion of ENVS Senior Thesis, Spring 2015.

- Henry, Tom. 2015. Evaluation of Bushy Lake as a Depressional Wetland Reference Site Under the California Rapid Assessment Method (CRAM). Completion of ENVS Senior Thesis, Spring 2015.

**CHAPTER 1. INTRODUCTION –** by Michelle Stevens and Elizabeth Blue (CSU Sacramento ENVS student intern)

The Bushy Lake Restoration Project (Project) consists of restoration and monitoring of wetland and riparian zones near Cal Expo on the American River Parkway (Parkway) in Sacramento, California. The Project includes citizen science and community education to promote long-term and widespread interest specifically in the Project area and generally in environmental studies.

The Project area is subject to frequent and severe anthropogenic disturbance through wildfires and human intrusion. In 2014, a fire at Cal Expo burned over 160 acres of the Parkway. The wildfire coincided with the Ecological Society of America (ESA) Conference held that year in Sacramento. A collaboration had been initiated between California State University (CSU), Sacramento; Yale University; University of California, Davis; Sacramento County Department of Regional Parks (County Parks); and American River Parkway Foundation prior to the conference. Impacts of the wildfire provided additional grist for the research mill.

The Earth Stewardship Initiative grew out of the ESA Conference with a goal of creating a fire-resilient landscape and long-term monitoring and adaptive management at Bushy Lake and in the Lower Parkway. The restoration experiment began in January 2015, with help from volunteers from the Parkway Foundation and County Parks, and continues to this day. Restoration, monitoring, and adaptive management have created a fire-resilient habitat island in the corner of Bushy Lake, helping to achieve policy goals designated in the American River Parkway Plan. When another large fire occurred in the Parkway in September 2016, wildlife species were observed taking refuge in the unburned restoration area.

Restoring native plant species; removing non-native weeds; enhancing the ecological resiliency of Bushy Lake and its surroundings; and strengthening community outreach, stewardship, and accessibility along the Parkway are all consistent with the policies and goals of the American River Parkway Plan (County of Sacramento et al., 2008). We plan to expand this restoration project to meet policies of the American River Parkway Plan, listed below, and provide monitoring and adaptive management recommendations to meet its goals.

This is what we did and the policy we addressed:

- Developed a collaborative relationship with colleges for assistance with research, monitoring, and survey projects. (Policy 3.2.0)
- Maintained and enhanced native vegetation in the Parkway. (Policy 3.2.1)
- Reintroduced native vegetation in the Parkway (*Carex barbarae* and *Elymus triticoides*). (Policy 3.2.2)
- Removed non-native invasive vegetation. (Policy 3.2.4)
- Increased wildlife habitat connectivity and corridors. (Policy 3.3)

- Improved Parkway resources, environmental quality, and natural resources, including ecological restoration of degraded resources. (Policy 3.4)
- Managed, enhanced, and protected riparian aquatic habitat (Bushy Lake) especially as concerns federally or state-listed or watch species (such as valley elderberry longhorn beetles, western pond turtles, Swainson's hawks, wood ducks, river otters). (Policy 3.11)
- Analyzed water quality protection and beneficial uses as wildlife habitat and recreation. (Policy 4.4)
- Operated and managed Bushy Lake in a manner that maximizes value to fish and wildlife, including monitoring and adaptive management to provide suitable habitat at adequate water depths and appropriate vegetation. (Policy 10.19)
- Restored and enhanced wetland and riparian habitat around Bushy Lake. (Policy 10.20)
- Removed non-native weeds and created grassland foraging habitat for raptor species.

Through a contract with County Parks, Dr. Michelle Stevens, and students and faculty from CSU Sacramento, are now completing the Bushy Lake Restoration and Environmental Education Project, which is a wetland/riparian restoration, monitoring, and citizen-science/community-education project (Stevens et al., 2015). Students from the Restoration Ecology class (ENVS 151), spring semester 2016, engaged in high-impact learning through restoration, experimental design, implementation, and adaptive management. We continued research through the summer and fall of 2016 through student and community participation. The Project also provides community service opportunities for area students and others to perform long-term monitoring in fulfillment of the American River Parkway Plan. Citizen science, positive publicity through CSU Sacramento, and public restoration projects all create goodwill in the greater community. The Project adds third party validation for the efforts of County Parks by providing positive publicity for the work they are doing in the Parkway.

## Goals and Objectives

Ecological restoration is increasingly called on to improve ecosystems to benefit humans, expand biodiversity, and create and protect wildlife habitat. The aim of this project is to evaluate restoration success on a "novel" restoration site subjected to frequent wildfires. We are using historic ecology and traditional resource management from local Maidu and Miwok tribal knowledge to inform sustainability in restoration design.

The Project's primary goal is to provide a cost-effective ecologically relevant restoration prescription for the Bushy Lake area into a sustainable wetland with fire-resilient native understory vegetation. The restoration experiment is designed to study the response of vegetation and soils to fire, and to enhance post-burn recovery based on our current ecological knowledge. The area around Bushy Lake provides a suitable location for ecological restoration using native plant species that are resilient to fire.

Before European settlement, the people of the Miwok and Maidu tribes practiced traditional resource management through burning and other tending practices of culturally significant resources. Santa Barbara sedge (*Carex barbarae*) and creeping wild rye (*Elymus triticoides*) are native species that have adapted to frequent fires and were chosen for understory restoration because they are resilient to fire. Restoring the native understory vegetation will promote accelerated succession of habitat for Parkway flora and fauna, as well as controlling invasive species. Project experiments will provide a visible example of the proactive effort to manage fire in the parkway with volunteer participation, public education, and monitoring.

Traditionally, Native American tribes in the Central Valley regularly burned the Sacramento landscape. The Miwok, Maidu, and other tribal groups utilized Traditional Resource Management (TRM) tools, such as fire, coppicing, resource rotation, and species management, to maintain their resources sustainably (Stevens 1999; Stevens 2003; Stevens 2004b). TRM tools like fire were especially important in creating heterogeneity among California vegetation, managing species distribution, and controlling intense fire by not allowing excess organic matter to build up in the soil (Hankins 2013; Stevens 1999; Stevens 2003; Stevens 2004b). The management of culturally significant native plants promoted fire-resilient vegetation and native vegetation in riparian areas, creating habitat heterogeneity beneficial for native plant species, pollinators, and wildlife (Cunningham 2010; Stevens 2004a).

Project results provide a high-visibility demonstration of the effectiveness of restoration efforts in response to fire. We have one “demonstration site” near the trail to demonstrate our experimental block design to the public (see before and after pictures below). With assistance from Parkway Foundation volunteers, we established a field experiment near Bushy Lake on January 24, 2015. Plugs of two native riparian understory plant species, *Carex barbarae* (CaBa) and *Elymus triticoides* (ElTr), were planted in areas where invasive species had encroached. The experiment is intended to test the effect of density and species composition on the survival and absolute cover of CaBa and ElTr and on the interaction between the plant density and species. Experiment areas were weeded and monitored weekly. We implemented adaptive management practices of watering and applying mulch when plant survival began to decline.

Experimental results showed that low density treatment had no significant difference from high density treatment over time; therefore, low density plantings are less expensive and easier to plant. *Elymus triticoides* has significantly higher relative cover than *Carex barbarae*, and outcompetes the CaBa when planted in heterogeneous plats. Therefore, future planting will be at low density (1-foot centers) and monotypic stands of either CaBa or ElTr.

The experimental restoration project demonstrates a proactive effort in restoring a riparian habitat into a fire-resilient landscape, which would allow for an increase in habitat value and native plants. Recommendations to ensure that proactive efforts will continue to expand restoration alternatives to conserve this region are to:

1) Engage volunteers from the CSU Sacramento and local community and environmental groups on the lower American River Parkway to conduct citizen science in the form of long-term monitoring and adaptive management as a result of the Project, and
2) Improve public outreach to bring together and educate the public about the significance of wetlands, riparian forests, and wildlife.

Another Project Goal is to estimate carbon stocks sequestered in soils and vegetation. By estimating the carbon sequestered in soils and vegetation, we will be able to quantify carbon sequestration and ecosystem health to assess adaptations to climate change. The impacts of climate change can be reduced through either reducing Greenhouse Gas Emissions or by increasing storage of carbon in vegetation and soils. Biological carbon sequestration is typically accomplished through soil restoration practices that enhance the storage of carbon or reduce CO2 emissions (such as suppressing wildfires). By estimating the carbon sequestered in soils and vegetation we will be able to quantify carbon sequestration and ecosystem health to assess adaptations to climate change. Assessment of stored carbon stock in soils and vegetation can result in calculating an economic value for carbon sequestration. Through this research, we will also assess the feasibility of using carbon credits as a restoration funding mechanism to offset restoration costs as a funding mechanism for restoration projects.

A major Project goal is to monitor the Bushy Lake Nature Study Area using the California Rapid Assessment Method (CRAM) module for depressional wetlands. We will also study long-term riparian habitat health and condition using the CRAM to establish a baseline to determine changes in wetland health over time (see Chapter 3 for a full discussion of CRAM). The northwestern corner of the lake had the highest CRAM score (75) and was the least disturbed. Key stressors include invasive species encroachment, unreliable water supply, and wildfire. Statewide, CRAM points range from 39 to 94, and are compared to other depressional wetlands scores recorded on eCRAM. A difference of 6 points is considered significant, meaning a significant difference in “wetland health” between the unburned northern assessment areas and the burned southern assessment areas. The overall scores are low-to-middling compared to other depressional wetlands in California. We anticipate changes to these scores over time, and intend to use the CRAM methodology to monitor changes in wetland health to evaluate and the contribution of restoration and management. After the September 2016 fire, we anticipate CRAM scores to decline significantly. The Restoration Project area scores should continue to increase over time with long-term management.

We discovered the wildlife habitat utilization at Bushy Lake by monitoring avian species and biotic structures for bird habitat. Ongoing monitoring of the following data elements will provide insight into habitat conditions and overall ecosystem health, and will help determine how successful conservation efforts have been.

A. AVIAN MONITORING

Historically, Bushy Lake has provided vital habitat for a variety of birds and is a popular birding location (Audubon Society). Birds are more easily observed than other wildlife and respond quickly to changes in their environment; therefore, they are ideal candidates to measure ecosystem improvement during both restoration activities and post-restoration monitoring. Furthermore, in the absence of a specific indicator species, bird monitoring can help gauge overall ecosystem success. Fewer species were observed in the southern areas where the riparian areas suffered great impacts from the fire; this area is taking longer to and potential avian habitat will improve in these areas with restoration, vegetation regrowth, and control of invasive species. We anticipate avian habitat quality to decrease due to burning forested riparian and wind throw in December-January reducing snags for cavity nesters such as owls, wood ducks and tree swallow.

In 2016, the following fauna were observed while conducting monitoring.

- A nesting pair of red-tailed hawks (*Buteo jamaicensis*) were observed on the west side of Bushy Lake.
- One species of flycatcher in the southwest assessment area. Although we were unable to identify the exact species, there is an endangered species of flycatcher that migrates through the Sacramento region in the spring. The willow flycatcher (*Empidonax trailii*) shows a nearly exclusive preference for areas with riparian cover (Sedgwick & Knopf, 1992). This species is listed as level S1 endangered by ESA (CNDDB, 2015).

B. WESTERN POND TURTLE

We observed over 26 western pond turtles (*Actinemys marmorata*) in Bushy Lake during high water in the American River (picture to the right). The turtles rely on a permanent water source with floating woody vegetation and muddy banks for basking. Western pond turtle has suffered a 99% decline in some areas and is listed as a species of special concern in California. Although this species is not yet recognized as federally endangered in California, its status is currently under review (Center for Biological Diversity, 2015). If Bushy Lake is allowed to dry up, the 700m distance to the American River may result in extirpation of the turtles from the area. Bushy Lake is a very important refuge for these turtles, and we recommend further study.

C. RIVER OTTER

The North American River Otter (*Lontra Canadensis*) is a keystone carnivore and another Bushy Lake resident that requires a permanent water source. We observed a pair of vociferous otters whom we believed were interested in denning in the area – they aggressively wanted us out of the area.

D. VELB

Elderberry (*Sambucus Mexicana*) is spouting and growing prolifically throughout the study area (see picture to right). Elderberry bushes have regrown from root crown sprouting in the Project area, providing flowers, nectar and berries for wildlife. The elderberry provides habitat for the Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*), a threatened species known to occur on the American River. We looked for but did not observe any exit holes, and recommend monitoring in 2017.

E. VEGETATION MONITORING

We observed species richness of 12 plant species. Fifty-two percent of the plants sampled were native. The prolonged spring rains and additional nitrogen from ash stimulated invasive species, with 39% invasive plants, and 9% non-native plant species. The poison hemlock (*Conium maculatum*) (23% relative cover) and prickly lettuce (*Lactuca serriola*) (3.8% relative cover) were over six-feet tall and dominate the site. Tall whitetop (*Lepidium latifolium*) (0.4% relative cover) were beginning to invade the disturbed sites. Himalayan blackberry (*Rubus armeniacus*) was patchy; without management, these tall invasive species are shading and eliminating the native understory species. Site conditions at Bushy Lake make long-term monitoring and adaptive management necessary Project components. A weed control plan will be essential to successfully restore habitat along the Lower Parkway. Growth of invasive species is stimulated by nitrogen fertilization from post-fire residual ash and extended spring rains. Dominant weedy species, such as poison hemlock and star thistle, grew over 6-feet tall in 2015, over-shadowing native species. The best way to control invasive species is to establish healthy soil and competitive vegetation on site. Watering new plants will be beneficial for plant establishment. However, we are using mulching to enhance survival, and weeding and eliminating invasive species to maintain native species composition and habitat value. We plan to continue and expand experimental research and long-term monitoring and adaptive management, to establish a long-term and reciprocal relationship with County Parks.

F. PRESENCE OF BEAR SCAT
While monitoring the site in August 2016, I discovered fresh evidence of bear scat. I showed Sage LaPena, Native American traditional knowledge holder, the evidence and she concurred it was bear. I also showed wildlife biologists at the launching event on September 23, and they also concurred it was bear scat. I have not seen a bear, nor have I seen additional scat. I believe the bear was passing through along the American River Corridor.

**Public Engagement**

Sacramento County Parks display, photo by Elizabeth Blue

In 2016, I was awarded a separate Woodlake Cal Expo Recreation and Education Program Grant to CSU Sacramento to expand the Bushy Lake Project to increase environmental education and public engagement at the site. Given its ecological significance, its proximity to CSU Sacramento and Cal Expo, and to the large number of people who use the Parkway for recreation, Bushy Lake is well suited to supporting public, passive, outdoor recreation, environmental education and STEM activities that re quire the use of natural wildlife habitat and an environment preserved for its "naturalness." Through this project, CSU Sacramento faculty members created background materials for passive recreation and science/environmental education with the aim of building future stewardship and a community land ethic (www.bushylake.com). Our long-term goal is to reach out to a broad range of the public and to teach the public, recreational users, and children about a precious living laboratory in our backyard. Citizen science and self-guided recreation activities will allow people to see the natural resources Bushy Lake offers, including refugia for western pond turtles during high water, denning river otters, and the songs of birds passing and soaring through the seasons and the years.

**Bushy Lake Project Unveiling**

We held an Unveiling of Bushy Lake Restoration and Environmental Education Event on September 23, 2016, with participation of local dignitaries, environmental, and scientific organizations, the public, and students. A wildfire burned over 140 acres right up to the edges of our restoration project (photo at right) the week before the event. Media coverage of the fire may have stimulated public interest, because over 200 people attended, including Sacramento County Supervisor Phil Serna and Congressman Kevin McCarty.


Dr. Michelle Stevens
Photo by Elizabeth Blue

The goal of the event was to showcase the work being done at Bushy Lake and along the American River to encourage greater community involvement. Several local agencies provided displays, showcasing their work along the American River, including the American River Conservancy, American River Parkway Foundation, Audubon Society, Effie Yeaw Nature Center, Nimbus Fish Hatchery and the California Department of Fish and Wildlife, Sacramento County Office of Education, Sacramento County Regional Parks, CSU Sacramento SIRIUS Program, CSU Sacramento Sustainability, Sacramento Water Conservancy, Water Forum, and U.S. Army Corps of Engineers. The event opened with a prayer by Sage LaPena, a Traditional Knowledge holder of Native American ancestry. Attendees were addressed by Dean Orn Bodvarsson of the College of Social Sciences and Interdisciplinary Studies at CSU Sacramento; Sacramento County Supervisor Phil Serna; Assemblyman Kevin McCarty; Dr. Jeff Foran, Chair of the Environmental Studies Department at CSU Sacramento; Dr. Tim Horner Chair of Geology Department at CSU Sacramento; Dr. Michelle Stevens (photo at left); and Mary Xiong, a CSU Sacramento alumna who completed her Master’s thesis on the restoration work at Bushy Lake. Each of the speakers described the importance of the American River Parkway and its diverse ecosystems to Sacramento.

Elizabeth Blue, far left, leading tour group. Photo by Guy Galante

Each speaker created public interest in the importance and value of Bushy Lake as significant habitat refugia for many species, providing the lower American River Parkway area with increased species diversity and richness. Students from ENVS 121 Field Methods class were docents leading groups through the restoration site and along the levee (photo at right). Student docents provided natural history interpretations and explained the significance of the native plants used in the project. Local Audubon society members established spotting scopes and stations to show the public the birds at the site. Docents discussed native plants such as Elderberry bushes, which provide habitat for the threatened Valley Elderberry Longhorn Beetle. Tours led up to the levee near Cal Expo to show the impact of the recent fire and how close it came to Bushy Lake and its hidden wonders.

One goal of the project is to have Cal Expo feature Bushy Lake during the monorail ride at the State Fair.

Student volunteer helping clear an area for public viewing of Bushy Lake.
Photo by Elizabeth Blue

**Unveiling Event Feedback**

Public feedback from our exit survey was overwhelmingly positive. Out of 66 respondents, 95% said they would return to Bushy Lake, and 36% said they were interested in volunteering at Bushy Lake. 52% said the event exceeded their expectations, and 48% said it met their expectations. Participants in the Bushy Lake launching event said they particularly enjoyed the following elements of the event: 24% said plants or restoration, 17% said fire, 11% said animals, and 9% said Native American knowledge systems (ethnobotany). Respondents indicated that they would like to have more information about Bushy Lake Plants and animals. Other feedback included wanting more information about future plans for Bushy Lake restoration, information on area history, concerns for homeless persons, requests to volunteer, improving visibility of the lake and the importance of wildlife refugia.

**Follow-Up**

Through fall 2016, and continuing in spring 2017, we engaged the community in adaptive management and weeding. Students from CSU Sacramento supported the effort through community service. Two areas were opened to allow visitors to view Bushy Lake, with the goal of limiting public access in these areas.

In spring 2017, the ENVS 151 Restoration Ecology class will be assisting with high-impact student/faculty research at Bushy Lake on the following projects:
a) Western pond turtle populations will be visually monitored. b) Elderberry bushes will be mapped to see if they survived the fire with root crown spouting or seed germination. Larger bushes will be monitored for exit holes of the projects the valley elderberry longhorn beetle. c) Conducting studies to determine carbon stock in woody vegetation. d) Replant and monitor existing restoration projects. e) Conduct new experiments with community help on companion planting with creeping wild rye or Santa Barbara sedge and mugwort. f) We will also be planning days for community volunteers to assist with planting, weeding, pruning, and maintenance of the Bushy Lake restoration site.

## **Chapter 2. Project Area –** by Michelle Stevens

The Bushy Lake Restoration Project is a wetland/riparian restoration, monitoring and citizen science/community education project located in the burned area near Cal Expo on the American River Parkway (Parkway) in Sacramento, CA. Bushy Lake is located on the Cal Expo floodplain, which resides within the Parkway) (Water Forum 2005) (Figures 1 & 2). The Parkway is a 23-mile riparian corridor along the Lower American River from Folsom Lake to the confluence of the Sacramento and American Rivers, which provides habitats for various regional flora and fauna and offers recreational activities for humans (County of Sacramento et al., 2008; Dillinger et al., 2005). The overall area has a Mediterranean climate meaning hot, dry summers and cold, wet winters with riparian vegetation along the American River.

Approximately two to seven percent of riparian habitat remains in the Central Valley of California due to urban development, agricultural alterations to the land, and other anthropogenic activities (Vaghti and Greco, 2007; Moore et al., 2011). Consequently, restoration of riparian areas has become increasingly important as riparian loss has adversely impacted the environment and wildlife while significantly reducing cultural resources for indigenous groups (Hankins 2013; Seavy et al., 2009; Stevens 2004a; Stevens 2015; Smith 1977).


**Figure 1.** Map of ARP along the Lower American River ending at the Sacramento and American River confluence (parkerdesign.info)

Riparian vegetation plays a major role in influencing biodiversity and ecosystem functions in a riparian ecosystem (Alpert et al., 1999). Resident and migratory bird species, native plants, and wildlife depend on healthy ecosystems where suitable habitats and natural resources are available (Gaines 1977). European settlements during the Gold Rush era in California resulted in major environmental changes, converting rich, fertile floodplains, and surrounding riparian forests in the Central Valley into agricultural land (Thompson 1977; Cunningham 2010).

**Figure 2. Map of Bushy Lake.** The white line indicates the area boundary within the Parkway (Google Earth 2014).

The State of California acquired the undeveloped land near Cal Expo in the 1940's and built the first structure in the 1960's. Development continued in the 1960's with construction of a golf course in this floodplain, completely reshaping Bushy Lake and its surrounding areas to fit that purpose. The Save the American River Association (SARA) interrupted that development by supporting the Bushy Lake Preservation Act to protect the remaining riparian forest and seasonal wetland areas, forcing the golf course construction to stop, when the bill was approved (County of Sacramento et al., 2008; Dillinger et al., 2005). Cal Exposition and Fairgrounds currently owns the land. County Parks has principal responsibility for administration and management of the Parkway through a management agreement with the State.

Bushy Lake is located within the lower American River floodplain. Historically, the river channel would meander and shift within this floodplain (Castaneda and Simpson, 2013). The depression that forms Bushy Lake was deepened from construction of the levee adjacent to Cal Expo. Bushy Lake was again altered by golf course construction efforts; soils were compacted and moved, and the pond shape and bathymetry was modified.

Seasonal creeks from the northeast – like Chicken Ranch and Strong Ranch Sloughs that pass through the Arden-Arcade area –also once contributed to water levels in Bushy Lake into the summer. Today, these creeks have been channelized and lined with concrete to collect storm water and convey it quickly into the American River.

Since Folsom dam was built in the middle of the last century, water releases to the lower American River have been controlled to protect Sacramento residents from flooding, which used to happen more regularly (Castaneda and Simpson, 2013). Consequently, water levels no longer rise high enough to fill the historic floodplain; nonetheless, Bushy Lake retains many riparian characteristics that demonstrate its ongoing relationship with the American River.

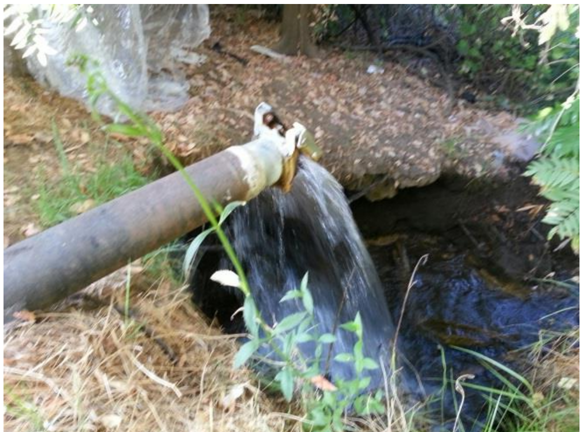


**Figure 3.** Outlet pipe into Bushy Lake from Cal Expo. Photo by Julian Fulton.

Nowadays, the water that feeds Bushy Lake comes mostly from a groundwater well on the Cal Expo side of the levee. This water is pumped through a pipe that lets out at the east end of Bushy Lake (see Figure 3). Cal Expo operates the pump to maintain the lake level in accordance with the Bushy Lake Preservation Act of 1976 (CSMSA 2008).

**Chapter 3 – Physical Resources: Geology, Soils, and Carbon Sequestration -** by Andrew Margenot and Michelle Stevens

*3.1 Geology and Soils - Background*

Before European settlement in 1849, the floodplain along the American River consisted of continuous, extensive riparian forests and vegetation. Human settlement, the Gold Rush, hydraulic mining, gold dredging, upstream dams, and levee constructions extensively transformed the river and floodplains, leading to the loss and fragmentation of the riparian habitat (The American River Natural History Association, 2005). Sand and gravel bars were created as a result of hydraulic gold mining, which had deposited from five to 30 feet of sand, fine gravel, and silt into the riverbed (Water Forum, 2005). Along with mining, gravel extraction activities occurred on the Lower American River and limited growth and sustainability of the riparian forests by decreasing the floodplain water table. When the levees were built, the topsoil from the Bushy Lake area was used to help build the levees. The soil that remained was compacted, altering soil type in the area. This site was also graded to become a golf course in the mid-1900's, resulting in a highly-modified soil profile.

Soils are Bushy Lake reflect their proximity to the American River. Soils of Bushy Lake are formed by a combination of human compaction and alluvial deposition. Two soil types are mapped for the northern embankment of the American River that constitutes Bushy Lake, the Columbia and Rossmoor series (Fig. 1; Appendix). Both soil series occur on high floodplains in the Sacramento Valley, and tend to be deep, well-drained soils with sandy loam textures developed on mixed alluvium from the Sierra foothills. The Parkway bike path roughly delineates the occurrence of these mapped soil types within Bushy Lake, with Columbia and Rossmoor occurring north and south of the path, respectively.

*3.2 Soils at Bushy Lake*

Soils are mapped as the Rossmoor fine sandy loam (Fluventic Haploxeroll) and Columbia sandy loam (Aquic Xerofluvent) (Figure 4) (Soil Web Survey, 2015). The Rossmoor and Columbia series formed from alluvial depositions on floodplains with low (0–2%) slope. The Columbia and Rossmoor series are close pedagogical relatives, differentiated largely by higher soil C in the upper depths of Rossmoor (mollic epipedon) compared to Columbia (ochric epipedon). The Rossmoor series (coarse-loamy, mixed, super-active, thermic Fluventic Haploxerolls) is unique to high floodplains of the American River. It is noted for having high soil C to depth (1.2% to 60 cm) due to deposition of C-rich sediments, indicated by the "Fluventic" classification. The Columbia series (coarse-loamy, mixed, super-active, nonacid, thermic Oxyaquic Xerofluvents) is more common throughout the Central Valley. Similar texture of both soil types indicates similar potential for soil C accrual and saturation, which is relatively low compared to finer texture soils (i.e., higher clay content). Both soils share similar physical and chemical properties.

They are distinguished by a mollic epipedon in the Rossmoor series indicative of higher soil organic C in the surface (0–6 in) horizon and reflective of this series position on higher floodplains, whereas the Columbia is typically located on lower floodplains lacks stratification including this organic-rich surface horizon.

However, the high degree of human activity and landscaping at this site, including leveled terraces for a golf course, suggests homogenization of these differences in surface horizons, further increasing similarity of soil properties at the site. Additionally, past and recent fires (e.g., July 2014 and September 2016) have modified C concentrations in the surface horizons, further altering taxonomic classification.


**Figure 4.** Soil map for the Bushy Lake generated by the USDA NRCS Soil Web Survey (accessed 13 Nov 2016). Numbers indicate soil map units, which for the sampling sites at Bushy Lake include 118 for Columbia and 204 for Rossmoor soil series (see Appendix). Soil profiles (purple starts) were excavated to assess potential soil variability surrounding the restoration sites (n =5 plots) (red star).

Soils were sampled at the Bushy Lake area in December 2014 and June 2016 by Dr. Andrew Margenot with assistance of students of the CSU Sacramento Environmental Studies Department. Soils samples from the two soil pits were analyzed (Figures 4 and 4.1). The observations showed that the top 6 inches of the soil upper horizon contain soil organic matter (SOM) darkening, consistent with the mollic epipedon mapped in the Rossmoor soils series.

### *3.3. Methods for Analysis of Soils*

Three soil pits were excavated and profiled to a depth of 40 inches on Dec. 5, 2014 to corroborate existing soil maps (Soil Survey Staff, 2015) and evaluate soil types in the vicinity of vegetation restoration plots (Figure 4). Profiles confirmed soil mapping as the Rossmoor-Columbia series with sandy loam textures. On June 17, 2015, soils were sampled at five revegetation plots in the Bushy Lake Park to a depth of 25 inches. For each plot (n=5), a composite soil sample (n=3) was obtained by auguring at three of depths: 0–5 inches, 5–10 inches, and 10–25 inches (total soils n=45). Additionally, a fourth soil profile was characterized near these sites to confirm the similarity of soil type from the previous three profiles.

Bulk density was determined following overnight drying of soils at 105 °C. Soil organic carbon (SOC) and total soil nitrogen (TSN) was determined as total soil C by combustion element analysis (Costech Analytical Technologies, Inc., Valencia, CA). Due to the lack of carbonates, total soil C was used to estimate SOC. C:N was calculated as the ratio of SOC to TSN. Permanganate-oxidizable C (POXC) was determined according to Culman (2013). Briefly, 2.5 grams of soil were oxidized for 12 minutes in 0.02 mol L-1 potassium permanganate. Soil C stocks were estimated by converting soil organic C concentrations at each depth into total C via bulk density.

*3.4 Soils and Carbon Sequestration*

Carbon (C) sequestration is an important mitigation strategy for climate change. Recent studies have shown that carbon sequestration has the potential to reduce carbon emissions by millions of metric tons, and may be an integral part of meeting California's long-term climate goals (Poulson et al., 2011). Forest soils present a strong potential for C sequestration due to their high primary productivity, and riparian forests facilitate even higher C storage due to slower decomposition (Lal 2004). Conversion of agricultural lands to restored riparian habitat (habitat associated with rivers or wetlands) provides a strategy to increase C sequestration.

There is, however, a lack of research on carbon sequestration in soils and native vegetation in riparian areas. In this study, we plan to develop metrics to estimate carbon accretion rates in riparian forests over time. Development of carbon credit metrics for native riverine forests will provide valuable data to estimate benefits and provide incentives to landowners for restoration projects. Both international and State policies on climate adaptation advocate for reforestation and restoration to increasing carbon sequestration and provide benefits to ecosystem services (Capon et al., 2013). The need for formal mechanisms for analysis of carbon sequestration and reimbursement for Ecosystem Services are prolific in contemporary policy and scientific literature on climate change.

Soils are a significant potential C sink, with nearly half of terrestrial soil C stored as soil organic carbon (SOC) (Lal 2004). Among other factors like climate, land use has a strong effect on SOC stocks, with 20–50% SOC under agricultural use compared to native forest (Laganiere 2010; Lal 2005). Forest soils present a strong actual and potential for C sequestration due to their high primary productivity (Lal 2004). In riparian forests, conditions of seasonal saturation facilitate higher C storage due to slower decomposition (Trettin & Jergensen, 2003; Rheinhardt 2014). Conversion and restoration of lands, such as agricultural use to reforestation, offer a strategy to increase C sequestration (Lal 2003).

Evaluations of C sequestration in riparian soils following restoration are limited, especially at scales at or below individual restoration sites. Such evaluations are limited to total C increases. In addition to total C, the stability of C must be considered in order to accurately determine the long-term effectiveness of C sequestration in soils, because differences in C stability influence its residence time (Lal 2005). The lability of SOC can explain differences in its accrual during land-use changes (Paul et al., 2002, Chen et al., 2010) and in conjunction with soil aggregate data, which can be used to evaluate longer-term stability of soil C increases that occur during revegetation (Clark et al., 2010). SOC lability can be determined by biochemical assays, including active carbon, the pool of rapidly cycling C, and in conjunction with the ratio of soil carbon to nitrogen (C:N) (Lal 2004; Lucas & Weil, 2012).

## *3.5 Results and Discussion*

### *3.5.1 Total and Labile Soil C*

Restoration plots showed the greatest soil organic C concentration in the surface layers (0–5 in), with lower but more similar C at subsurface layers to the measured depth of 25 inches. C:N and POXC generally decreased with depth, indicating greater lability of soil C in surface horizons and its increasing stability with depth. Across the three measured depths, soil C showed greater decreases (mean 15.3, 7.5, 5.3 g C $kg^{-1}$ soil) than POXC (645, 404, 322 mg C $kg^{-1}$ soil). Across plots, variability in soil C was similar to POXC in the surface (CV = 0.12 vs 0.13, respectively) and greater with depth (5–10 in, CV = 0.23 vs. 0.18; 10-25 in, CV = 0.24 vs. 0.11).

**Table 3-1. Total and labile soil C at five restoration plots at Bushy Lake**

| **Plot** | Depth (in) | Organic C | (g $kg^{-1}$) | C:N | | POXC (mg $kg^{-1}$) | |
|---|---|---|---|---|---|---|---|
| | | mean | se | mean | se | mean | se |
| **1** | 0–5 | 16.5 | 1.4 | 12.1 | 0.3 | 701 | 19 |
| | 5–10 | 6.7 | 0.3 | 10.7 | 0.2 | 396 | 20 |
| | 10–25 | 5.4 | 0.2 | 11.2 | 0.2 | 310 | 1 |
| **2** | 0–5 | 12.7 | 0.3 | 11.4 | 0.0 | 500 | 4 |
| | 5–10 | 5.6 | 0.0 | 10.5 | 0.2 | 338 | 3 |
| | 10–25 | 3.6 | 0.4 | 12.6 | 0.1 | 281 | 15 |
| **3** | 0–5 | 17.1 | 1.4 | 11.8 | 0.1 | 715 | 61 |
| | 5–10 | 7.5 | 0.0 | 12.1 | 0.3 | 399 | 18 |
| | 10–25 | 4.9 | 0.1 | 13.6 | 0.1 | 323 | 2 |
| **4** | 0–5 | 15.8 | 0.2 | 12.7 | 0.3 | 642 | 2 |
| | 5–10 | 8.0 | 1.1 | 14.7 | 2.0 | 360 | 6 |
| | 10–25 | 7.2 | 0.1 | 14.3 | 0.6 | 377 | 2 |
| **5** | 0–5 | 14.5 | 0.2 | 11.5 | 0.0 | 665 | 23 |
| | 5–10 | 10.4 | 0.2 | 12.2 | 0.1 | 527 | 10 |
| | 10–25 | 5.3 | 0.1 | 10.7 | 0.1 | 317 | 6 |

*C, carbon; N, nitrogen; POXC, permanganate-oxidizable C*

*3.5.2 Estimate of Soil C sequestration*
Soil C stocks to a depth of 25 inches were estimated to range from approximately 38–60 t $ha^{-1}$ with a mean of 50.9 t $ha^{-1}$ (Table 3-2). As these are based on extrapolation from 1 $m^2$ soil profile, they are better regarded as an estimate that is scaled up for greater ease of interpretation. Alternatively, C stocks can be expressed as $CO_2$ equivalents, the unit of measure to express C forms and greenhouse gases in a common unit based on radiative forcing.

Although soil C concentration is greatest in the surface layer and decreases with depth (Table 3-1), the consistent soil C concentration with depth to 25 inches and similar bulk density (Table 3-2) entails net greater C storage in subsurface layers, with 63 ± 4% of soil C across 5–25 inch depth. Furthermore, the greater biochemical stability of soil C with depth (Table 3-1) suggests potentially greater long-term storage of such C. On the other hand, the importance of surface layer (0–5 in) contains a high proportion of soil C stock (37 ± 4%) relative to its component (20%) of measured depth.

Management that increases soil C in surface depths and maintains subsurface C is therefore a potential strategy to increase net C storage in soils (Johnson and Curtis, 2001). Restoration of grasslands has been found to increase C storage at rates of 0.3–6 t $ha^{-1}$ $yr^{-1}$ (Potter et al., 1999; Post and Kwon, 2000; Schuman et al., 2002), with positive association of time in grassland and SOC concentrations. Effects of grassland restoration on C cycling and storage is partially mediated by litter chemistry (Martens 2003), highlighting the importance of restoration species when considering C sequestration outcomes. Addition of C (e.g., mulch) to soils during restoration efforts can improve restoration success due to effects on soil N availability (i.e., nitrate and ammonium), with general net suppression of invasive weeds (Blumenthal et al., 2003).

**Figure 4.1.** Soil Pits Profile

These results do not address whether soils at the Bushy Lake site are net sinks or sources of C, because we did not measure fluxes (e.g., $CO_2$ emissions, SOC changes). Finally, these data address soil C storage, but not total C storage, for which above-ground measurements (e.g., biomass C) would be necessary.

Bulk densities for 0–5 in, 5–10 in, 10–25 in depths were 0.963 g $cm^{-3}$, 1.085 g $cm^{-3}$, 1.076 g $cm^{-3}$, as shown in Table 3-2, below; equivalents were calculated by a conversion factor from soil organic C of 3.667.

**Table 3-2. Estimated soil C stocks across 5 restoration plots at Bushy Lake.**

| *Plot* | Depth (in) | Organic C (t $ha^{-1}$) | Total organic C (t $ha^{-1}$) | $CO_2$ eq. (t $ha^{-1}$) |
|---|---|---|---|---|
| *1* | 0–5<br>5–10<br>10–25 | 20.1<br>9.2<br>22.1 | 51.5 | 188.8 |
| *2* | 0–5<br>5–10<br>10–25 | 15.5<br>7.7<br>14.8 | 37.9 | 139.1 |
| *3* | 0–5<br>5–10<br>10–25 | 20.9<br>10.3<br>20.1 | 51.3 | 188.3 |
| *4* | 0–5<br>5–10<br>10–25 | 19.3<br>11.0<br>29.5 | 59.9 | 219.5 |
| *5* | 0–5<br>5–10<br>10–25 | 17.7<br>14.3<br>21.7 | 53.7 | 197.0 |

***Abbreviations:*** *C, carbon; t, tons; ha, hectare; $CO_2$, carbon dioxide*

## Chapter 4 – California Rapid Assessment Method

The United States Environmental Protection Agency (USEPA) has proposed a three-tiered monitoring paradigm (Level 1-2-3) that provides a structured framework for conducting more integrated assessments of wetland resources across multiple scales (Solek et al., 2008; Stein et al., 2009). The California Rapid Assessment Method (CRAM) is a Level 2 Rapid Assessment method used to provide rapid and scientifically defensible data regarding a given wetland's conditions at the time of the assessment. This method has been approved by the California Water Quality Monitoring Council and has been subjected to the peer review process of the California State Water Resources Control Board and California Environmental Protection Agency (EcoAtlas, 2014). The "Water Quality Control Plan for Wetlands" clarifies the State Water Board's existing authority in protecting the beneficial uses of wetlands from pollution under both Porter Cologne and Section 401 certification of the Clean Water Act.

The framework of the CRAM is divided into three levels:

- Level 1 Landscape Assessment uses remote sensing data and field surveys to catalogue the wetlands of a region.
- Level 2 Rapid Assessment uses field diagnostics and existing data to assess conditions at wetland sites.
- Level 3 Intensive Site Assessment provides the field data necessary to validate the CRAM, characterizes reference condition, and tests hypotheses about the causes of wetland conditions as observed through Levels 1 and 2 using quantitative methods such as assessment of plant community composition and soils analysis. (EcoAtlas, 2014.)

This report does not include a thorough description of CRAM, which is available at: (www.cramwetlands.org), including information about its development, application, and implementation. It is important to this paper to emphasize that CRAM is an assessment method for wetland conditions; CRAM is not a wetland identification/delineation methodology or a wetland functional assessment methodology.

### *4.1 Bushy Lake CRAM Ambient Monitoring*

We used CRAM to evaluate the health of Bushy Lake's ecosystem and compare the site to other depressional wetlands in the Central Valley of California. CRAM is designed to be an efficient and cost-effective tool to assess the condition of a wetland ecosystem and the stressors that affect it (Stein et al., 2009). This methodology can be performed on scales ranging from an individual wetland to a watershed or larger region. Wetlands can also be evaluated to detect changes over periods of time. This information can then be used in planning wetland monitoring and restoration activities (EcoAtlas, 2014).

**Figure 5. Bushy Lake CRAM Assessment Area Map**


The CRAM module is focused on characterizing the following attributes for each wetland class:

1) Buffer and Landscape Context,
2) Hydrology,
3) Physical Structure, and
4) Biotic Structure.

Each CRAM module assesses these four attributes, although the metrics used in each module varies to address the class-specific relationships of a wetland. In each module, the CRAM “Index Score” is calculated as the average of the four attribute scores listed above. Interpreting the results of CRAM's application requires consideration of the attribute scores (or even metric scores in some applications). Indicators that make up the various sub-metrics of each attribute have been found to directly correlate to the overall condition of the ecosystem (Stein et al., 2009). Each attribute is totaled into a raw score; then, a final score is calculated for each attribute. The final Index Score for the assessment area is calculated from the average of the four final attribute scores (CWMW, 2013). The score points range between 30 and 94 and are comparable to all depressional wetlands scores in California's Central Valley.

### *4.2 CRAM Assessment Methodology*

Over the past three years, we have conducted three CRAM field evaluations (dated March 24, 2015; October 19, 2015; and May 26, 2016) using the Depressional Wetlands Module (Version 6.1, 2013). Initially, four assessment areas were selected due to the heterogeneous landscape resulting from the July 2014 fire; the two northern assessment areas were in the unburned area, and the two southern assessment areas were in the burned area. Assessment areas selected in October 2015 and May 2016 were on the northwest half of Bushy Lake. CRAM data will be used to establish a baseline condition to determine site changes over time. Dramatic changes have occurred in site conditions from 2014 to the present. A fire occurred in September 2016 after the May 2016 CRAM had been conducted, and we recommend evaluating the condition of the post-fire site condition using CRAM. We predict a reduced CRAM Index Score will result from the impact of the fire.

### *4.3 CRAM Results*

Index Scores summarize the information for the CRAM assessment; these numbers can be compared to all depressional wetlands throughout California. The numbers vary from 0–100, and we obtained scores in the average range. In March 2015, after the first fire, the Index Scores for the northern CRAM Index Scores averaged 67. In October 2015, after sheep grazed the site, the Index Score was 61. In July 2016, the Index Score was 70. Index Scores often are not as sensitive to changes over time as the Attribute and Metric Scores (see Table 4-1); however, a 3-point difference in score indicates some improvement in the site condition.

In 2014, during the first CRAM assessment with four assessment areas, the northern edges of the site had higher scores than the southern areas. A large fire burned the site, and CRAM score results varied within each of the four assessment areas and correlated to the extent to which each area was impacted by the fire. The southern side of the lake was more severely impacted from the fire than the northern side, resulting in lower CRAM scores. The northern assessment areas had the highest Index Scores.
Table 4-1 presents CRAM data from March 2015, October 2015, and October 2016, and compares Index Scores, Attribute Scores, and Metric Scores. We then explain and evaluate each metric.

**Table 4-1. Bushy Lake Summary Assessment – CRAM Index Scores**

| **Assessment Area** | | | | | | |
|---|---|---|---|---|---|---|
| **CRAM** | **2015 NW** | **2015 NE** | **2015 SW** | **2015 SE** | **2015 NW** | **2016 NW** |
| **Date** | **3/24/2015** | **3/24/2015** | **3/24/2015** | **3/24/2015** | **10/19/2015** | **7/1/2016** |
| Buffer and Landscape | 37.50 | 48.92 | 47.88 | 47.88 | 57.9 | 57.9 |
| Hydrology | 58.33 | 58.33 | 66.67 | 58.33 | 50 | **66.67** |
| Physical | 87.50 | 75.00 | 75.00 | 62.50 | 62.5 | **75** |
| Biotic | 91.96 | 77.78 | 63.85 | 55.56 | 75 | **80.56** |
| Score: | **69.00** | **65.00** | **63.00** | **59.00** | **61** | **70** |

**Table 4-2. Bushy Lake Summary Assessment – CRAM Attributes, Metrics, and Index Scores**

| **Assessment Area** | **2015 NW** | **2015 NE** | **2015 SW** | **2015 SE** | **2015 NW** | **2016 NW** |
|---|---|---|---|---|---|---|
| **Date** | **3/24/2015** | **3/24/2015** | **3/24/2015** | **3/24/2015** | **10/19/2015** | **7/1/2016** |
| **Buffer and Landscape** | **37.5** | **48.92** | **47.88** | **47.88** | **57.9** | **57.9** |
| Aquatic Area Abundance | D/3 | D/3 | D/3 | D/3 | C/6 | C/6 |
| A. Percent Buffer | A/12 | A/12 | A/12 | A/12 | A/12 | A/12 |
| B. Average Buffer Width | D/3 | D/3 | A/12 | A/12 | B/9 | B/9 |
| C. Buffer Condition | C/6 | B/9 | C/6 | C/6 | C/6 | C/6 |
| **Hydrology** | **58.33** | **58.33** | **66.67** | **58.33** | **50** | **66.67** |
| A. Water Source | C/6 | C/6 | C/6 | C/6 | C/6 | C/6 |
| B. Hydroperiod | B/9 | B/9 | B/9 | B/9 | B/9 | B/9 |
| C. Hydrologic Connectivity | C/6 | C/6 | B/9 | C/6 | D/3 | B/6 |
| **Physical Structure** | **87.50** | **75.00** | **75.00** | **62.50** | **62.5** | **75** |
| Structural Patch Richness | A/12 | B/9 | B/9 | B/9 | B/9 | B/9 |
| Topographic Complexity | B/9 | B/9 | B/9 | C/6 | C/6 | B/9 |
| **Biotic Structure** | **91.96** | **77.78** | **63.85** | **55.56** | **75** | **80.56** |
| A. Number of Plant Layers | A/12 | A/12 | B/9 | C/6 | A/9 | A/12 |
| B. # Co-Dominant Species | A/12 | C/6 | D/3 | D/3 | B/9 | A/12 |
| C. % Invasive Species | A/12 | B/9 | A/12 | A/12 | B/9 | B/9 |
| Horizontal Interspersion | B/9 | B/9 | B/9 | C/6 | B/9 | B/9 |
| Vertical Biotic Structure | B/9 | C/6 | C/6 | C/6 | B/9 | B/9 |
| **INDEX SCORE** | **69** | **65** | **63** | **59** | **61** | **70** |

## Attribute 1: Buffer and Landscape Context

### Aquatic Area Abundance

Aquatic area abundance is a measure of an assessment area’s spatial association with other aquatic resources; it measures the distance of the closest aquatic feature to the study site in the four cardinal compass directions (CWMW 2013, Version 6.1). This metric would increase if disturbed areas were restored, because areas connected to neighboring water features would be created, restored, and enhanced (see Table 4-2). This score may decline due to loss of riparian vegetation in this area in the 2016 fire.

Percent of Assessment Area with Buffer
The percent of assessment area with buffer metric assesses the overall quality and presence of the buffer (CWMW 2013, Version 6.1). All assessment areas are surrounded by cover types that provide 100% buffer. This metric score would not change with implementation of restoration alternatives.

Average Buffer Width
The average buffer width measures the ability of the buffer to serve as habitat for wildlife, to reduce the inputs of non-point source contaminants, to control erosion, and to protect the wetland from human activities (CWMW 2013, Version 6.1). This metric score is likely to decline due to the burning of riparian vegetation in the buffer area in September 2016.

Buffer Condition
The buffer condition assesses the extent and quality of plant cover, the overall condition of the substrate (soil disturbance), and the amount of human visitation (CWMW 2013, Version 6.1). Metric scores for buffer condition are likely to decrease after the fire, from burned vegetation, increasing invasive species, and increased soil erosion. This area would benefit from restoration and adaptive management.

**Attribute 2: Hydrology**

Water Source
The water source affects the extent, duration, and frequency of saturated or ponded conditions within an assessment area and assesses whether water inputs to the site are from natural or artificial sources (CWMW 2013, Version 6.1). This metric score is unlikely to change, because Bushy Lake's water source is groundwater pumping by Cal Expo.

Hydroperiod
The hydroperiod is the characteristic frequency and duration of inundation or saturation of a wetland during a typical year. Slope wetlands typically have a high degree of variation; this metric assesses the seasonal patterns of the water levels and how closely these levels correspond to natural inundation/drainage cycles (CWMW 2013, Version 6.1). This metric score is unlikely to change.

Hydrologic Connectivity
The hydrologic connectivity assesses water flowing into and out of the wetland and the wetland's ability to accommodate floodwaters (CWMW 2013, Version 6.1). This metric score is unlikely to change.

## Attribute 3: Physical Structure

Structural Patch Richness

The structural patch richness metric is a surrogate for determining potential habitat types for both terrestrial and aquatic species and is evaluated using 17 different patch types (CWMW 2013, Version 6.1). Scores for the structural patch richness metric are lower in disturbed assessment sites, and are likely to increase in disturbed areas with implementation of proposed restoration alternatives (see Table 4-2). The post-fire condition is expected to have lower scores for this metric.

Topographic Complexity

This metric refers to the micro- and macro-topographic relief and the variety of elevations within a wetland due to physical and abiotic features and elevation gradients that affect moisture gradients of that influence the path of flowing water (CWMW 2013, Version 6.1). This metric is unlikely to change, although it is hard to predict the topographical impacts of the recent fire over time.

## Attribute 4: Biotic Structure

Number of plant layers

The CRAM methodology for assessing biotic structure is composed of the number of plant layers, the number of co-dominant plant species, and the percentage of invasive species (CWMW 2013, Version 6.1). To be counted as a plant canopy layer (floating/canopy forming, short, medium, tall, and very tall), the layer must cover at least 5% of the assessment area and include only those plants within the prescribed range of plant heights. A larger number of plant layers is important for maintaining habitat complexity and preventing encroachment of invasive species. Scores for the metrics vegetation and number of plant layers are very high for the referenced assessment areas. Bushy Lake has very high scores and five layers of vegetation. This score was affected by grazing, which reduced vertical stratification and invasive species. The post-fire condition is expected to have lower scores for this metric.

Number of co-dominant species

Once a layer has been determined, the co-dominant plant species represent at least 10% relative cover of the assessment area (CWMW 2013, Version 6.1). The total numbers of co-dominant species are summed from each plant layer, and are counted only once. The scores for the metric number of co-dominant plant species are very good to high, with a lot of diversity on the site. The post-fire condition is expected to have lower scores for this metric.

Percent invasion

The percent invasion metric is a calculation of the percentage of invasive plant species among the dominant plant species for all layers of plants in the assessment area (CWMW 2013, Version 6.1). The invasive status for many California wetland and riparian plant species is based on the Cal-IPC list. At the time of sampling, the site had relatively good scores. Poison hemlock (*Conium maculatum*) is the invasive species in the riparian wetlands surrounding Bushy Lake that presents the greatest cause for concern. Fire tends to provide nitrogen fertilization and stimulate invasive species, giving them a competitive advantage over native species. The post-fire condition is expected to lower scores for this metric.

Horizontal Interspersion

Horizontal interspersion refers to the variety and interspersion of plant “zones,” patches of monocultures, or obvious multi-species associations that are arrayed along gradients of elevation, moisture, or other environmental factors that seem to affect the plant community organization in a two-dimensional plan view. Interspersion is essentially a measure of the number of distinct plant zones or “communities AND the amount of edge between them” (CWMW 2013, Version 6.1). The presence of a high degree of interspersion means there are more distinct plant zones with overlap between them, which results in more habitat niches. The metric for horizontal interspersion is lower in disturbed assessment areas, and is likely to improve with implementation of restoration (see Table 4-2). The post-fire condition is expected to lower scores for this metric.

## Conclusion and Recommendations

CRAM will provide an interesting tool to monitor site conditions. In 2015, the area was recovering from a fire, and in 2017, it will be again. CRAM provides us a tool to measure fire resiliency and create adaptive management tools.

## **Chapter 5 – Biological Resources** – by Kayla Henry and Michelle Stevens

### *5.0 Introduction*

The fire severely damaged biotic structure throughout the site, which presented an opportunity for monitoring and adaptive management beginning with the restoration of understory native plants including creeping wild rye (*Elymus triticoides*) and Santa Barbara sedge (*Carex barbarae*). Dominant plant species recovering at Bushy Lake after the burn included walnut (*Juglans californica*), sandbar willow (*Salix exigua*), arroyo willow (*Salix lasiolepis*), Goodding's willow (*Salix gooddingii*), box elder (*Acer negundo*), Oregon ash (*Fraxinus latifolia*), Fremont's cottonwood (*Populus fremontii*) and non-native elm (*Ulmus species*). Shrubs included elderberry (*Sambucus Mexicana*), coyote brush (*Baccharis pilularis*), Himalayan blackberry (*Rubus armeniacus*), California blackberry (*Rubus ursinus*), and California grape (*Vitis californica*). The elderberry (*Sambucus Mexicana*) is especially important as part of the area is designated for the Valley Elderberry Longhorn beetle (*Desmocerus californicus* dimorphus) species. Dominant understory species colonizing the site included creeping wild rye (*Elymus triticoides*), Santa Barbara sedge (*Carex barbarae*), and mugwort (*Artemisia douglasiana*) (Table A-1).

### *5.1 Project Goal*

The goal of the project is to collect baseline data for the proposed restoration project by correlating CRAM data to avian species richness. We will use CRAM to assess avian habitat availability at the Bushy Lake restoration site and illustrate the significant impact this restoration project will have on bird populations that are native to the Sacramento region and on other bird species that use the Parkway during migrations. These data can be used to establish a citizen-science avian monitoring protocol with CSU Sacramento students.

When monitoring the success of restoration efforts, it is important to consider the recolonization of both animal communities and vegetation. Vegetation is often the only aspect considered when monitoring post-restoration sites, and it is assumed that once vegetation has recolonized, animal populations will follow (Golet 2008). The goal of this project is to gather baseline data for the restoration project by collecting CRAM data and validating that data by conducting bird surveys and quantitative vegetation sampling to gain further insight into habitat conditions and overall health of the ecosystem. This baseline data will be used to establish citizen-science programs to help conduct long-term Project monitoring and recommend habitat management practices.

### *5.2 Bird Habitat at Bushy Lake*

Historically, Bushy Lake has provided vital habitat for a variety of birds and is a popular birding location (Audubon Society). Resident species observed during sampling were two pairs of wood ducks (*Aix sponsa*) and a pair of Great horned owls (*Bubo virginianus*). Birds are more easily observed than other wildlife and respond quickly to changes in their environment; therefore, they are ideal candidates on which to base measurement of ecosystem improvement during the Project and post-restoration monitoring (Young et al., 2013). Furthermore, in the absence of a specific indicator species, bird monitoring can be used to gauge overall ecosystem success (Young et al., 2013).

### *5.3 Wildlife Sighted while Monitoring at Bushy Lake*

In addition to being an Audubon Society hot spot, Bushy Lake provides habitat for a variety of other animals that were also observed during sampling.

*5.3.1* - Western Pond Turtle (*Actinemys marmorata*)

- Relies on a permanent water source with floating woody vegetation and muddy banks for basking (California Wildlife Habitat Relationships System, California Department of Fish and Wildlife, California Interagency Wildlife Task Group).
- Although able to migrate overland for short distances, its range is generally restricted, making Bushy Lake ideal habitat for when water is available.
- Has suffered a 99% decline in some areas, and is listed as a species of special concern in California. Although this species is not yet recognized as federally endangered in California, its status is currently under review (Center for Biological Diversity, 2015).

*5.3.2* - North American River Otter *(Lontra Canadensis)*

- Keystone carnivore and another Bushy Lake resident that requires a permanent water source; however, there is little information about their status and range in California.
- Unlike the western pond turtle, river otters can travel large distances in search of food, mates, or suitable living areas (Bouly et al., 2015).

*5.3.3* - Elderberry *(Sambucus Mexicana)*

- Spouting and growing prolifically through the study area. Lengthy spring rains and nutrient supplements from ash have resulted in rapid re-growth.
- Provides habitat for the valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), a threatened species fully protected under the federal Endangered Species Act of 1973.
- Looked for but did not observe any exit holes and recommend monitoring next year.

*5.3.4* - Nesting Red-Tailed Hawks (*Buteo jamaicensis*)

- Observed on the west side of Bushy Lake

*5.3.5* – Willow Flycatcher (*Empidonax trailii*)

- We observed one species of flycatcher in the southwest assessment area. Although we were unable to identify the exact species, there is an endangered species of flycatcher that migrates through the Sacramento region in the spring. The endangered willow flycatcher (*Empidonax trailii*) shows a nearly exclusive preference for areas with riparian cover (Sedgwick & Knopf, 1992).

    - This species is listed as level S1 endangered by ESA (CNDDB, 2015), meaning that it is considered critically imperiled in California and is in steep decline (CNDDB, 2015).
- Bushy Lake meets the habitat requirements for this bird and would be a potential refuge if water levels were maintained.

### *5.4 Methods for Avian Sampling*

#### *5.4.1 Point Bird Count*

We utilized the point bird count method to validate avian habitat characterized by the CRAM attributes physical structure and biotic structure (Huff et al., 2000). A point count was conducted within each site for a duration of 15 minutes beginning at approximately 7:30 am on March 25, 2015. An additional point count was conducted on the evening of April 13, 2015 beginning at approximately 5:00 pm. Sampling occurred within four predetermined assessment areas (northeast, northwest, southeast, and southwest) measuring 100m in length. The point count method tallies all birds detected visually and audibly from a fixed station in a specified time (Huff et al., 2000). Observed birds were listed in two categories: from 0 to 50m distant or as flyovers of the habitat.

We tallied numbers of each bird sighted or heard within the 15-minute observation period. A two-minute waiting period was allotted prior to sampling to allow remaining birds to acclimate to the presence of the observers (Huff et al., *2*000). Once the timed observations were complete, attempts were made to further observe and identify any species in question. “Typical detection” is defined by birds observed 0–50 m from the observer(s) from the ground and to canopy layer (Hostetler & Main, 2015). “Fly-overs” are defined as birds observed above the canopy that might or might not be associated with the habitat (Hostetler & Main, 2015). Best professional judgment was used to decide whether these were associated or independent sightings. In addition to bird counts, we used data from the Audubon Society’s annual bird counts and Ebird to determine which species are common to the Sacramento region, natives, and migrants.

### *5.5 Avian Biodiversity*

#### *5.5.1 Avian Species and Breeding Evidence at Bushy Lake*

The goal of these surveys was to compile a comprehensive species list of birds utilizing the Bushy Lake habitat, with emphasis placed on evidence of confirmed breeding birds in the area. Nests, birds sighted carrying nest material, birds carrying food, and fledgling sightings are all signs of confirmed breeding. These observations will help to illustrate the importance of this habitat for a variety of avian species as well as provide educational opportunities for students and the public.

Point counts were conducted at five locations for a 15-minute duration beginning at approximately 7:30 am on March 24, April 4, and May 18, 2016, as described above. A total of 44 species were recorded. Breeding was confirmed for the tree swallow, spotted towhee, wood duck, common mallard, and song sparrow. Possible breeders include downy woodpecker, black-headed grosbeak, and house finch, mourning dove, Eurasian-collared dove, northern mockingbird, Bewick's wren, house wren, ruby-crowned kinglet, and red-winged blackbird. Possible breeders were observed singing, in pairs, or utilizing a potential nest cavity without further breeding proof such as carrying nest material, carrying food, utilizing a nest, or sighted with fledglings.

Standing snags are ideal habitat to support woodpecker species, and in turn, create habitat for secondary cavity nesters. A group of tree swallows was observed beginning to colonize cavities within point 5. Tree swallows rely heavily on abandoned cavities excavated by woodpeckers. They prefer trees near water that afford them with a healthy diet of flying insects, which Bushy Lake provides (Robertson et al.).

Western bluebirds, house wrens, northern flickers, and European starlings are also possible breeders that utilize nest cavities; these species were detected during the survey, and although breeding was not confirmed, woodpeckers and standing snags have helped provide valuable nesting sites for these birds. Dead trees are a vital part of the Bushy Lake habitat in combination with the lake itself, and surrounding open grassland.

Western bluebirds prefer the edges of woodland areas and thrive in disturbed habitats that contain standing dead trees, which offer suitable nesting sites (Guinan et al., 2008). Spotted towhees prefer dense thickets of vegetation with plenty of leaf litter to forage in. They build their nests hidden in shrubs close to the ground or on the ground itself (Bartos et al., 2015). Bushy Lake provides ideal habitat for these birds, as well. Several individuals were observed carrying nest material and exhibiting agitated behavior, which could indicate nest guarding.

Black-headed grosbeaks are another species that prefers habitats containing a dense understory of vegetation. They also favor sites close to water, and build their nests concealed in trees or shrubs (Batos & Greenlaw, 2015). A pair was observed during a survey, but no further breeding evidence was documented.

Wood ducks with young were observed at the site and are one of Bushy Lake's most striking and charismatic residents. They nest in cavities near marshes or ponds and prefer a thick cover of vegetation. Woodpecker cavities are often not used because they are not large enough. Instead, they use trees in which branches have broken off causing the wood to rot, creating a cavity (Hepp & Bellwood, 1995). Fremont's cottonwood (*Populus Fremontii*) found at Bushy Lake creates perfect sites for nesting.

Bushy Lake is a rich wetland habitat containing an understory, including beardless wild rye (*Elymus triticoides*) and Santa Barbara sedge (*Carex barbarae*); dense shrubs, including elderberry (*Sambucus Mexicana*), coyote brush (*Baccharis pilularis*), California blackberry (*Rubus ursinus*), and California grape (*Vitis californica*); and a variety of trees, including sandbar willow (*Salix exigua*), arroyo willow (*Salix lasiolepis*), Goodding's willow (*Salix gooddingii*), box elder (*Acer negundo*), and Fremont's cottonwood (*Populus fremontii*) (Stevens 2015). This, in addition to supplying water, provides an array of habitat for a variety of birds, from residents to migrants and from nesting to foraging activity.

**Table 5-1. 2016 Point 1 Avian Observations with Best Breeding Evidence Noted**

| Date | Point # | Start Time | Species | Number Detected | Sex/Age (M, F, J,U ) | Best Breeding Evidence |
|---|---|---|---|---|---|---|
| 3/26/2016 | 1 | 7:52 | American Robin | 2 | U | |
| | | | House Wren | 3 | M | Singing |
| | | | Ruby-crowned Kinglet | 2 | M | Singing |
| | | | Yellow-rumped Warbler | 2 | M | |
| | | | Canada Goose | 3 | U | |
| | | | Song Sparrow | 1 | U | |
| 4/4/2016 | 1 | 7:30 | Song Sparrow | 2 | M | Singing |
| | | | European Starling | 1 | U | |
| | | | Tree Swallow | 10 | U | |
| | | | House Finch | 1 | M | Singing |
| | | | Brewer's Blackbird | 5 | U | |
| | | | Spotted Towhee | 2 | U | Carrying nest material |
| | | | Anna's Hummingbird | 1 | M | |
| | | | California Quail | 1 | M | Singing |
| 5/18/2016 | 1 | 7:30 | Song Sparrow | 2 | M | Singing |
| | | | Spotted Towhee | 1 | M | |
| | | | Mourning Dove | 2 | U | |
| | | | Anna's Hummingbird | 1 | M | |
| | | | Tree Swallow | 6 | U | |
| | | | Western Scrub Jay | 1 | U | |
| | | | Lesser Gold Finch | 1 | M | Singing |
| | | | Pacific-slope Flycatcher | 1 | U | |

**Table 5-2. 2016 Point 2 Avian Observations with Best Breeding Evidence Noted**

| Date | Point | Start Time | Species | Number Detected | Sex/Age (M, F, J, U) | Best Breeding Evidence |
|---|---|---|---|---|---|---|
| 3/26/2016 | 2 | 8:32 | Anna's Hummingbird | 1 | U | |
| | | | Tree Swallow | 3 | U | |
| | | | Downy Woodpecker | 1 | M | |
| | | | Western Scrub Jay | 1 | U | |
| | | | European Starling | 1 | U | |
| | | | Northern Flicker | 1 | U | |
| | | | California Towhee | 1 | U | |
| | | | Canada Goose | 3 | U | |
| | | | Nuttall's Woodpecker | 1 | U | |
| | | | House Sparrow | 1 | U | |
| | | | Oak titmouse | 1 | U | |
| | | | Song Sparrow | 1 | M | Singing |

| Date | Point | Start Time | Species | Number Detected | Sex/Age (M, F, J, U) | Best Breeding Evidence |
|---|---|---|---|---|---|---|
| 4/4/2016 | 2 | 7:50 | House Wren | 1 | M | Singing |
| | | | Brewer's Blackbird | 2 | U | |
| | | | Wood Duck | 1 | F | |
| | | | Song Sparrow | 1 | M | Singing |
| | | | Western Kingbird | 1 | U | |
| | | | Red -shouldered Hawk | 1 | U | |
| | | | Mourning Dove | 2 | U | |
| 5/18/2016 | 2 | 7:50 | Spotted Towhee | 1 | U | |
| | | | House Sparrow | 3 | U | |
| | | | Song Sparrow | 2 | U | Carrying nest material |
| | | | Wilson's Warbler | 1 | M | |
| | | | House Wren | 1 | M | Singing |
| | | | Red-tailed Hawk | 1 | U | |

**Table 5-3. 2016 Point 3 Avian Observations with Best Breeding Evidence Noted**

| Date | Point | Start Time | Species | Number Detected | Sex/Age (M, F, J, U) | Best Breeding Evidence |
|---|---|---|---|---|---|---|
| 3/26/2016 | 3 | 8:50 | Canada Goose | 9 | U | |
| | | | Tree Swallow | 2 | U | |
| | | | Song Sparrow | 1 | U | Singing |
| | | | American Coot | 2 | U | |
| | | | Nuttall's Woodpecker | 1 | U | Possible nest |
| | | | House Wren | 2 | U | Possible pair |
| 4/4/2016 | 3 | 8:23 | Song Sparrow | 1 | M | Singing |
| | | | Red-winged Blackbird | 1 | M | Singing |
| | | | Tree Swallow | 10 | U | Singing |
| | | | Bewick's Wren | 1 | U | Singing |
| 5/18/2016 | 3 | 8:10 | Belted-kingfisher | 1 | F | |
| | | | Canada Goose | 2 | U | |
| | | | Mallard | 1 | M | Pair |
| | | | Mallard | 1 | F | Pair |
| | | | American Coot | 1 | U | |
| | | | Wood Duck | 1 | M | Pair with young |
| | | | Wood Duck | 1 | F | Pair with young |
| | | | Wood Duck | 5 | J | |
| | | | Spotted Towhee | 1 | U | |
| | | | House Wren | 2 | M | Singing |
| | | | Red-winged Blackbird | 1 | M | Singing |
| | | | Anna's Hummingbird | 1 | U | |
| | | | Wood Duck | 1 | M | Fledglings |
| | | | Wood Duck | 1 | F | Fledglings |

| Date | Point | Start Time | Species | Number Detected | Sex/Age (M, F, J, U) | Best Breeding Evidence |
|---|---|---|---|---|---|---|
| | | | Wood Duck | 8 | J | |
| | | | Tree Swallow | 1 | U | |
| | | | Mourning Dove | 2 | U | Possible pair |

**Table 5-4. 2016 Point 4 Avian Observations with Best Breeding Evidence Noted**

| Date | Point | Start Time | Species | Number Detected | Sex/Age (M, F, J, U) | Best Breeding Evidence |
|---|---|---|---|---|---|---|
| 3/26/2016 | 4 | | American Robin | 2 | U | |
| | | | Tree Swallow | 3 | U | Possible nest |
| | | | Northern Flicker | 2 | U | |
| | | | Western Scrub Jay | 1 | U | |
| | | | Lesser Gold Finch | 2 | M | |
| | | | Lesser Gold Finch | 1 | F | |
| | | | Mallard | 1 | M | |
| | | | House Finch | 1 | M | Singing |
| | | | Nuttal's Woodpecker | 1 | M | |
| | | | Mourning Dove | 2 | U | Possible pair |
| | | | Eurasian Collared-dove | 4 | U | |
| 4/4/2016 | 3 | 8:23 | Song Sparrow | 1 | M | Singing |
| | | | Red-winged Blackbird | 1 | M | Singing |
| | | | Tree Swallow | 10 | U | Singing |
| | | | Bewick's Wren | 1 | U | Singing |
| 5/26/2016 | 3 | 8:10 | Belted-kingfisher | 1 | F | |
| | | | Canada Goose | 2 | U | |
| | | | Mallard | 1 | M | Pair |
| | | | Common Mallard | 1 | F | Pair |
| | | | American Coot | 1 | U | |
| | | | Wood Duck | 1 | M | Fledglings |
| | | | Wood Duck | 1 | F | Fledglings |
| | | | Wood Duck | 5 | J | |
| | | | Spotted Towhee | 1 | U | |
| | | | House Wren | 2 | M | Singing |
| | | | Red-winged Blackbird | 1 | M | Singing |
| | | | Anna's Hummingbird | 1 | U | |
| | | | Wood Duck | 1 | M | Fledglings |
| | | | Wood Duck | 1 | F | Fledglings |
| | | | Wood Duck | 8 | J | |
| | | | Tree Swallow | 1 | U | |
| | | | Mourning Dove | 2 | U | Possible pair |

**Table 5-5. 2016 Point 5 Avian Observations with Best Breeding Evidence Noted**

| Date | Point | Start Time | Species | Number Detected | Sex/Age (M, F, J, U) | Best Breeding Evidence |
|---|---|---|---|---|---|---|
| 3/26/2016 | 5 | 9:51 | Wood Duck | 1 | M | |
| | | | Hummingbird sp. | 2 | U | |
| | | | Spotted Towhee | 2 | U | Carrying nest material |
| | | | Tree Swallow | 9 | U | Possible nests |
| | | | House Wren | 2 | M | Singing |
| | | | Mallard | 1 | F | |
| | | | Northern Flicker | 1 | U | |
| | | | American Robin | 1 | U | |
| | | | Yellow-rumped Warbler | 3 | M | |
| | | | Mourning Dove | 1 | M | Singing |
| | | | Mallard | 3 | | |
| 4/4/2016 | 5 | 9:06 | Wild Turkey | 2 | M | |
| | | | Wild Turkey | 2 | F | |
| | | | Western Scrub Jay | 2 | U | |
| | | | Spotted Towhee | 2 | U | Possible pair |
| | | | Mourning Dove | 2 | U | Possible pair |
| | | | Brewer's Blackbird | 1 | U | |
| | | | Tree Swallow | 6 | U | |
| | | | California Quail | 1 | U | |
| | | | Anna's Hummingbird | 1 | M | |
| | | | Eurasian Collared-dove | 5 | U | |
| | | | Nuttal's Woodpecker | 1 | F | Possible nest |
| | | | Yellow-rumped Warbler | 3 | M | |
| | | | Mourning Dove | 1 | M | Singing |
| | | | Wild Turkey | 3 | F | |
| | | | Wild Turkey | 1 | M | |
| | 5 | 9:08 | Spotted Towhee | 2 | M | |
| | | | Spotted Towhee | 1 | U | |
| | | | Mourning Dove | 1 | U | |
| | | | Red-winged Blackbird | 1 | M | Singing |
| | | | Nuttal's Woodpecker | 1 | M | |
| | | | Black-crowned Night Heron | 1 | U | |
| | | | House Wren | 1 | M | Singing |

# Chapter 6. Riparian Restoration Experiment

Riparian habitats along the American River provide essential habitat for regional flora and fauna; however, these areas are subject to frequent and unpredictable disturbance from wildfires. The primary goals of these experiments are to test cost-effective resilient restoration and adaptive management strategies for riparian restoration. We are creating habitat islands of native species to recruit and expand spatially and temporally in the area. Two dominant riparian understory species in the nearby Sacramento-San Joaquin Delta with drought-tolerant and fire-resilient characteristics are tested to restore riparian understory at Bushy Lake.

In 2015, our first experiments compared survival and relative cover between Santa Barbara sedge (*Carex barbarae*) and creeping wild rye (*Elymus triticoides*) treatments, using two planting densities and three species compositions to find the most efficient treatment for restoration. We found that low-density plantings were more cost-effective and less time-intensive than high-density plantings. We also found that creeping wild rye outcompeted Santa Barbara sedge when planted together, so in the next experiment we planted monotypic plots. In 2016, we based the second experiments on the results from 2015. We found that inter-planting under native umbrella plants facilitated higher rates of survival and increased production in contrast to herbicide treatment. Experimental design, methods, results, and recommendations are included in this chapter of the report.

The project goals include increasing resiliency to fire and expanding restoration and enhancement of riparian habitat around Bushy Lake, removal of invasive species, to provide wildlife habitat, and encourage citizen science and environmental education along the lower American River, and specifically Bushy Lake. Project goals are designed to implement the Cal Expo Area Plan Policies in the American River Parkway Plan (County of Sacramento et al., 2008).

## *6.1 Native Fire-Resistant and Drought-Tolerant Plant Species*

Enhancing the resiliency of riparian ecosystems to adapt to disturbance and climate change is a priority among restoration scientists. Increasing intensity and frequency of wildfires on the lower Parkway riparian corridors creates an opportunity to design a fire-resilient landscape. Riparian ecosystems are naturally resilient, provide linear habitat connectivity, link aquatic and terrestrial ecosystems, and create thermal refugia for wildlife, all characteristics that can contribute to ecological adaptation to climate change. Because riparian systems and the projected impacts of climate change are highly variable geographically, there is a pressing need to develop a place-based understanding of climate change threats to riparian ecosystems (Seavy et al., 2016).

The Bushy Lake project was initiated after a large stand-replacing fire in 2014. In September 2016, a second wildfire occurred in the project area. To ensure that Bushy Lake restoration and management efforts are sustainable, and to provide long-term habitat resources for wildlife, the area needs to be resilient to disturbances and capable of regenerating. Encouraging and planting native fire-resistant and drought-tolerant plant species, such as *Carex barbarae* and *Elymus triticoides*, in the Bushy Lake area provides a resilient landscape.

What are mechanisms for fire resiliency? What are ecological models of fire resilience?

1) Co-evolution with fire through indigenous traditional resource management;
2) Re-sprouting from below- ground biomass and prolific rhizome production;
3) Structure of canopy resists damage; habitat patches persist and recover rapidly;
4) Accumulation of senescent vegetation reduces temperature of burning point;
5) Annual seed production after fire; and
6) Other long-term and competitive adaptations of the plant to survive.

Both Santa Barbara sedge and creeping wild rye co-evolved with fire via indigenous traditional resource fire management and have prolific below-ground rhizome production. This allows the plants to regenerate from below-ground roots and rhizomes.

Emergent native aquatic species such as cattail and bulrush are present around the edge of the lake while native woody species are re-sprouting in the upland ecotone. Drought-tolerant and fire-resistant understory plant species such as Santa Barbara sedge (*Carex barbarae*), creeping wild rye (*Elymus triticoides*), mugwort (*Artemisia douglasiana*), native blackberry (*Rubus ursinus*), and California native grape (*Vitis californica*) were re-colonizing the site in patches after the 2014 fire. These species propagate naturally from belowground rhizomes and once established are very resilient to fire. Santa Barbara sedge can produce as many as 100 rhizomes in one growing season, is very environmentally plastic and resistant to both flooding and drought, and is an excellent species for natural restoration process (Stevens 1999). Native riparian vegetation provides wildlife nesting habitats, food for birds and insects, nectar production for birds and insects, and soil stabilization (Stevens 2004b; Stevens 2006; Young-Matthews and Winslow, 2005). Perennial plant species like *Carex barbarae* and *Elymus triticoides* provide erosion control due to extensive rhizome and perennial root formation (CNPS, 2014). They also increase carbon sequestration in soils.

Observations of natural recruitment and ecological succession of native plant species after fire provided us the plant palate for experiments designed to create fire-resilient landscapes based on plant resiliency and tolerance of fire, which helps determine the plants most suitable for restoration (Brooker et al., 2008). These patches of native plants that persist after fire provide an onsite micro-reference template for restoration design the theory behind initiating restoration experiments with *Carex barbarae* and *Elymus triticoides* was that we could get active recruitment and rapid colonization of native species advantageous for wildlife habitat with an open physiognomy to invite public education and recreation. After the 2016 fire, birds and other wildlife species concentrated in our restoration area, taking refuge where native grasses and shrubs provided food and shelter in a desolate, blackened landscape. We are continuing monitoring ecosystem health, wildlife use of the site, and species health and composition over time. Long-term monitoring will help us predict the trajectory of the plot in the presence of invasive species. Monitoring data also forms the basis for effective adaptive management.

This chapter is organized by 2015 Experiment A measuring species density and composition. In 2016, we created Experiment B comparing the differences between herbicide treatment and umbrella plant or facilitation inter-planting treatment.

*6.2 Restoration Experiment A – Design and Implementation.*
We established Experiment A near Bushy Lake on January 24, 2015, with help from volunteers of the American River Parkway Foundation. We planted two native riparian understory species: *Carex barbarae* (CaBa) and *Elymus triticoides* (ElTr) plugs in areas where invasive species have encroached. The experiment tests the effect of density and species composition on the survival and absolute cover of CaBa and ElTr and on the interaction between the plant density and species. The study can be used to determine:

1) If there is a significant difference in plant survival between plant treatments (CaBa, ElTr, Mixed – CaBa and ElTr);
2) If there is a significant difference in high-density (HD) plantings vs. low-density (LD) plantings.

The experimental design consisted of a randomized complete block design with five replicate blocks. The block locations (experiment sites) were chosen non-randomly in open, flat areas, under low to moderate tree cover, dominated by non-native understory vegetation. Plots were selected where native plants were not colonizing and natural process restoration was not occurring.

Within each block (13ft by 8.5ft), six plots (4ft by 4ft) were randomly assigned to two treatments of planting density—high-density (HD – 36 species) and low-density (LD – 16 species)—and three plant mixtures for species composition—monotypic stands of CaBa, monotypic stands of ElTr, and a heterogeneous mixture of both species (Mixed) (Figure 6). Six-inch gaps were set between each plot to allow a buffer and clear separation between plots. Approximately two feet of buffer were created outside of the block to remove any non-experimental plants from confounding the experiment.

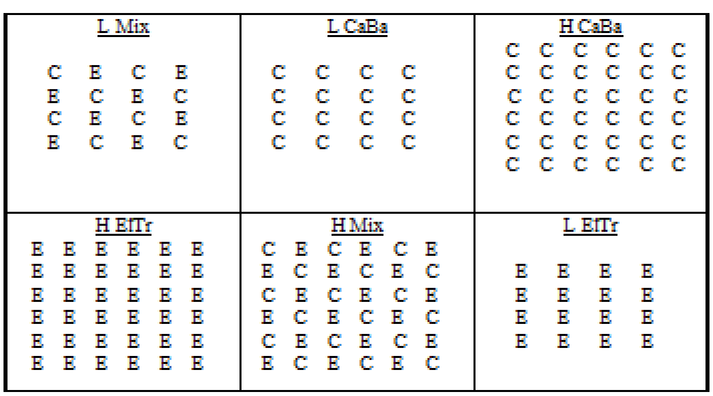



**Figure 6.** Experimental Block Design demonstrating how one of the block looks like with six randomized treatments. Low-density has 16 plants, high-density has 36 plants, C = *Carex barbarae,* E = *Elymus triticoides*, M = mix of C + E

Prior to the experiment set-up in January 2015, invasive species included poison hemlock (*Conium maculatum*), winter vetch (*Vicea villosa*), tall whitetop (*Lepidium latifolium*) and annual grasses. Hand weeding all blocks created homogeneous conditions for each experimental treatment. CaBa and ElTr plugs (Ecotype: Yolo Bypass, Yolo Co) were purchased from Hedgerow Farms (Winters, CA). Plugs were planted in a grid pattern of either 12 inches on center or 8 inches on center with each hole planted with one plug of either the CaBa or ElTr (Figure 6). Fertilizer and mycorrhizal inoculum (E.B. Stone Organics Sure Start 4-6-2) was sprinkled in and around each planting hole and sealed by pinching the top of the soil with fingers.

### *6.3 Experiment A – Monitoring and Adaptive Management.*

Each plot and buffer zone was weeded after the third week to ensure that non-experimental plants would not impede the experimental plants from establishing. Plant survival was recorded on a weekly basis. Extensive weeding in and outside the plots and creation of a clear trail to the back plots by lopping away invasive species such as poison hemlock (*Conium maculatum*), Himalayan blackberry (*Rubus armeniacus*), and black mustard (*Brassica nigra*) began on May 8, 2015, with help from CSUS Environmental Studies students and community volunteers. Spring rains allowed us to delay supplemental watering until week 19 and 20. Plots were watered every other week starting June 16, 2015, as plant survival began to decline drastically with hotter weather. Water was brought to the area by a large tank on a truck and hand-watered with buckets. Due to the difficulty of watering, each plot was mulched on June 26, 2015. Watering and mulch treatments were essential to keeping the plants alive. The mulch will also increase soil organic matter, increase soil moisture holding capacity, and help store carbon in the soil.

### *6.4 Experiment A Results and Discussion*

Results and discussion of plant and density treatments are evaluated in three sections: 1) plant survival, 2) absolute cover, and 3) June 2015 percent cover using two-way ANOVA for statistical analysis.

#### *6.4.1 Monitoring Plant Survival over Time (Weekly Basis)*

Time series charts were generated to show the plant survival throughout the first seven months of monitoring on a weekly basis (Figure 7). Monitoring of plant survival ended after Week 30 due to CaBa being grazed, while percent cover data was collected at the end of the experiment. These results did not indicate the density or cover of experimental treatments. The survival rate of all plant treatments were moderately high with all average percentage either equal to or more than 86% (Figure 8). The percent survival could change since some plants either re-sprouted from their roots or simply needed watering. Although aboveground biomass appeared brown and dead, green shoots emerged from the roots, indicating that there was belowground biomass, and roots could form new growth. Monotypic stands of white root (CaBa) treatments had an 89.0% survival, and monotypic stands of creeping wild rye (ElTr) treatments had an 88 to 95.25% survival. The Mixed treatment had an 86% survival (Figure 8).

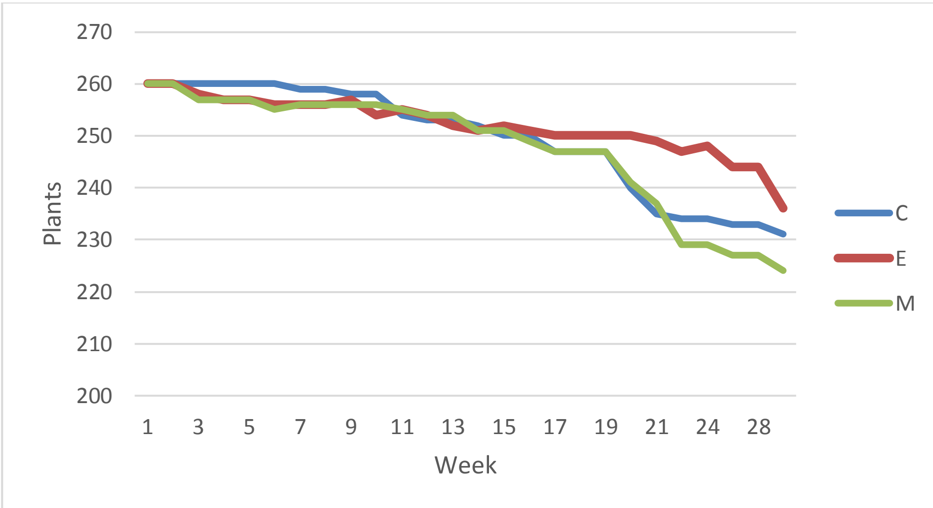



**Figure 7**. Weekly plant survival for each treatment over the period of 30 weeks. C = *Carex barbarae*, E = *Elymus triticoides*, M = mix of C + E

Observations of the experiment showed that both plant species had similar average percent survival; although ElTr species in the LD group had a 96.25% survival. Through observation, ElTr had more aboveground biomass than CaBa species both in its monotypic treatment and Mixed treatment. The percent cover for Mixed and CaBa groups were similar while most of the percent cover from the Mixed group were from ElTr. Density treatment for monotypic stands of CaBa was similar with 89% CaBa survival, and the density between the LD and HD for the Mixed were also similar with 86% plant survival (Figure 8).

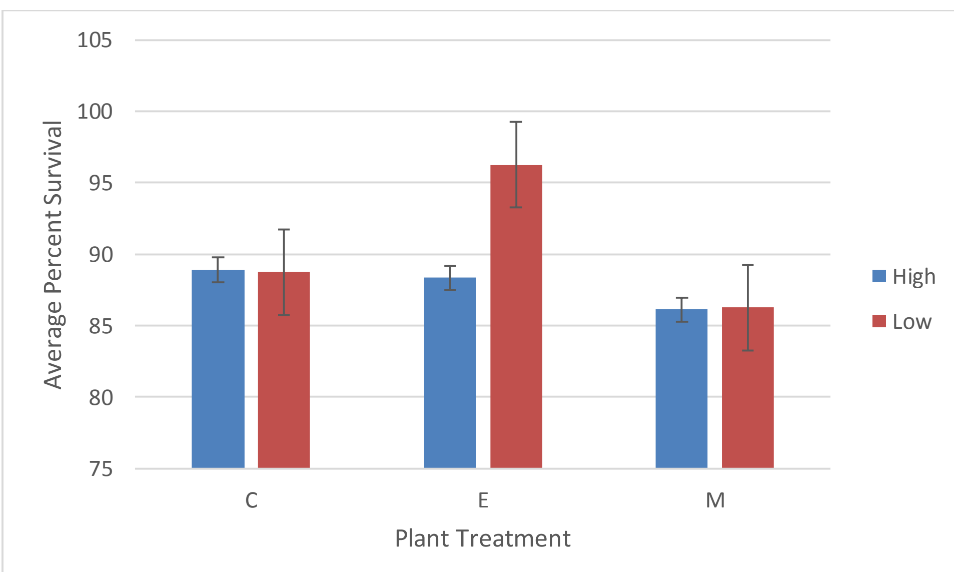



**Figure 8**. Absolute average percent survival of plant treatments and densities for Week 30. C = *Carex barbarae*, E = *Elymus triticoides*, M = mix of Carex and Elymus. + E. *High or Blue* = high density with 36 plants, *Low or Red* = low density with 16 plants

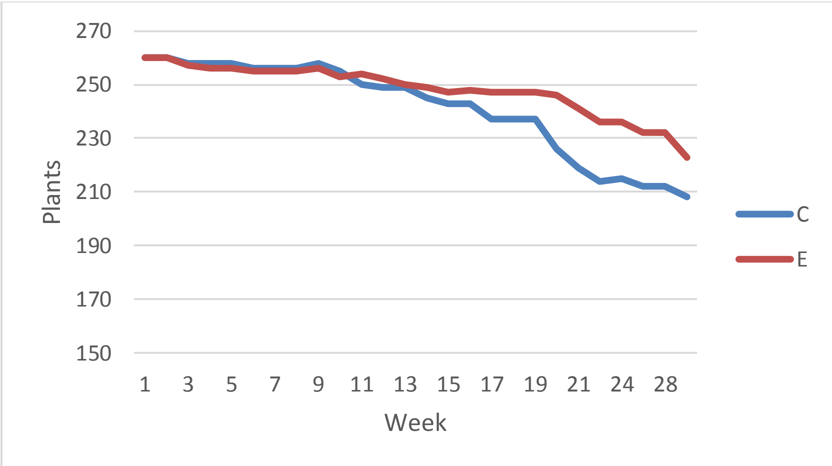



**Figure 9.** Plant survival of C versus E species over the period of 30 weeks. C = *Carex barbarae*, E = *Elymus triticoides*

A comparison of the mortality rate between CaBa and ElTr showed that CaBa had an 80.0% survival while ElTr had an 85.77 % survival (Figure 10). The results for the plant species' percent survival support the plant treatment data set as it indicated that ElTr had a higher percent survival than CaBa.

### *6.4.2 Absolute Cover by Density and Plant Species*

The absolute cover was analyzed on June 8, 2016. The high-density (HD) ElTr treatment had a 70% cover, HD Mixed treatment with 68% cover, and HD CaBa with a 36% cover respectively (Figure 10). Absolute cover for low density (LD) ElTr was slightly lower with a 68% cover while the absolute cover for LD CaBa and Mixed treatments were 75% and 81% respectively (Figure 10). Although CaBa were grazed to the ground surface in October 2015, most of those plant roots were still intact underground. Along with the rain during the 2016 spring months, this had allow for the CaBa plants to grow back.

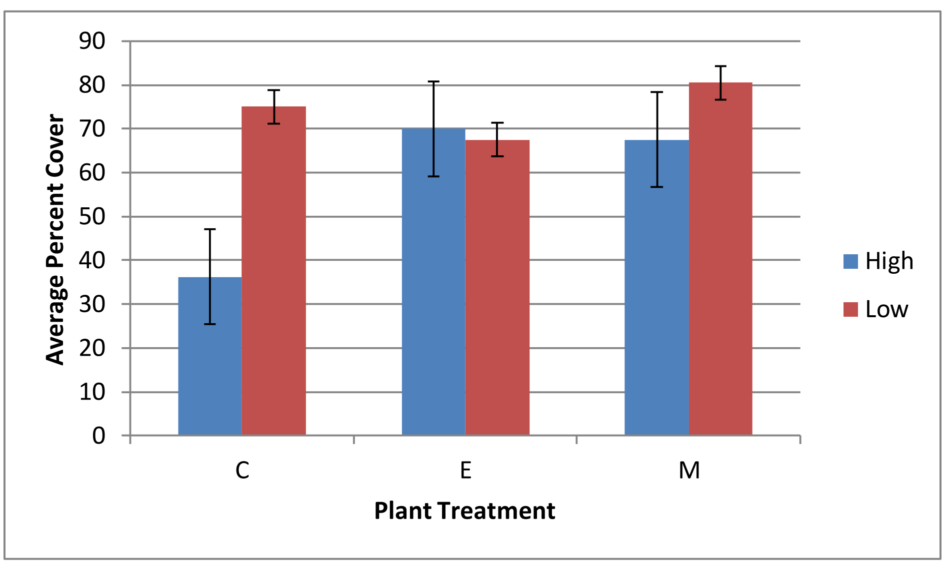



**Figure 10.** Absolute average percent cover of plant treatments and densities. C = *Carex barbarae*, E = *Elymus triticoides*, M = mix of C + E, High = high density with 36 plants, Low = low density with 16 plants

(a) High-density plot of ElTr (b) High-density plot of CaBa

(c) High-density plot of Mix

**Figure 11.** A comparison between high-density plantings. (A) High-density plot of ElTr, (b) High-density plot of CaBa, and (c) High-density Plot of Mixes ElTr and CaBa. ElTr dominates in the cover.

**Figure 12.** A comparison of the initial high-density planting versus low-density planting. Left plot is a high-density (36) treatment of ElTr, and right plot is a low-density (16) treatment of ElTr.

### *6.4.3 Two-Way ANOVA*

A two-way ANOVA was conducted to statistically evaluate experimental data from the randomized block design based on the two densities and three species compositions. The density treatment was significantly different with a $p=0.022$ at alpha level=0.05. High-density plantings had higher absolute cover than low-density plantings. The species composition treatment was also significant with a $p=0.032$ at alpha level=0.05.

*Elymus triticoides* had higher above-ground absolute cover in both homogenous and mixed planting treatments than *Carex barbarae*. There was no interaction between density and plant species composition treatments at the time of sampling. There was also no difference between the blocks: they were adequate replicates. There were no statistical differences or effects of percent survival.

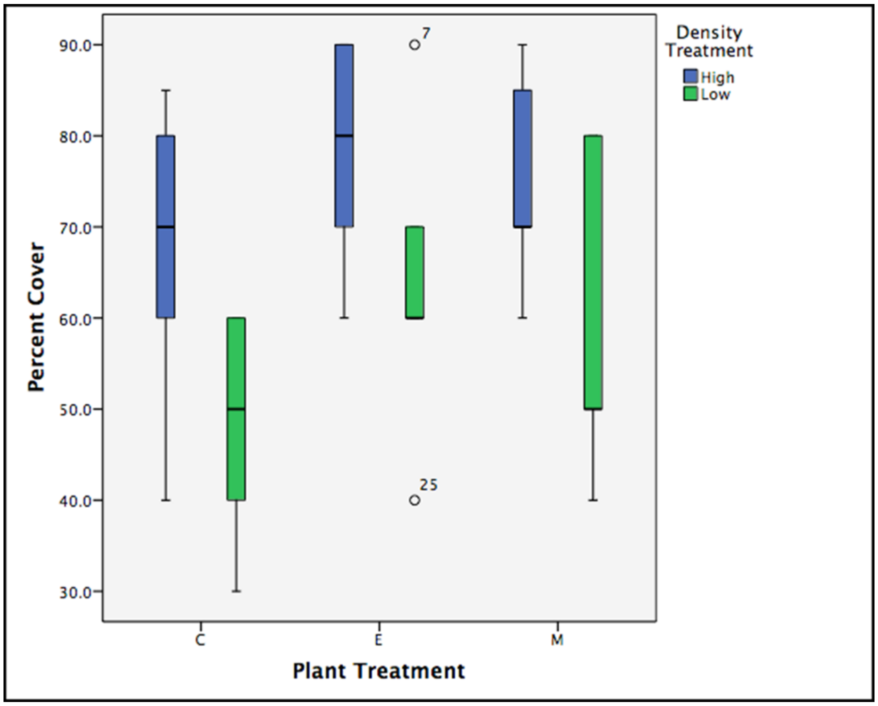



**Figure 13.** A graph showing the absolute percent of cover for each plant treatment. Blue indicates high-density cover, and Green indicates low-density cover. Percent of cover for plants with low-density treatment is higher than the percent of cover for high-density planting treatment.

**Table 6-1. Tests of Between-Subject Effects with Percent Cover as Dependent Variable**

| **Source** | | **Type III Sum of Squares** | **df** | **Mean Square** | **F** | **Sig** |
|---|---|---|---|---|---|---|
| Intercept | Hypothesis | 128053.333 | 1 | 128053.333 | 130.611 | .000 |
| Density/ Treatment | Hypothesis | 1920.000 | 1 | 1920.000 | 13.054 | **.022** |
| Plant Treatment | Hypothesis | 981.667 | 2 | 490.833 | 5.466 | **.032** |
| Density Treatment* Plant Treatment | Hypothesis | 3921.667 | 4 | 980.417 | 6.742 | **.081** |
| Density Treatment * Block | Error | 412.098 | 4 | 147.083 | 1.608 | .263 |
| Density Treatment* Plant Treatment | Hypothesis | 35.000 | 2 | 17.500 | .191 | .830 |
| Density Treatment* Block | Hypothesis | 588.333 | 4 | 147.083 | 1.608 | .263 |
| Plant Treatment* Block | Hypothesis | 718.333 | 8 | 89.792 | .982 | .510 |

*6.5 Experiment B Herbicide vs. Umbrella Species Treatment.*
Experiment B was initiated in 2016, designed to evaluate differences between herbicide treatment and companion planting or umbrella species planting experimentally. Based on results from the 2015 Experiment A, we planted using low-density, 1-foot, center plantings, and monotypic plots of *Elymus triticoides* and *Carex barbarae*. Both native plants species are environmentally plastic, and are well adapted to both flooding and drought conditions that occur along riparian corridors.

*6.5.1 Experiment B Hypotheses*
We hypothesis there will be a difference in survival and relative cover between the Herbicide treatment (B) and the Umbrella or Facilitation plant treatment (A) in survival of *Carex barbarae* and *Elymus triticoides*.

*6.5.2 Experiment B Methods*
For this experiment, creeping wild rye (*Elymus triticoides*) and Santa Barbara sedge (*Carex barbarae*) were grown by Hedgerow Farms Nursery as seedlings that were approximately 5 centimeters in length. Seedlings were chosen over seeds since they are known to have a greater chance at establishment (Moore et al., 2011). These species were selected based on experimental results in 2015, selected due to their adaptation and resiliency to fire (Stevens et al., 2015). Preliminary results from the 2015 experiment have determined that both species are beginning to establish habitat islands in the area and are therefore known to have some success in the conditions present at Bushy Lake despite the presence of invasive species.

Stevens et al. (2015) found that creeping wild rye outcompetes Santa Barbara sedge; therefore, plots were planted in homogeneous units. Santa Barbara sedge plots were planted closer to Bushy Lake in shadier conditions with more clay in the soil. Creeping wild rye plots were planted in the eastern portion of the restoration area in sunnier conditions sandier soils. All seedlings were planted at 1-foot spacing in a grid of 11-foot-by-16-foot plots; every plot contained 100 individual seedlings. In Treatment A, native species that were already present in each plot, primarily mugwort (*Artemisia douglasiana*) and California blackberry (*Rubus ursinus*), were left as umbrella species in the plots before the initial planting. Planting for Treatment A took place February 6, 2016. These native plants were left to act as nurse plants that could provide shade, increased nutrient availability and protection against herbivores (Callaway 1995). Due to the lack of an efficient watering system, all seedlings received moisture strictly from rainfall throughout the entirety of the experiment. Plots containing creeping wild rye had four replicates and plots containing Santa Barbara sedge had three replicates.

Treatment B included herbicide treatment in the form of glyphosate, applied to experimental plots through a backpack sprayer by a certified County Parks employee. The glyphosate was sprayed onto the poison hemlock during its rosette stage, which is when it is known to be most effective (Ammee 1988; Jeffery and Robinson, 1990). Planting in Treatment B took place two weeks after herbicide treatment, on February 20, 2016. Timing delay in planting may have been a confounding impact on experimental results.

Throughout the duration of the experiment, plant survival was monitored for the duration of the experimental period. Plants were flagged to allow for easy identification once weeds became too overgrown. To examine the reference area that represented an area that was untreated, three stratified random transects using the line intercept method were used. In addition, precipitation and temperature was recorded throughout the experimental period. Temperature and precipitation are always potential confounding factors in in situ restoration experiments, since they have a fundamental impact on plant survival and productivity.

*6.5.3 Monitoring and Adaptive Management*

As weather became warmer and the experimental area became drier, we applied mulch and cardboard around every plant to increase plant survival by preventing desiccation. On April 23, we applied mulch and cardboard. No watering was available in 2016, so mulching around plants was especially important for ensuring seedling survival. Non-native species were weeded from the plots in both treatments. Data on plant survival was taken throughout the experimental period. Permanent photo stations were utilized to create photo-documentation for every plot.

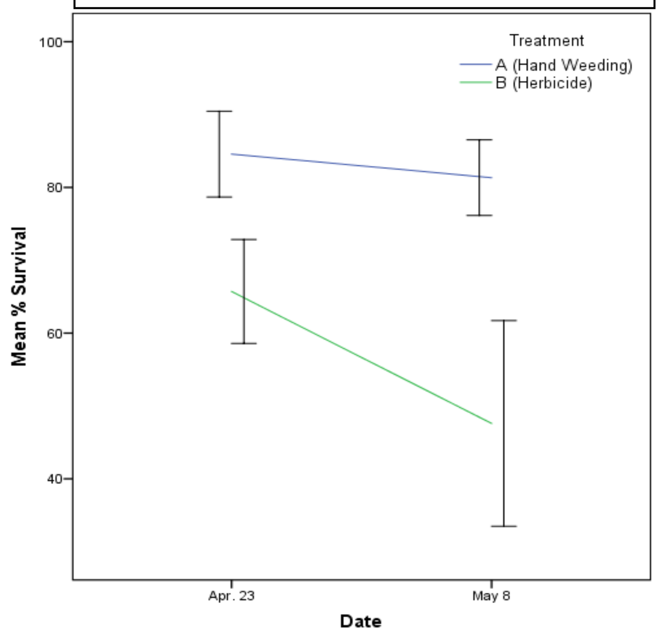
Statistical Analysis

A univariate analysis of variants was utilized to test the differences among treatments in relation to plant survival.

*6.5.4 Experiment B Results and Discussion*

As shown in Figure 14, Treatment A (using Umbrella plants and hand-weeding) had significantly higher survival rates than Treatment B (herbicide treatment), with a p-value of .002 (α = .05). All native plants in plots subjected to hand weeding (Treatment A) had a significantly higher percent of survival than those found in plots subjected to herbicide treatment (Treatment B).

**Figure 14.** Plant survival is higher in Inter-Planting Treatment A than Herbicide Treatment B.




There was also more variability in the survival of plants in the herbicide-treated plots. It is important to note that the results found in this experiment occurred in a relatively short timeframe. Long-term results for plant survival and revegetation will vary after the dry, hot summer period.

**Figure 15.** Contrasting Plant Success using Treatment A and B

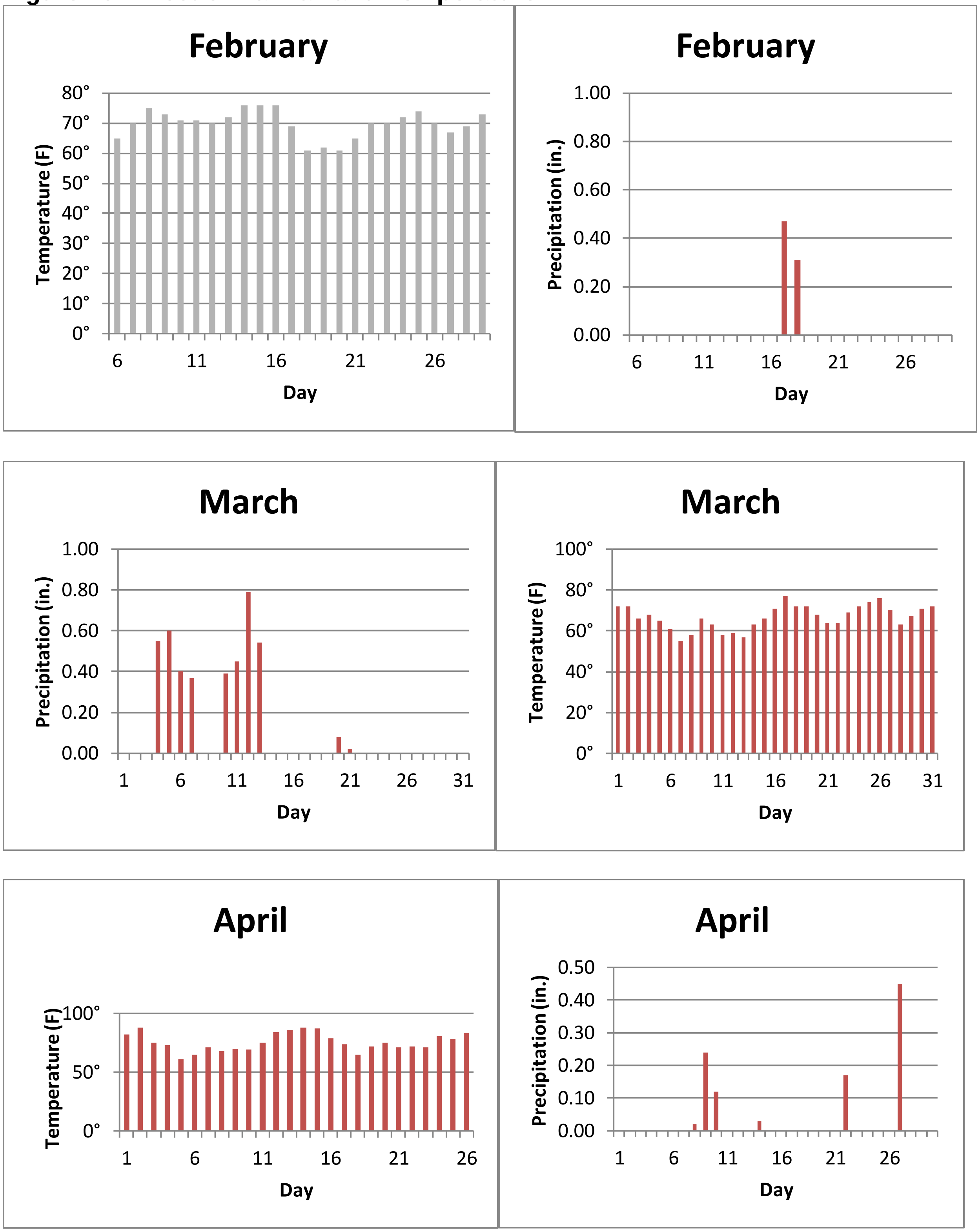
Native plants, such as mugwort and native blackberry, remaining in hand-weeded plots (Treatment A), provided shade and cooler temperatures, reducing stress on plants and potentially increased available soil moisture. The differences between interplanted and herbicide treated plots is illustrated above. Seedlings in the herbicide-treated plots were exposed to the sun, with warmer temperatures and increased evapotranspiration leading to desiccation. Seedlings were also more exposed to herbivores. Deer and other herbivores preferentially browse on Santa Barbara sedge over creeping wild rye. The herbicide-treated plots clearly showed more signs of browsing than inter-planted plots, but that may be because the plants were more easily accessible to herbivores. We observed that deer and sheep strongly prefer Santa Barbara sedge to creeping wild rye.

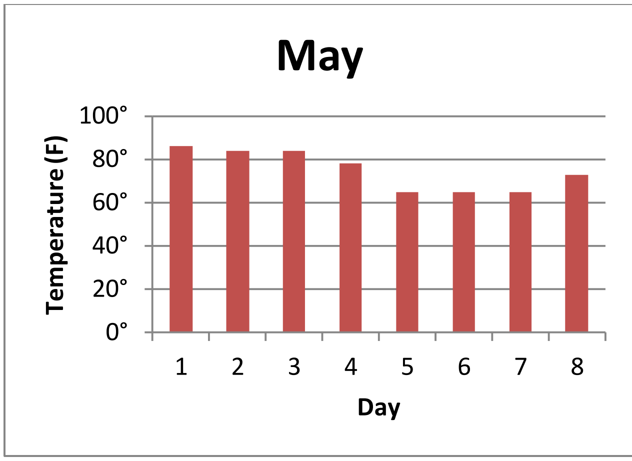
Plant survival was also impacted by the variability in student planting techniques. Some students who assisted with the experiment lacked experience and knowledge regarding proper planting techniques. This inexperience led to higher mortality from insufficient contact between seedling roots and the soil. Proper planting is vital to seedling survival seedlings, and may change experimental results.

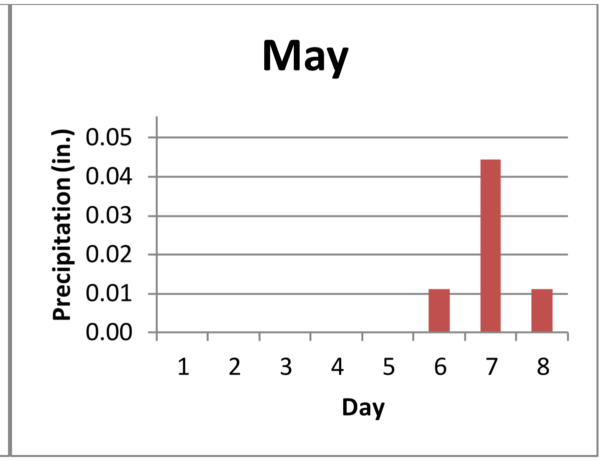
Another confounding factor was possibly related to the difference in soils between each experimental planting area The Santa Barbara sedge plots were planted on Rossmoor fine sandy loam, with more fine-textured soils and organic matter in the soils structure. The Rossmoor soil has a higher degree of organic material present near the surface of the soil. Creeping wild rye plots were planted on Columbia sandy loam. The Columbia series has very little organic material near the surface (Stevens et al., 2015), which influences moisture-holding potential and plant survival.

We monitored temperature and rainfall during the experimental period (see below). All seedlings were planted in February, and were initially unable to receive an adequate amount of precipitation. February turned out to be very dry, with precipitation total amounting to 0.78 inches. While dry February may have affected seedling survival, precipitation in March was 4.19 inches of rain, and in April a little over 1 inch of rain occurred. The experiment ended in early May, which was characterized by some early rain showers that have provided additional moisture.

**Figure 16. Effect of Rainfall and Temperature**





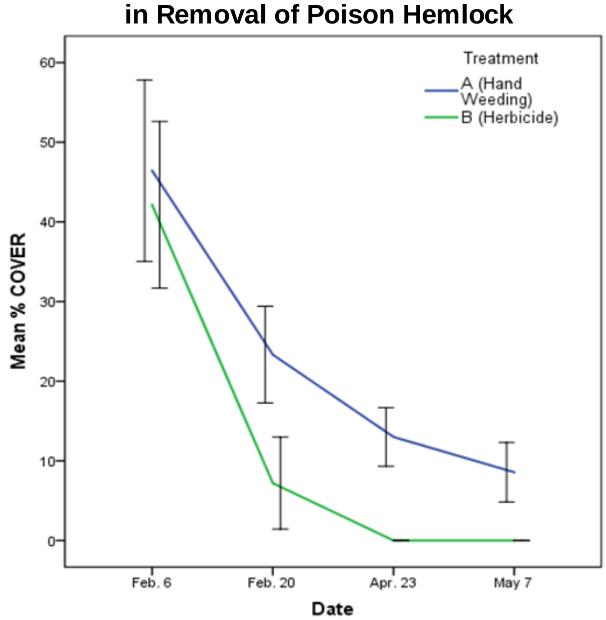




Temperatures remained very warm throughout the duration of the experiment, which may have contributed to some seedling mortality. The month of February was characterized by abnormally warm weather with an average temperature of 70°F. March had an average temperature of 67°F, while average temperatures in April were 75°F.

Poison Hemlock Removal

We found increased percent cover of poison hemlock in Treatment A Umbrella Species Interpolating Treatment than Treatment B Herbicide Treatment. The herbicide treatment effectively removed sprouts of poison hemlock, and significantly reduced emergency of hemlock in the plots (p-value of .030, $\alpha = .05$). Herbicide (Treatment B) has proven to be more effective than hand weeding in removing poison hemlock. The reference condition, which received no treatment or weeding, had 76% cover of poison hemlock. Both treatments showed percent cover of poison hemlock decreasing over time.

**Figure 17. Effectiveness of Treatment A vs Treatment B in Removal of Poison Hemlock**



Despite the effectiveness of herbicide, it is too early to determine whether it will continue to remain effective in the future. Since seeds produced by poison hemlock can remain in the soil for up to three years, it is likely that over time, the weed will eventually return to the herbicide plots. In the future, additional applications of herbicide could potentially be necessary to address the issue of returning weeds. However, herbicide treatment suppresses native plant species in the restoration area.

Although there is a significant difference between the effectiveness of each treatment on poison hemlock, the percent cover of poison hemlock declined in both cases. Ultimately, further study is needed to ensure the difference will remain significant over time.

*6.6 Conclusion.*

The experiment was designed to evaluate differences in planting densities and species composition to inform future restoration projects and to provide guidelines for the most cost effective restoration process for the study site. At this time, we found that the *Elymus triticoides* or the mixture with *Elymus triticoides* had significantly higher absolute cover than the *Carex barbarae*. While the grass had more above-ground biomass production, there may be more below-ground production with Santa Barbara sedge. The preliminary data does not take into account the below-ground growth and vegetative reproduction of both species, which are very important for restoration success. Below-ground biomass production, especially rhizome production, is very important for expanding the restoration of native vegetation. The below-ground biomass production is even more important for building resiliency into the restoration project as plants can re-sprout from wild fire and colonize new sites. Both native plant species are well adapted to flooding and drought along riparian corridors.

Based on our data analysis, we recommend the lower density planting treatment with monotypic plantings of seedlings be used in future restoration efforts. Due to the confounding factors in 2016, we would like to experimentally plant facilitated plantings of mugwort with Santa Barbara sedge and plots with mugwort and creeping wild rye to understand companion planting of umbrella species. Both plant root systems need time to establish and mature first before long-term survival and density impacts can be analyzed. Both plant species are fire-resilient, exemplary species for restoration, and can prove to be beneficial to the fire-prone areas around Bushy Lake. While non-native weeds can inhibit the growth of native plant species, adaptive management can help in controlling the weeds while encouraging restoration, which can create significant habitats for wildlife.

## Chapter 7. Building a Fire-Resilient Landscape: Recommendations for Ecological Restoration, Monitoring, and Adaptive Management

I have been monitoring and stewarding this site with the help of students and the community for the past two years. We held the Bushy Lake Launching Event on September 23, 2016, with over 200 attendees. We have visited the site over ten times to conduct adaptive management to maintain the restoration project. If we do not continue working on this project, poison hemlock will take over, and the extensive efforts made for wildlife habitat and public education will be for naught. In 2017, I received a small grant from the Sacramento Audubon Society to pay for new seedlings to continue experimental planting and replanting. I am teaching ENVS 151 restoration ecology in spring 2017, and will engage students in high-impact restoration research. The Bushy Lake Restoration and Environmental Education Plan includes:

a) Experimental design using a facilitation model of planting;

b) Replanting, monitoring, and adaptive management of existing restoration projects;

c) Creation of a carbon budget for the project, adding sampling of carbon stocks in riparian vegetation; and

d) Monitoring of western pond turtles, blue elderberry and their colonization by valley elderberry longhorn beetle, and birds.

I will utilize contacts with environmental organizations and the community along the river to help sustain restoration efforts at the Bushy Lake site. Control of invasive species is a top priority for this effort.

*7.1 Facilitation/Companion Planting Experimental Design and Implementation.*
The new experiment will build on results from last year, and utilize facilitated or companion planting techniques. We will plant *Artemisia douglasiana* and *Carex barbarae* in one treatment, *Artemisia douglasiana* and *Elymus triticoides* in the other treatment, and evaluate survival and biomass production.

*7.2 Replanting and Adaptive Management.*
We will replant and expand the restoration project area with *Carex barbarae* and *Elymus triticoides* seedling that have died over the past year. We will need help with mulch and cardboard after planting, as will not have access to water to maintain seedlings.

*7.3 Carbon Sequestration in Riparian Communities and Soil.*
To estimate the amount of carbon that this riparian area stores in vegetation and soils, we will estimate the carbon sequestration capacity in the vegetation. We have collected and analyzed carbon content in soils in the restoration area. This spring we will gather data on woody vegetation and herbaceous vegetation to quantify carbon sequestration in above-ground biomass.

*7.4 Monitoring Western Pond Turtle (*Actinemys marmorata*)*

Last year, we observed as many as 26 western pond turtles (WPT) at Bushy Lake. As well as being significantly threatened in the state of California, recent studies have found the WPT to be seriously threatened in most of its range (Jennings and Hayes, 1994). Populations are in serious decline due to habitat loss and other anthropogenic factors. The past few drought years have had a significantly deleterious impact on WPT populations. Within the state of California, the WPT has been delegated as a "Species of Special Concern." The state of Washington listed the WPT as endangered, and the state of Oregon has listed WPT as "Sensitive-Critical" (Bury et al., 2012). Bushy Lake provides an ideal refuge for WPT on the lower American River parkway. No invasive red-eared slider turtles (Trachemys scripta elegans) have been observed.

This year we plan to conduct visual encounter surveys for quick evaluations of turtle species within the study area (Bury et al., 2012c). Visual surveys are based on consistent timed periods in which quick assessment of species occurrence (found/not found) and population counts can be measured. We plan to conduct visual surveys on a weekly basis; today, January 27, we did not observe any pond turtles and believe they are overwintering. Many WPT populations overwinter by burying themselves in leaf litter or other terrestrial substrates (Bury et al., 2012b). Typically, they will begin to emerge in spring, from March through April. We will be checking to see when they emerge at Bushy Lake. After we have gathered more observational data, we plan to apply for a State scientific study permit. Once the permits have been obtained, we plan to utilize very careful trapping or capturing of WPT to assess population factors, such as demographic structure, sex ratio, and other individual parameters. We are collaborating and gathering input from western pond turtle experts and will be closely involved with them and gain experience before increasing monitoring efforts. For this year, we will just conduct visual surveys.

*7.5 Monitoring Valley Elderberry Longhorn Beetle (*Desmocerus Californicus dimorphus*) and Post-Fire Blue Elderberry (*Sambucus Mexicana*) Survival.*

Valley elderberry longhorn beetle (VELB) is a federally listed threatened species that are endemic to California's Central Valley. Adult females lay eggs on the stem or leaves of the blue elderberry and they will hatch after a few days. From there, the larvae will bore into the stems to develop for one-to-two years. VELB can only be detected when adults vacate the plant through an exit hole of about 4–10 mm in diameter (Collinge 2001). Adult VELB live from a few days to a few weeks between mid-March and mid-May (Davis and Comstock, 1924; Linsley and Chemsak, 1972; USFWS 1984) with most records from late-April to mid-May (Arnold 1984b; USFWS 1984; Halstead and Oldham, 1990; Talley 2003a). Exit holes will usually be made from March to mid-May at the same time the elderberry shrubs are flowering to provide a food source for emerging insects. Elderberry shrubs are most prevalent on mid- to high-elevation floodplains similar to Bushy Lake. The structure of beetle populations within smaller scales (<10 km) were consistent with a meta-population structure (Talley 2005). The beetle's population structure consists of a network of local aggregations that composed a larger patch (Ibid.). Local aggregations covering 25–50 m scales (therefore multiple shrubs) occurred at distances of 200–300 m apart along the American River. Recent large fires have eliminated large patches of elderberry bushes, and the new growth is smaller and in widely separated patches. We will sample whether recolonization has occurred, as well as mortality of elderberry bushes.

Elderberry shrubs re-sprout after fire, and provide significant season-long flowers and berries providing food, nectar, and habitat for wildlife. We will monitor elderberry bushes around and adjacent to Bushy Lake to determine post-fire sprouting of elderberry bushes; the diameter and approximate age of stems; and presence or absence of exit holes. We plan to coordinate with Theresa Nally to replicate her surveys to determine impacts of fire on elderberry bushes and VELB along the lower American River.

### *7.6 Adaptive Management of Invasive Species*

Invasive species posing most threat to the native species at the site are poison hemlock (*Conium maculatum*), tall whitetop (*Lepidium latifolium*), yellow star thistle (*Centaurea solstitialis*), milk thistle (*Silybum marianum*), prickly lettuce (*Lactuca serriola*) and Himalayan blackberry (*Rubus armeniacus*), and black mustard (*Brassica nigra*). If invasive species are not controlled, they will eliminate native plant species by invading the areas. Adaptive management plan will help in limiting invasive species while meeting the objectives of sufficiently and cost-effectively restoring the area and providing space and time for native species to recruit. We plan to continue our efforts to hand lop or dig up the poison hemlock.

Poison hemlocks (*Conium maculatum*) and prickly lettuce (*Lactuca serriola*) can be managed in similar manner. Both can be cut near the root before seeding and piled down on the ground for mulch. Although manual control effort such as hand removal of the *Conium maculatum* taproots would be most effective in controlling the plant, this would cause soil disturbance (Di Tomaso, J.M., et al., 2013). As a result, cutting and weeding the *Conium maculatum* and Lactuca serriola are the techniques we have used unless replanting new experimental plots. With the restoration and colonization of native plants, this can lessen the likelihood for invasive species to grow back (DiTomaso, J.M., et al., 2013).

The following are adaptive management strategies for controlling the three most prevalent invasive weeds at the study area.

#### *7.6.1 Poison Hemlock*

*Conium maculatum* – Grows in disturbed area to over 7-feet tall. All parts of poison hemlock are toxic to humans and animals when ingested; handling plants can cause contact dermatitis in some people. Wildlife and livestock are also susceptible to the toxic effects of poison hemlock. Poison hemlock can spread quickly after the rainy season in areas that have been cleared or disturbed. Once established, it is highly competitive and prevents establishment of native plants by over-shading.

Cal-IPC Inventory Rating: Moderate

Management: Poison hemlock reproduces only by seed, which is dispersed by water, mud, wind, animal fur, human clothing, boots, and machinery (Pitcher 1986; GGNRA 1989). It has no means of vegetative reproduction.

Physical control:

- Manual methods: Hand-pulling of poison hemlock is effective, especially prior to seed set, and easiest when the soil is wet (Parsons 1992). Because of the biennial nature of the plant, the entire root system does not need to be removed (Pitcher 1986).
- Mechanical methods: Spring mowing has proven effective in killing mature plants, yet regrowth may occur and new seedlings may continue to establish (Ammee, 1988). A second mow in late summer is recommended to eliminate remaining or subsequent growth (GGNRA, 1989). Because poison hemlock seed has been shown to germinate up to three years after dispersal, a third year of mowing may be necessary (Baskin & Baskin, 1993).
- Prescribed burning: Joseph DiTomaso, with the University of California, Davis, Weed Science Group, states that burning is probably not a good control option. In areas where poison hemlock is the dominant vegetation (usually moist environments), sufficient dried material would not be available to provide adequate fuel to control poison hemlock before fruit maturation. This method has yet to be tried on poison hemlock.

Chemical control:

- Effective post-emergent herbicides include 2,4 D ester, 2,4 D amine, and glyphosate plus surfactant, all to be applied in late spring. 2,4 D has been effective when sprayed at 1.0 lb ai/acre (1.1 kg/ha) and mixed with a wetting agent (Jeffrey and Robinson, 1990). Glyphosate at a rate of 1.0 lb/acre (1.1 kg/ha) plus surfactant (as Roundup®) has also proved effective in killing poison hemlock, especially in the rosette stage (Ammee 1988; Jeffery and Robinson 1990). Glyphosate plus surfactant (as Roundup®) at a rate of 1.0 lb/acre (1.1 kg/ha) has also proved effective in killing poison hemlock, especially in the rosette stage (Ammee 1988; Jeffery and Robinson, 1990).

*7.6.2 Perennial Pepperweed (Tall Whitetop)*

*Lepidium latifolium* - a perennial herb (family *Brassicaceae*) found in moist or seasonally wet sites throughout California. Perennial pepperweed grows very aggressively, forming dense colonies that exclude native species. Perennial pepperweed is a state-listed noxious weed in California and many other western states.

Cal-IPC Inventory Rating: High

Management: We weed and remove as soon as we see it. It has not been allowed to gain a foothold in the study area. It reproduces by seed, from its roots, and small root fragments. Seeds and root fragments

*7.6.3 Himalayan Blackberry*

*Rubus armeniacus* – grows into a dense thicket of woody canes and branches with thorns, five large, broad leaflets and white flowers when mature. Common in riparian areas and areas where there is a period of water inundation (Katibah et al., 1984). Dense thickets of blackberries are occurring in the study area. They can cause fire hazard.

Cal-IPC Inventory Rating: High

Management: Physical or Chemical Control

7.6.4 Monitoring Recommendations

Ensure long-term community efforts will continue to restore and protect this region by:

1) Utilizing the public, community, CSU Sacramento students, and American River Parkway Foundation volunteers to engage in citizen science for long-term monitoring and adaptive management of the project, and
2) Improving public outreach to community to bring together and educate the public about the significance of wetlands, riparian forests, and wildlife residing there.

Restoring plant native species, removing non-native weeds, enhancing the quality of Bushy Lake and its surrounding without causing detriments, and strengthening the community and accessibility along the Parkway are all consistent with the policies and goals of the American River Parkway Plan (County of Sacramento et al., 2008). With the continuation of the experiment and future research, the plan would be one step closer toward reaching its goals.

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## Appendices

**Table A-1. Plant species present at Bushy Lake**

| **Common Name** | **Scientific Name** | **Native, Yes/No** |
|---|---|---|
| Arroyo willow | *Salix lasiolepis* | Yes |
| Creeping wild rye | *Elymus triticoides* | Yes |
| Bermuda grass | *Cynodon dactylon* | No |
| Black mustard | *Brassica nigra* | No |
| Black walnut | *Juglans nigra* | Yes |
| Box elder | *Acer negundo* | Yes |
| California grape | *Vitis californica* | Yes |
| California man-root | *Marah abacus* | Yes |
| California native blackberry | *Rubus ursinus* | Yes |
| California rose | *Rosa californica* | Yes |
| Cattail (spp.) | *Typha spp.* | Yes |
| Cottonwood | *Populus fremontii* | Yes |
| Coyote brush | *Baccharis pilularis* | Yes |
| Elderberry | *Sambucus mexicana* | Yes |
| Elm | *Ulmus spp.* | No |
| Goodding’s willow | *Salix gooddingii* | Yes |
| Himalayan blackberry | *Rubus armeniacus* | No |
| Horseweed | *Conesa Canadensis* | Yes |
| Milk thistle | *Silybum marianum* | No |
| Milkweed | *Asclepius spp.* | Yes; 15 are native to CA |
| Mugwort | *Artemisia douglasiana* | Yes |
| Oregon ash | *Fraxinus latifolia* | Yes |
| Poison hemlock | *Conium maculatum* | No |
| Poison oak | *Toxicodendron diversilobum* | Yes |
| Prickly lettuce | *Lactuca serriola* | No |
| Sandbar willow | *Salix exigua* | Yes |
| Santa Barbara sedge | *Carex barbarae* | Yes |
| Tall whitetop | *Lepidium latifolium* | No |
| Yellow star thistle | *Centaurea solstitialis* | No |

**Table A-2. Common Species List for the Sacramento Region***

| Species | √ | Species | √ | Species | √ |
|---|---|---|---|---|---|
| Greater White-fronted Goose **W** | | American Avocet **S** | | House Wren | |
| Snow Goose **W** | | Spotted Sandpiper | | Marsh Wren | |
| Ross' Goose **W** | | Greater Yellowlegs **W, M** | | Golden-crowned Kinglet **W** | |
| Cackling Goose **W** | | Long-billed Curlew **W, M** | | Ruby-crowned Kinglet **W** | |
| Canada Goose | | Western Sandpiper **M** | | Western Bluebird | |
| Tundra Swan **W** | | Least Sandpiper **W, M** | | Swainson's Thrush **M** | |
| Wood Duck | | Dunlin **W** | | Hermit Thrush **W** | |
| Gadwall | | Long-billed Dowitcher **W, M** | | American Robin | |
| American Wigeon **W** | | Wilson's Snipe **W** | | Varied Thrush **W** | |
| Mallard | | Ring-billed Gull **W** | | Wrentit | |
| Cinnamon Teal | | California Gull **W** | | Northern Mockingbird | |
| Green-winged Teal **W** | | Herring Gull **W** | | European Starling | |
| Northern Shoveler **W** | | Caspian Tern **S, M** | | American Pipit **W** | |
| Northern Pintail **W** | | Forster's Tern | | Cedar Waxwing **W, M** | |
| Canvasback **W** | | Rock Pigeon | | Phainopepla | |
| Ring-necked Duck **W** | | Eurasian Collared-Dove | | Orange-crowned Warbler **M, W** | |
| Lesser Scaup **W** | | Mourning Dove | | Nashville Warbler **M** | |
| Bufflehead **W** | | Barn Owl | | Yellow Warbler **M** | |
| Common Goldeneye **W** | | Great Horned Owl | | MacGillivray's Warbler **M** | |
| Common Merganser | | Burrowing Owl | | Yellow-rumped Warbler **W, M** | |
| Ruddy Duck | | White-throated Swift | | Black-throated Gray Warbler **M** | |
| Ring-necked Pheasant | | Black-chinned Hummingbird **S** | | Townsend's Warbler **M** | |
| Wild Turkey | | Anna's Hummingbird | | Common Yellowthroat | |
| California Quail | | Rufous Hummingbird **M** | | Wilson's Warbler **M** | |
| Pied-billed Grebe | | Belted Kingfisher | | Spotted Towhee | |
| Eared Grebe **W** | | Acorn Woodpecker | | California Towhee | |
| Western Grebe | | Red-breasted Sapsucker **W** | | Lark Sparrow | |
| Clark's Grebe | | Nuttall's Woodpecker | | Savannah Sparrow **W** | |
| American White Pelican | | Downy Woodpecker | | Fox Sparrow **W** | |
| Double-crested Cormorant | | Northern Flicker **W, rare S** | | Song Sparrow | |
| American Bittern | | Pacific-slope Flycatcher **M** | | Lincoln's Sparrow **W** | |
| Great Blue Heron | | Black Phoebe | | White-crowned Sparrow **W** | |
| Great Egret | | Say's Phoebe **W** | | Golden-crowned Sparrow **W** | |
| Snowy Egret | | Ash-throated Flycatcher **S** | | Dark-eyed Junco **W** | |
| Cattle Egret | | Western Kingbird **S** | | Western Tanager **M** | |
| Green Heron | | Loggerhead Shrike | | Black-headed Grosbeak **M, S** | |
| Black-crowned Night Heron | | Cassin's Vireo **M** | | Lazuli Bunting **M, S** | |
| White-faced Ibis | | Hutton's Vireo | | Red-winged Blackbird | |
| Turkey Vulture | | Warbling Vireo **M** | | Tricolored Blackbird | |
| White-tailed Kite | | Western Scrub-Jay | | Western Meadowlark | |
| Northern Harrier | | Yellow-billed Magpie | | Yellow-headed Blackbird | |
| Sharp-shinned Hawk **W** | | American Crow | | Brewer's Blackbird | |
| Cooper's Hawk | | Common Raven | | Great-tailed Grackle | |
| Red-shouldered Hawk | | Horned Lark | | Brown-headed Cowbird | |
| Swainson's Hawk **S** | | Purple Martin **S** (City of Sacto) | | Bullock's Oriole **S** | |
| Red-tailed Hawk | | Tree Swallow **S**, rare **W** | | House Finch | |
| American Kestrel | | No. Rough-winged Swallow **S** | | Lesser Goldfinch | |
| Virginia Rail | | Cliff Swallow **S** | | American Goldfinch | |
| Sora | | Barn Swallow **S** | | House Sparrow | |
| Common Moorhen | | Oak Titmouse | | | |
| American Coot | | Bushtit | | **Year Round Unless Noted:** | |
| Sandhill Crane **W** | | White-breasted Nuthatch | | **M** = Migrant (spring and fall) | |
| Killdeer | | Rock Wren | | **S** = Summer (often spring - fall) | |
| Black-necked Stilt | | Bewick's Wren | | **W** = Winter (often fall - spring | |

***** Retrieved from http://www.audubon.org/news/the-species-list. Bird Species.