**FINAL REPORT**
**Saratoga Horticultural Research Endowment 2014-2016**
**November 30, 2016**

# Developing Irrigation Guidelines for the Establishment of California Native Plants in the Landscape (Year 1)


**Principal Investigator:**

Karrie Reid, UCCE Environmental Horticulture Advisor, San Joaquin County
2101 E. Earhart Ave., Ste 200
Stockton, CA 95206-3949
(209) 953-6109 office
skreid@ucdavis.edu

**Co-Investigator:**

Lorence (Loren) R. Oki, Ph.D., CE Specialist, Dept. of Plant Sciences, UC Davis

**Cooperators:**

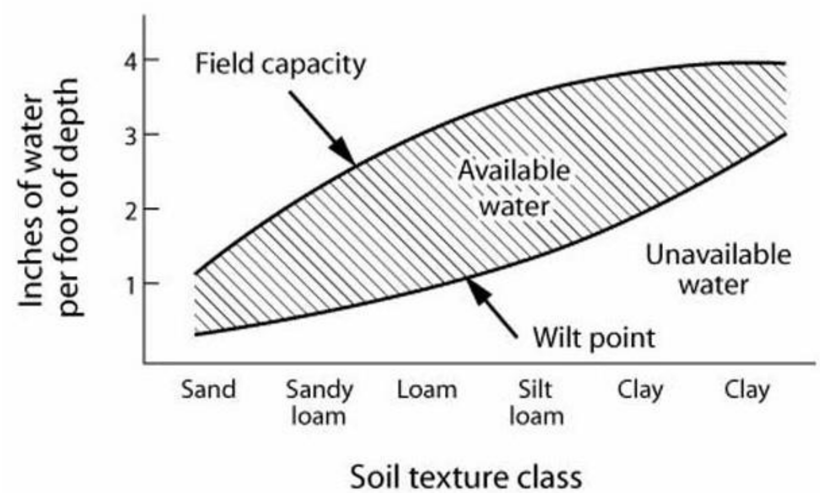
David W. Fujino, Ph.D., Director, California Center for Urban Horticulture, UC Davis
Jared Sisneroz, Staff Research Associate, UC Davis Dept. of Plant Sciences
Woodbridge Golf and Country Club
Cornflower Farms Nursery, Elk Grove, CA
Devil Mountain Growers, Acampo, CA


## Introduction

California native plant species have enjoyed a surge in interest as landscape plants, due in large part to the prolonged drought which followed on the heels of the Water Conservation Act of 2009 and the accompanying Water Efficient Landscape Ordinance and updates (CA DWR, 2009, 2015). Urban water restrictions and heightened awareness of the need to conserve have caused both home gardeners and professional landscapers to look for plants that will fit into a new style of landscape with lower water needs. The gardening public and much of the landscape industry have had the general perception that all California native plants need little water, will be drought-tolerant immediately after planting, and are therefore universally suited to a reduced-water landscape situation. However, this view does not take into account the wide diversity of ecosystems and habitats across the state where these plants naturally occur, or the rainfall patterns to which they are adapted. Plant failures then ensue when selections unsuitable to a particular climate zone or microclimate are used, or when irrigation is applied in a manner that kills the plants before they get established.

The advice from virtually all experienced California native horticulturists is to plant most species during the fall and to irrigate regularly during at least the first year of establishment. It is an unavoidable fact, however, that landscapes will be installed during less than optimal seasons, and much of commercial landscaping in particular takes place during spring and into summer. Because of the many reported failures of California native plants during this period, this study aimed to develop irrigation guidelines for first-year establishment for warm season planting for five commonly used landscape species (Table 1).

Although poor nursery stock may be the culprit in some plant failures in the landscape, problems often arise from too much or too little water applied too often or too infrequently. The recommendations to irrigate “regularly” are too vague to be useful to the average landscape manager or home gardener. Recommendations for irrigation will necessarily vary by soil type, since soils vary by texture in their water-holding capacity, at field capacity, and in how much of that water is available to plants. Clay soils hold more total water than sandy or loamy soils, but the amount of unavailable water is also high. Irrigation controllers using weather-based models calculate and trigger an irrigation event when a site has reached 100% of the management allowable depletion, or MAD, usually at around 50% of the soil’s plant available water (PAW). This is roughly the point at which water becomes increasingly difficult for plants to extract, and when 100% of available water is reached, it is therefore called the permanent wilting point (PWP). The issue here is that PWP varies by soil type, with clay soils holding their water more tightly than sandy soils, and therefore at both extreme ends of the soil-type spectrum soils have a PAW number that is less than 50% of the WHC. Sandy soils hold less total water, and therefore require a shorter interval between irrigations since, given the same weather conditions, they will reach the MAD sooner. This study was duplicated in silty clay loam and fine sandy loam soils to provide more breadth to the applicability of the resulting guidelines.




When plants are first put in the ground, there is usually a stark difference between the native soil and the environment directly around the roots in the potting medium. During the establishment phase, particularly in warm weather, some adjustment down needs to be made to the usual MAD reached before watering, or the immediate root environment will become too dry before the roots have grown into the surrounding soil. The question this study sought to answer was: in two common soil types, what MAD percentage results in the least mortality and best health for these five native species during the first irrigated growing period, or in plain terms, how much should the soil be allowed to dry between irrigations during the first growing season for spring planting of these species?

Most landscape managers do not use soil moisture sensors to determine when to irrigate, but they do have access to reference evapotranspiration data ($ET_0$) online through the California Irrigation Management Information System (CIMIS, http://wwwcimis.water.ca.gov/). For this reason, and since many “smart” irrigation controllers also use this data, we chose to base our method of determining irrigation application timing on the water-budget model using this data (CIMIS, 2016).

Table 1. Plants installed in April 2015 in both clay loam soil (Davis, CA) and sandy loam soil (Woodbridge, CA).

| Botanical Name | Common name |
|---|---|
| *Arctostaphylos uva-ursi* ‘Wood’s Compact’ | Wood’s compact bearberry (kinnikinnick) |
| *Arctostaphylos uva-ursi* ‘Point Reyes’ | Point Reyes bearberry (kinnikinnick) |
| *Ceanothus* ‘Concha’ | Concha California lilac |
| *Eriogonum giganteum* | Giant buckwheat |
| *Salvia clevelandii* ‘Allen Chickering’ | Allen Chickering Cleveland sage |

**Methods and Materials**

Two fields were prepared to conduct irrigation trials in full sun. Located in Davis, CA, Field 1 has a clay loam soil; Field 2 in Woodbridge, CA has a fine sandy loam soil. Both fields are in USDA hardiness zone 9b and Sunset Zone 14. Each field was laid out with five rows and 24 planting spaces; rows and spaces were 2m apart. Six reps of each species on each of the four irrigation treatments were randomly placed in two complete blocks (north and south; three reps per treatment and species per block) for a total of 120 plants. The rows were covered with three inches (7.5cm) of chipped-wood mulch, and a ring of internal-emitter drip tubing with a combined application rate of 3.2gph (12.1 l/h) was laid beneath the mulch at the potting medium/native soil interface of each plant.

The soil from each field was sampled at field capacity, weighed, dried and weighed again to determine the WHC; standardized charts were then used to estimate the total plant available water (AW) for each soil type (UCANR, 2009). An irrigation budget was developed for each field based on four percentages of PAW for the MAD for each soil type, and using daily $ET_0$, as described in Water Use Classification of Landscape Species IV (http://ucanr.edu/sites/WUCOLS/). The MAD percentages used in this trial were 25%, 50%, 75%, and 100% of each soil type’s AW. Data from CIMIS Station #6 in Davis was used in the water budget for Field 1; data from an onsite private weather station was used for Field 2.

Plant width, length, and height measurements were taken monthly. A plant growth index (PGI) was calculated to quantify the comparative growth of plants under different irrigation treatments using the formula [(l +w)/2 +h]/2, where *l*, *w*, and *h* represent length, width, and height of the plant (Irmak et al, 2004). Relative PGI was calculated to make up for initial plant size differences using the formula (current PGI/initial PGI). Qualitative performance ratings (on a scale of 1-5) were made monthly in the following categories: foliage appearance, flowering abundance, pest tolerance, disease resistance, vigor, and overall appearance- the “WOW” factor- (Standardized Trialing Protocol, 2014).

**Results and Discussion**

The tables below summarize the recommendations for MAD for all species and the average number of days between irrigations for each treatment by month for each field (Tables 2 and 3). Recommendations are derived from the correlation of the best growth and appearance combined with lowest mortality where significant. These are followed by tables showing percent mortality, the average overall appearance rating, and the relative plant growth index in November 2015 for each species by field. Since there was no irrigation related mortality in Field 2 (Woodbridge), that is not shown in the tables. Any pertinent comments for the species follow each table. Lower-case superscript letters indicate statistically significant differences using ANOVA and Tukey's HSD at $p \leq 0.05$. No superscript indicates statistically significant differences were not present. A table at the end of the discussion shows the rubric for quality evaluations (Table 9). Photos are be found in the Appendix and show a representative from each species in each field on the recommended establishment irrigation regime.

**NOTES:**

The trials were originally intended to run for a full year. Deer browsing in the Woodbridge field began in late November and became severe starting in December. They began selectively browsing the flower stalks of *Eriogonum giganteum* and the tips of *Ceanothus* 'Concha'. After they had devoured these two, they moved on to the tips of the *Arctostaphylos* cultivars. The only untouched plants were the *Salvia*. For this reason, the early November ratings and measurements were used as the final ratings for all species in all fields for a more accurate comparison. Since this represents the irrigated growing season, and the winter rain was more than enough to replace $ET_0$, the reported results should be adequate for recommendations.

The Davis field received a strong pre-plant treatment of pre-emergent herbicide that was subsequently flushed from only half the field (the north block). The plants in the unflushed half of the field (the south block) suffered extremely high mortality rates, which led to the discovery of the improperly treated field. (Only *Ceanothus* 'Concha' suffered mortality that was not correlated to herbicide effects.) For this reason, only data from the north block was used, and the "n" number is three (at most) for all statistical analyses of Field 1 data.

**Results Dissemination**

The results of this study are of high interest to the nursery and landscape industry. California Landscape Contractors Association has requested that we submit results from this and next year's study as soon as possible for publication in their newsletters statewide. The same request has been made by the Association of Professional Landscape Designers California Chapter, the nursery staff at Rancho Santa Ana Botanic Garden, and a bi-lingual southern California landscaper training company. We plan to fulfill all these requests soon after the first of the year, and to look for other media outlets where the information would be appropriate. We will also be preparing a manuscript for publication that includes the results from both years of the trial as soon as the final data from the Year 2 trial is ready for processing. As usual, the results will also be posted on the CCUH website and shared at every opportunity at landscape training events including the upcoming Green Gardener Qualification Trainings in Stockton and Sacramento this winter.

## Summary of Recommendations

Table 2. Recommended irrigation management allowable depletion (MAD) for spring planting for five California native landscape species in two soil types.

| PLANT NAME | Recommended rate (MAD %) | |
|---|---|---|
| | Clay loam | Sandy loam |
| *Arctostaphylos uva-ursi* 'Point Reyes' | **25-50** | **50** |
| *Arctostaphylos uva-ursi* 'Wood's Compact' | **50-75** | **50** |
| *Ceanothus* 'Concha' | **50** | **75-100** |
| *Eriogonum giganteum* | **25[1]** | **25** |
| *Salvia clevelandii* 'Allen Chickering' | **75** | **25** |

1. Not recommended in this soil type due to mortality at all irrigation levels.

Table 3. Average days between irrigations by month for each MAD percentage during the growing season of 2015 for silty clay loam and fine sandy loam soils.

| MAD% | Gals applied[1] | April | May | June | July | August | Sept | Oct |
|---|---|---|---|---|---|---|---|---|
| **Clay loam[2]** | | | | | | | | |
| 25 | 3.6 | | 3 | 3 | 3 | 3 | 3 | 5 |
| 50 | 7.2 | | 7 | 5 | 5 | 5 | 7 | 11 |
| 75 | 10.8 | | 10 | 8 | 8 | 8 | 10 | 15 |
| 100 | 14.3 | | 14 | 10 | 10 | 11 | 13 | 19 |
| **Sandy loam[3]** | | | | | | | | |
| 25 | 3.1 | 2 | 4 | 3 | 3 | 3 | 4 | 6 |
| 50 | 6.2 | 2 | 6 | 5 | 5 | 5 | 7 | 12 |
| 75 | 9.3 | 2 | 14 | 8 | 8 | 8 | 11 | 18 |
| 100 | 12.4 | 2 | 19 | 11 | 11 | 11 | 13 | 22 |

1. Per plant at each irrigation event.
2. Plants were installed on April 29.
3. Plants were installed in late April and irrigated every other day in the sandy soil until May.

## Individual Species Results

### *Arctostaphylos uva-ursi* 'Point Reyes'

'Point Reyes' bearberry is a commonly used groundcover in low-water landscapes, but this trial has led us to think there are probably better choices for the Central Valley, particularly in clay loam where it rarely scored higher than average in overall appearance. In the sandy soil of Field 2 it more often scored a "very good" rating of "4", but still only averaged somewhere just above acceptable. In both valley sites it had a tendency to develop necrosis at both the growing tips and mid-stem for undetermined reasons. The name gives a clue to its bioregion of origin, and probably to its preference for slightly cooler summer temperatures than are found inland. However, if this cultivar is used, the recommended rate of MAD during the first growing season is 25-50% for clay soils and 50% for sandy soils. Plants in clay soil should not be expected to add more than 30% in size during the first growing season.

Table 4. *Arctostaphylos uva-ursi* 'Point Reyes' first-year performance on 4 irrigation schedules based on percentages of management allowable depletion (MAD) of plant available water.

| MAD% | 100 | 75 | 50 | 25 | Rec. rate |
|---|---|---|---|---|---|
| **Davis, CA- silty clay loam** | | | | | **25-50** |
| Mortality | 0.0% | 0.0% | 0.0% | 0.0% | |
| Average Overall appearance rating | 3.2 | 3.0 | **3.3** | **3.3** | |
| Final rPGI | 1.0[b] | 1.0[b] | **1.2[ab]** | **1.3[a]** | |
| **Woodbridge, fine sandy loam** | | | | | **50** |
| Average Overall appearance rating | 3.1 | 2.9 | **3.4** | 2.9 | |
| Final rPGI | 1.3[b] | 1.8[a] | **1.9[a]** | 1.9[a] | |

### *Arctostaphylos uva-ursi* 'Wood's Compact'

This bearberry cultivar showed a clear preference for irrigation at a MAD of 50-75% in clay and 50% in sandy soil. It suffered some of the same leaf necrosis symptoms as the 'Point Reyes', but not to the same extent, and achieved a "very good" average appearance rating on the 50% treatment in sandy soil.

Table 5. *Arctostaphylos uva-ursi* 'Wood's Compact' first-year performance on 4 irrigation schedules based on percentages of management allowable depletion (MAD) of plant available water.

| MAD% | 100 | 75 | 50 | 25 | Rec. rate |
|---|---|---|---|---|---|
| **Davis, CA- silty clay loam** | | | | | **50-75** |
| Mortality | 0.0% | 0.0% | 0.0% | 0.0% | |
| Average Overall appearance rating | 3.1 | 3.1 | 3.0 | 3.2 | |
| Final rPGI | 1.4[b] | 1.8[ab] | 2.0[a] | 1.4[b] | |
| **Woodbridge, fine sandy loam** | | | | | **50** |
| Average Overall appearance rating | 3.7 | 3.4 | 4.2 | 3.8 | |
| Final rPGI | 2.0 | 2.0 | 2.4 | 2.1 | |

### *Ceanothus* 'Concha'

Much of the literature on California native plants espouses this cultivar of *Ceanothus* as more garden-friendly than most, by which they mean it will tolerate some summer irrigation and a variety of soil types. In our initial trials on irrigation regimes after establishment, this cultivar suffered very high mortality during the first (establishment) and second (treatment) years, which is why it was included in this establishment trial. In clay soil, the highest rating and best growth was achieved at the 50% MAD rate; in sandy soil, the plants performed best at the higher MAD level of 75-100%. While many plants in Field 2 tended to have chlorotic leaves, especially on the lower and inner canopy as the season wore on, it was more pronounced in the more frequently irrigated plants, leading to unacceptable quality ratings. It may be that the nitrogen-fixing bacteria that form on *Ceanothus* roots were not present in the sandy trial soil, and frequent irrigation washed resident nutrients through the soil leaving the plants deficient.

Table 6. *Ceanothus* 'Concha' first-year performance on 4 irrigation schedules based on percentages of management allowable depletion (MAD) of plant available water.

| MAD% | 100 | 75 | 50 | 25 | Rec. rate |
|---|---|---|---|---|---|
| **Davis, silty clay loam** | | | | | **50** |
| Mortality | 33.3% | 66.7% | 0.0% | 100.0% | |
| Overall appearance rating | 3.0 | 2.3 | 3.7 | Ø | |
| Final rPGI | 2.2 | 0.7 | 3.3 | Ø | |
| **Woodbridge, fine sandy loam** | | | | | **75-100** |
| Overall appearance rating | 3.1 | 3.3 | 2.5 | 2.7 | |
| Final rPGI | 2.8 | 2.7 | 2.9 | 2.7 | |

### *Eriogonum giganteum*

This plant performed well in the sandy soil while mortality was unacceptably high in clay. In both fields it had a tendency to be non-uniform in shape, and its brittle branches were easily broken off by animals or wind. However, there were very attractive specimens that were dense, symmetrical and healthy. In both of our soil types, the best growth and appearance combination was on the 25% MAD treatment.

Table 7. *Eriogonum giganteum* first-year performance on 4 irrigation schedules based on percentages of management allowable depletion (MAD) of plant available water.

| MAD% | 100 | 75 | 50 | 25 | Rec. rate |
|---|---|---|---|---|---|
| **Davis, silty clay loam** | | | | | **25 (NR)[1]** |
| Mortality | 66.7% | 33.3% | 66.7% | 33.3% | |
| Overall appearance rating | 3.6 | 3.2 | 3.8 | 3.9 | |
| Final rPGI | 2.4 | 1.9 | 1.9 | 2.4 | |
| **Woodbridge, fine sandy loam** | | | | | **25** |
| Overall appearance rating | 3.8 | 3.8 | 3.7 | 3.7 | |
| Final rPGI | 2.6 | 2.8 | 2.7 | 3.4 | |

1. Not recommended for clay soils.

***Salvia clevelandii* 'Allen Chickering'**

In clay soil, this sage cultivar on all irrigation regimes tended to get yellow and brown leaves. The leaf effects may have been due to the boron present in the water in the Davis field, since this was not a consistent issue in Woodbridge. In both fields plants tended to split apart and become non-uniform near the end of summer/beginning of fall. It is usually recommended to prune *S. clevelandii* hard after flowering, which the trial protocol did not allow. Some of the overall appearance ratings were adversely affected by this. This may also be a species that does not require 100% of $ET_0$ replacement during the entire establishment period, but this would require further study to determine.

Table 8. *Salvia clevelandii* 'Allen Chickering' first-year performance on 4 irrigation schedules based on percentages of management allowable depletion (MAD) of plant available water.

| MAD% | 100 | 75 | 50 | 25 | Rec. rate |
|---|---|---|---|---|---|
| **Davis, silty clay loam** | | | | | **75** |
| Mortality | 0.0% | 0.0% | 0.0% | 0.0% | |
| Overall appearance rating | 2.8 | 3.0 | 2.2 | 2.0 | |
| Final rPGI | 3.1 | 3.2 | 3.4 | 3.5 | |
| **Woodbridge, fine sandy loam** | | | | | **25** |
| Overall appearance rating | 3.5 | 3.7 | 3.0 | 3.8 | |
| Final rPGI | 2.8 | 2.9 | 3.2 | 3.3 | |

**References**

California Department of Water Resources. 2009. Water Conservation Act of 2009; Senate Bill X7-7. 11 November, 2016. http://www.water.ca.gov/wateruseefficiency/sb7/docs/SB7-7-TheLaw.pdf

California Department of Water Resources. 2015. Water Efficient Landscape Ordinance. 11 November, 2016. http://www.water.ca.gov/wateruseefficiency/landscapeordinance/

California Irrigation Management Information System. 2016. Irrigation scheduling: the water budget method. 12 November, 2016. http://wwwcimis.water.ca.gov/Content/pdf/Irrigation_Scheduling_Using_CIMIS.pdf

Irmak, Suat, D.Z. Haman, A. Irmak, J.W. Jones, K.L. Campbell, T.L. Crisman. 2004. Measurement and Analyses of Growth and Stress Parameters of *Viburnum odoratissimum* Grown in a Multi-pot Box System. *HortScience* 39(6):1445-1455.

National Plant Trials Database. 2016. Standardized Trialing Protocol. 12November, 2016. http://www.planttrials.org/index.cfm/fuseaction/home.showpage/pageID/4/index.htm.

University of California Division of Agriculture & Natural Resources, Center for Urban and Landscape Horticulture. 2009. Soil Water Holding Characteristics. 12 November, 2016. http://ucanr.edu/sites/UrbanHort/Water_Use_of_Turfgrass_and_Landscape_Plant_Materials/Soil_Water_Holding_Characteristics/

Table 9. Description of quality ratings

| RATING | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|
| **Foliage** | perfect to excellent; plant is in full leaf with no signs of leaf burn, disease or insect damage, and has an appealing shape and uniformity | same as 5 except for minor tip burn, edge damage, or minor damage to only a few leaves that does not much affect the overall appearance | acceptable but not its best; possibly non-uniform; minor damage to all leaves that is less evident from a distance, or severe damage to no more than 25% of plant | unacceptable; moderate damage to most of the plant or major damage to more than 25%; plant is declining and may not recover; may be extremely non-uniform | unacceptable; close to dead |
| **Flowering** | full, glorious bloom; the height of bloom for the species | 61-80% of plant in bloom | 41-60% of plant in bloom | 21-40% of plant in bloom | 1 bloom open to 20% in bloom |
| **Pest Tolerance/ Disease Resistance** | no visible damage | minor to moderate damage to one or two leaves or stems, or only very minor damage to a few leaves (<25%) | minor damage to many of the leaves or flowers; appearance still acceptable from a distance (25-50%) | major damage ; appearance unacceptable (51-75%) | severely damaged and probably dying (>75% affected) |
| **Vigor** | pushing out a lot of new growth from every growing point | pushing out new growth from many growing points | Plant is surviving and healthy, but not pushing out much new growth, if any | Plant is very small for the species or unhealthy, and declining | Plant is barely alive; close to death |
| **Overall Appearance** | An impressive plant; everything works together: flowers (if present), leaves, the shape and condition of the plant are all very appealing. It has the WOW factor that makes it an attractive garden plant, even if each individual factor isn't perfect. | a very attractive plant; may be a 5 when in bloom, or just a very nice species that lacks the WOW factor or is not quite at its prime | Acceptable but nothing special; may be past or not quite to its prime; might be better if more uniform; may be described as an 'okay' plant. | unacceptable for any of the above reasons | completely unacceptable and not likely to improve |

# APPENDIX

Figure 1. Davis- Field 1 in November 2015 showing the heavy mortality in the south end.

Figure 2. Field 2 in October 2015 on the Woodbridge Country Club golf course.

Figure 3. Typical necrosis pattern for *Arctostaphylos* 'Point Reyes' in Davis.

Figure 4. *Arctostaphylos* 'Wood's Compact' on 50% MAD in Davis in November 2015.

Figure 5. *Ceanothus* ‘Concha’ on 50% MAD in Davis in November 2015.

Figure 6. An attractive *Eriogonum giganteum* in Davis in November 2015.

Figure 7. *Salvia clevelandii* 'Allen Chickering' in Davis on 75% MAD in November 2015.

Figure 8. *Arctostaphylos* 'Point Reyes' on 50% MAD in Woodbridge in September 2015.

Figure 9. *Arctostaphylos* 'Wood's Compact' on 50% MAD in Woodbridge in October 2015.

Figure 10. *Ceanothus* 'Concha' on 100% MAD in Woodbridge in October 2015 showing chlorosis.

Figure 11. Handsome *Eriogonum giganteum* on 25% MAD in Woodbridge in Sept. 2015.

Figure 12. *Salvia clevelandii* 'Allen Chickering' on 25% MAD in Woodbridge in Sept. 2015.