Final Report

1. Project Title: **Experimental investigation of the effects of deficit irrigation on plant vigor, floral display and insect interactions in California landscape plants**
2. Project total Budget: **$9169** (reduced from requested amount)
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5. Project location: **Davis, CA**
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8. Cooperating Entities (other organizations involved in this project): **University of California, Davis, College of Agricultural and Environmental Sciences, Departments of Biological and Agricultural Engineering and Human Ecology, UC Davis Arboretum and Public Gardens and California Center for Urban Horticulture; Horticulture Industry Stakeholders (California Flora Nursery, Hedgerow Farms, Netafim, Hunter Industries, Scotts Miracle-Gro, Ewing Irrigation, Baseline System, Agromin, Garden Enlightenment)**

I. Introduction

Given predictions of variable and reduced water supply in California, homeowners, municipalities and businesses may be increasingly incentivized to conserve water. One area where these diverse groups can realize large water savings is in managed landscapes. Landscape plantings can be designed and maintained in a number of ways to reduce water use (Kjelgren, Rupp et al. 2000). First, installing low-water use plants, including native plant species that are adapted to low water conditions, can reduce water use and at the same time promote wildlife conservation. Irrigation systems are frequently used in cities and large landscape projects. These systems can also be used to reduce water use by targeted application to plants, timing watering for ideal times during the day, and through the use of sensors, to eliminate excess water application (Dukes 2012). However, the implementation of these water-saving landscape elements is limited by familiarity with systems, few guidelines on water application frequency or amount, or plant species water requirements. In the scientific literature, few studies examine how water supply influences desirable traits of ornamental landscape plants, particularly with regard to flowering phenology, duration, and other traits (Fereres, Goldhamer et al. 2003, Costa, Ortuño et al. 2007).

Despite the availability of general irrigation guidelines, how variation in water supply influences landscape plants is poorly understood, particularly with regard to flowering traits. Studies on low water use or reduced irrigation are generally not conducted in a standardized manner where conclusions can be applied outside that particular study system. For example, watering conditions in one location may not be comparable to another simply because of variation in evapotranspiration (ET) or other conditions. Here, we propose to install replicated hydrozones with water sensors so that we can apply a water budget as per Model Water Efficient Landscape Ordinance (MWELO; https://water.ca.gov/Programs/Water-Use-And-Efficiency/Urban-Water-Use-Efficiency/Model-Water-Efficient-Landscape-Ordinance). This offers benefits for replicability and applicability across systems for a few reasons. First, in-ground Time Domain Reflectometry (TDR) water sensors will allow us to adjust flow and water application to ensure equivalent soil moisture across replicates of the same treatment (hydrozone). Second, managing soil moisture within and across treatments will allow our setup to be comparable to other sites, making our findings relevant to a large audience. Finally, the use of flow meters, soil moisture sensors and plant measurements will allow us to calculate the water budget for each hydrozone individually, so we can compare within and among treatments, as irrigation treatments can also influence water use efficiency (WUE) and other plant physiological traits (Stabler and Martin 2000).

Although effects of watering on plant survival and growth have been documented for some plant species, few other traits of landscape plants have been examined (and published) with regard to deficit irrigation. One key trait of importance for both gardeners, landscape designers and wildlife is floral display and floral traits. Floral number and flowering season determine both the color display of plantings as well as the amount of floral resources, including nectar and pollen, available for pollinators and other beneficial organisms. Except for a few common plants (e.g. Petunia, Rosemary, Rose), effects of deficit irrigation on floral display or floral traits have not been rigorously documented. Moreover, most studies documenting the effects of deficit irrigation on landscaping plants have been performed in pots or containers, further limiting their applicability to field conditions.

Moreover, insects often rely on plant tissues for food, shelter or other resources. Specifically, many pollinators and beneficial insects (predators and parasitoids of pests) consume floral resources like nectar and pollen. Insects of conservation concern, including butterflies, rely on foliar material for larval stages. Of particular interest, monarch butterflies (*Danaus plexippus*) are also sensitive to plant phenology and foliar quality, which is influenced by drought conditions. Previous work has shown that water availability can influence nectar quality, flowering phenology and floral resources. Given the effects of water availability on plant quality and flower number and quality, irrigation regimes within a hydrozone are likely to cascade through plant quality to influence multiple insect groups, particularly in urban or suburban settings where alternate food sources are not readily available. However, these effects are poorly understood and have only been documented for a few species. Given the importance of landscape plantings for the maintenance of biodiversity, including urban populations of insects and other beneficial organisms, studies documenting how irrigation influences plant health and resource for these organisms will be essential.

As landscape managers transition from turf and other high-water landscape plantings to low-water installations, demonstration plantings and the results of rigorous experiments such as those proposed here will be key to guide both the planting and irrigation guidelines to ensure good survival, attractiveness and flowering of landscape plantings. Here, we propose to investigate the effects of variation in irrigation on the survival, flowering phenology, and floral resources produced by multiple California native plant species, as well as its effects on insect visitation to plants. We outline our specific objectives below.

II. Materials and Methods

The proposed experiment is part of a larger installation on the campus of UC Davis within the "Smart Farm" site (Figure 1). Although funding for the site prep has been provided by the UC Davis campus, funding for installation of the experimental plots is not provided. See budget details below including in-kind donations etc. Within this site, we propose to install replicated irrigation plots (hydrozones) (Fig 1) with three water regimes, very low, low, and medium, as classified by MWELO. Specifically, we will calculate expected ET for the plant species and number of plants included in each plot per WUCOLS IV (https://ucanr.edu/sites/WUCOLS/Download_WUCOLS_IV_User_Manual/) and estimate water application needs for late spring/summer irrigation. Each hydrozone plot will contain a TDR soil moisture sensor and will be individually controlled to maintain evapotranspiration levels as per MWELO guidelines using a Baseline irrigation unit and adjusted as necessary to account for variation in plant survival and other hydrozone-specific factors. Replicated plantings of multiple native species will be outplanted in each plot and monitored for survival, plant quality and flowering parameters and interactions with beneficial insects as detailed below.

Site specifications

The site will be graded, compost incorporated (as per MWELO) and water main line and lateral irrigation lines installed in May-June 2019. Further site prep will be completed by summer 2019 and ready for irrigation system installation (smart controller, inline drip, irrigation valves and flow meter) and outplanting in fall 2019. Each hydrozone will be 15’ x 25’ edged by landscape-grade material and separated by buffer strips. Plants will be installed in fall 2019 and mulched to retain moisture and reduce weed pressure.

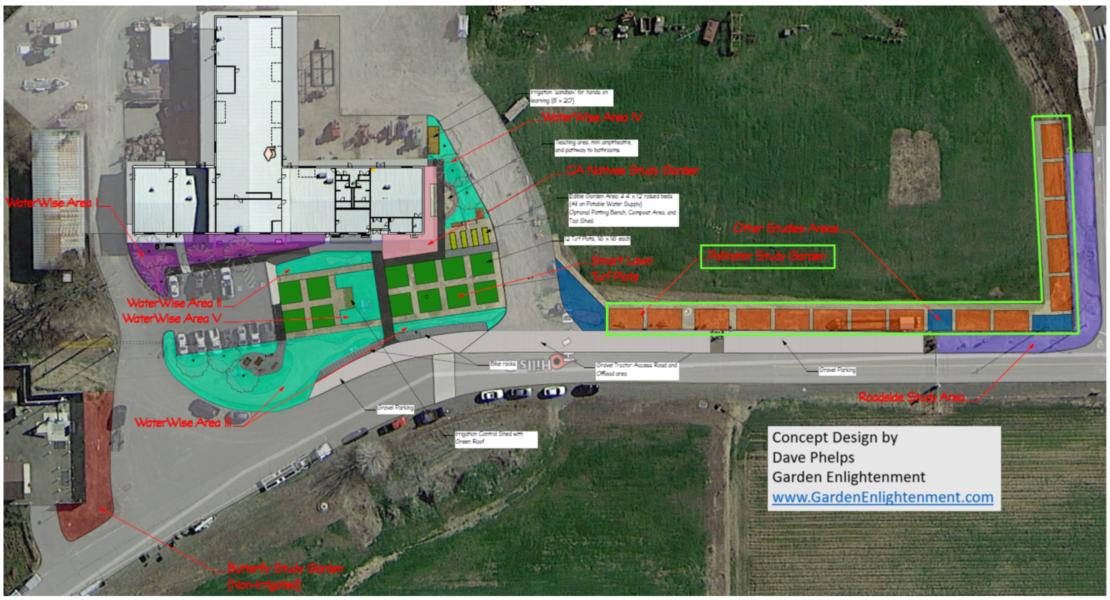

Figure 1. Smart farm A) site plan, including 15 replicated hydrozones for the pollinator study garden, outlined in green with each replicate hydrozone indicated by an orange rectangle.

III. Results

The goals of the project were to:

1. **Install high visibility irrigation experiment containing multiple native plant species.**
2. **Assess effects of irrigation treatments on plant performance, floral display and phenology.**

In the reporting period, the planting design was finalized, the site has been graded, compost incorporated (as per MWELO) and water main line and lateral irrigation lines installed. Further site prep has also been performed by volunteer and student teams and site is nearly ready for outplanting in winter 2020. Each hydrozone is 15’ x 25’ edged by landscape-grade material and separated by buffer strips. Photos below document progress on site installation. Other photos are available at: https://www.facebook.com/ccuh.ucdavis/.

We have successfully constructed plots, installed the irrigation system and soil moisture sensors and installed plants (Table 1, below). We are working through plant establishment (see photos below) and plan to initiate the irrigation treatments in 2021 after plants have successfully established to ensure equal survival and representation across treatments. This start to the treatment will also allow us to examine a full seasonal effect of reduced irrigation.

Photo of plots during establishment (photos by L. Yang)


Panoramic view of plots during establishment (photos by L. Yang)

IV. Discussion, obstacles and future goals

Our timeline has been pushed back somewhat due to multiple factors, including COVID-related delays. Despite these challenges, we have been able to install all plot infrastructure and plants. These plants are undergoing establishment and we continue to validate the experimental setup and will begin irrigation treatments in 2021. As we do this, we plan to continue to investigate effects of reduced irrigation on the response variables outlined above. Our entire team is committed to maintaining these plots and performing the proposed experiments to validate effects on plant vigor, floral display and interactions with insects over the upcoming years. We plan to pursue funding from SHRE and other sources in the future in order to ensure that these plots remain a valuable resource to research, teaching and outreach over the long-term.

Table 1.

PSG Plant Species and Numbers by Block

Block 1 (Beds 1 – 3)
# of species per bed (total per block)
3 (9) Penstemon heterophyllus 'Margarita BOP'
5 (15) Achillea millefolium
3 (9) Verbena lilicina de la mina
8 (24) Sporobolus airoides
5 (15) Asclepias cordifolia
5 (15) Asclepias eriocarpa
5 (15) Asclepias fascicularis
5 (15) Asclepias speciosa
5 (15) Epilobium canum 'Everett's Choice'
5 (15) Epilobium canum 'Chaparral Silver'
5 (15) Epilobium canum ssp canum
5 (15) Epilobium canum 'Calistoga'

Block 2 (Beds 4 – 6)
# of species per bed (total per block)
5 (15) Monardella villlosa
5 (15) Bouteloua gracilis 'Blonde Ambition'
3 (9) Achillea millefolium
8 (24) Sporobolus airoides
5 (15) Asclepias cordifolia
5 (15) Asclepias eriocarpa
5 (15) Asclepias fascicularis
5 (15) Asclepias speciosa
5 (15) Epilobium canum 'Everett's Choice'
5 (15) Epilobium canum 'Chaparral Silver'
5 (15) Epilobium canum ssp canum
5 (15) Epilobium canum 'Calistoga'

Block 3 (Beds 7 – 9)
# of species per bed (total per block)
1 (3) Salvia clevelandii 'Winifred Gilman'
5 (15) Bouteloua gracilis 'Blonde Ambition'
3 (9) Solidago californica 'Cascade Creek'
8 (24) Sporobolus airoides
5 (15) Asclepias cordifolia
5 (15) Asclepias eriocarpa
5 (15) Asclepias fascicularis
5 (15) Asclepias speciosa
5 (15) Epilobium canum 'Everett's Choice'
5 (15) Epilobium canum 'Chaparral Silver'

5 (15) Epilobium canum ssp canum
5 (15) Epilobium canum 'Calistoga'

Block 4 (Beds 10 – 12)
# of species per bed (total per block)
1 (3) Muhlenbergia rigens
5 (15) Bouteloua gracilis ‘Blonde Ambition’
3 (9) Verbena lilicina de la mina
3 (9) Penstemon heterophyllus 'Margarita BOP'
8 (24) Sporobolus airoides
5 (15) Asclepias cordifolia
5 (15) Asclepias eriocarpa
5 (15) Asclepias fascicularis
5 (15) Asclepias speciosa
5 (15) Epilobium canum 'Everett’s Choice’
5 (15) Epilobium canum ‘Chaparral Silver'
5 (15) Epilobium canum ssp canum
5 (15) Epilobium canum 'Calistoga'

Block 5 (Beds 13 – 15)
# of species per bed (total per block)
1 (3) Muhlenbergia rigens
5 (15) Achillea millefolium
3 (9) Solidago californica 'Cascade Creek'
5 (15) Monardella villlosa
8 (24) Sporobolus airoides
5 (15) Asclepias cordifolia
5 (15) Asclepias eriocarpa
5 (15) Asclepias fascicularis
5 (15) Asclepias speciosa
5 (15) Epilobium canum 'Everett’s Choice’
5 (15) Epilobium canum ‘Chaparral Silver'
5 (15) Epilobium canum ssp canum
5 (15) Epilobium canum 'Calistoga'