

2019

Center for Water-Efficient Landscaping

ANNUAL REPORT | JULY 2018 - JUNE 2019

UTAH STATE UNIVERSITY



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Larry A. Rupp, Director
Center for Water Efficient Landscaping
Utah State University

MESSAGE FROM THE DIRECTOR

The year 2019 marks 20 years since the Utah State Legislature approved House Bill 30 *Appropriation for Center for Landscape Water Management*. The house bill was sponsored in a bipartisan effort by Judy Ann Buffmire (D) and Evan L. Olsen (R) in recognition of the need for landscape water conservation and it resulted in creation of the Center for Water-Efficient Landscaping (CWEL) at Utah State University (USU). While water and its management remains a critically important issue (as was foreseen in 1999), there has been progress in landscape water conservation across the state as a whole. Most notably in my mind is that 20 years ago, water conservation was skeptically viewed as a fringe approach to water management. Now the concept is embraced statewide as a necessary tool to ensure Utah's water is used both wisely and equitably. We are excited at CWEL to continue research and Extension programs designed to improve landscape water management at scales from the individual plants to entire communities. New faculty and students continue to breathe fresh air and critical thinking into our programs and bring the enthusiasm necessary to carry this program forward. Once again, we hope you enjoy reviewing our accomplishments of the past year and encourage your comments and suggestions.

Larry A. Rupp



WHO WE ARE

FACULTY



DR. LARRY A. RUPP

Director, Center for Water-Efficient Landscaping
Professor of Ornamental Horticulture, Extension Specialist
Department of Plants, Soils and Climate
College of Agriculture and Applied Sciences

Dr. Rupp works on the development of plants native to the intermountain region for use in water conserving landscapes.



DR. JOANNA ENDTER-WADA

Professor of Natural Resource Policy and Social Science
Department of Environment and Society
Quinney College of Natural Resources

Dr. Endter-Wada researches social science and policy aspects of urban landscape water use and conservation, and the human dimensions of drought and climate change.



DR. PAUL G. JOHNSON

Department Head and Professor of Turfgrass Science
Plants, Soils and Climate
College of Agriculture and Applied Sciences

Dr. Johnson develops bluegrass species with increased drought and salt tolerance for better adaptation to Intermountain West environments.



DR. KELLY KOPP

Professor/Extension Water Conservation and Turfgrass Specialist
Department of Plants, Soils and Climate
College of Agriculture and Applied Sciences

Dr. Kopp's research aims to improve the efficiency of landscape irrigation with projects that include plant water use efficiency evaluations, appropriate irrigation system design, and smart water application technologies.



DR. YOUPIING SUN

Assistant Professor of Landscape Horticulture
Department of Plants, Soils and Climate
College of Agriculture and Applied Sciences

Dr. Sun works on urban landscape horticulture with an emphasis on understanding whole-plant responses to natural or managed water stress and promoting the use of native plants for water-efficient landscapes.



CANDACE SCHAIBLE, MS

Professional Practice Extension Associate Professor
Iron County Extension

Ms. Schaible focuses on horticulture and works to educate homeowners on best practices for water conservation in the landscape.

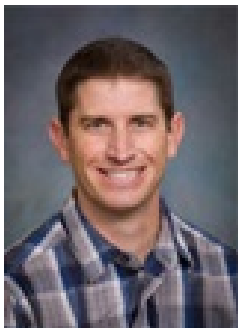
STAFF



SUSAN BUFFLER, MS, MLA

Program Coordinator (March, 2019 to present)
Center for Water-Efficient Landscaping

Susan has a background in landscape architecture, plant science (agriculture), and art. Her interests include native and waterwise plants, edible landscaping, plants for pollinators, and waterwise planting design.



PAUL HARRIS

Research Technician
Center for Water-Efficient Landscaping

Paul's professional interests include furthering research in turfgrass drought tolerance and promoting landscape water conservation. Paul is also pursuing a master's degree in plant science.



MICHAEL KILCREASE

Research Technician
USU Botanical Center & Center for Water-Efficient Landscaping

Michael is a research technician based at the USU Botanical Center in Kaysville. He assists with a variety of research projects for CWEL at that location.



ADREA WHEATON, MPSH

Program Coordinator (through January, 2019)
Center for Water-Efficient Landscaping

With a background in landscape architecture and horticulture, Adrea's interests include promoting landscape water conservation through smart plant selection.

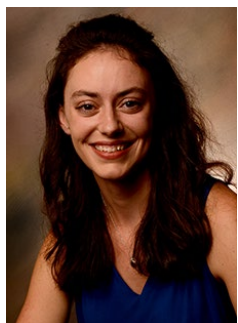


DIANA WUENSHELL, MS

Senior Research Technician (through March 2019)
Department of Environment and Society

Diana was the project manager with the WaterMAPS™ Initiative of CWEL and has contributed to research focusing on water conservation behavior.

RESEARCH GRADUATE STUDENTS



PAIGE BOYLE

Graduate Student, PhD Ecology

Undergraduate Degree: Environmental, Soil & Water Science, University of Arkansas

Master's Degree: Horticulture, University of Arkansas

Dissertation Project: Clover Inclusion for Value-Added Turf



KYLIE LAWSON

Graduate Student, MS Plant Science

Undergraduate Degree: Plant Science, Utah State University

Thesis Project: Selecting and Grafting Single-leaf Pinyon Pine



SHANE EVANS

Graduate Student, MS Plant Science

Undergraduate Degree: BS Environmental Science, Brigham Young University

Thesis Project: Can Smart Irrigation Controllers Improve Water Use Efficiency in Urban Landscapes?



IVY THOMSON

Graduate Student, MS Environment and Society

Undergraduate Degree: Interdisciplinary Studies, Utah State University

Master's Degree: Master of Professional Studies in Horticulture, Utah State University

Current Thesis Project: Policy Review of Best Management Practices in Urban Landscape Water Conservation



PAUL HARRIS

Graduate Student, MS Plant Science

Undergraduate Degree: Horticulture, emphasis in Turfgrass Management, Utah State University

Thesis Project: Salinity Tolerance in Kentucky Bluegrass Hybrids



ASMITA PAUDEL

Graduate Student, MS Plant Science

Undergraduate Degree: Agricultural Science (BSC Agriculture) Tribhuvan University (Nepal)

Thesis Project: Propagation and Production of Utah Native Plants



JI-JHONG CHEN

Graduate Student: MS Plant Science

Undergraduate Degree: Horticultural Science, National Chung Hsing University (Taiwan)

Thesis Project: Using Actinobacteria to Improve Adaptability of Urban Landscape Plants.

MASTER OF PROFESSIONAL STUDIES IN HORTICULTURE (MPSH) STUDENTS



TREVOR KIMBALL

Undergraduate Degree: Landscape Architecture, Utah State University

Capstone Project: Trevor worked with Perennial Favorites wholesale nursery in Layton, Utah to create perennial trial beds.

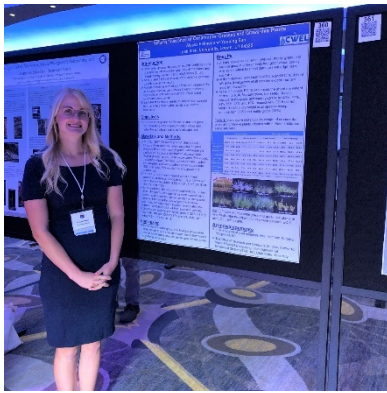


GILBERT YOUNG

Undergraduate Degree: Plant Science, Utah State University

Capstone Project: Gilbert works for USU Facilities and manages the Innovation Campus landscape. His capstone project is redesigning and installing a new native landscape north of the Big Blue parking terrace on USU's main campus.

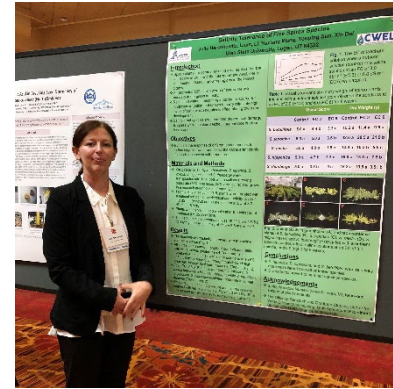
UNDERGRADUATE RESEARCHERS



ALYSSA PALMER

Undergraduate Research Project: Salinity Tolerance of Ornamental Grasses & Grass-like Plants

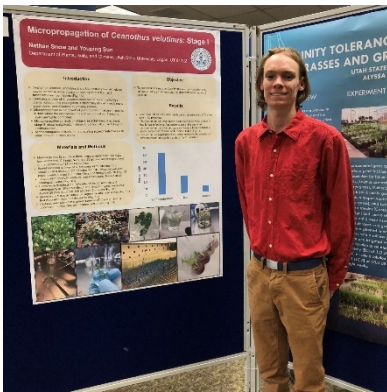
Faculty Advisor:
Dr. Youping Sun – Department of Plants, Soils and Climate



JULIE HERSHKOWITZ

Undergraduate Research Project: Micropropagation of Utah Native Plants & Salt Tolerance of Ornamental Grasses.

Faculty Advisor:
Dr. Youping Sun - Department of Plants, Soils and Climate



NATHAN SNOW

Undergraduate Research Project: Micropropagation of *Ceanothus velutinus*: Stage 1

Faculty Advisors:
Drs. Youping Sun and Larry Rupp – Department of Plants, Soils and Climate



ANIKKA BURKHARDT

Undergraduate Research Fellow

Undergraduate Research Project: Propagation of Native Juniper

Faculty Advisor: Dr. Larry Rupp – Department of Plants, Soils and Climate

CENTER FOR WATER-EFFICIENT LANDSCAPING INTERNS



KIARRA MILLER

Undergraduate in Biology
Department of Biology

CWEL social media outreach
CWEL website management
Water-efficient landscaping Fact Sheets
Video editing



LIZZY SWINK

**Undergraduate in Plant Science,
Ornamental Horticulture**
Department of Plants, Soils and Climate

CWEL social media outreach
CWEL website management
CWEL student worker: UAES Greenville
Farm

ABBREVIATIONS

CAAS	College of Agriculture and Applied Science
CWEL	Center for Water-Efficient Landscaping
ENVS	Department of Environment and Society
ET	Evapotranspiration
FRRL	Forage and Range Research Lab
FS	Forest Service
GIS	Geographic Information Systems
PSC	Department of Plants, Soils, and Climate
QCNR	Quinney College of Natural Resources
LAEP	Department of Landscape Architecture and Environmental Planning
MPSH	Master of Professional Studies in Horticulture
UAES	Utah Agricultural Experiment Station
USDA	United States Department of Agriculture

WHAT WE DO



RESEARCH

Currently, it is estimated that approximately 50-65% of Utah's culinary water is used for landscape irrigation. Research has demonstrated that the amount of water applied to landscapes could be reduced substantially without affecting landscape quality or consumer lifestyles. Water use could be reduced even further if alternative landscape designs and management programs were practiced.

CWEL's specific goals currently include research on water requirements of trees and turfgrass, effects of short-term drought on landscapes, development and use of drought-tolerant grasses and landscape plants, characterization of community-wide landscape water demand and use patterns, and development of water conservation policy.



IMPLEMENTING WATER CONSERVATION STRATEGIES IN EAGLE MOUNTAIN CITY, UTAH



PROJECT INFORMATION

PRINCIPAL INVESTIGATORS

- Joanna Endter-Wada** – Professor, Natural Resource Policy and Social Science, ENVS, CWEL
- Larry Rupp** – Professor, Extension Landscape Horticulture Specialist, PSC, CWEL
- Kelly Kopp** – Professor, Extension Water Conservation and Turfgrass Science Specialist, PSC, CWEL

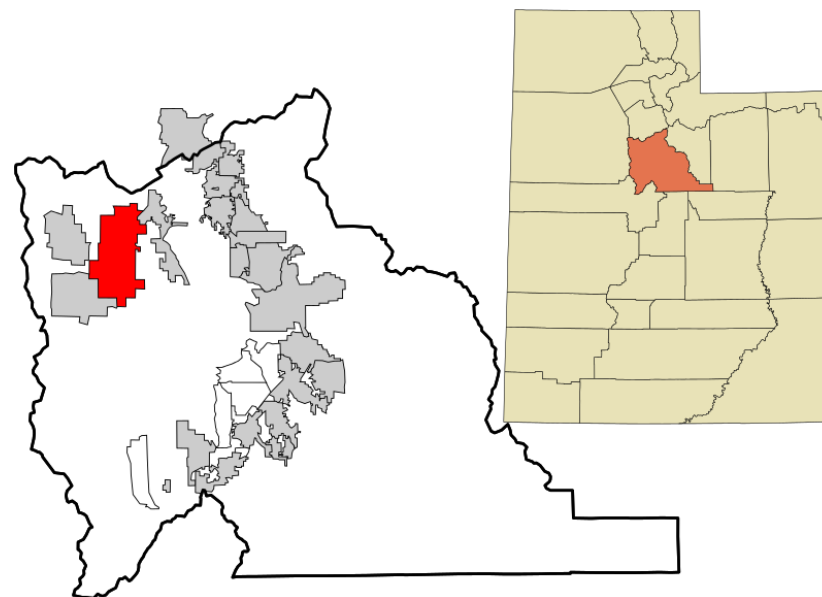
PROJECT TEAM MEMBERS

- Paul Johnson** – Department Head and Professor, Turfgrass Science, PSC
- Youping Sun** – Assistant Professor, Landscape Horticulture, PSC
- David Anderson** – Professional Practice Associate Professor, Landscape Architecture and Environmental Planning (LAEP)
- David Bell** – Professor, Landscape Architecture Extension Specialist, LAEP
- Diana T. Wuenschell** – Senior Research Technician, ENVS, CWEL
- Adrea Wheaton** – CWEL Program Coordinator, PSC
- Ivy Harvey Thomson** – Ph.D. Student, CWEL
- Logan Oates** – M.S. Student, LAEP
- Chris Garrard** – Programmer/Analyst, Remote Sensing and GIS Lab
- Ellie McGinty** – GIS Specialist, Remote Sensing and GIS Lab
- Chris McGinty** – Assistant Director, Remote Sensing and GIS Lab

CO-INVESTIGATORS/COOPERATORS (EAGLE MOUNTAIN CITY)

- Tom Westmoreland** – Mayor
- Ifo Pili** – City Administrator
- Evan Berrett** – Management Analyst, Eagle Mountain-USU Project Manager
- Brad Hickman** – Director, Parks and Recreation
- Lori Jolley** – Accountant, Utility Billing

LOCATION: **Eagle Mountain City, UT**



Wikimedia.org/Wikimedia Commons (see p. 60)



<https://eaglemountaincity.com/>

PROJECT OBJECTIVES

We are assisting Eagle Mountain City with water conservation through customized application of several Extension programs and public outreach efforts including WaterMAPS™ analyses, delivery of Water Checks, landscape planning and design for public spaces, and providing information to citizens.

Eagle Mountain City is one of the fastest growing communities in Utah. The city is striving to become a Utah model for effective community-wide water conservation efforts and is wisely seeking documentation of program efficacy by establishing a baseline of current water use prior to program implementation. This project provides an excellent opportunity for USU Extension to work with Eagle Mountain City to develop a municipal case study of documented practices that will benefit water conservation outreach efforts throughout the state.

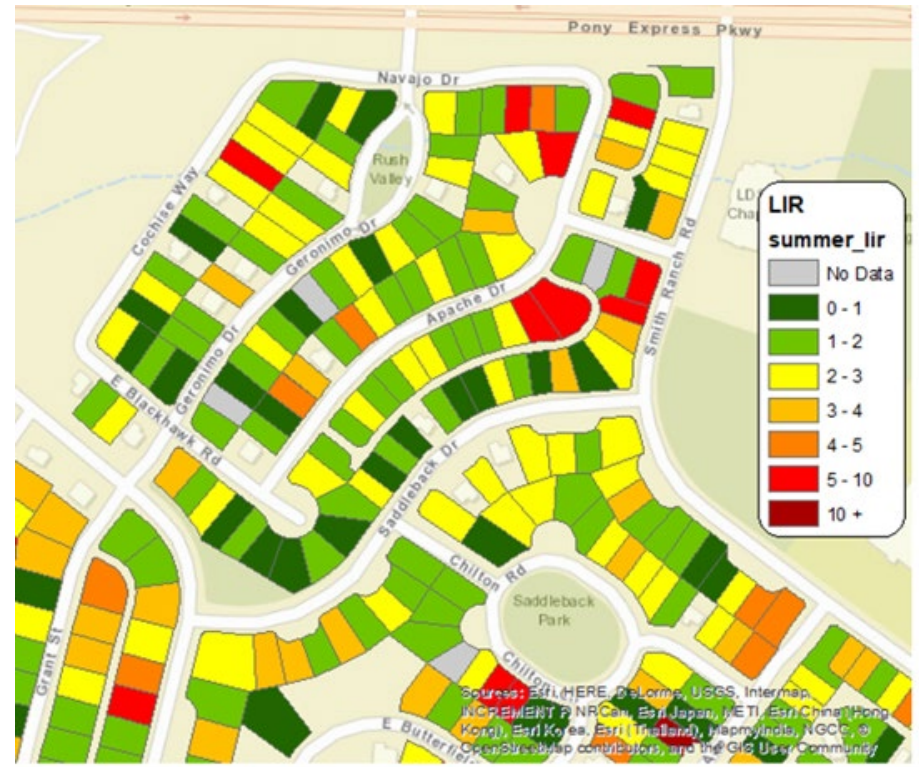
PROJECT SUMMARY



WaterMAPS™ baseline analyses have been conducted to determine how efficiently community residents are using water on their landscapes. WaterMAPS™

software, developed at USU, integrates various databases (property boundaries, aerial imagery of landscape features, water use data, and real-time weather data) to produce parcel-specific landscape irrigation ratios (LIRs) based on landscape water use as compared to estimated landscape water need. The LIRs indicate which landscapes are being overwatered and, thus, where the highest capacity to conserve exists. Results can be spatially and temporally displayed and analyzed.

The analyses conducted for Eagle Mountain City found that 57% of single-family residential locations have a substantial capacity to conserve water used on their landscapes.



Illustrative WaterMAPS™ Baseline Analysis (not based on actual data)

These locations are distributed throughout the city and no single neighborhood appears to be wholly less efficient than another. Every neighborhood has the potential to increase landscape water use efficiency. Results are being used to direct Water Checks to locations with capacity to conserve.



In 2018, Water Checks were offered to residents and 45 household locations participated. Results from these Water Checks are being compared to results from the WaterMAPS™ analyses and being analyzed using localized data from newly installed weather stations (more below). We continue to work with the city to provide citizen information and programming aimed at promoting water conservation city-wide.



Landscape Planning and Design. Logan Oates, a master of landscape architecture student (MLA) from Utah State University (USU), accepted an assistantship and developed a design for a low-water landscape

for the area surrounding the city hall and police department. The design was completed in November 2017 and this landscape will be the focus of an educational program through its associated role as a demonstration garden.



Landscape Ordinances and Policy. J. Ivy Harvey Thomson, a master of science (MS) student from USU, has conducted a review of water conservation literature and synthesized best management practices (BMPs) for Eagle Mountain City officials and staff to consider adding to their policy toolkit to achieve goals articulated in the city's

General Plan. The report identified relevant and impactful best management practices (BMPs) and available resources for implementation.

USU's Water Check program completed irrigation system evaluations on 24 large city properties (city parks, sports fields, etc.) in 2017. Public officials in Eagle Mountain City have adopted a city-wide water conservation philosophy and strategy. The mayor felt that it was essential for the city to demonstrate this commitment before asking its citizens to conserve water.

USU interns provided professional evaluations of irrigation systems. The services included an evaluation of the irrigation system design and maintenance, catch cup tests to determine the system's distribution uniformity and precipitation rate, a soil feel test to determine soil type, a recommended watering schedule, and conservation recommendations for the irrigation system, plants, and soil.





**MOCK BEARBERRY
MANZANITA** ☀️🌧️💧

Arctostaphylos x coloradensis
Woody, evergreen groundcover with urn-shaped, white flowers that produce small red berries.
Zones: 5-8 H x W: 10-24" x 36-60"



**'POWIS CASTLE'
ARTEMISIA** ☀️💧

Artemisia x 'Powis Castle'
Pleasing mounded shape with silvery gray foliage that is also fragrant. Sub-shrub that can be cut back to 1/3 to rejuvenate growth.
Zones 4-10 H x W: 36" x 30"



CREeping OREGON GRAPE ☀️🌧️💧

Berberis (Mahonia) repens
Holly-shaped evergreen leaves and fragrant yellow flowers. Zones: 4-7 H x W: 12-18" x 36"



BLUE MIST SPIREA ☀️💧

Caryopteris x clandonensis
Mounded shrub covered in blue flowers late summer. Zones: 5-9 H x W: 2-4' x 2-4'



FERNBUSH ☀️🌧️💧

Chamaebatiaria millefolium
Finely divided foliage and showy white flowers.
Zones: 4-8 H x W 3-6' x 3-6'

Top 10 Low-Water Brochures--trees, shrubs, perennials, and ornamental grasses

Information Design for Citizens. A series of custom Extension flyers were developed for the city. The city is located in a unique micro-climate and residents have had a difficult time selecting plant material for their landscapes that will survive the city's harsh growing conditions. The series identifies the "Top 10 Low-Water" trees, shrubs, perennials, and ornamental grasses with characteristics well-suited for the area. New infrastructure, current technology, and accurate data are all vital to a city's water conservation efforts, but will fall short of their potential without appropriate educational programming such as localized plant lists to promote water conservation.

Extension Publications Designed to Provide Citizen Information:

- **Wheaton, A.; L.A. Rupp and M. Caron.** "10 Low-Water Trees Ideal for Water-Efficient Landscapes in Eagle Mountain, Utah" (2018). *All Current Publications*. Paper 1856. https://digitalcommons.usu.edu/extension_curall/1856
- **Wheaton, A., L.A. Rupp and M. Caron.** "10 Low-Water Ornamental Grasses Ideal for Water-Efficient Landscapes in Eagle Mountain, Utah" (2018). *All Current Publications*. Paper 1855. https://digitalcommons.usu.edu/extension_curall/1855
- **Wheaton, A., L.A. Rupp and M. Caron.** "10 Low-Water Perennials Ideal for Water-Efficient Landscapes in Eagle Mountain, Utah" (2018). *All Current Publications*. Paper 1853. https://digitalcommons.usu.edu/extension_curall/1853
- **Wheaton, A., L.A. Rupp and M. Caron.** "10 Low-Water Shrubs Ideal for Water-Efficient Landscapes in Eagle Mountain, Utah" (2018). *All Current Publications*. Paper 1854. https://digitalcommons.usu.edu/extension_curall/1854
- **Wheaton, A., L.A. Rupp and M. Caron.** "Landscape Plants for Eagle Mountain, Utah" (2018), *All Current Publications*. Paper 1857. https://digitalcommons.usu.edu/extension_curall/1857

Weather Stations. The CWEL team has collaborated with the Utah Climate Center to cost share and obtain additional financial resources from the USU Office of Research and Graduate Studies to install and maintain two weather stations in Eagle Mountain City in 2018 (EMCNolan, UT and EMCPony Ex, UT). These weather stations are being maintained as part of the Utah Climate Center network of public weather stations in Utah and will fill a critical data gap.

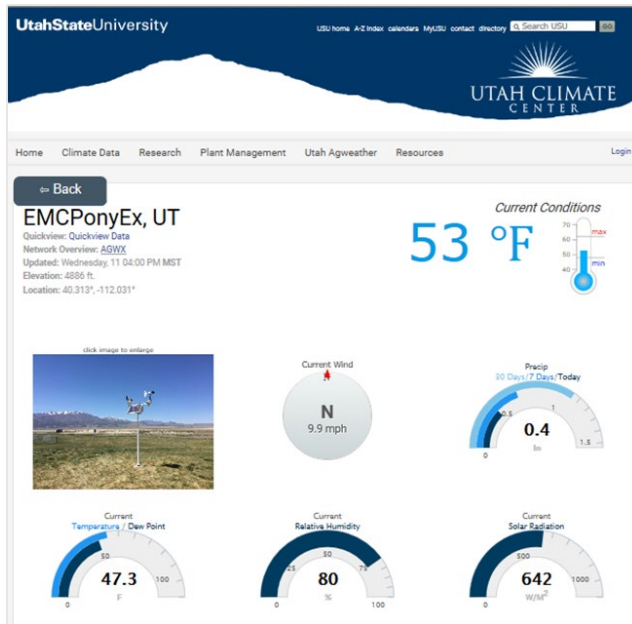
Eagle Mountain City is the largest geographic city in the state of Utah encompassing 53 square miles located in the Cedar Valley west of Utah Lake. The city has significant observable climatic differences between the “city center” and “ranches” areas within the city. Data from these state-of-the-art weather stations support research being conducted by CWEL and the Utah Climate Center, provide citizens and businesses with local weather data for use with irrigation smart controllers, and make available new opportunities for delivering educational programs related to weather, climate, and water use efficiency to schools and community groups.

PROJECT STATUS

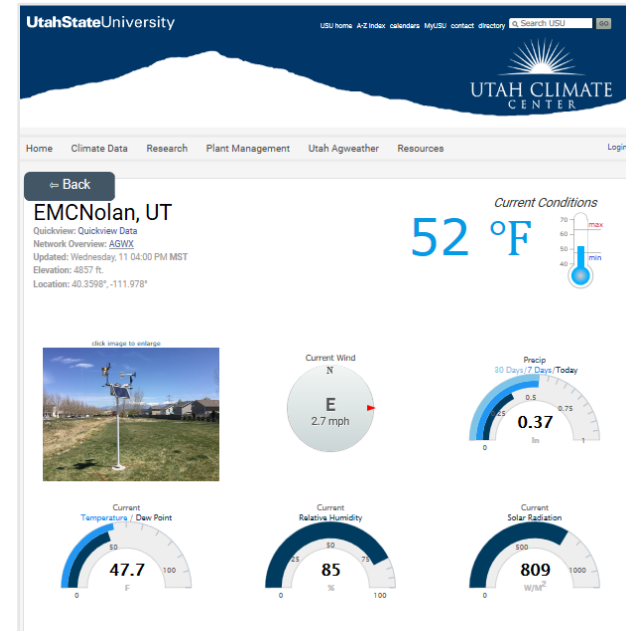
This project received funding for Phase II, which will run through 2020. This next phase of the project will deliver a complete analyses of city-wide landscape water use patterns over a five-year period, a report on water conservation BMPs and ordinances, and additional landscape and irrigation system information and evaluations to city residents.

PRESENTATIONS

Endter-Wada, J. (2019, February 27-28). Implementing Water Conservation Strategies in Eagle Mountain City, Utah. Presented at the Utah Extension Annual Conference. Logan, UT.



Website view of public data from Eagle Mountain weather stations maintained by Utah State University Climate Center.



LANDSCAPE WATER USE ANALYTICS FOR INSTITUTIONAL AND CORPORATE PROPERTIES

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS:

- Joanna Endter-Wada** – Professor, Natural Resource Policy and Social Science, ENV5, CWEL
- Larry Rupp** – Professor, Extension Landscape Horticulture Specialist, PSC, CWEL

PROJECT TEAM MEMBERS

- Chris Garrard** – Programmer/Analyst, Remote Sensing and GIS Lab
- Diana T. Wuenschell** – Senior Research Technician, ENV5, CWEL
- Chris McGinty** – Assistant Director, Remote Sensing and GIS Lab
- Kathryn Johnson** – Master of Professional Studies (MPSH) student, CWEL

LOCATIONS: **Throughout the state of Utah**

PROJECT OBJECTIVES

A specialized WaterMAPS™ web application is being developed that will enable large property owners to analyze and track landscape water use at their various facilities. As an assessment and monitoring tool, this web application will help guide property managers on water conservation efforts and inform landscape replacement and operations decisions. The WaterMAPS™ web application is being designed for direct use by institutional or corporate entities that own and/or manage multiple urban properties in dispersed locations.

PROJECT SUMMARY

The innovation of this project is to extend the ability to use the WaterMAPS™ software to individual entities who can supply their own landscape classification (or use the software's mapping tool to determine it)

Center for Water-Efficient Landscaping



Examples of institutional and corporate properties



and water meter data needed to do the calculations to determine landscape water use efficiency. This project is geared to professional institutional and corporate property managers who generally have these data capabilities. It provides them with mapping and assessment interfaces.

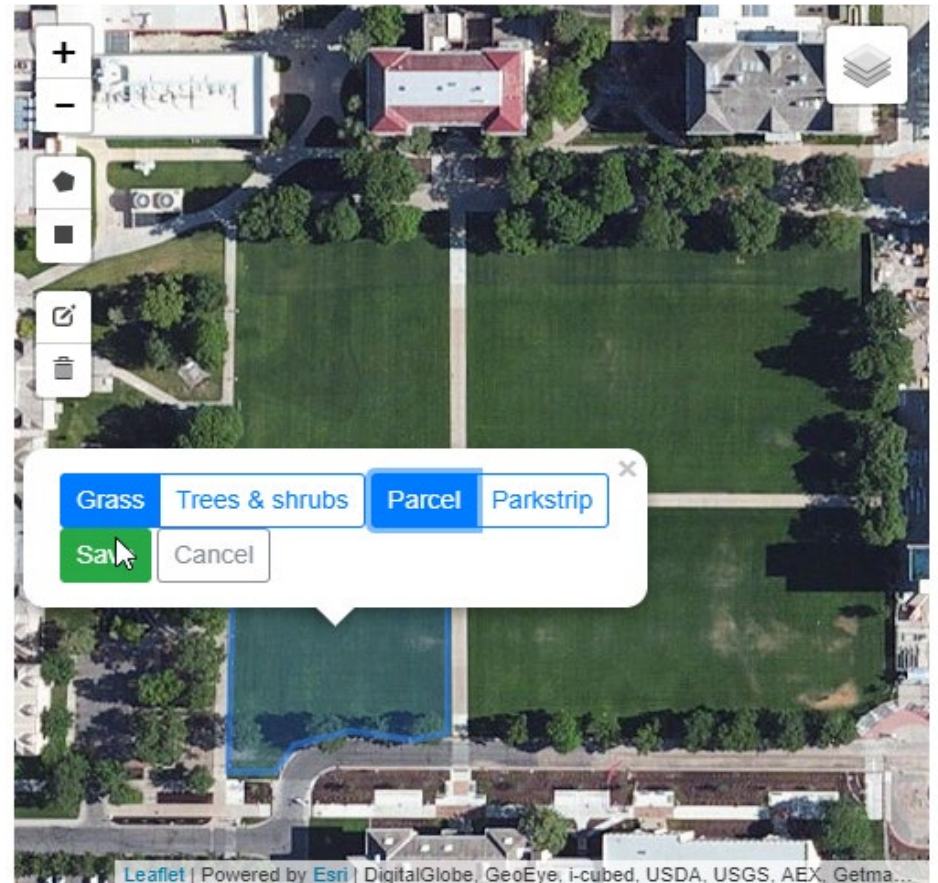
WaterMAPS™ Portal. We facilitate use of WaterMAPS™, a leading-edge urban landscape water demand management software application, and add a web-based interface. The customized portal enables institutional-level assessments of managed landscapes. It also provides local property managers with new tools to aid their local water management decisions. The portal includes a mapping tool and integrates the additional needed data, such as Geographic Information Systems (GIS) data for property locations and the new urban evapotranspiration (ET) weather data supplied by the Utah Climate Center (evapotranspiration is the sum of evaporation from the land surface plus transpiration from plants). The portal enables joint data access and sharing between different levels of property management within an institution to facilitate decision making and achievement of water conservation and stewardship goals.

Once development, testing and implementation is done with these more professionalized property managers, it will be quite feasible to make WaterMAPS™ accessible to individual users of all types via a supported web application and service.

WaterMAPS™ Analysis. Project researchers are conducting a state-wide comparative analysis of a partner’s landscape water use by ecoregions, landscape types, assigned management team and other factors in order to identify where transitions from traditional landscapes to low-water landscapes would yield the most water savings. We are also helping that partner determine how other management operations could increase water use efficiency on existing landscapes.

Tree Watering Guidelines. We identified best management practices and developed interim guidelines for irrigation of established trees in newly constructed low-water landscapes, traditional landscapes, and existing

Center for Water-Efficient Landscaping



WaterMAPS™ mapping tool

traditional landscapes being transitioned to low-water plant material while retaining existing trees. Mature trees play a significant role in mitigating the urban heat island effect and protecting human health during heat waves.

RELATED PUBLICATIONS

Johnson, K. and L.A. Rupp. (2019, in press). “Transitioning Trees from Traditional to Low-Water Landscapes”. Utah State University Extension.

UTAH STATE CAPITOL GROUNDS LANDSCAPE WATER USE ASSESSMENT

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS/COOPERATORS:

WaterMAPS™ Team:

Joanna Endter-Wada – Professor, Natural Resource Policy and Social Science, ENVS, CWEL

Diana T. Wuenschell – Senior Research Technician, ENVS, CWEL

Chris Garrard – Programmer/Analyst, Remote Sensing and GIS Lab

Ellie McGinty – GIS Specialist, Remote Sensing and GIS Lab

Water Check Team:

Kelly Kopp – Professor, Extension Water Conservation and Turfgrass Science Specialist, PSC, CWEL

Jennie Hoover – Water Check Program Manager

LOCATION: **Utah State Capitol**, Salt Lake City, UT



[Wikimedia.org/Wikimedia Commons](https://commons.wikimedia.org/wiki/File:Utah_State_Capitol.jpg) (see p. 60)

PROJECT DESCRIPTION

These CWEL researchers produced a report containing an analysis of landscape water use for the Utah State Capitol grounds. It was provided in response to a legislative request for this information.

The Capitol grounds crew requested and received a Water Check in July and August of 2018. It was provided through the Water Check program affiliated with the Center for Water Efficient Landscaping (CWEL) at Utah State University (USU) Extension. The Water Check program has been offered under contract with Metropolitan Water District of Salt Lake & Sandy since 2009 and delivered to customers in the Salt Lake City Department of Public Utilities (SLCDPU) service area as part of Utah’s “Slow the Flow” initiative.

More recently, the WaterMAPS™ (Water Management Analysis and Planning Software) team, also part of CWEL at USU Extension, was asked to provide an estimate of the “capacity to conserve” water applied to landscapes at the Capitol. The WaterMAPS™ program currently has a collaborative USU Extension Water Initiative project with SLCDPU to analyze landscape water use for residential locations within its service area. The WaterMAPS™ team worked with SLCDPU in preparing this requested Utah State Capitol landscape water use analysis, relying on information and meter data that they prepared and provided. In this report, we focus on presenting the methodology and results of the WaterMAPS™ analysis for the Utah State Capitol grounds. The analysis looks at landscape water use from 2010-2018 in order to identify recent patterns and potential opportunities for efficiency and conservation savings.

SUMMARY OF KEY FINDINGS

- Land cover classification of aerial multispectral imagery shows that irrigated landscaped area on the Utah State Capitol grounds is 69% turfgrass, 29% trees and shrubs, and 2% beds and planters containing sparse vegetation consisting of mostly woody, perennial, and some annual plants.

- Reference evapotranspiration (ET_o)* relevant to the Capitol grounds for 2010-2018 shows high seasonal and monthly variability. Compared to the 30-year average ET_o for 1978-2008, the 2010-2018 period exhibits general increase in ET_o, yet landscape irrigation still exceeds plant need.
- WaterMAPS™ analysis for 2010-2018 demonstrates:
 - average annual capacity to conserve water applied to the Capitol grounds is 38%;
 - annual capacity to conserve ranged from 23% (in 2011 and 2014) to 52% (in 2012);
 - the Capitol grounds are not overwatered in the early spring and only half the time in late fall, but irrigation exceeds the peak season plant water need nearly every year;
 - the highest periods of inefficiency generally occur in August and September, when ET_o declines but water use is not cut back to appropriately track reduction in plant water need;
 - irrigating to meet plant water need determined by actual ET_o can yield water savings;
 - a weather station on the Capitol grounds and other irrigation infrastructure investments would aid the grounds crew in irrigating to meet plant water need.
- The Water Check report (in the full report Appendix) points to strategies for increasing landscape water use efficiency on the present Utah State Capitol grounds through maintenance, repair and operation of the existing irrigation systems. Implementation of an optimized irrigation schedule would be enhanced with investments in irrigation system improvements, such as installing weather-based controller and soil-moisture sensor technologies.
- For 2010-2018, the difference in depth inches needed to water existing turfgrass compared to beds and planters is approximately 34%. Additional water conservation could be achieved through transitions in plant material, either to new varieties of turfgrass requiring much less water or to more area in beds and planters, if such transitions are accompanied by

appropriate irrigation to meet lower plant water need.

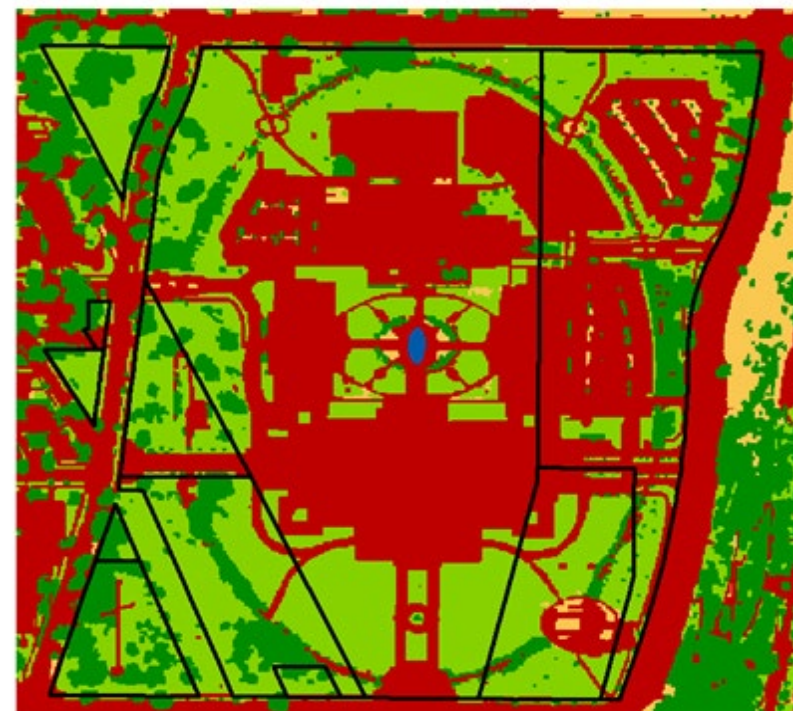


Figure showing the Utah State Capitol grounds landscape classification with parcel boundaries shown in black lines.

Landscape classification	
CLASS	
DEVELOPED_IMPERVIOUS	Red
GRASS_TURF	Green
SPARSE_VEGETATION	Yellow
TREES_SHRUBS	Dark Green
WATER	Blue

A copy of the **FULL REPORT** is available at:
<https://cwel.usu.edu/files/CapitolAssessment.pdf>

*The definition of reference evapotranspiration (ET_o) is available at
https://www.weap21.org/WebHelp/Mabia_Alq_ETRef.htm

IDENTIFYING AND MEETING SALT LAKE CITY'S LANDSCAPE WATER CONSERVATION POTENTIAL

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS (USU)

Joanna Endter-Wada – Professor, Natural Resource Policy and Social Science, ENVS, CWEL

Kelly Kopp – Professor, Extension Water Conservation and Turfgrass Science Specialist, PSC, CWEL

PROJECT TEAM MEMBERS

Diana T. Wuenschell – Senior Research Technician, ENVS, CWEL

Adrea Wheaton – CWEL Program Coordinator, PSC

Chris Garrard – Programmer/Analyst, Remote Sensing and GIS Lab

Ellie McGinty – GIS Specialist, Remote Sensing and GIS Lab

Chris McGinty – Assistant Director, Remote Sensing and GIS Lab

CO-INVESTIGATORS/COOPERATORS (SLC)

Stephanie Duer – Salt Lake City Water Conservation Program Manager (lead)

Staff Members, Salt Lake City Department of Public Utilities



PROJECT DESCRIPTION

Salt Lake City Department of Public Utilities (SLCDPU) has led customers to a sustained water use reduction of more than 20 percent since 2001. However, the city is convinced that more can be done, especially in relation to landscape water use. This project is providing SLCDPU with technical assistance and science-based analysis to locate and quantify landscape

water conservation potential through application of USU's Water Management Analysis and Planning Software (WaterMAPS™) in its service

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area. WaterMAPS™ is a custom software application that has been developed by an interdisciplinary team of USU researchers for the purpose of promoting urban landscape water conservation (visit website at watermaps.usu.edu). WaterMAPS™ integrates water meter data with property records, weather data, and landscape classifications into one database, then enables different time-step calculations of site-specific Landscape Irrigation Ratios (LIRs) that compare landscape water use to landscape water need. These LIRs are being mapped and investigated for the SLCDPU service area.

This project's purpose is to address several important questions. How much more water applied to landscapes can SLCDPU expect to save, that is, how much water conservation potential exists within its service area? Where does SLCDPU have capacity to conserve water (geographically at particular locations; temporally at certain times of the irrigation season)?

The USU WaterMAPS™ Team is conducting "baseline" landscape water use patterns on residential and public properties in the SLCDPU service area for 2014-2018. It is identifying locations and periods of time where overuse occurs and categorizing landscape water use patterns based upon efficiency and volume. This analysis is helping SLCDPU with water conservation planning and will be valuable for future water conservation program design, delivery, and evaluation. It will also help the community to be adaptive and responsive in its relationship with water in order to create a more sustainable water supply now and for the future. In this project, several different innovations will be implemented in the application of WaterMAPS™ to help SLCDPU meet the challenge of refining and focusing its water conservation programs in the future.

PROJECT STATUS

This project is in process. This project was initiated in 2018 and will be completed in 2020.

NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP) VARIETY TRIALS

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS

Paul Johnson – Department Head and Professor, Turfgrass Science, PSC, CWEL

Kelly Kopp – Professor, Extension Water Conservation and Turfgrass Science Specialist PSC, CWEL

CO-INVESTIGATORS/COOPERATORS

Paul Harris – Research Technician, CWEL

LOCATION:

Utah Agricultural Experiment Station (UAES) Greenville Research Farm, Logan, UT

Objective:

The National Turfgrass Evaluation Program (NTEP) is a national turfgrass research program that works with plant breeders and researchers to provide the turfgrass industry and consumers with objective evaluation of varieties of seventeen turfgrass species in as many as forty states in the US and six provinces Canada.

At USU, we have cooperated with NTEP for more than 20 years to provide high quality data on species in northern Utah and the northern Intermountain West region. With that data, we help identify the stress tolerant species and varieties for our region with emphasis on acceptable quality under reduced irrigation. All of this data from Utah and elsewhere in the country is available at <http://ntep.org>. The data we collect on these evaluation trials throughout the year include:

- Visual quality
- Color
- Spring greenup

- Density and Uniformity
- Percent living cover (% survival)
- Percent disease infection

Currently we are conducting the following trials:

- USGA/NTEP Water use and drought tolerance, cool-season species-2016.
- Perennial ryegrass—standard and drought test-2016
- Kentucky bluegrass-2017
- Tall fescue-standard and drought test-2018
- Bentgrass putting green—standard and drought-2014
- Bentgrass fairway/tee drought-2014
- Cool-season low-input-2015
- Warm-season low input-2018 (in St. George, UT)

Some top performing varieties for visual quality* in trials more than 2 years old include:

- **Kentucky bluegrass-2017:** Top performing varieties in year 1 of this trial include Orion, Prosperity, Midnight, Selway, Skye, Barvette-HGT, and After Midnight. However real adaptation to the low input conditions will be evaluated in the coming years. First year data is often quite different in terms of color and quality.
- **Water use and drought tolerance - 2016:** As a whole, tall fescue varieties showed better quality at low irrigation replacement, as expected. Kentucky bluegrass varieties struggled in 2018 due to billbug feeding. Effects of billbug damage were consistent across all varieties.
- **Cool-season low input-2015:** Tall fescue entries maintained green color longer than many other grasses without any supplemental irrigation, but have stands that are gradually thinning over time. Western yarrow (Yaak) provided green color by far the longest into summer compared to other entries. We included entries of intermediate wheatgrass and crested wheatgrass into the trial.

- Although not officially part of the trial (for NTEP), those species are showing excellent spring color and survival without irrigation. Entries that have good cover compete well with weeds in the plots.
- **Bentgrass putting green-2014:** Kingdom, Nightlife, PST-ROPS, Armor, Pure Select, 777, Piranha, V-8.
- **Bentgrass fairway/tee-2014:** None recommended. Nearly all varieties produced excessive thatch and no plots with high quality.
- **Colonial bentgrass** did perform better than expected.



All the bluegrass varieties have good quality in mid-June.



And good quality in August among the bluegrass entries.

** those listed are varieties near the top of the average ratings but do not include all varieties that performed within the same statistical group.*



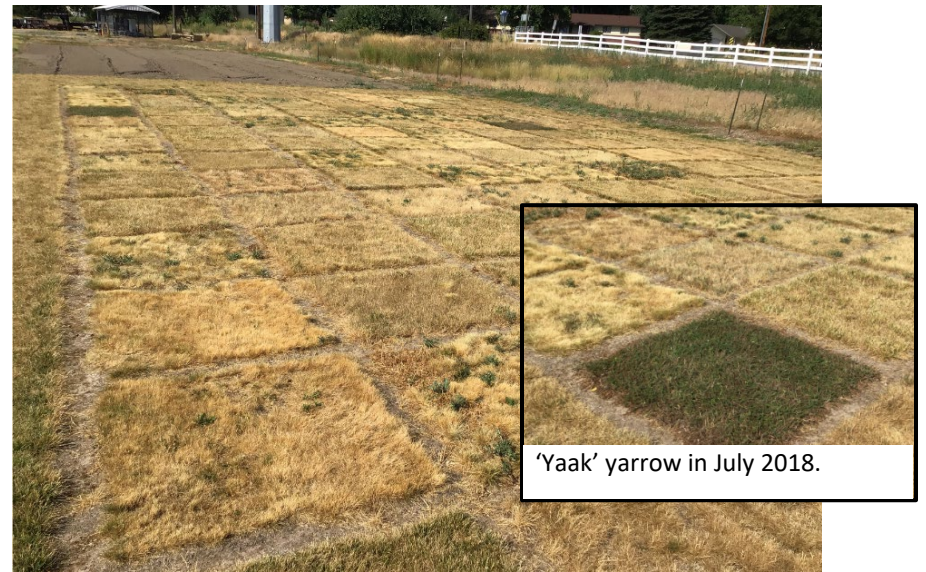
Bentgrass putting green trial in mid-July. Variation in color and density is significant. This is being irrigated at 80% of ET.



Quality of the bentgrass entries on the putting green is similar at 60% ET replacement but recoverability is significantly reduced.



The quality of the low-input cool-season trial plots was quite good in May 2018. Nearly all survived the previous year with good coverage.



By July 2018, nearly all the plots were dormant except for 'Yaak' yarrow.



Survival of plots after a very dry and hot 2018 resulted in variable survival into 2019. Yarrow survived well. K31 tall fescue thinned but survived. Intermediate wheatgrass survived well. Sheep fescue did not survive.

IMPROVEMENT OF BLUEGRASS AND OTHER NATIVE AND ADAPTED SPECIES

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Joe Robins – Research Geneticist, USDA

Shaun Bushman – Research Geneticist, USDA

Paul Johnson – Department Head and Professor, Turfgrass Science, PSC, CWEL

GRADUATE STUDENT (Master of Science)

Paul Harris – Research Technician, CWEL

LOCATION:

United States Department of Agriculture (USDA) Forage & Range Research Laboratory (FRRL), Logan, UT

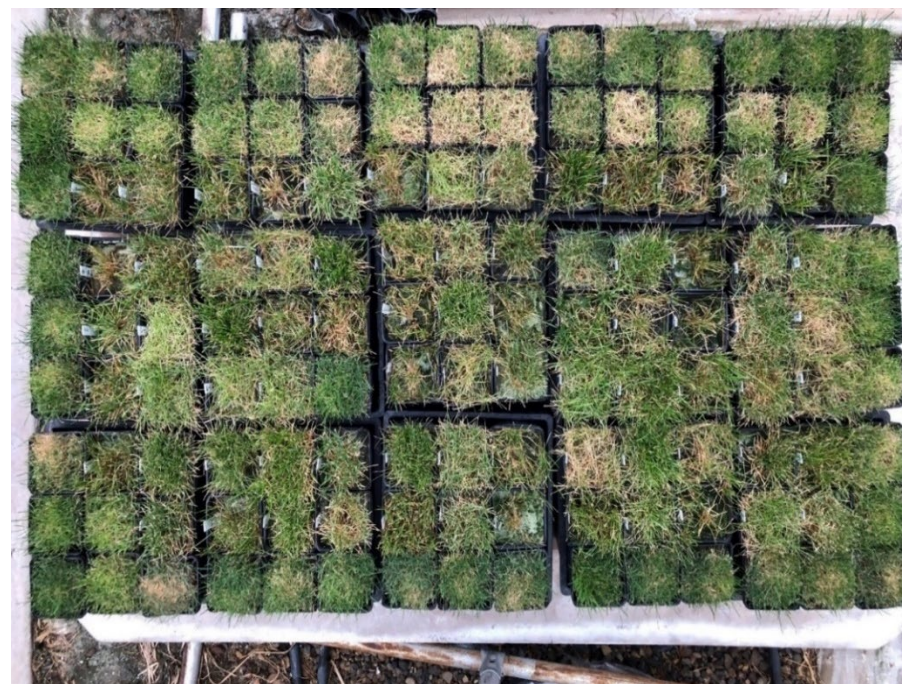
PROJECT SUMMARY

CWEL cooperates with scientists at the USDA Forage and Range Research Laboratory (FRRL) located on the Utah State University campus. In the 2000s, cooperation between USU and the FRRL started in earnest with wheatgrasses adapted to low maintenance turf conditions - improving quality characteristics of well adapted grass species. That work has continued along with research and development of *Poa*, or bluegrasses. This latter project takes the opposite approach of improving stress tolerant characteristics of a grass that has excellent turfgrass use adaptation.

The main objectives of both approaches are to identify and develop plant materials with good turfgrass quality and salt and drought tolerance. At the same time, we are gaining a better understanding of these genetically complex species to improve breeding progress.



This project evaluated 27 Kentucky bluegrass varieties and 30 tall fescue varieties as detailed below.



Bluegrass parent lines and hybrids after 8 weeks of salinity stress.

Research work this year by graduate student and research associate Paul Harris was another step in this project. Hybrid plants from crosses of salt-tolerant bluegrasses and those with high turfgrass quality were evaluated for salt tolerance. The goal of this work was to start identifying the inheritance of salt tolerance traits and the ability to make breeding progress. The outcomes of this work were mixed. Due to the highly complex genetics of Kentucky bluegrass, hybrid plants exhibited a range of tolerance to salt stress from lower to equal to higher tolerance than the parents without obvious patterns. This is not unexpected. The results do highlight the importance of hybridization and rigorous evaluation of progeny for important traits.

PRESENTATIONS

Harris, P. (2018, November 4-7). Poster presentation: Salinity Tolerance in Kentucky Bluegrass Hybrids. Presented at the ASA and CSSA Annual Meeting, Baltimore, Maryland (American Society of Agronomy and the Crop Science Society of America).

A-LIST KENTUCKY BLUEGRASS TRIAL

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Kelly Kopp – Professor, Extension Water Conservation and Turfgrass Science Specialist, PSC, CWEL

CO-INVESTIGATORS/COOPERATORS

Paul Johnson – Department Head and Professor, Turfgrass Science, PSC, CWEL
Paul Harris – Research Technician, CWEL

LOCATION:

UAES Greenville Research Farm, Logan, UT

PROJECT BACKGROUND

The Alliance for Low Inter Sustainable Turf (A-LIST) is a national non-profit organization that seeks to aid turfgrass managers and grass growers by providing holistic guidelines that account for all factors in sustainable plant growth.

A-LIST members are comprised of universities and industry companies that test, identify, and promote grass varieties that combine high turf quality and low-input performance; such as reduced water, chemical, and fertilizer. Information is developed on certified, high quality turf that is verified via transparent protocols and independently tested at leading regional universities, including USU. This project is evaluating 23 varieties of Kentucky bluegrass including 11 named varieties and 12 experimental varieties.

PROJECT OBJECTIVES

- Evaluate evapotranspiration (ET) based drought tolerance of experimental and control varieties of Kentucky bluegrass under acute drought stress.
- Develop recovery curves for the tested varieties based on the number of days to recovery after irrigation is applied.



PROJECT STATUS

This project was established in 2017. Data collection began in 2018 and will be completed in 2019.

JACKLIN® SEED KENTUCKY BLUEGRASS TRIAL

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Kelly Kopp – Professor, Extension Water Conservation and Turfgrass Science Specialist, PSC, CWEL

CO-INVESTIGATORS/COOPERATORS

Paul Johnson – Department Head and Professor, Turfgrass Science, PSC, CWEL
Paul Harris – Research Technician, CWEL

LOCATION: **UAES Greenville Research Farm**, Logan UT

PROJECT BACKGROUND

The J.R. Simplot Company is a vertically integrated seed production, farming, fertilizer manufacturing, frozen-food processing, and food brands and distribution company. Jacklin® Seed is a leader in turfgrass research, breeding, and production. The company offers a full product line of turfgrass varieties including Kentucky bluegrass, perennial ryegrass, creeping bentgrass, tall and fine fescues, and other specialty grasses.

This project is evaluating 25 experimental varieties of Kentucky bluegrass.

PROJECT OBJECTIVES

- Evaluate evapotranspiration (ET) based drought tolerance of experimental and control varieties of Kentucky bluegrass under acute drought stress.
- Develop dry down curves for the tested varieties based on cumulative ET loss.
- Develop green up curves for the tested varieties based on the number of days to recovery after irrigation is applied.



PROJECT STATUS

This project was established in 2017. Data collection began in 2018 and will be completed in 2019.

CLOVER INCLUSION FOR VALUE-ADDED TURF

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Paige Boyle, PhD student – PSC, CWEL, Ecology Center

CO-INVESTIGATORS/COOPERATORS

Kelly Kopp – Professor, Extension Water Conservation and Turfgrass Science Specialist, PSC, CWEL

Paul Johnson – Department Head and Professor, Turfgrass Science, PSC, CWEL

Shaun Bushman – USDA FRRL

Steve Young – Assistant Professor, PSC

Andrew Kulmatiski – Assistant Professor, Department of Wildland Resources, Ecology Center

LOCATION: **Logan, UT, Kaysville, UT, and Salt Lake City, UT**

PROJECT BACKGROUND

Legumes, primarily white clovers, were historically included in seed mixtures, but recently have fallen out of use, due to the desire for a uniform green turf; however, with focus shifting toward reducing inputs in turf systems, incorporating legumes into turf swards has become a topic of interest once again. Research has shown that incorporation of legumes into grass systems can lead to reduced fertilizer inputs and can add value to lawns by increasing green cover, improving drought tolerance, and providing pollinator forage. Some research has investigated Kentucky bluegrass/white clover mixes, but not much is known about interactions between Kentucky bluegrass and other clover species in lawn settings.

PROJECT OBJECTIVES

The goal of this study is to evaluate the effect of rose, crimson, strawberry,



and white clover incorporation on function and quality of Kentucky bluegrass lawns.

PRESENTATIONS AND SEMINARS

Clover Establishment in Seeded Kentucky Bluegrass Turf. November 2019. American Society of Agronomy, the Crop Science Society of America, and the Soil Science Society of America International Annual Meeting, San Antonio, TX.

PROJECT SUMMARY AND STATUS AS OF JUNE 2019

Project Period: June 2019-December 2021. Stands at three locations (Logan, UT; Kaysville, UT; and Salt Lake City, UT) were seeded June 6. Establishment data will be collected during the first year, and function and quality data will follow in years 2-3.

APPLIED DROUGHT RESEARCH ON SALT LAKE CITY MUNICIPAL GOLF COURSES

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Kelly Kopp – Professor, Extension Water Conservation and Turfgrass Science Specialist, PSC, CWEL

CO-INVESTIGATORS/COOPERATORS

Paul Johnson – Department Head and Professor, Turfgrass Science, PSC, CWEL
Shaun Bushman – Research Geneticist, USDA FRRL

LOCATION:

Salt Lake City municipal golf courses, Salt Lake City, UT

PROJECT BACKGROUND

As part of the Drought Plan Update process, the Salt Lake City Department of Public Utilities Water Conservation Program initiated a collaborative effort with the Salt Lake City Golf Division. The purpose was to discuss issues pertaining to potential water shortages and to devise strategies to minimize or mitigate negative impacts as a result of drought-driven changes in water supply. Working with the Water Conservation Manager, SLC Golf developed course-specific drought plans. These plans articulate impacts on playability and site conditions in the event of hypothetical water use reductions.

Working with USU and United States Department of Agriculture Forage and Range Research Laboratory (USDA FFRL) personnel, it was determined that field-based research would provide the Golf Division with the information necessary to select and implement programs that will optimize the desired outcomes of reduced water use and improved site efficiency while maintaining course playability.



PROJECT OBJECTIVES

- Evaluate drought-tolerant turfgrass species and varieties in rough and out-of-bounds areas.
- Reduce irrigation on fairways and roughs where grass must still be mowed.
- Establish demonstration areas of lower water use turfgrass varieties in highly visible areas of the courses.
- As drought watering restrictions are implemented, determine the effectiveness of soil surfactant/wetting agent products for maintaining soil moisture and turfgrass health through the growing season.
- Monitor the effectiveness of the Maximum H2O system for maintaining turfgrass health and playability through the growing season.

PROJECT STATUS This project began in 2018 and will continue through 2019.

DOCUMENTING WATER USE FOR TURFGRASSES IN THE UNITED STATES

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Kelly Kopp – Professor, Extension Water Conservation and Turfgrass Science Specialist, PSC, CWEL

CO-INVESTIGATORS/COOPERATORS

Paul Harris – Research Technician, CWEL

LOCATION: **UAES Greenville Research Farm**, Logan, UT

PROJECT BACKGROUND

Turfgrass surface area in the U.S. has been estimated to be three times greater than any other irrigated crop, potentially requiring nearly 1000 L water daily and models of irrigation requirements have been used to estimate the potential use of water by turfgrasses in discrete situations. The actual amount of water use by turf areas is unknown and complex to understand. Locally available sources of sod were evaluated in six locations (Utah, California, Texas, Tennessee, Minnesota, and Connecticut) across the U.S., representing a diversity of climates and species, as well as high and low level fertility management. Evapotranspiration (ET) rates were estimated at each location and compared against the actual amount of water used.

At USU, Kentucky bluegrass, tall fescue and fine fescue sod was established and evaluated during 2016 and 2017 and was maintained with either high or low levels of fertility. Once sod was established, irrigation was withheld until green coverage was less than 50%. Once plots reached green coverage of less than 50%, irrigation for recovery was applied until plots exceeded 50% green cover. The process continued through the 2016 and 2017 growing seasons.



PROJECT OBJECTIVES

To document the amount of water required to maintain 50% green cover of turfgrasses commonly used as lawn grasses in key climates across the U.S. under high and low levels of fertility.

PROJECT STATUS

- Irrigation requirements often differed among grasses at each location, though relative requirements depended on the climate as well as species.
- In Utah, the amount of irrigation required to maintain 50% green cover for the species evaluated was least for tall fescue, regardless of fertility treatment, and most for fine fescue sod receiving low fertility management.
- Kentucky bluegrass results were mixed across year, although Kentucky bluegrass receiving lower fertility treatments required more irrigation than that receiving higher fertility treatments.
- The results of this research are currently being prepared for publication.

A COMPARISON OF SMART CONTROLLERS IN THE URBAN LANDSCAPE

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Shane Evans, graduate student - PSC

CO-INVESTIGATORS/COOPERATORS

Kelly Kopp – Professor, Extension Water Conservation and Turfgrass Science Specialist, PSC, CWEL

Paul Johnson – Department Head and Professor, Turfgrass Science, PSC, CWEL

Bryan Hopkins – Professor, Department of Plant and Wildlife Sciences, Brigham Young University (BYU), Provo, UT

LOCATION: **UAES Greenville Research Farm**, Logan UT



This research looks at solving issues regarding water use in home and commercial landscapes. Irrigation controllers are great resources that help conserve water when programmed appropriately and turned off as necessary. Unfortunately, sprinklers at homes or businesses are often left running during a rainstorm. This occurs when homeowners have a “set it and forget it” mentality. Many companies have realized this phenomenon

and have developed smart controllers. This project aims to compare three different smart controllers, in hopes of improving irrigation scheduling to conserve more water.

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The smart irrigation controllers being compared are the Rachio, Skydrop, and Orbit B-Hyve controllers.

Each controller requires various inputs to create a smart schedule. The inputs include: vegetation type, slope, sun exposure and selecting a local weather station. Once a schedule is created, the controller can make decisions based on local weather data and inputs selected. For example, the author’s controller is scheduled to run from 4:00 am-4:45 am on Wednesday. If it rains on Tuesday night, the smart controller can determine the amount of rainfall based on weather data and cancel the irrigation event. It could also change the schedule to water 15 minutes instead of the standard 45 minutes. A manually scheduled controller cannot do this.



In total, this project consists of 20 plots of Kentucky bluegrass (*Poa pratensis* L.) accompanied by a selection of ornamental plants. The turfgrass area is 225 ft² and watered with Hunter MP 2000 rotor sprinkler heads. The ornamental plants are watered with drip irrigation.

To measure total water use, iPerl low-flow water meters will be used. These new meters are so accurate, they can be used to collect water use data from the zones watered by drip irrigation.

To determine how much water was needed, a catch cup test was performed and a schedule was created based on USU Extension guidelines. This schedule will be reflected in the control for the experiment, a Hunter X-Core irrigation controller, and the three smart irrigation controllers. The smart controllers will be allowed to alter this schedule as described above. In addition to looking at water use for each plot, plant health will be measured using various environmental instruments.

Soil moisture will be measured with the Campbell Scientific Hydrosense II. Canopy temperature will be monitored using a FLIR E5 infrared camera. NDVI measurements will be recorded with the FieldScout TCM 500. Percent green cover will be determined using the computer program TurfAnalyzer. Reference ET will be calculated with an on-site weather station and actual ET which will be measured with on-site lysimeters.



After 1 year of data collection, the Skydrop controller has shown it uses less water than a manually programmed irrigation controller. Though water use varies between the four controllers, not much difference is observed in below ground (soil) and above ground (NDVI, percent green cover) measurements. Currently, this data is being analyzed to see if measurements of water use and plant health are significantly different.



SELECTION AND PROPAGATION OF NATIVE PLANTS FOR LOW-WATER LANDSCAPING

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Larry Rupp – Professor, Extension Landscape Horticulture Specialist, PSC, CWEL

CO-INVESTIGATORS/COOPERATORS

Youping Sun – Assistant Professor, Landscape Horticulture, PSC, CWEL

Richard Anderson – Curator of Plant Development, USU Botanical Center

Jerry Goodspeed – Director, USU Botanical Center / Ogden Botanical Gardens

JayDee Gunnell – Director and Extension Professor, Cache County Extension

Brent Black – Professor, Extension Fruit Specialist, PSC

Tiffany Maughan – PSC

Stephen Love – Professor, Aberdeen Research and Extension Center, University of Idaho

Jim Klett – Professor, Landscape Horticulture, Ornamentals, and Nursery Management, Colorado State University

William A. Varga – Professor Emeritus, PSC; Consultant, Perennial Favorites

Johnnie Bobb – Shoshone Nation

Lance Brown – USDA–Forest Service (FS) Toiyabe National Forest

LOCATION:

UAES Research Greenhouse and Greenville Farm, Logan, UT

USU Botanical Center, Kaysville UT

PROJECT OBJECTIVE

To select superior woody plants with characteristics amenable to attractive, functional, low-water landscaping; determine appropriate means of propagation and production; evaluate landscape performance; and introduce into the landscape industry.



PROJECT SUMMARY

The nature of woody, native plants is such that any project must be considered on a scale of years. Currently, this project has selected a number of native plants that have been evaluated in depth. Several of these have developed to the point of being considered for release, including bigtooth maple ('Alice' and five other selections), littleleaf mountain mahogany ('Hoodoo' and 'DoubleDown' selections), creeping Oregon grape ('Semi-Gloss', 'Matte', and 'Angel' selections), and mountain lover ('Teton' and 'City Creek' selections). Additional research is currently being done with a number of plants, however selections for further development have not been made. These plants include prostrate ceanothus, snowbrush ceanothus, huckleberry oak, pinyon pine, curleaf mountain mahogany, white rabbitbrush, Gambel oak, ninebark, serviceberry, sagebrush, greenleaf manzanita, and Rocky Mountain maple.

PROJECT STATUS

In addition to selection of elite accessions, this research is also exploring propagation of various species, production in nurseries, and performance in the landscape. Recent research has illustrated the importance of establishing stock plants in a controlled environment to improve propagation success. For example, 'Hoodoo' littleleaf mountain mahogany from the field has less than 5% success as a rooted cutting, while greenhouse-grown plants approach 70% success. Current research is examining the impact of exotic sugar maple rootstocks on iron chlorosis in bigtooth maple and the effect of irrigation and native soil inoculum on longevity of a buffaloberry hybrid in the landscape.

RELATED PUBLICATIONS

Maughan, T., B. Black, L.A. Rupp, and M. Yost. (2018). Propagation techniques for *Sambucus cerulea* (Blue Elderberry). *Native Plants Journal* 19:80-89.

Muntz, H. and L.A. Rupp. "Landscaping in Dry Shade - 15 Great Landscape Plants for Dry Shady Areas" (2018). *All Current Publications*. Paper 1844. https://digitalcommons.usu.edu/extension_curall/1844

Rupp, L.A., R.M. Anderson, J. Klett, S.L. Love, J. Goodspeed, and J. Gunnell. (2018). Developing native and adapted plants for low-water landscaping. *HortTechnology* 28:431-435.

SELECTING AND GRAFTING SINGLE-LEAF PINYON PINE (*PINUS MONOPHYLLA*)

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Larry Rupp – Professor, Extension Landscape Horticulture Specialist, PSC, CWEL

CO-INVESTIGATORS/COOPERATORS

Kylie Lawson – Graduate Research Assistant, PSC

Paul Harris – Research Technician, CWEL

Teryl Roper – Professor, Pomology, PSC

Mike Kuhns – Department Head and Professor, Department of Wildland Resources

LOCATIONS:

UAES Research Greenhouse and Greenville Farm, Logan, UT

Austin, NV; Hamlin Valley, UT; Eureka, UT; Raft River Mountains, UT

UAES Blue Creek Farm, and USU Botanical Center

PROJECT OBJECTIVE

Single-leaf Pinyon Pine (*Pinus monophylla*) is a xeric tree native to the Great Basin. This species produces large, soft-shelled pine nuts that are in great demand. Current production relies on harvesting nuts from wild trees. The selection and propagation of superior nut producing trees should increase production in both orchards and marginal wildlands. The goal of this research is to identify wild, high-yield trees and then determine the most effective method of clonal propagation.



PROJECT SUMMARY

In April of 2018, scions from *Pinus monophylla* trees in Juab County, UT were top grafted to unirrigated *Pinus edulis* trees at the UAES Blue Creek Experimental Research Farm. Grafting was done by using either side-wedge or side-veneer grafts. The scions

consisted of shoot tips with both needles and buds while the grafting site was last year's growth. Grafts were tied with grafting rubber bands and Parafilm®, sealed in a clear plastic bag, and then shaded with white opaque plastic to reduce heat buildup. After 4 weeks the sealed bags were cut and then after 5 weeks all plastic removed.

Branches were pruned back to just the scions after 16 weeks. After 2 months, 82% of the grafts were alive while after a year 68% of the grafts were still alive. This experiment was repeated in 2019 using scion wood collected from Box Elder County and the same grafting techniques and crew. Evaluation in August, 2019 indicates a 100% success rate for the grafts.

In addition to the grafting experiment, in 2019, 196 seedling *P. edulis* trees grafted to *P. monophylla* were transplanted to an orchard at the C. Reed Funk UAES Research Farm in Richmond, UT. These trees were over-wintered in a 4°C cooler and transplanted on April 24, 2019. Possibly due to a cool, moist spring, these trees had 99% survival as of July. A total of 12 accessions from four different locations (Lander County, NV and Iron, Juab, and Box Elder Counties, UT). The trees are currently under irrigation until established and then should become a highly sustainable, low-input orchard for many years to come.



PROJECT STATUS

We have determined effective methods of grafting pinyon seedlings and mature trees of *P. edulis* with *P. monophylla*. In addition, we have established an orchard of 12 different accessions that will be of future use in determining the most effective production practices for pine nut production. Additional research is being planned with cooperating ranches and fruit growers.

SELECTED PRESENTATIONS

Rupp, L.A. and K. Lawson. (2018, September) "Selecting and Propagating Pinyon Pine", WERA-1013, Cheyenne, WY.

Lawson, K. and L.A. Rupp. (2018, July) "Selecting and Grafting Wild *Pinus monophylla* on containerized *Pinus edulis* rootstocks", IPPS-WR Annual Conference. Kona, HI.

Lawson, K., L.A. Rupp, and R. Newhall. (2018, July). "Topworking Mature *Pinus edulis* with *Pinus monophylla*", IPPS-WR Annual Conference. Kona, HI.

Lawson, K., L.A. Rupp, C. Reid, and R. Newhall. (2019, May). Selection and Propagation of Single-Leaf Pinyon. Extension Regional Conference. Nephi, UT.

Rupp, L.A., Gardening with Native Plants. (2019, July). Canyon Conversations at the Stokes Nature Center. Logan, UT.

RELATED AND PENDING PUBLICATIONS

Lawson, K. and L.A. Rupp. (in press). Selecting and Grafting Wild *Pinus monophylla* on containerized *Pinus edulis* rootstocks. International Plant Propagators Society Proceedings.

Lawson, K., L.A. Rupp, and R. Newhall. (in press). Topworking mature *Pinus edulis* with *Pinus monophylla*. International Plant Propagator Society Proceedings.

COLLECTING AND PROPAGATING NATIVE WOODY PLANTS FROM UTAH

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Larry Rupp – Professor, Extension Landscape Horticulture Specialist, PSC, CWEL

CO-INVESTIGATORS/COOPERATORS

JayDee Gunnell – Director and Extension Professor, Cache County Extension

Annika Burkhardt – Undergraduate researcher, PSC

Richard Anderson – Curator of Plant Development, USU Botanical Center

LOCATIONS:

Logan Canyon, Utah

UAES Research Greenhouse, Logan, UT

PROJECT OBJECTIVE

This report is an example of the unique plants that are available for domestication throughout the Great Basin and even close to home. The objective here was to locate and propagate a very columnar Rocky Mountain juniper for evaluation as a potential landscape plant.



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PROJECT SUMMARY

The initial effort to propagate this promising accession was done by cuttings in December of 2014. Unfortunately, none of the cuttings rooted. A second attempt was made in December of 2018 with the assistance of Annika Burkhardt, an undergraduate researcher.



Cuttings were collected and treated with a wider range of rooting hormones than is normally used to see if we could successfully propagate the plant. We also allowed the cuttings to stay on the propagation bench longer than usual. After 6 months we were able to root 7 root plants from 194 cuttings for a dismal 3% success, but we feel fortunate in that we finally have some plants we can grow in a nursery environment where we can manipulate them and hopefully get better rooting success. We also discovered that larger cuttings have a greater success rate.

PROJECT STATUS

With the successful rooting of several cuttings, the project should shift from a field collection effort to a nursery production effort. Continued research is required to determine how this plant will perform in the landscape and how to improve rooting success to get it to a commercially viable level.

RELATED AND PENDING PUBLICATIONS

Rupp, L.A., M. Williams and C. Schaible. "Collecting Plants on Public Lands for Utah Landscaping" (2019). Paper 1997.
https://digitalcommons.usu.edu/extension_curall/1997

COLLECTING AND PROPAGATING NATIVE PLANTS FROM SOUTHWESTERN IDAHO

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Larry Rupp – Professor, Extension Landscape Horticulture Specialist, PSC, CWEL

CO-INVESTIGATORS/COOPERATORS

Richard Anderson – Curator of Plant Development, USU Botanical Center

Stephen Love – Professor, Aberdeen Research and Extension Center, University of Idaho

Daniel Dewey – Faculty, Applied Plant Science, BYU-Idaho

Tony McCammon – Bloom Horticulture Specialists

LOCATIONS:

Collection sites throughout the Great Basin

UAES Research Greenhouse, Logan, UT



PROJECT OBJECTIVE

Adapted, native plants have the potential to perform well in low-water landscapes. The goal of this activity was to search areas of southwest Idaho for superior woody plant accessions that could potentially be developed for use in landscaping throughout the Intermountain region.

PROJECT SUMMARY

On May 30, 2018, we went to several areas ranging from the Owyhee River basin to the Reynolds Creek area of the Tonto National Forest. Several plant species were collected, including Rocky Mountain maple; rockspray spirea; golden, wax and sticky currant; shrubby penstemon, creeping Oregon grape, snowberry, curleaf mountain mahogany, bitterbrush, singlehead goldenbush, and hopsage. We were successful in propagating all of the plants except singlehead goldenbush and hopsage. The most unique plant

was a selection of creeping Oregon grape that had both a shiny leaf and a deep green color. The other plants collected were mostly typical of their species, with the Rocky Mountain maple also being an outstanding accession.

PROJECT STATUS

We are continuing to collect and propagated native woody plants as opportunity permits. Some plants, such as goldenbush and hopsage remain very difficult to propagate asexually and will require further work.

SELECTED PRESENTATIONS

Rupp, L.A. (2018, November) "The Center for Water Efficient Landscaping", Cache Water Conservancy District Meeting, Logan, UT.

Rupp, L.A. (2018, September). Landscape Water Optimization Research and Extension at Utah State University. Guest Lecturer, Jilin Agricultural University, Changchun, China.

Rupp, L.A. (2018, September). Selecting and Propagating Native Plants for Low Water Landscaping. Guest Lecturer, Jilin Agricultural University, Changchun, China.

Rupp, L.A. (2018, June). Selection, Propagation, and Use of Native Plants for Low-Water Landscaping. Red Butte Gardens, Salt Lake City, UT.

RELATED AND PENDING PUBLICATIONS

Rupp, L.A., M. Williams and C. Schaible. "Collecting Plants on Public Lands for Utah Landscaping" (2019). *All Current Publications*. Paper 1997. https://digitalcommons.usu.edu/extension_curall/1997

LAYER PROPAGATION OF BIGTOOTH MAPLE AND GAMBEL OAK TREES

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Larry Rupp – Professor, Extension Landscape Horticulture Specialist, PSC, CWEL

CO-INVESTIGATORS/COOPERATORS

Paul Harris – Research Technician, CWEL

Michael Kilcrease – Research Technician, USU Botanical Center, CWEL

LOCATION:

UAES Research Greenhouse, Logan, UT

USU Botanical Center, Kaysville, UT

PROJECT OBJECTIVE

The overall goal of this project is to foster a means of native woody plant propagation that can be successfully used by Utah growers. This would facilitate the production of native plants within the state of Utah and hopefully further encourage their use in low-water landscapes.

PROJECT SUMMARY

One of the most low-tech methods of vegetative propagation for woody plants is layering. This is a process whereby new daughter plants are rooted while still attached to the mother plant. Propagation using this method requires only land, irrigation water, and a rooting substrate such as wood shavings. Using this method to produce selected cultivars of native plants will result in plant material that is of much higher value than traditional seedling-grown plants. We are continuing to work on optimizing propagation of bigtooth maple and Gambel oak.



PROJECT STATUS

We have an established layer bed of selected bigtooth maple clones at the USU Botanical Center in Kaysville. Over the past several years we have used these mother trees to propagate additional daughter plants. Currently we are supplying some of these plants to local nurseries to determine how well they grow in production after being propagated. During 2018, our best treatment resulted in 87% of the layered shoots being rooted.

SALT TOLERANCE OF ORNAMENTAL GRASSES

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Youping Sun – Assistant Professor, Landscape Horticulture, PSC, CWEL

CO-INVESTIGATORS/COOPERATORS

Alyssa Palmer – Undergraduate researcher, PSC

LOCATION: **UAES Research Greenhouse**, Logan, UT

PROJECT OBJECTIVE

To evaluate the responses of ornamental grasses to saline water irrigation and select the salt tolerant ornamental grasses for landscape use.

PROJECT SUMMARY

Ornamental grasses are popular in urban landscape in Utah and the Intermountain West. An estimated \$158 million worth of ornamental grasses are sold annually in U.S. Alternative waters are becoming important resources for landscape irrigation. These water sources are known to carry relatively high levels of salts, which negatively affect plant growth and development. Understanding the salinity tolerance of different ornamental grasses can be beneficial for preventing salt damage while maintaining appealing landscapes. The purpose of this project was to evaluate the responses of nine ornamental grass species and two ornamental grass-like species to saline irrigation water.

PROJECT STATUS

Two separate experiments have been conducted in the UAES research greenhouse. The first experiment “Responses of ornamental grass and



grass-like plants to saline water irrigation” has been published in *HortTechnology*. The results produced from the second experiment “Growth, Gas Exchange, and Mineral Nutrients of Ornamental Grasses Irrigated with Saline Water” has been accepted for publication in *HortScience*.

PRESENTATIONS

Abstract “Responses of Four Ornamental Grasses to Saline Irrigation Water” was accepted by American Society for Horticultural Science (ASHS) and will be presented at the Annual Conference of ASHS, Las Vegas, NV, July 23, 2019. Presenter: Alyssa Palmer and Youping Sun

Abstract “Relative Salt Tolerance of Ornamental Grasses and Grass-like Plants”, The Annual Conference of American Society for Horticultural Science, Washington, D.C., Aug. 1, 2018. Presenter: Alyssa Palmer and Youping Sun (**Alyssa Palmer received the Third Place Award for Undergraduate Student Poster Competition**).

SALT TOLERANCE OF SPIREA PLANTS

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Youping Sun – Assistant Professor, Landscape Horticulture, PSC, CWEL

LOCATION: **UAES Research Greenhouse**, Logan, UT

PROJECT OBJECTIVE

To evaluate the responses of *Spiraea japonica* cultivars to saline irrigation water and select the salt tolerant spirea for landscape use.

PROJECT SUMMARY

Spiraea is a genus in *Rosaceae* with about 80-100 species of shrubs. They are native to the temperate northern hemisphere with great diversity in eastern Asia. Many species of *Spiraea* are widely used as ornamental plants in temperate climates, particularly for their showy clusters of dense flowers. In the United States, an estimated \$29 million spirea are sold annually for garden and landscape uses, making them the fourth best-selling deciduous shrubs (U.S. Department of Agriculture, 2018). There are numerous named hybrids and cultivars that are selected from natural populations and bred in gardens. For example, *Spiraea japonica* and *Spiraea* × *nipponica* are commonly used in Utah landscapes and the Intermountain West. The fact that many spirea species and cultivars with diversified salt tolerance are planted in gardens and landscapes warrants further research. This project will investigate the relative salinity tolerance of eight *Spiraea japonica* cultivars and four *Spiraea* spp..

PROJECT STATUS

Spiraea japonica plants donated from Spring Meadow Nursery were evaluated in the UAES research greenhouse. One paper titled “Relative salt



tolerance of *Spiraea japonica* cultivars” has been published in *HortTechnology*.

PRESENTATIONS

Abstract “Salt Tolerance of Five Spirea Species” was accepted by American Society for Horticultural Science (ASHS) and will be presented at the Annual Conference of ASHS, Las Vegas, NV, on July 23, 2019, by Julie Herschkowitz and Youping Sun.

COMPARING THE SALT TOLERANCE OF THREE LANDSCAPE PLANTS USING A NEAR-CONTINUOUS GRADIENT DOSING SYSTEM

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Youping Sun – Assistant Professor, Landscape Horticulture, PSC, CWEL

LOCATION: **UAES Research Greenhouse**, Logan, UT

PROJECT OBJECTIVE

To evaluate the responses of three landscape plants to saline water irrigation and determine their salinity threshold values

PROJECT SUMMARY

Rose of Sharon (*Hibiscus syriacus*), Ninebark (*Physocarpus opulifolius*), and Japanese spirea (*Spiraea japonica*) are commonly used in urban landscapes in Utah and the Intermountain West. However, the thresholds for their salinity tolerance have not been identified. This project was to evaluate the responses of three popular landscape plants to saline water irrigation using a near-continuous gradient dosing system. Their salinity thresholds were also determined. The system allows researchers to evaluate a large number of plants for salinity tolerance with multiple treatments, more flexibility, and reduced efforts of irrigation.



PROJECT STATUS

This project has been completed and a paper has been published in *HortTechnology*.

PRESENTATIONS

Chen, J.J. (2019, April 11). Comparing the Salt Tolerance of Three Landscape Plants Using a Near-Continuous Gradient Dosing System. Student Research Symposium, Utah State University, Logan, UT.

Chen, J.J. (2019, March 26). Comparing the Salt Tolerance of Three Landscape Plants Using a Near-Continuous Gradient Dosing System. Spring Runoff Conference, Utah State University, Logan, UT.

Chen, J.J. (2019, March 25). Comparing the Salt Tolerance of Three Landscape Plants Using a Near-Continuous Gradient Dosing System. Department Showcase, Department of Plants, Soils and Climate, Utah State University, Logan, UT.

Chen, J.J. (2019, March 21). Comparing the Salt Tolerance of Three Landscape Plants Using a Near-Continuous Gradient Dosing System. The 10th Annual Intermountain Sustainability Summit, Weber State University, Ogden, UT.

Abstract “Comparing the Salt Tolerance of Three Landscape Plants Using a Near-Continuous Gradient Dosing System” was accepted by American Society for Horticultural Science (ASHS) to be presented at the ASHS Annual Conference, Las Vegas, NV, July 24, 2019. Presenters: Ji-Jhong Chen and Youping Sun.

SALT TOLERANCE OF SEGO SUPREME™ PLANTS

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS/COLLABORATORS

Young Sun – Assistant Professor, Landscape Horticulture, PSC, CWEL
Larry Rupp – Professor, Extension Landscape Horticulture Specialist, PSC, CWEL
Richard Anderson – Curator of Plant Development, USU Botanical Center

LOCATION: **UAES Research Greenhouse**, Logan, UT

PROJECT OBJECTIVE

To evaluate the responses of Sego Supreme™ plants to saline water irrigation.

PROJECT SUMMARY

Sego Supreme™ is a designated plant introduction program at the Botanical Center and the Center for Water Efficient Landscaping, Utah State University (USU). This plant selection program is to introduce native and adaptable plants into the arid West for aesthetic landscape and water conservation. The plants are evaluated for disease resistance, drought tolerance, and invasiveness. However, salt tolerance has not been considered during the evaluation processes. This project was to look into four Sego Supreme™ plants irrigated with salt solutions at different salinity levels in a greenhouse to determine their salt tolerance through measuring their growth and physiological responses.

PROJECT STATUS

This project has been completed. One paper titled “Salt tolerance of Sego Supreme™ plants” has been accepted for publication in *HortScience*.

Center for Water-Efficient Landscaping



PRESENTATIONS

Paudel, A. (2019, April 11) Salt Tolerance of Sego Supreme™ Plants. USU Student Research Symposium, Utah State University, Logan, UT.

Paudel, A. (2019, March 25) Salt Tolerance of Sego Supreme™ Plants. Department of Plants, Soils and Climate Showcase, Utah State University, Logan, UT.

Paudel, A. (2019, March 21). Salt Tolerance of Sego Supreme™ Plants. The 10th Annual Intermountain Sustainability Summit, Weber State University, Ogden, UT.

Abstract “Salt Tolerance of Sego Supreme™ Plants” was accepted by American Society for Horticultural Science (ASHS) to be presented at the Annual Conference of ASHS, Las Vegas, NV. July 23, 2019. Presenters: Paudel, Asmita and Young Sun.

SALT TOLERANCE OF VIBURNUM PLANTS

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS/COLLABORATORS

Youping Sun – Assistant Professor, Landscape Horticulture, PSC, CWEL

LOCATION: **UAES Research Greenhouse**, Logan, UT

PROJECT OBJECTIVE

To evaluate the responses of viburnum plants to saline water irrigation and select salt tolerant viburnum plants for landscape use.

PROJECT SUMMARY

Viburnums have been widely used in American landscapes for their showy and often fragrant flowers, richly colored foliage, and persistent winter fruits. It is estimated that three million viburnum plants are sold annually in the United States with a wholesale value of over \$22 million dollars (Pooler, 2010). Additional information on the salinity tolerance of viburnum species and cultivars is needed. The objective of this project was to study the effects of saline irrigation water on plant growth and development, physiological responses and mineral nutrient status of 12 viburnum species and evaluate their relative salinity tolerance.

PROJECT STATUS

This experiment has been completed, and the manuscript(s) are under preparation for submission to *HortScience*.



LANDSCAPE PLANT RESPONSE TO WATER DEFICIT

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS

Younging Sun – Assistant Professor, Landscape Horticulture, PSC, CWEL
Kelly Kopp – Professor, Extension Water Conservation and Turfgrass Science Specialist, PSC, CWEL

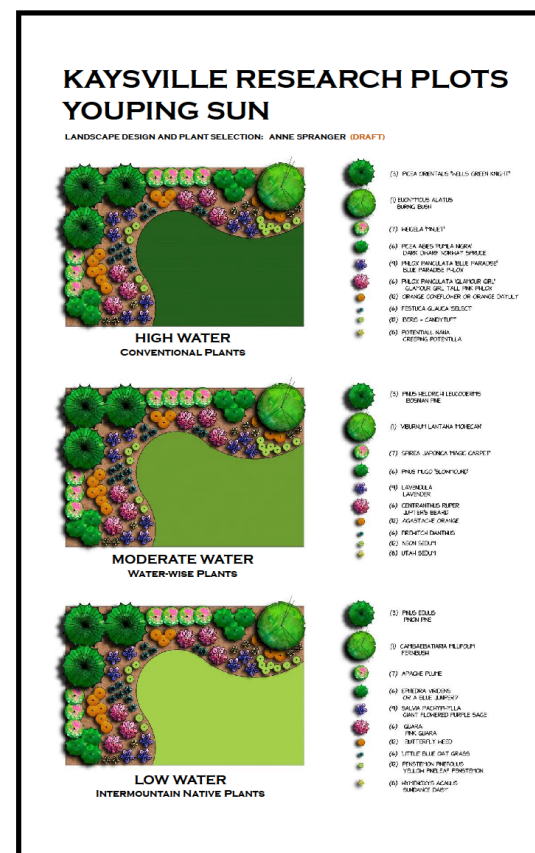
LOCATION: **USU Kaysville Research Farm**, Kaysville, UT

PROJECT OBJECTIVE

To characterize the water-use of different plant types (woody, herbaceous perennial, and turf) and water use categorizations (mesic, mixed and xeric) in designed landscapes under water-limited conditions to define the minimum water needs for water-efficient landscapes.

PROJECT SUMMARY

Climate and human-driven changes in water quantity and quality could result in more agricultural and urban landscape irrigation restrictions. These water-use sectors utilize 82% of freshwater resources in Utah. Water conservation is becoming critically important in Utah and the Intermountain West, one of the driest and fastest growing regions in the United States. Governor Gary Herbert has set a statewide goal to use 25% less water per person by 2025 from 2000 levels. Although Utahns are willing to significantly reduce water use, they do not want limited water supplies to diminish their ability to maintain aesthetically appealing landscapes. There is an urgent need for empirical data to distinguish water use of different plant types and water use categorizations under water-limiting conditions. This research will be conducted in designed landscapes comprised of three putative water use characterizations - mesic, mixed, and xeric - and plant materials of three different types—woody, herbaceous perennial, and turf. The water use of



different plant types and water use categorizations at the first 2 years of establishment will be characterized under well-watered conditions. Subsequently, their water use will be measured under increasingly water-limited conditions to define the minimum water needs for water-efficient landscapes.

STATUS

This project is in preparation.

MICROPROPAGATION OF UTAH NATIVE PLANTS

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS/COLLABORATORS

Youping Sun – Assistant Professor, Landscape Horticulture, PSC, CWEL
Larry Rupp – Professor, Extension Landscape Horticulture Specialist, PSC, CWEL
John Carman – Professor, Plant Genetics, PSC

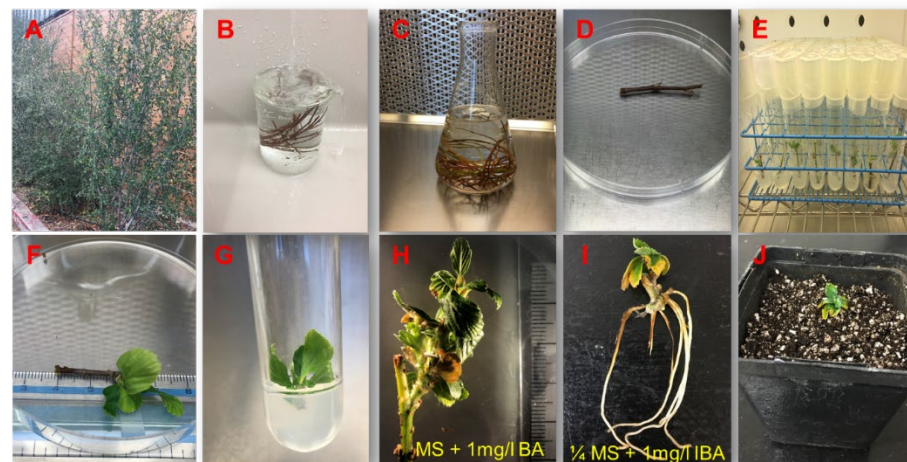
LOCATION: **USU Agricultural Sciences Building (AGRS)**, Logan, UT

PROJECT OBJECTIVE

To develop efficient mass propagation protocols for Utah native plants.

PROJECT SUMMARY

Native plants are of keen interest to the green industry. Many are adapted to harsh conditions in the arid and semiarid environment and are resistant to insects and fungi prevalent in their home regions. For these reasons, native plants are excellent candidates for water efficient landscaping. Promoting the use of native plants for low water use landscapes is vital for water conservation and environmental stewardship. Additional information on how to propagate enough plants for field evaluation and nursery production is needed. Plant tissue culture is the growth of plant organs or tissues in aseptic culture where the environment as well as nutrient and hormone levels are tightly controlled. Tissue culture, or micropropagation, is useful for

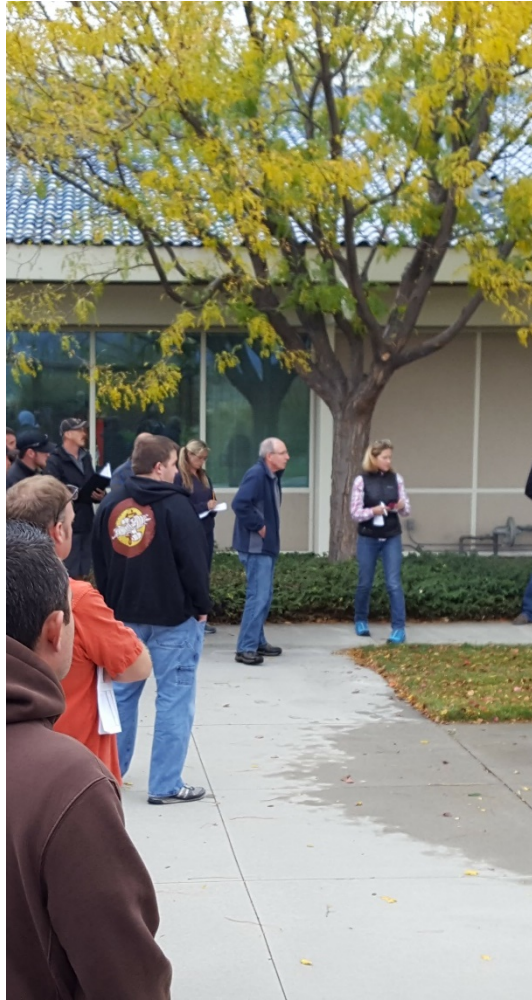


propagating plants that are difficult or slow to propagate with other approaches. Micropropagation consists of four stages. stage I: establishment of explants (A-G), stage II: shoot multiplication (H), stage III: root formation (I), and stage IV: acclimatization (J). This project is to develop efficient micropropagation protocols for Utah native plants with significance in the green industry. *Ceanothus velutinus* and *Cercocarpus Montanus* are under culture with different plant growth hormones to promote shoot proliferation.

PRESENTATIONS

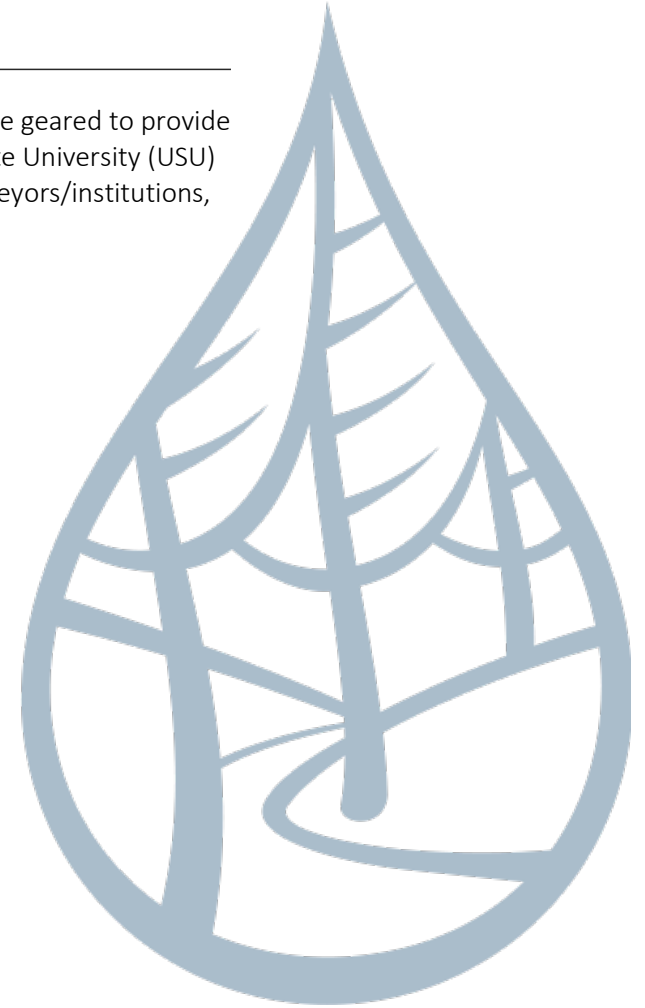
Abstract “Micropropagation of *Cercocarpus Montanus*: Stage II” was accepted by American Society for Horticultural Science (ASHS) to be presented at the Annual Conference of ASHS, Las Vegas, NV, July 23, 2019. Presenters: Asmita Paudel and Youping Sun.

WHAT WE DO



OUTREACH & EDUCATION

Outreach and education programs from CWEL are geared to provide expertise and information to statewide Utah State University (USU) Extension offices, the green industry, water purveyors/institutions, and the general public.



TURF GRASS INTEGRATED PEST MANAGEMENT ADVISORY

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS

Kelly Kopp – Professor, Extension Water Conservation and Turfgrass Science Specialist PSC, CWEL

CO-INVESTIGATORS/COOPERATORS

Paul Johnson – Department Head and Professor, Turfgrass Science, PSC, CWEL

Ryan Davis – USU Arthropod Diagnostician and School IPM Associate, Integrated Pest Management, Department of Biology

Ricardo Ramirez – Associate Professor, USU Extension Entomology Specialist

Claudia Nieschwitz – Associate Professor and USU Extension Plant Pathology Specialist, Department of Biology

Diane Alston – Department Head and Professor, USU Extension Entomology Specialist, Department of Biology

Marion Murray – Professional Practice Extension Assistant Professor, IPM Project Leader, Department of Biology

PROJECT BACKGROUND

In 2008, the first Turfgrass IPM Advisory was published and distributed to a listserv of 210 members. The advisory is published quarterly (corresponding to season) and serves two purposes. Subscribers receive alerts on turfgrass insect and disease pests that are active in the state and where they are located. Subscribers also receive information on general turfgrass management practices and their timing. New USU Extension fact sheets are also highlighted. As of May 2018, the listserv has grown to 7091 subscribers.

PROJECT OBJECTIVES

- Alert turfgrass managers in the state regarding active turfgrass insect pests and diseases.



- Provide science-based recommendations for managing turfgrass insect pests and diseases in the state.
- Provide recommendations on routine turfgrass management practices and their timing.

PROJECT STATUS

Project Period: 2008-present

The USU Extension Turfgrass IPM Advisory has been extremely well-received as evidenced by the continued growth of listserv subscriptions. Subscribers have responded with appreciation and additional questions, allowing ongoing communications and education on the topics that are addressed. The cooperative nature of the effort has also facilitated communication and collaboration among USU Extension faculty both on campus and off campus.



Turfgrass IPM Advisory

Quarterly Turfgrass Pest Update, USU Turfgrass Extension Vol. 11(2), Summer 2018

Turfgrass Integrated Pest Management

An integrative approach to the management of turfgrass insect pests, diseases and weeds is most effective. Prevention is the best strategy!

What to Watch For

It's hot and damage from pests and diseases may be more apparent than when temperatures were cooler. Be prepared for cool-season turf dormancy (yellowing) to show up as well.

Pest Alert: *Ascochyta* Leaf Blight

Ascochyta leaf blight has been identified in Salt Lake, Iron, Emery, Utah, San Pete and San Juan counties this year.

Ascochyta leaf blight is a disease that primarily effects Kentucky bluegrass, but may also occur on tall fescue and perennial ryegrass.

Conditions favoring the disease are not well understood, though it appears to be enhanced by changes in soil moisture. Frequent mowing or mowing with dull blades may exacerbate symptoms by increasing infection sites.

Symptoms

The symptoms of *Ascochyta* leaf blight may develop at any time during the growing season, but are especially apparent during hot and dry periods that may follow cooler, rainier conditions. The disease is primarily a disease of the leaves and does not effect the roots or crowns of the grass plant. The disease may resemble drought stress. However, the symptoms appear very quickly, as opposed to slowly over time.

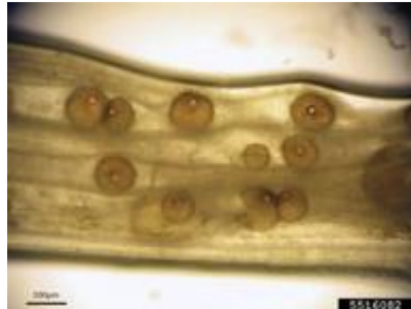


Figure 1. *Ascochyta* fungal fruiting bodies (Photo credit: Lee Miller, University of Missouri, bugwood.org).

Sometimes, symptoms may even appear overnight. Infected leaves often have a bleached tip that dies back to 1/2 or 1/3 of the total length of the leaf. The margin between the damaged and healthy tissue is abrupt and may be slightly pinched. Other symptoms may include white banding or leaves may collapse entirely.



RECENT TURFGRASS IPM ADVISORIES

Kopp, K. (Ed.). (2018, Fall). USU Extension Turfgrass IPM Advisory. Utah State University. Vol. 11(3).

Kopp, K. (Ed.). (2018, Summer). USU Extension Turfgrass IPM Advisory. Utah State University. Vol. 11(2).

Kopp, K. (Ed.). (2018, Spring). USU Extension Turfgrass IPM Advisory. Utah State University. Vol 11 (1).

Kopp, K. (Ed.). (2018, Winter). USU Extension Turfgrass IPM Advisory. Utah State University. Vol 10 (4).

Kopp, K. (Ed.). (2017, Fall). USU Extension Turfgrass IPM Advisory. Utah State University. Vol 10 (3).

Kopp, K. (Ed.). (2017, Summer). USU Extension Turfgrass IPM Advisory. Utah State University. Vol 10 (2).

WATER CHECK PROGRAM

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

Kelly Kopp – Professor, Extension Water Conservation and Turfgrass Science Specialist PSC, CWEL

CO-INVESTIGATORS/COOPERATORS

Joanna Endter-Wada – Professor, Natural Resource Policy and Social Science, ENVS, CWEL

Candace Schaible – Extension Associate Professor, Iron County, CWEL

Helen Muntz – Extension Assistant Professor, Morgan and Weber Counties

Jaydee Gunnell – Director and Extension Professor, Cache County Extension

PROJECT BACKGROUND

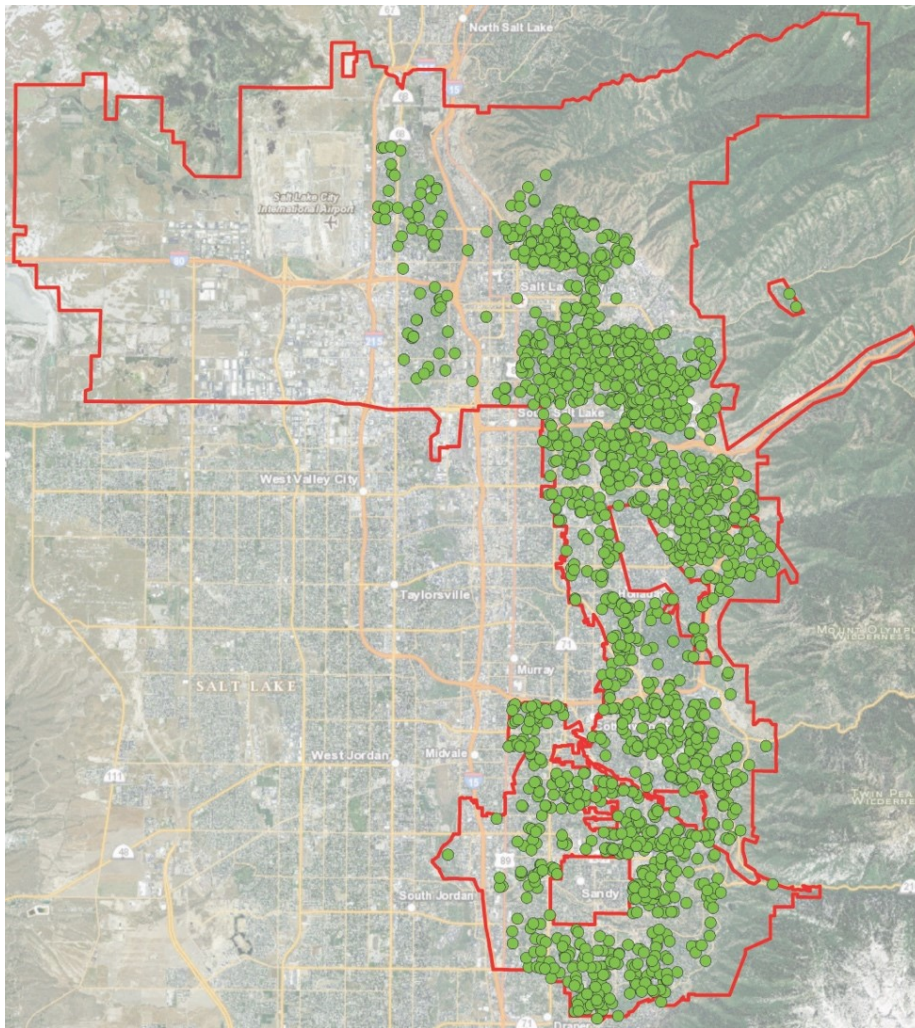
The Water Check Program began in 1999 as a cooperative effort between USU Extension and water providers in the Salt Lake Valley. Over the many years since, the program has been adopted by other USU County Extension offices, water conservancy districts, providers and utilities.

The program sends pairs of trained employees to properties to evaluate the irrigation system and landscape, identifying flaws that contribute to decreased irrigation efficiency. The program is offered free of charge to participants who request the service. They receive a customized irrigation schedule based on catch cup results and a list of conservation recommendations based on an evaluation of the landscape. Participants are also able to ask questions and receive additional information on relevant topics of their choice.

PROJECT OBJECTIVES

- Provide educational support and practical guidance to homeowners and landscape managers on ornamental landscape irrigation.





- Provide a positive means of interaction between water providers and homeowners and landscape managers.
- Decrease landscape irrigation water use.

PROJECT STATUS

PROJECT PERIOD: 1999-present

To date, over 14,000 residential and 600 commercial and institutional properties have received Water Checks. Program evaluation is performed on an ongoing basis, with more detailed analyses performed for Salt Lake City due to the city's provision of water billing data. Key findings for Salt Lake City include:

- 2013 Water Check participants have maintained a reduction in water use every year since participation.
- Over time, water use of program participants has gone from exceeding city-wide average use on average to closely reflecting city-wide average use, on average. This finding may reflect an increasing water conservation ethic in the city and is a trend we are following closely.

In 2018, the Water Check Program, in cooperation with Salt Lake City, received a USU Extension Water Initiative grant to incorporate GIS capabilities into the program. The resulting application is currently undergoing beta testing and will allow for the development of irrigation system maps for the properties evaluated.

SELECTED PRESENTATIONS

Kopp, K. (2019, November). Center for Water Efficient Landscaping Annual Report. Presented at Metro Metropolitan Water District of Salt Lake and Sandy, UT.

QUALIFIED WATER EFFICIENT LANDSCAPER (QWEL) PROGRAM

PROJECT INFORMATION

COLLABORATORS

Kelly Kopp – Professor, Extension Water Conservation and Turfgrass Science Specialist, PSC, CWEL

Larry Rupp – Professor, Landscape Horticulture Specialist, PSC, CWEL

Candace Schaible – Utah Extension Associate Professor, Iron County, CWEL

PROJECT OBJECTIVES

- Provide an affordable, proactive, local approach to reducing landscape water demand.
- Provide landscape professionals with knowledge in water-efficient and sustainable landscape practices, including water management and preservation of other valuable resources.

PROJECT BACKGROUND

The Qualified Water Efficient Landscaper program continues to be the most consistent educational outreach effort for commercial landscapers that we participate in. The curriculum has recently been revised and the number of Professional Certifying Organizations (PCOs) continues to grow. It also represents a significant and highly effective collaboration between Utah State University Extension, Jordan Valley Water Conservancy District, and the Utah Nursery and Landscape Association for workshops along the Wasatch Front. Elsewhere throughout the state, collaborations are also forged with local water conservancy districts. With the support of USU, any water district throughout the state could host the training program and rely on USU faculty and local experts to teach the material.



SELECTED PRESENTATIONS

Rupp, L.A. (2018, February 26-28). The Qualified Water Efficient Landscaper program. Extension Annual Conference. Logan, UT.

PROJECT STATUS

PROJECT PERIOD: 2012-present. To date, over 450 landscape professionals have been certified through the QWEL training program. Currently, two trainings are offered per year.

'WATER WELL WITH CWEL' WEBINAR SERIES

PROJECT INFORMATION

ORGANIZERS

Candace Schaible – Utah Extension Associate Professor, Iron County, CWEL
Adrea Wheaton – CWEL Program Coordinator, PSC

COLLABORATORS

Joanna Endter-Wada – Professor, Natural Resource Policy and Social Science, ENVS, CWEL
Kelly Kopp – Professor, Extension Water Conservation and Turfgrass Science Specialist, PSC, CWEL
Larry Rupp – Professor, Extension Landscape Horticulture Specialist, PSC, CWEL
Paul Johnson – Department Head and Professor, Turfgrass Science, PSC, CWEL
Youping Sun – Assistant Professor, Landscape Horticulture, PSC, CWEL
Diana T. Wuenschell – Research Technician, ENVS, CWEL

PROJECT OBJECTIVES

- Engage with professionals throughout the country to provide an easy and affordable way to connect professionals, practitioners and academics with research and on-the-ground lessons learned.
- Provide a forum for water conservation professionals in a variety of professions to earn continuing education units (CEUs) while learning about landscape water conservation.

PROJECT BACKGROUND

Webinars are a way to reach a substantial audience that may not be able to spend time or money on travel to conferences. The 'Water Well with CWEL' webinar series aims to create a forum for dialog between researchers and outreach professionals.



PROJECT STATUS

The 'Water Well with CWEL' webinar series started in January, 2018, and is broadcast most months every second Tuesday at 2 pm MST. The following webinars have been broadcast with a total of 459 registrants, 255 participants and 907 post-webinar video views on the CWEL YouTube channel. The audience is growing each month and we hope to expand our reach with upcoming webinars that are geared towards turfgrass and irrigation specialists.

- **Drought Tolerant Turfgrass Varieties.** (2019, June). Jack Karlin, Program Administrator, Turfgrass Water Conservation Alliance (TWCA).
- **Optimal Soil-plant Water Relations Through Enhanced Soil Health.** (2019, April). Dr. Grant Cardon, Extension Soils Specialist, Utah State University
- **Orchard Irrigation Principles.** (2019, March). Dr. Brent Black, Extension Fruit Specialist, Utah State University.
- **Water Conservation and Growing Succulents.** (2019, February). Fritz Kollmann, Red Butte Garden.
- **Lessons Learned & Water Saved Through Metering Irrigation Water.** (2018, December). David Rice Weber Basin Water Conservancy District
- **Water, Trees, and Arid Urban Landscapes.** (2018, November). Dr. Heidi Kratch, University of Nevada Cooperative Extension.
- **Water University: Science Based Homeowner Education.** (2018, October) Clint Wolf, Water University, Texas A&M University
- **Right Plants, Right Place: Creating and Managing a Large Landscape with Limited Water** Bridger Varga, Wasatch Academy (2018, September)
- **Turfgrass Science 7 Industry Cooperate to Answer the Call for Reduced Water Use.** (2018, July). Kelly Kopp, USU Extension Turfgrass and Water Conservation Specialist.

COMBINATIONS FOR CONSERVATION

PROJECT INFORMATION

EDITORS

Adrea Wheaton – CWEL Program Coordinator, PSC
Larry Rupp – Professor, Extension Landscape Horticulture Specialist, PSC, CWEL

COLLABORATORS

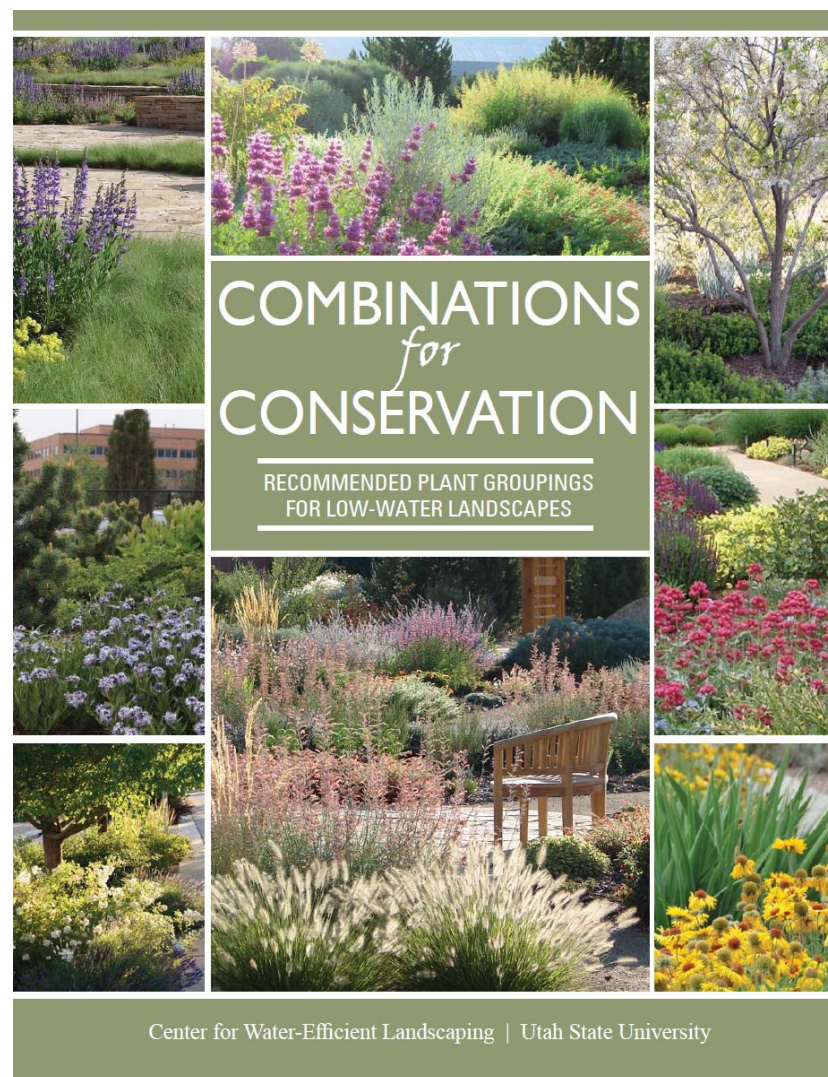
David Anderson – Professional Practice Associate Professor, LAEP
Paul Johnson – Department Head and Professor, Turfgrass Science, PSC, CWEL
Roger Kjulgren – Professor, PSC (formerly USU)
Kelly Kopp – Professor, Extension Water Conservation and Turfgrass Science Specialist, PSC, CWEL
Anne Spranger – Senior Lecturer, Landscape Design, PSC
William A. Varga – Professor Emeritus, PSC; Consultant, Perennial Favorites

PROJECT OBJECTIVES

- Give homeowners and designers the confidence to create beautiful, low-water landscapes by showing them examples of plant combinations that have been successful in low-water gardens throughout the Intermountain West.
- Provide tips and suggestions for water conservation on a residential landscape scale.

PROJECT STATUS

Combinations for Conservation was published through USU Extension in January of 2017. The book is sold through the USU Extension online store and at USU Extension offices throughout the state. The first printing of 1000 books is currently sold out and a second printing is planned for July 2019.



PRESENTATIONS

Buffler, S. (2019, May 4). Combinations for Conservation. Presented at Ogden Botanical Gardens, Weber Association of Master Gardeners, Ogden, UT.

MASTER OF PROFESSIONAL STUDIES IN HORTICULTURE (MPSH) ONLINE DEGREE

PROGRAM BACKGROUND

Using landscape water efficiently is a multifaceted issue involving an understanding of plant science, irrigation technologies, human behaviors, and landscape design, all set within the political and economic contexts of communities challenged to meet the water demands of growing populations.

The purpose of the Master of Professional Studies in Horticulture (MPSH) degree is to provide horticulturists with the knowledge and skills needed to promote landscape water conservation effectively.

PROGRAM OBJECTIVES

Prepare graduates for careers as highly qualified water conservation specialists through a curriculum grounded in horticulture, water policy, turfgrass science, and irrigation.

PROGRAM STATUS

Utah State University is the only university offering a professional master's degree that focuses on urban landscape water conservation. The MPSH degree includes a specialization in Water Efficient Landscaping and has been offered through Utah State University since 2001, with 34 graduates to date. In 2016, we began offering the MPSH as an online degree. Currently, there are five students enrolled in the program, three are online students and two are on-campus.



PRESENTATIONS

Buffler, S. (2019, May 4). Combinations for Conservation. Presented at Ogden Botanical Gardens, Weber Association of Master Gardeners, Ogden, UT.

Chen, J.J. (2019, March 21). Comparing the Salt Tolerance of Three Landscape Plants Using a Near Continuous Gradient Dosing System. The 10th Annual Intermountain Sustainability Summit, Weber State University, Ogden, UT.

Chen, J.J. (2019, March 25). Comparing the Salt Tolerance of Three Landscape Plants Using a Near Continuous Gradient Dosing System. Showcase at the Department of Plants, Soils and Climate, Utah State University, Logan, UT.

Chen, J.J. (2019, March 26). Comparing the Salt Tolerance of Three Landscape Plants Using a Near Continuous Gradient Dosing System. Spring Runoff Conference, Utah State University, Logan, UT.

Chen, J.J. (2019, April 11). Comparing the Salt Tolerance of Three Landscape Plants Using a Near Continuous Gradient Dosing System USU's Student Research Symposium, Utah State University, Logan, UT.

Endter-Wada, J. (2019, June 11). Connecting Land and Water: Research in the Colorado River Basin. Invited presentation for panel at Universities Council on Water Resources (COWR) Annual Conference, Snowbird, UT.

Endter-Wada, J. (2019, January 31). Conservation Behavior: What's the Potential? Invited presentation for the Central Texas Water Conservation Symposium entitled "Integrated Water: Keeping Water Conservation at the Forefront," Austin, TX.

Endter-Wada, J. (2019, January 15) Developing Water Policy to Support Resiliency. Invited presentation for Confluence sponsored by the Weber River Partnership, Ogden, UT.

Endter-Wada, J. (2018, October 2-5). Conservation Behavior Panel: What's the Potential? Learning from Behavior Practitioners. Presented at Water Smart Innovations Conference, Las Vegas, NV.

Endter-Wada, J. (2019, February 27-28). Implementing Water Conservation Strategies in Eagle Mountain City, Utah. Presented at the Utah Extension Annual Conference. Logan, UT.

Evans, S., K. Kopp, P. Johnson and B. Hopkins (2018, November 4-7). A Comparison of Smart Controllers in the Urban Landscape. Poster presented at the Crop Science Society of America (CSSA) Annual Conference, Baltimore, MD.

Harris, P. (2018, November 4-7). Poster presentation: Salinity tolerance in Kentucky bluegrass hybrids. Presented at the ASA and CSSA Annual Meeting, Baltimore, MD.

Kilcrease, M., B. Hunter, J. Goodspeed, J.D. Gunnell, M. Pace, D. Drost and L.A. Rupp. Water Usage Monitoring. (2019, February, 27-28). Demonstration and Education at the Utah State University Botanical Center – Water Initiative Grant. Extension Annual Conference, Utah State University, Logan, UT.

Lawson, K. and L.A. Rupp. (2018, July). Selecting and Grafting Wild *Pinus monophylla* on containerized *Pinus edulis* rootstocks", IPPS-WR Annual Conference, Kona, HI.

Lawson, K., L.A. Rupp, C. Reid and R. Newhall. (2019, May). Selection and Propagation of Single-Leaf Pinyon. Extension Regional Conference. Nephi, UT.

Paudel, A. (2019, April 11). Salt Tolerance of Segoe Supreme™ Plants. USU 2019 Student Research Symposium, Utah State University, Logan, UT.

Paudel, A. (2019, March 25) Salt Tolerance of Segoe Supreme™ Plants. Department of Plants, Soils and Climate Showcase, Utah State University, Logan, UT.

Paudel, A. (2019, March 21) Salt Tolerance of Segoe Supreme™ Plants. The 10th Annual Intermountain Sustainability Summit, Weber State University, Ogden, UT.

Rupp, L.A. (2019, May 29). Low-Water Landscaping. Utah Valley Earth Forum. Orem, UT. Invited.

Rupp, L.A. (2019, May 16). The Water Conservation Forum: A Retrospective and Thoughts for the Future. Presented at the Water Conservation Forum, Conservation Garden Park, West Jordan, UT.

Rupp, L.A., J. Endter-Wada, K. Kopp, Y. Sun and P.G. Johnson. (2019, March 19). " Urban Landscape Water Conservation ", Utah Water Users Workshop, St. George, UT. Invited.

Rupp, L.A. (2018, November) "The Center for Water Efficient Landscaping", Cache Water Conservancy District Meeting, Logan, UT. Invited.

Rupp, L.A. and K. Lawson. (2018, September) Selecting and Propagating Pinyon Pine, WERA-1013, Cheyenne, WY.

Rupp, L.A. (2018, September). "Landscape Water Optimization Research and Extension at Utah State University", Guest Lecturer, Jilin Agricultural University, Changchun, China. Invited.

Center for Water-Efficient Landscaping

Rupp, L.A., (2019, June) Gardening with Native Plants. Canyon Conversations at the Stokes Nature Center. Logan, UT.

Sun, Y. (2018, October 5). Propagation of *Ceanothus velutinus*, Annual Meeting of WERA-1013: Intermountain Regional Evaluation and Introduction of Native Plants, Cheyenne, WY.

Sun Y. (2018, August 2). Salt Tolerance of *Punica granatum* 'Wonderful', Annual Conference of the American Society for Horticultural Science, Washington, D.C.

Sun, Y. (2018, August 2). Single Molecule Real Time Transcript Sequencing Unveiled Flowering Regulatory Genes in *Crocus sativus*, Annual Conference of the American Society for Horticultural Science, Washington, D.C.

Sun, Y. and A. Palmer. (2018, August 1). Relative Salt Tolerance of Ornamental Grasses and Grass-like Plants. Presented at The Annual Conference of the American Society for Horticultural Sciences, Washington, DC.

PUBLICATIONS

PEER-REVIEWED JOURNAL ARTICLES

Barnett, M.J., D. Jackson-Smith and J. Endter-Wada. (2019). Implications of Nontraditional Housing Arrangements for Urban Water Management in the United States Intermountain West. *Society & Natural Resources*. DOI: <https://doi.org/10.1080/08941920.2018.1539200>

Chen, J., Y. Wang, A. Paudel and Y. Sun. (2019, in press). Comparing the Salt Tolerance of Three Landscape Plants Using a Near-Continuous Gradient Dosing System. *HortTechnology*.

Endter-Wada, J., K.M. Kettenring and A.E. Sutton-Grier. (2018). Sustaining Wetlands to Mitigate Disasters and Protect People. Guest Editorial. *Frontiers in Ecology and the Environment* 16(8):431. DOI:10.1002/fee.1959

Hale, R.L., C.G. Flint, D. Jackson-Smith, and J. Endter-Wada (2018). Social Dimensions of Urban Flood Experience, Exposure, and Concern. *Journal of the American Water Resources Association* 54(5):1137-1150. DOI: 10.1111/1752-1688.12676

Li, E., J. Endter-Wada and S. Li. (2019). Dynamics of Utah's Agricultural Landscapes in Response to Urbanization: A Comparison Between Irrigated and Non-Irrigated Agricultural Lands. *Applied Geography* 105:58-72. DOI: <https://doi.org/10.1016/j.apgeog.2019.02.006>

Maughan, T., B. Black, L.A. Rupp and T. Yost. (2018). Propagation Techniques for *Sambucus cerulea* (Blue Elderberry). *Native Plants Journal* (accepted).

Muntz, H. and K. Kopp. (2019). Influencing Water Consumption Through the Water Check Program. *Journal of Extension*. 57 (4).

Sun, Y. and A. Palmer (2018). Responses of Ornamental Grass and Grass-like plants to saline water irrigation. *HortTechnology* 28(6): 799-806.

Sun, Y., G. Niu., J.G. Masabni and G. Ganjegunte. (2018). Relative Salt Tolerance of 22 Pomegranate (*Punica granatum*) Cultivars. *HortScience* 53(10):1513-1519.

Tong, T., L. Shao, Z. Peng, and Y. Sun. (2018). *Osmanthus fragrans* 'Cai Ye Gui', a Variegated Cultivar. *HortScience*, 53(5), 729-731.

Wang, Y., Y. Sun, G. Niu, Z. Deng, Y. Wang and J. Gardea-Torresdey (2019, in press). Growth, Gas Exchange, and Mineral Nutrients of Ornamental Grasses Irrigated with Saline Water. *HortScience*.

Wang, Y., L. Li, Y. Sun and X. Dai. (2019). Relative Salt Tolerance of *Spirea japonica* Cultivars. *HortTechnology* 29(3): 367-373.

RESEARCH REPORTS AND PROCEEDINGS

Endter-Wada, J., D.T. Wuenschell, Christine Garrard, Ellie Leydsman McGinty, Kelly Kopp, Jennie Hoover. (2019). Research Report: Utah State Capitol Grounds Landscape Water Use Assessment. Available at: http://works.bepress.com/joanna_endterwada/105/

Lawson, K., L.A. Rupp and R. Newhall. (2019, in press). Topworking Mature *Pinus edulis* with *Pinus monophylla*. International Plant Propagator Society Proceedings.

Lawson, K. and L.A. Rupp. (2019, in press). Selecting and Grafting Wild *Pinus monophylla* on Containerized *Pinus edulis* Rootstocks. International Plant Propagators Society Proceedings.

EXTENSION FACT SHEETS

Johnson, K. and L.A. Rupp. (2019, in press). "Transitioning Trees from Traditional to Low-Water Landscapes". Utah State University Extension.

Rupp, L.A., M. Williams and C. Schaible. "Collecting Plants on Public Lands for Utah Landscaping" (2019). All Current Publications. Paper 1997 https://digitalcommons.usu.edu/extension_curall/1997

Wheaton, A.; R.A. Rupp and M. Caron. "10 Low-Water Trees Ideal for Water-Efficient Landscapes in Eagle Mountain, Utah" (2018). *All Current Publications*. Paper 1856. https://digitalcommons.usu.edu/extension_curall/1856

Wheaton, A., L.A. Rupp and M. Caron. "10 Low-Water Ornamental Grasses Ideal for Water-Efficient Landscapes in Eagle Mountain, Utah" (2018). *All Current Publications*. Paper 1855. https://digitalcommons.usu.edu/extension_curall/1855

Wheaton, A., L.A. Rupp and M. Caron. "10 Low-Water Perennials Ideal for Water-Efficient Landscapes in Eagle Mountain, Utah" (2018). *All Current Publications*. Paper 1853. https://digitalcommons.usu.edu/extension_curall/1853

Wheaton, A., L.A. Rupp and M. Caron. "10 Low-Water Shrubs Ideal for Water-Efficient Landscapes in Eagle Mountain, Utah" (2018). *All Current Publications*. Paper 1854. https://digitalcommons.usu.edu/extension_curall/1854

Wheaton, A., L.A. Rupp and M. Caron. "Landscape Plants for Eagle Mountain, Utah" (2018), *All Current Publications*. Paper 1857. https://digitalcommons.usu.edu/extension_curall/1857

IMAGE CITATIONS

Eagle Mountain City location in Utah County and the state of Utah (p.10). https://upload.wikimedia.org/wikipedia/commons/thumb/5/52/Utah_County_Utah_incorporated_and_unincorporated_areas_Eagle_Mountain_highlighted.svg/800px-Utah_County_Utah_incorporated_and_unincorporated_areas_Eagle_Mountain_highlighted.svg.png

Utah State Capitol (p. 17) https://commons.wikimedia.org/wiki/File:Utah_State_Capitol,_Salt_Lake_City.jpg#filelinks

AWARDS

Hershkowitz, J. (2019, July). Second Place, Student Plant ID Contest. American Society for Horticultural Science (ASHS) Annual Conference, Las Vegas, NV

Hershkowitz, J. (2019). American Society for Horticultural Sciences Collegiate Scholars Award.

Palmer, A. (2019, July 22). ASHS Scholars' Scholarship Award, American Society for Horticultural Sciences Annual Conference, Las Vegas, NV.

Palmer, A. (2018, August 1) Third place, Undergraduate Student Poster Competition "Relative Salt Tolerance of Ornamental Grasses and Grass-like Plants". Presented at the American Society for Horticultural Sciences, Annual Conference, Washington, DC.

Wheaton, A., L.A. Rupp, D.T. Anderson, P.G. Johnson, R. Kjelgren, K. Kopp, A.M. Spranger and W.A. Varga. (2018). American Society for Horticultural Sciences Extension Division Material Award for Combinations for Conservation: Recommended plant groupings for low-water landscapes. Utah State University Extension. Logan, UT.

WEBSITE



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