

2020

Center for Water-Efficient Landscaping

ANNUAL REPORT | JULY 2019 - JUNE 2020

UTAH STATE UNIVERSITY



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Kelly Kopp, Director
Center for Water Efficient Landscaping
Utah State University

MESSAGE FROM THE DIRECTOR

This year, 2020, marks the beginning of the USU Center for Water-Efficient Landscaping's (CWEL) third decade and my first as director. Early this year, we bid a fond farewell to former director, Dr. Larry Rupp, as he retired from USU and I often reflect on his legacy in CWEL as I work to fill his very large shoes.

As we enter this new decade, CWEL continues to benefit from the foresight and leadership shown by Judy Ann Buffmire and Evan L. Olsen, state legislators who recognized the need for water conservation in Utah's urban and suburban landscapes, as well as our former colleague Dr. Rupp.

CWEL has continued our landscape water management research and Extension efforts this year despite the challenges we have faced due to the global pandemic. We have continued with the overarching goal of ensuring that Utah's water resources are used wisely and equitably, and that efficient landscape water management contributes to those efforts.

New students continue to breathe fresh air and critical thinking into our research projects and programs and bring the enthusiasm necessary to carry the CWEL mission forward. We have also begun the search process to replace our dear colleague Dr. Rupp and hope to have a new team member on board soon.

We hope you enjoy reviewing our accomplishments of the past year and encourage your comments and suggestions.

Kelly Kopp



WHO WE ARE

FACULTY



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. LARRY A. RUPP
Professor Emeritus Ornamental Horticulture / Extension Specialist
Former CWEL Director, Professor Emeritus of Ornamental Horticulture, Extension Specialist
Department of Plants, Soils and Climate
College of Agriculture and Applied Sciences

Dr. Rupp's work focused on the development of plants native to the intermountain region for use in water-conserving landscapes.



DR. PAUL JOHNSON
Department Head and Professor of Turfgrass Science
Department of 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.



CANDACE SCHAIBLE, MS
Professional Practice Extension Associate Professor
Iron County Extension
Utah State University Extension

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



DR. KELLY KOPP
Professor/Extension Water Conservation and Turfgrass Specialist, Director
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. YOUPING 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.

CAREER SPECIALIST AWARD

The **Career Specialist Award** is the most prestigious award that the USU Extension Specialist Association can bestow on an individual.

In January of 2020, former CWEL Director **Dr. Larry Rupp** was honored with this award at the annual Utah Extension Conference.

The award is given to an individual who effectively uses a variety of educational methods, such as mass media, publications, high-tech methods and direct teaching, conducts, publishes and disseminates applied research, generates monetary and cooperative support for programs, works well with colleagues in counties and departments, and works with enthusiasm, dedication and willingness to go the extra mile.



Left to right: **Dr. Larry Rupp**, Professor Emeritus Ornamental Horticulture, Extension Specialist, and former CWEL Director; **Dr. Ken White**, Vice President of Extension & Dean of the College of Agriculture and Applied Sciences; **Dr. Karl Hoopes**, Equine Extension Specialist (photo taken January, 2020).



STAFF



SUSAN BUFFLER, MS, MLA
Coordinator of Programs III
Center for Water-Efficient Landscaping

Susan CWEL team catherder. She has a background in landscape architecture, plant science, and art. Susan coordinates a variety of CWEL programs. She is the Master of Professional Studies in Horticulture advisor and social media outreach coordinator.



PAUL HARRIS, MS
Research Technician
Center for Water-Efficient Landscaping

Paul's professional interests include furthering research in turfgrass drought tolerance and promoting landscape water conservation. Paul recently completed a master of science degree in plant science.



CHRIS GARRARD, MS
Programmer / Analyst
Remote Sensing / GIS Laboratory College of Natural Resources / Center for Water-Efficient Landscaping

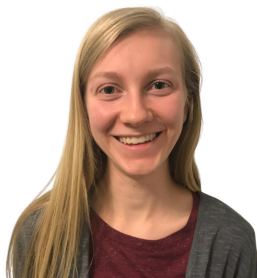
Chris does the software programming for the WaterMAPS™ project and teaches courses on Python scripting for GIS.



MICHAEL KILCREASE
Research Technician and Grounds Manager
USU Botanical Center / Center for Water-Efficient Landscaping

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

CWEL STUDENT INTERNS



MELANIE ROBINSON
Extension Outreach Assistant
Center for Water-Efficient Landscaping

Undergraduate in Plant Science
Department of Plants, Soils and Climate
Website management, CWEL social media outreach, and video production



LIZZY SWINK
CWEL Intern
Center for Water-Efficient Landscaping

Undergraduate in Plant Science, Ornamental Horticulture
Department of Plants, Soils and Climate
CWEL social media outreach, website management, student worker at UAES Greenville Farm

RESEARCH GRADUATE STUDENTS



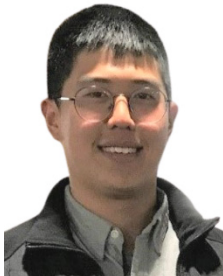
PAIGE BOYLE
Graduate Student, PhD Ecology

Undergraduate Degree: Environmental, Soil & Water Science, University of Arkansas
Master's Degree: Horticulture, University of Arkansas
Dissertation Project: Clover Inclusion for Value-Added Turf
Committee chair - Dr. Kelly Kopp



ASMITA PAUDEL
Graduate Student, MS Plant Science

Undergraduate Degree: Agricultural Science, Tribhuvan University (Nepal)
Thesis Project: Propagation and Production of Utah Native Plants
Committee chair - Dr. Youping Sun



JI-JHONG (JJ) CHEN
Graduate Student, MS Plant Science

Undergraduate Degree: Horticultural Science, National Chung Hsing University (Taiwan)
Thesis Project: Nodulation and growth of *Shepherdia* × *utahensis* 'Torrey'
Committee chair - Dr. Youping Sun



CHRISTOPHER M. MCGINTY
Graduate Student, PhD Ecology

Undergraduate Degree: Management and Human Resources, Utah State University
Dissertation Project: TBD
Committee chair – Dr. Joanna Endter-Wada

MASTER OF PROFESSIONAL STUDIES IN HORTICULTURE (MPSH) STUDENTS



KATRIEL CLOWARD
Graduate Student: MPSH

Undergraduate Degree: Technical Communication, English, B.S., minor: Biology, Utah State University

Faculty advisor - Dr. Kelly Kopp



NYSSE WILSON
Graduate Student: MPSH

Undergraduate Degree: Individualized Studies / Socio-Cultural Anthropology, B.A., Northern Michigan University

Faculty advisor - Dr. Kelly Kopp



MORIAH JACKSON
Graduate Student: MPSH

Undergraduate Degree: Psychology, B.S., minor: Chemistry & Nutrition, The University of Utah

Faculty advisor - Dr. Kelly Kopp

MASTER OF SCIENCE THESES AWARDED 2019/2020



PRESTON COLVER
Graduate Student, MS Plant Science (Spring 2020)

Undergraduate Degree: Plant Biology, Brigham Young University
Thesis Project: Water Use in Jujube (*Ziziphus jujube*) With Applications on Irrigation Timing and Quantity

Committee chair - Dr. Larry Rupp



KYLIE LAWSON
Graduate Student, MS Plant Science (Summer 2020)

Undergraduate Degree: Plant Science, Utah State University
Thesis Project: Selecting and Grafting Single-leaf Pinyon Pine

Committee chair - Dr. Larry Rupp



SHANE EVANS
Graduate Student, MS Plant Science (Summer 2020)

Undergraduate Degree: Environmental Science, Brigham Young University
Thesis Project: Can Smart Irrigation Controllers Improve Water Use Efficiency in Urban Landscapes?

Committee chair - Dr. Kelly Kopp



J. IVY HARVEY THOMSON
Graduate Student, MPPH & MS Environment & Society (Summer 2020)

Undergraduate Degree: Interdisciplinary Studies, Utah State University
Thesis Project: Policy Review of Best Management Practices in Urban Landscape Water Conservation.

Committee chair - Dr. Joanna Endter-Wada



PAUL HARRIS
Graduate Student, MS Plant Science (Spring 2020)

Undergraduate Degree: Horticulture, emphasis in Turfgrass Management, Utah State University
Thesis Project: Salinity Tolerance in Kentucky Bluegrass Hybrids.

Committee chair - Dr. Paul Johnson



LOGAN OATES
Graduate Student, MLA Landscape Architecture (Summer 2020)

Undergraduate Degree: Landscape Management, Brigham Young University
Thesis Project: Designing Water Conservation Landscapes Using Local Water Audit Data

Committee chair – Dave Anderson, LAEP (CWEL Committee members Dr. Larry Rupp and Adrea Wheaton)

UNDERGRADUATE RESEARCHERS

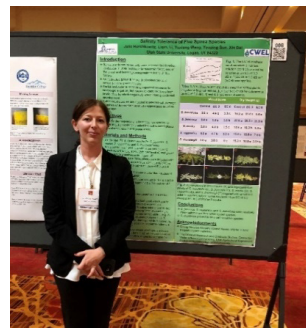


ALYSSA PALMER

Undergraduate Research Project: Response of Four Ornamental Grasses to Saline Irrigation Water

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



Photos taken August, 2019.

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 |

CORONAVIRUS (COVID-19) PANDEMIC COMPLIANCE STATEMENT

Images of people inserted into this document were taken both before and during the Coronavirus (COVID-19) pandemic. Research and activities covered in this document occurred between July, 2019 and June, 2020. Therefore, for the purposes of this document, Utah State University COVID-19 health and safety protocols were followed from mid-March, 2020 through June, 2020.

WHAT WE DO



Collecting Bigtooth maple samples at the Utah Botanical Center, Kaysville, UT (Fall, 2019).

RESEARCH

Water conservation is critical to meet Utah's future water needs. CWEL is dedicated to helping the State of Utah meet its water conservation goals through its focus on gaining greater efficiencies in watering urban landscapes. It is estimated that approximately 50-65% of Utah's culinary water is used for landscape irrigation.

Research demonstrates that the amount of water applied to landscapes can 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, analysis of human behaviors contributing to efficiency and overuse of water used on urban landscapes, and development of water conservation policy and best practices.



IMPLEMENTING WATER CONSERVATION STRATEGIES IN EAGLE MOUNTAIN CITY, UTAH – PHASE II

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS

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

Larry Rupp – Professor Emeritus, 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

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

Jobie Carlisle – Utah Climate Center, PSC

J. Ivy Harvey Thomson – M.S. Student, ENVS, CWEL

CO-INVESTIGATORS/COOPERATORS (EAGLE MOUNTAIN CITY)

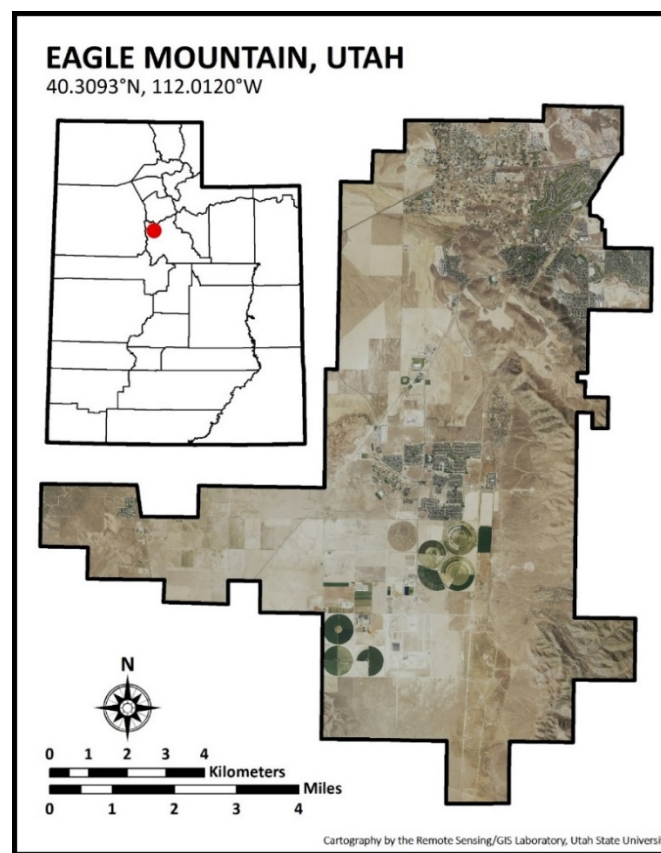
Tom Westmoreland – Mayor

Evan Berrett – Management Analyst, Eagle Mountain-USU Project Manager
Eagle Mountain City Administrators and Staff

LOCATION: **Eagle Mountain City, UT**

PROJECT OBJECTIVES

This project focuses on urban water conservation and furthers an Extension Water Initiative community-based collaboration between USU’s Center for Water-Efficient Landscaping (CWEL) and Eagle Mountain City. Project objectives are to: 1) continue helping Eagle Mountain City as it seeks to conserve water on existing urban landscapes and looks ahead to ensure that



future growth incorporates landscape water efficiency; 2) couple and apply two signature CWEL landscape water conservation programs, WaterMAPS™ and the Water Check program, in Eagle Mountain City; and, 3) produce research and Extension products based on this case study that can inform conservation programming in other Utah communities.

PROJECT SUMMARY



WaterMAPS™ Analysis. Since Eagle Mountain City is such a fast-growing community, the WaterMAPS™ analysis being conducted by USU focuses on

water use efficiency over time as landscapes are installed, become established, and are maintained. In order to make the efficiency estimates as accurate as possible, detailed land cover classification has been compiled using 2014, 2016, and 2018 NAIP imagery and two Utah Climate Center weather stations were installed in 2018 for localized evapotranspiration data. WaterMAPS™ analyses include both temporal and spatial patterns of water use efficiency that can be used to focus water conservation messaging and program delivery.



Water Checks. Water Checks continued to be administered in Eagle Mountain City during the summer irrigation season. Services included an evaluation of irrigation system designs and maintenance, catch cup tests to determine system distribution uniformity

and precipitation rate, soil texture characterization, a customized irrigation schedule, and water conservation recommendations for the irrigation system, plants, and soil. Program administrators worked to provide Water Checks in 2020 in COVID-compliant ways.

USU's Water Check Program focused on evaluations of home landscapes in 2020. These residential Water Checks followed previous evaluations of larger city properties (city parks, sports fields, etc.) in 2018 and 2019 and reflect a city-wide water conservation philosophy and strategy.



A Utah Climate Center weather station in Eagle Mountain city

Water Check results are being combined with the results of WaterMAPS™ analyses and are being analyzed using localized data from weather stations installed in 2018. We continue to work with the city to provide citizen information and programming aimed at promoting water conservation city-wide.

People can sign up for Water Checks at: cwel.usu.edu/watercheck

Landscape Ordinances and Policy. J. Ivy Harvey Thomson completed a Master of Science degree with a thesis that reviewed water conservation literature and synthesized best practices with particular relevance for Eagle Mountain City. She included recommendations for city officials and staff to consider adding to their policy toolkit to achieve goals articulated in the city's general plan. She highlighted unique opportunities that Eagle Mountain City has to implement water-smart infrastructure in the construction phase of development.

PROJECT STATUS

This project will continue through 2021.

PROJECT PRODUCTS

Thomson, J. I. Harvey (2020). *Evaluation of best practices for urban water conservation and water-smart growth implementation in Utah* [Master of Science thesis, Utah State University]. Digital Commons <https://digitalcommons.usu.edu/etd/7911/>

LANDSCAPE WATER USE ANALYTICS FOR INSTITUTIONAL AND CORPORATE PROPERTIES

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

PROJECT TEAM MEMBERS

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

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

Chris McGinty – Assistant Director, Remote Sensing and GIS Lab

Kathryn Johnson – Master of Professional Studies in Horticulture (MPSH) student, CWEL

LOCATIONS: **Throughout the state of Utah**

PROJECT OBJECTIVES

A specialized WaterMAPS™ web application was developed to enable large property owners to analyze and track landscape water use at their various facilities. As an assessment and monitoring tool, this web application guides property managers on water conservation efforts and informs landscape replacement and operations decisions. The WaterMAPS™ web application was 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 was 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)



Examples of institutional and corporate properties

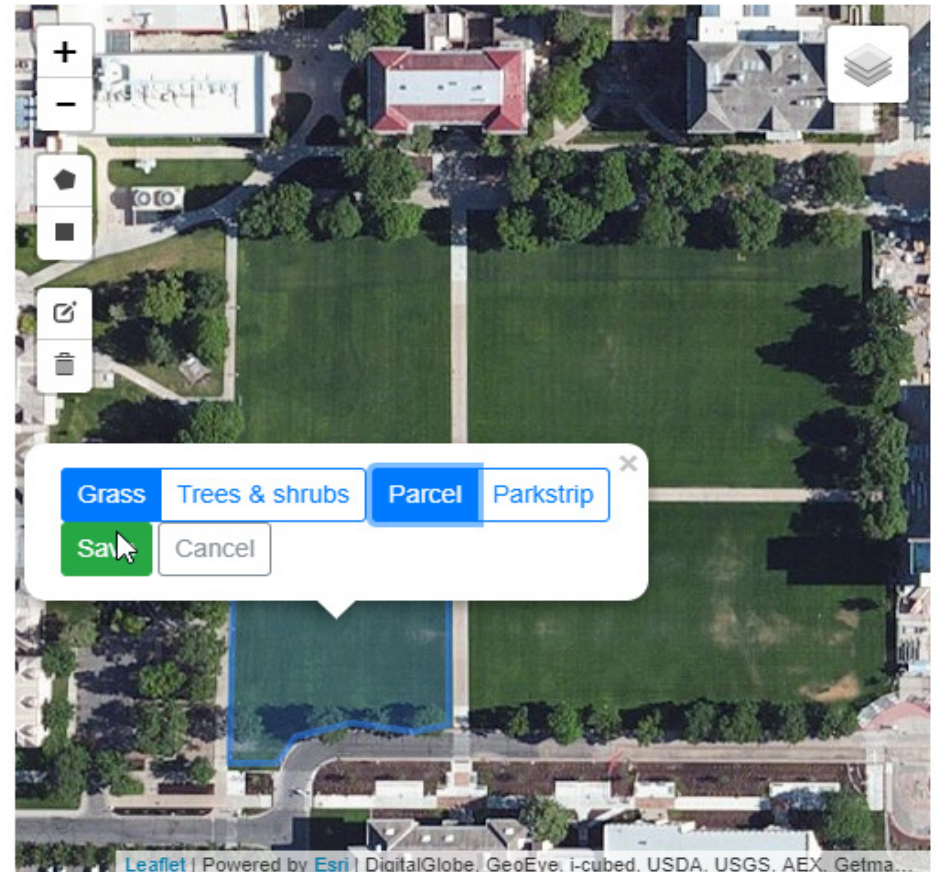


and water meter data needed to do the calculations to determine landscape water use efficiency. The tool developed through this project is geared to professional institutional and corporate property managers who generally have these data capabilities.

WaterMAPS™ Portal. We facilitated use of WaterMAPS™, a leading-edge urban landscape water demand management software application, and added a web-based interface. The customized portal enables institutional-level assessments of managed landscapes and 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 data for property locations and the new urban evapotranspiration weather data supplied by the Utah Climate Center. The portal enables data access and sharing between different levels of property management within an institution to facilitate achievement of water conservation and stewardship goals. Development, testing and implementation of the portal was done with a group of property managers with our institutional partner for this project.

WaterMAPS™ Analysis. Project researchers demonstrated how to conduct a state-wide comparative analysis of an institutional 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 helped that partner determine how other management operations could increase water use efficiency on existing landscapes.

Tree Watering Guidelines. We met a specific information need that our institutional partner had for caring for trees in landscapes being transitioned to mostly low-water plant material while retaining existing, largely non-native trees. Mature trees play a significant role in mitigating the urban heat island effect and protecting human health during heat waves.



WaterMAPS™ mapping tool

PROJECT PRODUCTS

Endter-Wada, J., Rupp, L.A., Garrard, C., McGinty, E.L., & McGinty, C. (2020). *Landscape water use analytics for institutional and corporate properties: Final project report*. Delivered to project partner. June 2020.

Johnson, K. & Rupp, L.A. (2019). *Transitioning trees from traditional to low-water landscapes*. Utah State University Extension. Digital Commons digitalcommons.usu.edu/extension_curall/2061/

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

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)

Tamara Wambeam – GIS/IT Administrator

Staff Members, Salt Lake City Department of Public Utilities



PROJECT OBJECTIVES

The Salt Lake City Department of Public Utilities (SLCDPU) is the largest water retail provider in the state of Utah, and one of the largest in the Intermountain West. Water demand is predicted to increase, with the city's 2020 Water Conservation Master Plan estimating the need to deliver 34% more water by 2060 in the absence of additional conservation practices. Conservation planning and implementation

practices must be furthered to achieve savings to match what the city has already achieved in the past. Detailed analysis of water-use patterns and conservation programming is needed to realize these additional, harder water conservation savings.

The objectives of this project are to provide 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 area. The project addresses several important questions: 1) how much more water applied to landscapes can SLCDPU expect to save, that is, how much water conservation potential exists within its service area; and, 2) where does SLCDPU have capacity to conserve water (geographically at particular locations; temporally at certain times of the irrigation season)?



PROJECT SUMMARY

The USU WaterMAPS™ Team conducted a “baseline” analysis of landscape water use patterns on 71,187 residential parcels (single family detached, duplex, and triplex residences) in the SLCDPU service area for 2014-2018. The analysis identified locations and periods of time where overuse occurred and categorized landscape water use patterns based upon efficiency and volume to assess capacity to conserve water within the residential sector. This analysis helped SLCDPU with water conservation planning for the 2020 Water Conservation Master Plan and for future water conservation program design, delivery, and evaluation. Continued application of WaterMAPS™ will help SLCDPU 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 were 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 was initiated in 2018 and work on analyzing residential sector use was completed in 2020.

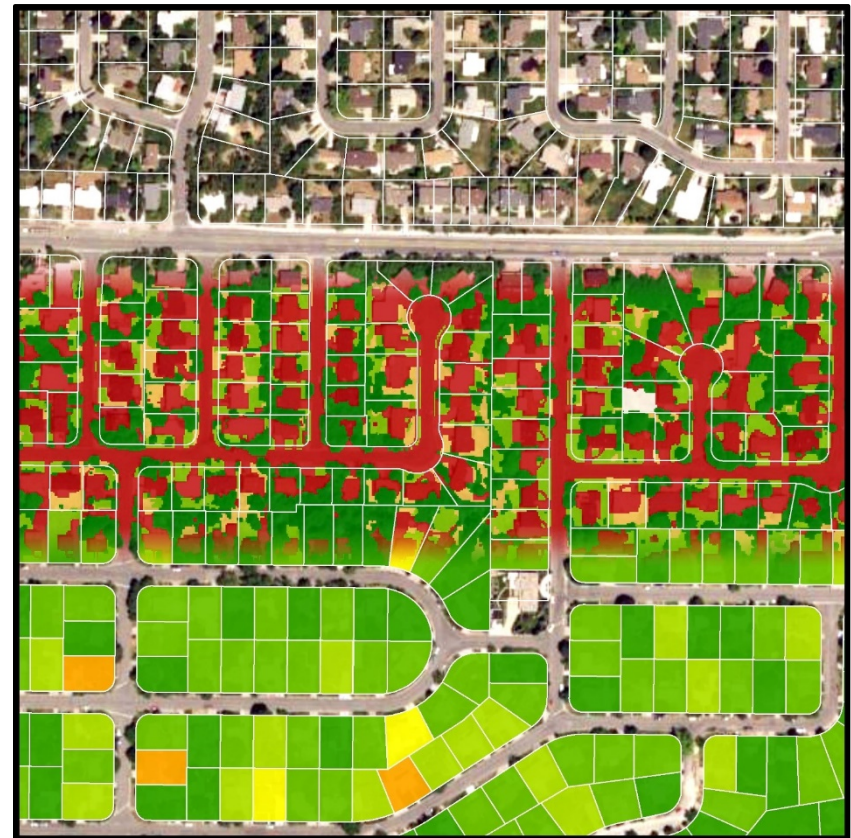
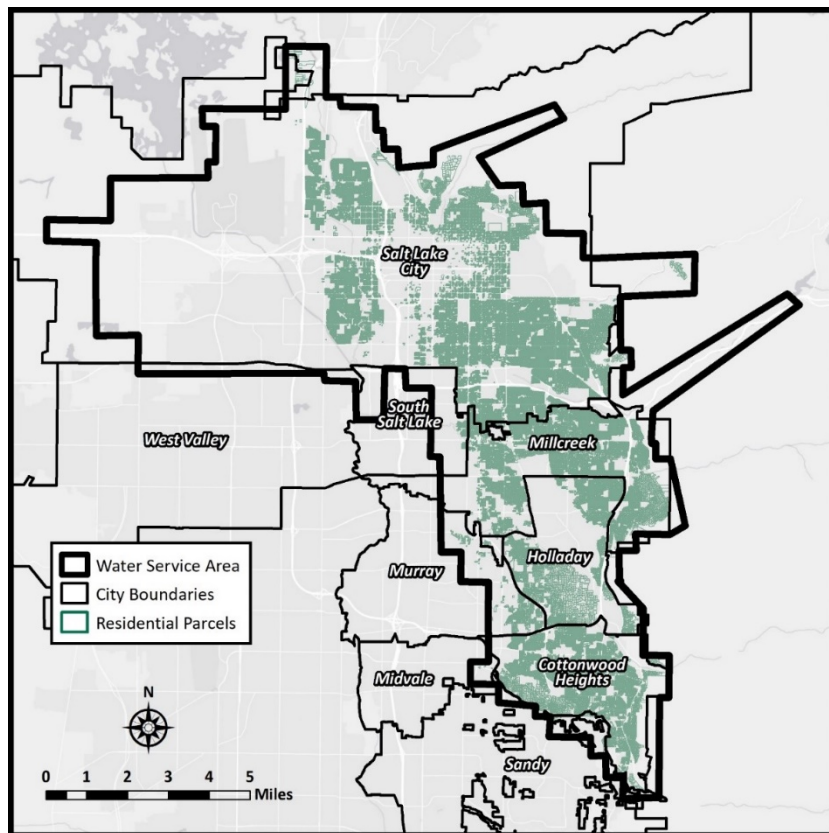
A second phase of this project was funded by SLCDPU and the USU Extension Water Initiative that will:

1) develop a conservation manager viewer application; 2) expand WaterMAPS™ analysis to institutional and commercial properties; 3) conduct targeted focus groups and surveys to inform conservation program design, delivery and tracking; and, 4) develop a customized WaterMAPS™ software application for SLCDPU that incorporates an analytics dashboard for water

managers and a water user portal for customers. The need for more localized and well calibrated weather information was recognized and a USU Extension Water Initiative Grant was obtained to install and upgrade six weather stations in the SLCDPU service area in summer/fall 2020.

PROJECT PRODUCTS

Endter-Wada, J., Garrard, C., McGinty, E.L., & McGinty, C. (2020, June). *Salt Lake City Department of Public Utilities WaterMAPS™ Analysis: Phase I draft report.*



TURFGRASS 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

We cooperate extensively with the National Turfgrass Evaluation Program (NTEP) to provide data on the adaptation of turfgrass species and varieties in northern Utah. We help identify those most appropriate for our region with emphasis on quality under reduced irrigation. NTEP is a national program that cooperates with seed companies and university researchers around the US and Canada to provide the turfgrass industry and consumers with impartial evaluation of varieties across many locations. Data from Utah and all the study locations is available at <http://ntep.org>.

We collect data on the following traits throughout the year:

- Visual quality
- Color
- Spring greenup
- Density and uniformity
- Percent survival
- Disease infection

Currently we are conducting the following variety trials:

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

Bentgrass putting green:

- In terms of color, the varieties fell into two categories: Blue-green and bright green. Nightlife, Armor, and Kingdom are very blue-green however are quick to show *Poa annua* infestations due to the difference in color. The other varieties are bright green to lighter green.
- Nightlife, GDE, Pure Select, L-93XD, Armor, Kingdom V-8, and 777 as well as some experimentals, exhibited the better visual summer quality. Penncross was always at the bottom of the list. Having been the standard variety for many years, it still can provide good putting surfaces at higher mowing heights and higher fertility levels. This plot was maintained at approximately 0.110 inch during summer with 3 lbs. N/1000 per year.
- Thatch production is a recurring issue with most bentgrasses, and accumulation of thatch promotes a spongy feel, slower green speed, and tendency for hydrophobic conditions. Constant management, low fertility, and traffic (something we didn't have on this plot) is necessary to maintain consistent and firm putting surfaces.

Perennial ryegrass:

- Spring color is one of the hallmarks of perennial ryegrass and nearly all entries had good color early in spring. While most are quite dark green thanks to selection by plant breeders, some that tended to be darker green in this recent year were Fireball, Hatrick, Pepper II and

a number of experimentals. In reality, most of the entries had very good dark green color.

- Summer quality was also quite similar in the standard trial with Furlong, Homerun, and a number of experimental varieties sifting to the top. But again, the differences among most were small and color rankings may change in different locations.

Kentucky bluegrass:

- Many people in the US like dark green turf. In terms of color, Prosperity, New Moon, and a number of experimental varieties tended to give the darkest green color that most people gravitate toward. The lightest green varieties included Kenblue, Barvette, and Baserati, but that doesn't mean those lighter green varieties performed poorly. Some did well in other characteristics like summer quality and spring greenup.
- Color is not the only trait that is important. Summer quality was the most differentiating factor this year with hot conditions and billbug insect activity affecting the appearance in summer months. Varieties doing best that time of year included Bombay, Starr, Barvette and a number of experimental varieties. Those that were at the bottom of the list included Midnight, Baserati, and NuRush and were likely most affected by the billbug feeding and lack of recovery.
- Spring greenup is another important trait in our region because cool springs can delay bluegrass from starting active growth early. Varieties with better spring greenup this year included Paloma, Finish Line, New Moon, and Barvette. Varieties with slowest greenup included Midnight and Twilight.
- This discussion is only one year's data and following them in the next few years will be important for their long-term quality and stress tolerance. Also, when looking for varieties to plant, find out what is available, look at previous years' data, and learn what seed suppliers are recommending based on their experience. Varieties go in and out of production quickly and some may not be available in any given year.



Portion of the Kentucky bluegrass trial showing plots damaged by billbug. Those plots with some green cover are recovering, those completely brown had incomplete recovery. The one plot mostly green is fine fescue and resistant to most billbug damage. September 19, 2019.

Tall fescue

- Tall fescue is the most stress-tolerant cool-season species. While giving good turfgrass quality in summer with less irrigation, it is slow to green-up in spring due to snow mold in Cache Valley. The long snow cover promotes severe pink and gray snow mold on tall fescue. No turf stand is lost, but in 2020, it did take until mid-May for the damage to be mostly replaced by green, growing leaves. This needs to be considered if spring quality is a priority.

Cool-season low-input:

- This continues to be a very interesting trial as it shows what grasses will survive and provide a turf without irrigation in northern Utah.
- Intermediate wheatgrass and crested wheatgrass entries have survived best but go dormant in summer (as is normal). Intermediate wheatgrass had the highest spring quality ratings because of even, consistent, fairly dense plot cover and green color, albeit lighter green than other grasses. Tall fescue entries maintained green color longer than many other grasses without any supplemental irrigation but have lower plot coverage. The old variety K-31 gives the best coverage but is light green in color. Some tall fescues (DTTHO Mix and Bullseye) had decent coverage and a darker green color for more of the year.

The tall fescue is doing fairly well in this plot because of its ability to root very deeply. However, if a site has soil conditions that reduce rooting depth, tall fescue varieties may not survive. Most bluegrass and fine fescue entries were poor in plot cover, weed encroachment, and quality throughout the year. The best bluegrass entry was Kenblue. Western yarrow (Yaak) provided green color by far the longest into summer compared to other entries and has survived well thus far.



Cool-season Low-input Trial, September 6, 2019. The plots range from green cover (yarrow) to dormant but complete turf coverage (wheatgrasses and some tall fescue) to patchy coverage and weeds in bluegrass and fine fescue entries.

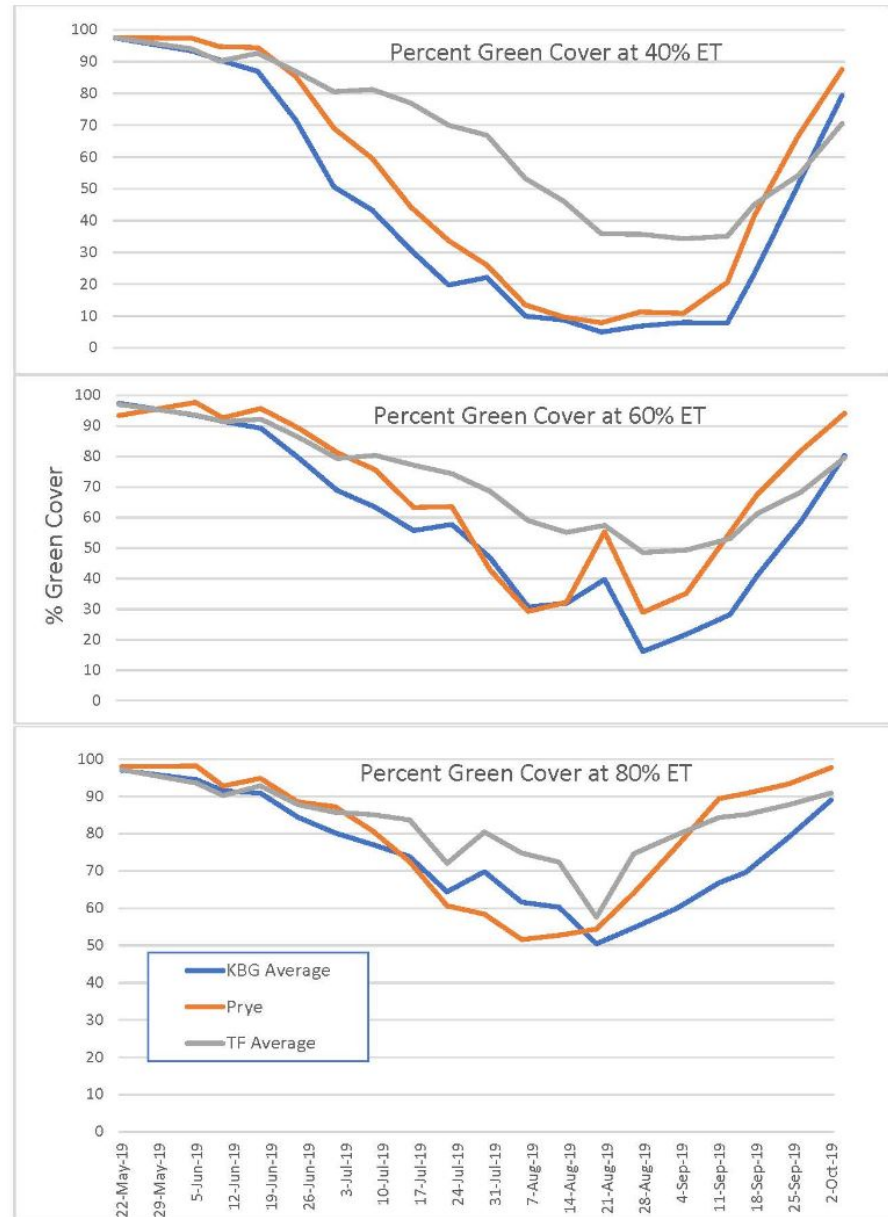
Warm-season low-input:

This plot is located in the St. George area and is our first variety trial in southern Utah. Thank you to the Washington County Water Conservancy District and USU Extension for helping make this possible. This trial includes bermudagrass, zoysiagrass, and buffalograss entries and was established in 2019. The bermudagrass and buffalograss entries filled in the plots quickly. Zoysiagrass entries were much slower. However, the density and color of the zoysiagrasses may result in higher quality long term. We will report next year on the initial quality data for this plot.

Cool-season water-use study

Tall fescue varieties continue to be the best at maintaining green color in summer with low levels of irrigation. This was again shown in 2019 in this trial. At 40% ET replacement, which is half of what is typically recommended for cool season grasses, tall fescue varieties maintained on average 35% green cover in August with some above 50% green cover. Kentucky bluegrasses and perennial ryegrass were dormant at this time with green cover averaging below 10%. At 80% ET replacement, all the grasses experienced some loss of green cover but none of the averages were below 50% with many above 75%. Results in the 60% ET replacement were immediately as expected.

In general, we can maintain acceptable turf with substantially reduced irrigation levels compared to those usually recommended, but recovery from wear and traffic is reduced under those conditions. For example, most information sources recommend for Kentucky bluegrass that 80% of reference evapotranspiration (ET_o) amounts be replaced at each irrigation. Replacing 60% of ET_o (a decrease of 25% in irrigation applied) can still provide acceptable turf in many Kentucky bluegrass varieties, but regrowth and the ability to tolerate traffic is reduced.



The graph at right shows the average percent green cover at 40, 60, and 80% of evapotranspiration (ET), respectively, for Kentucky bluegrass (KBG), Perennial ryegrass (Prye), and Tall Fescue (TF).

TURFGRASS WATER CONSERVATION ALLIANCE TRIALS – TALL FESCUE

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR/CONTACT PERSON

Kelly Kopp - Department of Plants, Soils and Climate / Center for Water Efficient Landscaping / USU Cooperative Extension
kelly.kopp@usu.edu, (435) 757-6650

CO-INVESTIGATORS/COOPERATORS

Paul Johnson - Department Head and Professor, Department of Plants, Soils and Climate
Paul Harris - Research Technician, CWEL

LOCATION:

UAES Greenville Research Farm, Logan, UT

PROJECT BACKGROUND

The Turfgrass Water Conservation Alliance (TWCA) was founded in 2009 by three grass seed production and marketing companies to provide a framework for evaluating low water use turfgrass species and varieties.

Partially inspired by the EPA's Water Sense Program, TWCA has established protocols for acute and chronic drought stresses on individual varieties using digital image analysis (DIA) to measure the exact amount of living plant material during various stages of water deprivation.

In the case of acute drought testing, irrigation is stopped and plots are allowed to decline until all varieties exhibit less than 25% green cover. At that point, recovery is initiated with the application of 2 inches of water.

Imagery and irrigation continue until the plots reach 100% green cover.

This is evaluating 49 tall fescue varieties including 6 named varieties and 43 experimental varieties.



Seeding the TWCA trial plots in September, 2020 (physical distancing protocol was observed).

PROJECT OBJECTIVES

- Evaluate ET-based drought tolerance of experimental and control varieties of tall fescue under acute drought stress.
- Develop dry down curves for the tested varieties based on cumulative ET loss.
- Develop greenup curves for the tested varieties based on the number of days to recovery after irrigation is applied.

PROJECT SUMMARY AND STATUS AS OF SEPTEMBER 2020

This project was seeded in September of 2020. Following a 1-year establishment period, drought stress will be imposed and data collection will begin.

PROJECT PERIOD: 2020-2023

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 Input 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.

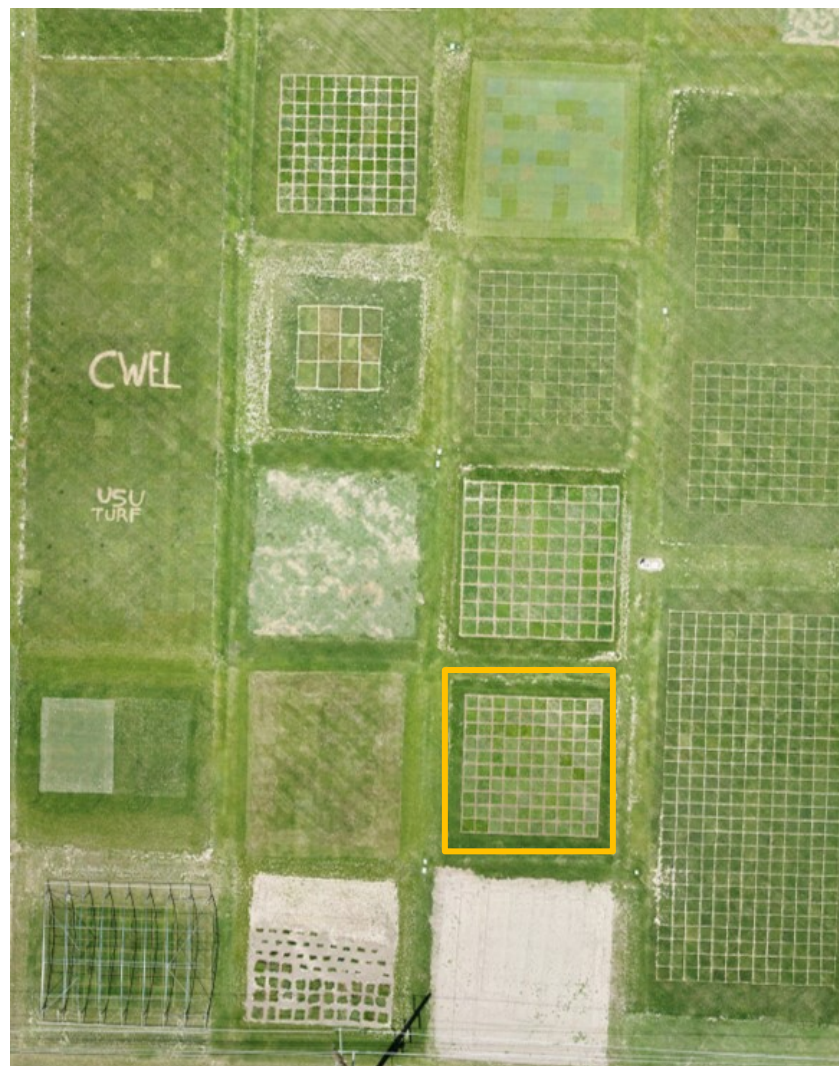
A-LIST members are comprised of universities and industry companies that test, identify, and promote grass varieties that combine high turf quality and low-input performance; such as reduced water, chemicals, and fertilizers. Information is developed on certified, high-quality turf that is verified via 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-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 was completed in 2020. The results developed at USU will now be compared to



those from other universities to identify varieties that have the most drought tolerance. Promising varieties will also be tested through the National Turfgrass Evaluation Program before receiving final approval.

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-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 evapotranspiration loss.
- Develop greenup curves for the tested varieties based on the number of days to recovery after irrigation is applied.



Jacklin Seed trial plots, Greenville Farm, North Logan, UT.

PROJECT STATUS

This project was established in 2017. Data collection began in 2018 and continued through 2020. Results have been shared with Jacklin Seed (now Barenbrug, U.S.A.).

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 2021.

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

Paul Grossl – Professor, Biogeochemistry, PSC

David Held – Professor, Entomology and Plant Pathology, Auburn University

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



Examining clover mix plots (Summer, 2019).

PRESENTATIONS AND SEMINARS

Boyle, P. (2019, November). “Clover Establishment in Seeded Kentucky Bluegrass Turf”. 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

New plots were seeded 04 May 2020. Data on cover and quality has been/will be assessed through the fall before we dormant seed for next spring.

SALT TOLERANCE OF ORNAMENTAL GRASSES

PROJECT INFORMATION

PRINCIPAL INVESTIGATOR

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

CO-INVESTIGATORS/COOPERATORS

Haifeng Xing – Visiting Scholar

Julie Hershkowitz – 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 landscapes in Utah and the Intermountain West. An estimated \$158 million worth of ornamental grasses are sold annually in the 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

From July to November 2019, an experiment was conducted in the UAES research greenhouse.



One manuscript entitled “Morphological and Physiological Responses of Ornamental Grasses to Salinity Stress” is currently in preparation for HortTechnology.

PRESENTATION

Abstract - Hershkowitz, J. & Sun, Y. (2020 August 9-13). “Salinity tolerance of six ornamental grass species” accepted by the American Society for Horticultural Science (ASHS) and will be presented by Julie Hershkowitz and Youping Sun at the Annual Conference of ASHS, Orlando, FL.

SALT TOLERANCE OF PENSTEMON PLANTS

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS/COLLABORATORS

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

CO-INVESTIGATORS/COOPERATORS

Asmita Paudel – Graduate researcher, PSC

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

PROJECT OBJECTIVE

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

PROJECT SUMMARY

Penstemon is a genus in Plantaginaceae family with approximately 250 species. Penstemons are flowering plants native to desert and alpine regions in North America. Most penstemon species can tolerate drought and grow best in well-drained soils. In the United States, it is estimated that \$3.2 million potted penstemons are sold annually for garden and landscape uses (U.S. Department of Agriculture, 2020). Comprehensive studies on the salt tolerance of penstemon species are needed. Salinity tolerance studies in various plants are conducted by applying saline solution manually. This process consumes more time, and a smaller number of salinity levels and replications can be included. Near-continuous gradient dosing (NCGD) system developed by Hawk et al. (2009) was used to maximize the number of salinity levels and replications. The effect of salt stress on growth and physiological responses of *Penstemon barbatus* (golden-beard penstemon) and *Penstemon strictus* (beardtongue) was studied using the NCGD system in a greenhouse. The salt tolerance of these two penstemon species was compared.



PROJECT STATUS

This experiment has been completed. A final report, “Salinity Tolerance of Penstemon Species” has been submitted to the American Penstemon Society. One manuscript entitled “Determining the Salt Tolerance of Two Penstemons Using a Near-continuous Gradient Dosing System” is currently in preparation for HortScience.

PRESENTATION

Abstract - Paudel, A. & Sun, Y. (2020, August 9-13). “Determining the salt tolerance of two penstemons using a near-continuous gradient dosing system” was accepted by American Society for Horticultural Science (ASHS) and will be presented by Asmita Paudel and Youping Sun at the Annual Conference of ASHS, Orlando, FL.

SALT TOLERANCE OF VIBURNUM PLANTS

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS/COLLABORATORS

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

CO-INVESTIGATOR

Ji-Jhong Chen – Graduate researcher, PSC

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. Two manuscripts entitled “Morphological Responses of Twelve Viburnum Taxa to Saline Water Irrigation” and “Gas Exchange and Mineral Nutrients of Twelve Viburnum Taxa Irrigated with Saline Water” have been accepted for publication in *HortScience*. (in press)



PRESENTATION

Abstract - Chen, J. & Sun, Y. (2020, August 9-13). “Salinity tolerance of twelve Viburnum taxa” was accepted by American Society for Horticultural Science (ASHS) and will be presented Ji-Jhong Chen and Youping Sun at the Annual Conference of ASHS, Orlando, FL.

QUANTIFYING EVAPOTRANSPIRATION RATES OF NEW LANDSCAPES USING LANDSCAPE-SCALE DRAINAGE LYSIMETERS

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS

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

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

CO-INVESTIGATORS/COOPERATORS

Ji-Jhong Chen – Graduate researcher, PSC

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 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.

PROJECT STATUS

New irrigation control and monitoring systems consisting of CR6 measurements & control datalogger, soil moisture sensors, relay controllers, and irrigation systems (sprinklers for turf; drip emitters for trees, shrubs, and perennials) have been installed as noted in Fig. 1. A total of 108 Acclima SDI-12 sensors (4 soil depths × 3 hydrozones × 9 lysimeters) have been installed to monitor soil moisture at four soil depths (5, 20, 45, and 80 cm).

Twenty-seven Gems™ water flow sensors have been installed to monitor the irrigation water amount for three hydrozones in each of nine lysimeter plots. Plants purchased from local wholesale and retail nurseries are currently planted following new landscape designs (Fig. 2) using standard horticultural practices. Irrigation will be turned off when soil water content readings of the controlling sensors reach the field capacity (28.8%) in the lysimeters and allow a depletion of 33%, 50%, and 67% for turf, perennial, and woody plant hydrozones, respectively (Sun et al., 2012).

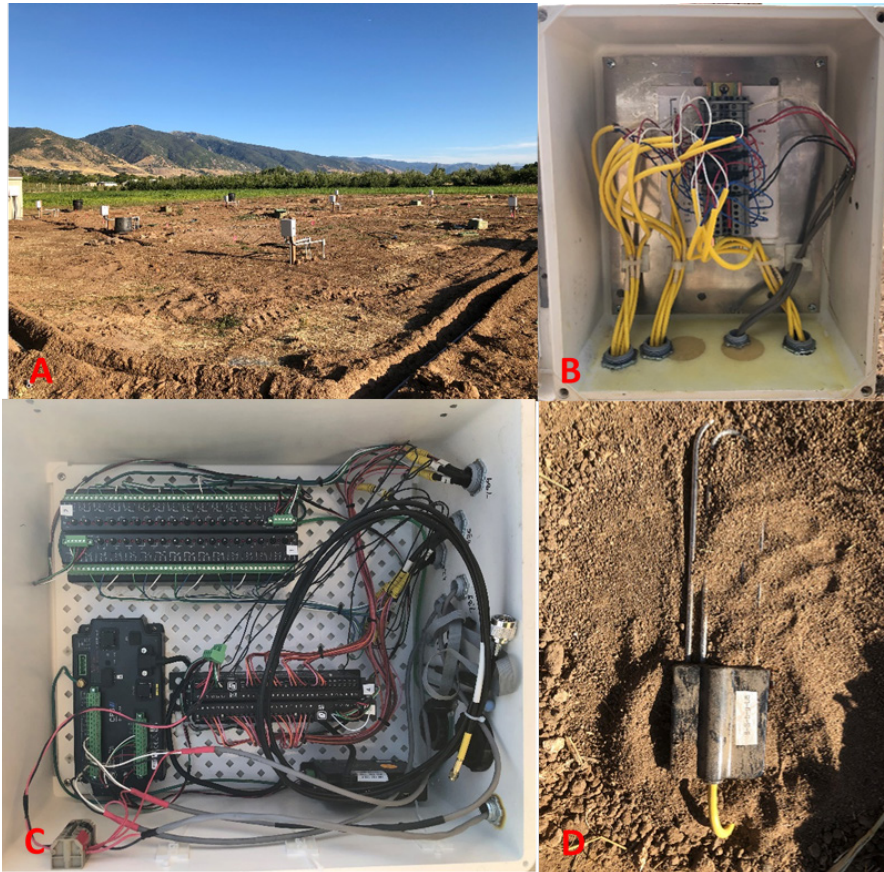


Fig. 1. Nine landscape-scale, drainage lysimeters are fully instrumented with 108 digital TDT sensors (ACC-SEN-SDI-12; Acclima, Meridian, ID), 27 RFO flow rate monitoring sensors (Gems Sensors, Plainville, CT), 16-channel AC/DC relay controller (SDM-CD16AC-SW; Campbell Scientific, Logan, UT), CR6 measurement & control datalogger (CR6-NA-ST-SW-CC; Campbell Scientific, Logan, UT).

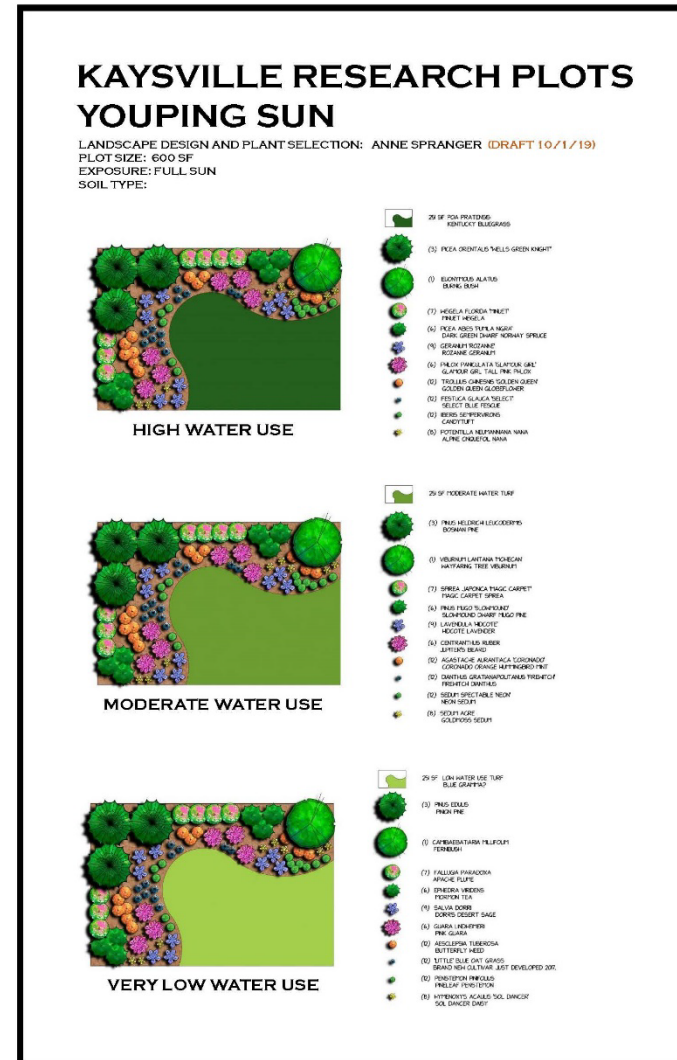


Fig. 2. Landscape design and plant selection for the landscape-scale, drainage lysimeters located at the Kaysville Research Farm.

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

CO-INVESTIGATORS/COOPERATORS

Asmita Paudel – Graduate researcher, PSC

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

PROJECT OBJECTIVE

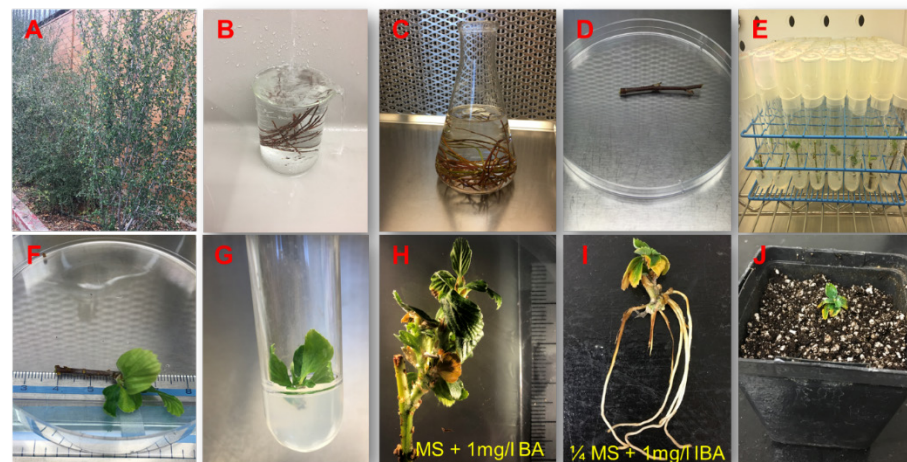
To develop efficient mass propagation protocols for Utah native plants.

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.

Micropropagation is useful for propagating plants that are difficult to propagate with other approaches. This project is to develop efficient micropropagation protocols for Utah native plants with significance in the green industry.



PROJECT STATUS

Ceanothus velutinus and *Cercocarpus Montanus* are under culture with different plant growth hormones to promote shoot proliferation.

PRESENTATIONS

Abstract - Paudel, A. & Sun, Y. (2019, July 23).

“Micropropagation of *Cercocarpus Montanus*: stage II.” Paper presented at the Annual Conference of the American Society for Horticultural Science (ASHS), Las Vegas, NV.

Abstract - *Paudel, A. (2019, September 28). “Propagation methods for *Cercocarpus montanus*.” Paper presented at the Annual Conference of International Plant Propagator’s Society (IPPS) Western Region, Santa Cruz, CA. *Asmita Paudel won the first-place award for the student poster competition.

PROPAGATION OF UTAH NATIVE PLANTS: SEED GERMINATION

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

CO-INVESTIGATORS/COOPERATORS

Asmita Paudel – Graduate researcher, PSC

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

PROJECT OBJECTIVE

To optimize seed germination protocols for two Utah native plants.

PROJECT SUMMARY

Ceanothus velutinus (snowbrush ceanothus) [Rhamnaceae] and *Cercocarpus montanus* (alder leaf mountain mahogany) [Rosaceae] are native actinorhizal species with potential to create unique aesthetics and conserve water in water efficient landscapes. Propagation protocols for these native species are not well established. *Ceanothus velutinus* seeds have double (physical and physiological) dormancy while *C. montanus* seeds are physiologically dormant. Due to dormancy, seed propagation requires scarification and/or stratification. A study was designed to further define protocols necessary to consistently increase germination rate of these two species.

PROJECT STATUS

This project has been completed. One manuscript has been accepted to Native Plants Journal.

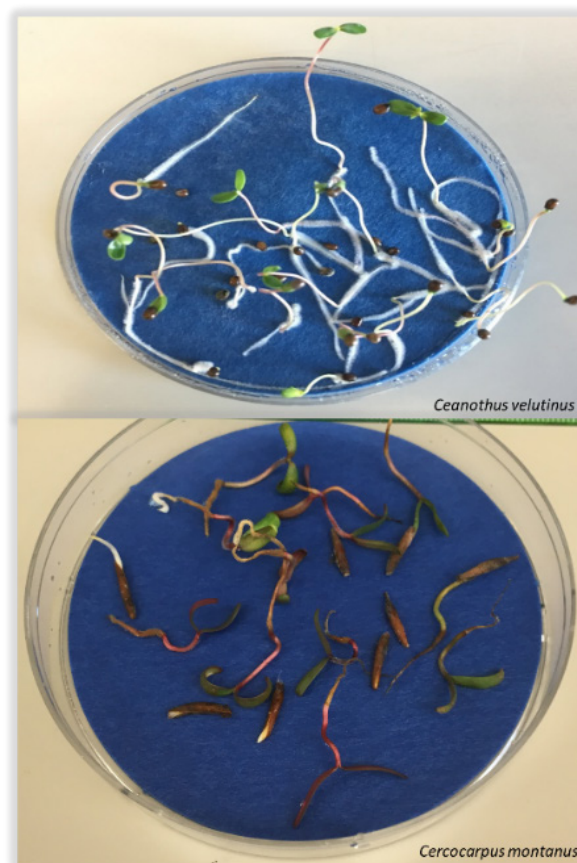
PRESENTATIONS

Abstract – “Overcoming seed dormancy in *Ceanothus velutinus* and *Cercocarpus montanus*” was accepted by the American Society for

Horticultural Science (ASHS) and will be presented at the Annual Conference of ASHS, Orlando, FL, August 9-13, 2020. Presenters: Asmita Paudel and Youping Sun.

Abstract – Paudel, A. (2020, March 19). “Overcoming seed dormancy in *Ceanothus velutinus* and *Cercocarpus montanus*” was presented at the Graduate Sustainability Research session, the Virtual Intermountain Sustainability Summit, Weber State University, Ogden, UT.

Abstract - Paudel, A. (2020, April 8). “Overcoming seed dormancy in *Ceanothus velutinus* and *Cercocarpus montanus*.” Paper presented at the Student Research Symposium, Utah State University, Logan, UT.



PROPAGATION OF UTAH NATIVE PLANTS: CUTTING PROPAGATION (I)

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

CO-INVESTIGATORS/COOPERATORS

Asmita Paudel – Graduate researcher, PSC

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

PROJECT OBJECTIVE

To develop an efficient cutting propagation protocol for *Ceanothus velutinus*.

PROJECT SUMMARY

Ceanothus velutinus (snowbrush ceanothus) is an evergreen shrub native to the Rocky Mountains. It has oval leaves and large pyramidal clusters of aromatic white flowers (Fig. 1). It is stress tolerant, but prefers full sun and coarse-textured, well-drained soils. It is known to be an actinorhizal plant that forms a symbiosis with nitrogen-fixing actinobacteria (*Frankia*) and other endophytes. Such microorganisms can play a soil-building role and supply nitrogen to host plants and serve as antifungal and pest-biocontrol agents as well as plant-growth promoters. As such, *Ceanothus velutinus* has great potential for use in sustainable landscaping, but it is difficult to propagate from seed because both physical and physiological dormancy are present. However, if *Ceanothus velutinus* seed is collected and handled carefully, 70-80% of the seeds will usually germinate. Seed propagation appears to be inefficient due to long germination times and potential seedling variation. Vegetative propagation through cuttings is also inefficient at this time because of seasonal variation and low rooting rates. Improved propagation protocols must be developed for *Ceanothus velutinus* for nursery production.



Fig. 1. Wild population of *Ceanothus velutinus* in Logan Canyon, UT, and its green leaves and long clusters of white flowers.



PROJECT STATUS

This project is still under way to evaluate the timing of cutting collection, types of cuttings, and plant rooting hormones for propagating *Ceanothus velutinus*.

PRESENTATIONS

Abstract - Paudel, A. & Sun, Y. (2020, August, 9-13). "Asexual propagation of *Ceanothus velutinus*" was accepted by the American Society for Horticultural Science (ASHS). Paper will be presented at the Annual Conference of ASHS, Orlando, FL.

PROPAGATION OF UTAH NATIVE PLANTS: CUTTING PROPAGATION (II)

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS/COLLABORATORS

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

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

CO-INVESTIGATORS/COOPERATORS

Asmita Paudel – Graduate researcher, PSC

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

PROJECT OBJECTIVE

To develop an efficient cutting propagation protocol for *Cercocarpus montanus*.

PROJECT SUMMARY

Cercocarpus montanus (alder leaf mountain mahogany), native to the western United States, is a shrub with leaves that are dark green above and whitish beneath. It possesses an extensive root system and adapts to medium to coarse textured soil. Its ability to fix nitrogen through symbiosis with actinobacteria (*Frankia*) makes it a potentially sustainable shrub for urban landscapes because application of nitrogen fertilizers is not necessary. However, research-based information on its propagation is limited. The objective of this project was to develop efficient cutting propagation protocol for *Cercocarpus montanus* 'USU-CEMO-001', an evergreen cultivar of *C. montanus*, which makes it one of the rare broadleaf evergreens found in the Intermountain region.

PROJECT STATUS

Cercocarpus montanus 'USU-CEMO-001' has been registered in the USU Inventor Portal (www.ipso.usu.edu) with an Invention ID #D20048. One manuscript is under review by UAES Variety Review Committee before being submitted to HortScience.



PRESENTATIONS

Abstract - *Paudel, A. (2019, September 28). "Propagation methods for *Cercocarpus montanus*." Paper presented at the Annual Conference of International Plant Propagator's Society (IPPS) Western Region, Santa Cruz, CA. *Asmita Paudel won the first-place award for student poster competition.

Abstract - Sun, Y. (2019, October 4). "Propagation of *Cercocarpus montanus*." Paper presented at the Annual Meeting of WERA-1013: Intermountain Regional Evaluation and Introduction of Native Plants, Spokane, WA.

NODULATION OF *SHEPHERDIA X UTAHENSIS*

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS/COLLABORATORS

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

CO-INVESTIGATORS/COOPERATORS

Ji-Jhong Chen – Graduate researcher, PSC

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

PROJECT OBJECTIVE

To develop a sustainable production protocol for *Shepherdia x utahensis* 'Torrey'.

PROJECT SUMMARY

Shepherdia x utahensis 'Torrey', a hybrid of *S. argentea* (silver buffaloberry) and *S. rotundifolia* (roundleaf buffaloberry), has a great potential for xeriscape use. It is an actinorhizal plant that fixes atmospheric nitrogen in root nodules. However, how to effectively induce nodules in *S. x utahensis* 'Torrey' using soil containing *Frankia* bacteria was unclear. In this study, *S. x utahensis* 'Torrey' formed nodules when grown in a commercial Metro-Mix® 820 substrate or in low organic-matter substrate amended with soil containing *Frankia* bacteria. In Metro-Mix® 820 substrate, plants irrigated with quarter-strength nitrogen (N)-free Hoagland's solution without ammonium nitrate (NH₄NO₃) at pH 6.5 showed nodules at the 12th week after experiment initiation. When quarter-strength N-free Hoagland's solution was applied, nodules formed in five weeks when *S. x utahensis* 'Torrey' plants were grown in a low organic matter substrate and the pH of irrigated solution was at 7.0. This research demonstrates that *S. x utahensis* 'Torrey' has the ability to form nodules and may be used in sustainable landscapes.



PROJECT STATUS

This project has been completed. One manuscript entitled "Nodulation of *Shepherdia utahensis* 'Torrey' is currently in preparation for *Scientia Horticulturae*.

PRESENTATION

Abstract - Chen, J.J. & Sun, Y. (2019, October 4). "Nodulation of *Shepherdia x utahensis*." Paper presented at the annual meeting of WERA-1013: Intermountain Regional Evaluation and Introduction of Native Plants, Spokane, WA.

NODULATION OF *SHEPHERDIA X UTAHENSIS* 'TORREY' TOPDRESSED WITH CONTROLLED-RELEASE FERTILIZER

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS/COLLABORATORS

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

CO-INVESTIGATORS/COOPERATORS

Ji-Jhong Chen – Graduate researcher, PSC

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

PROJECT OBJECTIVE

To develop a sustainable nursery production protocol for *Shepherdia x utahensis* 'Torrey'.

PROJECT SUMMARY

Shepherdia x utahensis 'Torrey' is an actinorhizal plant with great potential for use in residential landscapes. However, its nitrogen-fixing capacity and the effect of fertilizers on nodulation remain largely unknown. In this study, nitrogen-free nutrient solution with or without addition of ammonium nitrate, or controlled-release fertilizer (CRF, 15N–3.9P–10K), was applied to

plants inoculated with field soil containing Frankia. *Shepherdia x utahensis* 'Torrey' plants produced nodules when they were inoculated with Frankia-containing soil, but nodulation was sensitive to the increasing nitrogen levels. During production, a controlled-release fertilizer (CRF) dosage lower than the manufacturer's prescribed rate might be used to save fertilizer, reduce nitrogen leaching, and promote nodulation for nitrogen fixation.

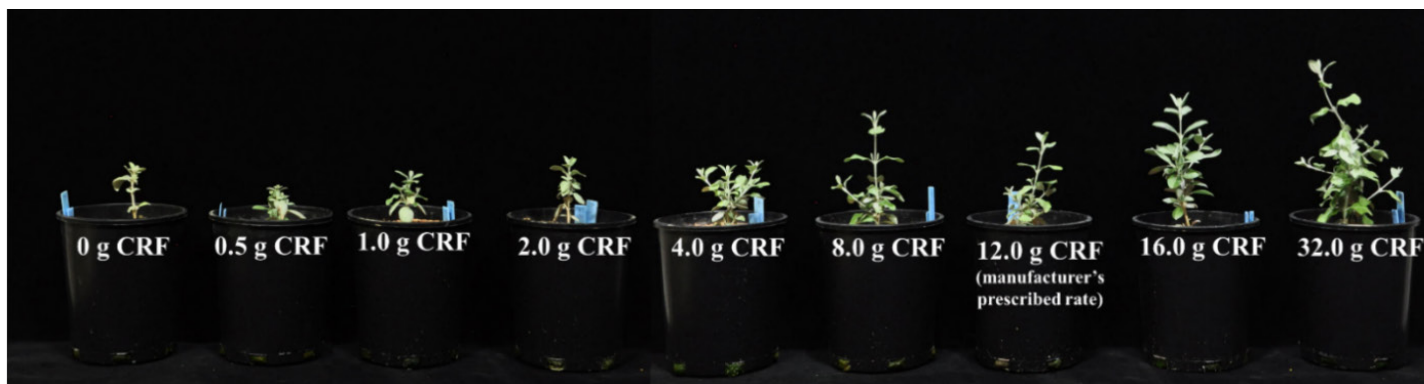
PROJECT STATUS

This project has been completed. One manuscript has been submitted to HortScience.

PRESENTATIONS

Abstract - Chen, J.J. & Sun, Y. (2020, March 19). "Nodulation of *Shepherdia x utahensis* 'Torrey' top-dressed with controlled-release fertilizer." Accepted by the American Society for Horticultural Science (ASHS). Paper will be presented at the Annual Conference of ASHS, Orlando, FL.

Abstract - Chen, J.J. (2020, March 19). "Nodulation of *Shepherdia x utahensis* 'Torrey' top-dressed with controlled-release fertilizer." Paper presented at Graduate Sustainability Research session, the Virtual Intermountain Sustainability Summit, Weber State University, Ogden, UT.



USING NDVI SENSORS TO DETERMINE THE CHLOROPHYLL CONTENT OF *SHEPHERDIA X UTAHENSIS* 'TORREY'

PROJECT INFORMATION

PRINCIPAL INVESTIGATORS/COLLABORATORS

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

CO-INVESTIGATORS/COOPERATORS

Ji-Jhong Chen – Graduate researcher, PSC

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

PROJECT OBJECTIVE

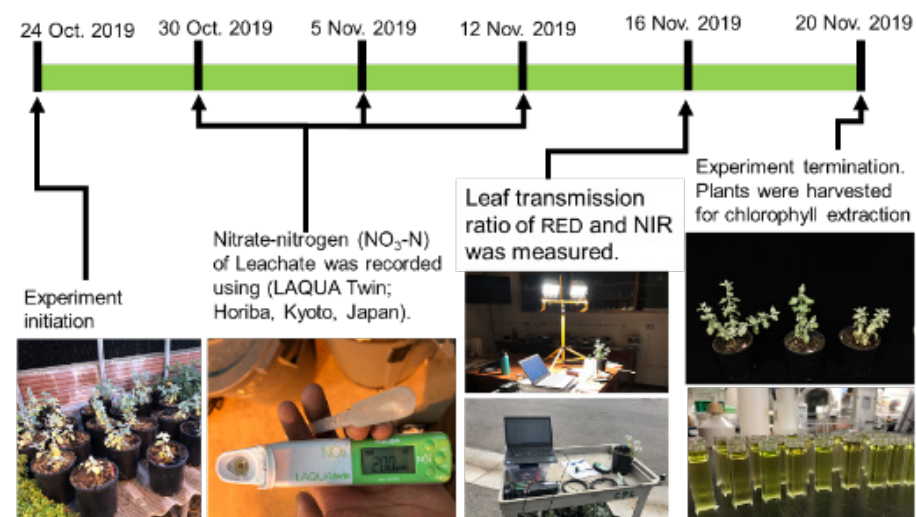
To estimate leaf chlorophyll contents using NDVI sensors.

PROJECT SUMMARY

Normalized difference vegetation index (NDVI) sensors are designed to measure the reflectance of RED at 650 nm and NIR at 810 nm and used in remote sensing to determine vegetation index since vegetation and non-vegetation surface have different reflectance spectral patterns. With similar detecting wavelengths to commercial chlorophyll meters, NDVI sensors may be used to estimate leaf chlorophyll content by measuring light transmission, although they are usually used to measure light reflectance. In our study, an NDVI sensor was used for measuring RED and NIR light transmission to estimate leaf chlorophyll content of *Shepherdia x utahensis* 'Torrey' treated with three ammonium nitrate (NH_4NO_3) levels.

Chlorophyll contents were also measured using Soil Plant Analysis Development (SPAD)-502 and MC-100 chlorophyll meters and chlorophyll extraction using DMSO solvent. The leaf chlorophyll distribution of *S. x utahensis* 'Torrey' was uniform. Leaf chlorophyll content estimated using the NDVI sensor was consistent with those from SPAD-502 and MC-100 chlorophyll meters and chlorophyll

extraction with high correlations between the NDVI sensor and chlorophyll meters. Therefore, NDVI sensors can be used to estimate leaf chlorophyll contents.



PROJECT STATUS

This project has been completed. One manuscript entitled "Using NDVI Sensors to Determine the Chlorophyll Content of *Shepherdia x utahensis* 'Torrey'" is currently in preparation for HortTechnology.

PRESENTATIONS

Abstract - Chen, J.J. & Sun, Y. (2020, August 9-13). "Using NDVI sensors to determine the chlorophyll content of *Shepherdia x utahensis* 'Torrey'." Accepted by the American Society for Horticultural Science (ASHS). Paper will be presented at the Annual Conference of ASHS, Orlando, FL.

Abstract - Chen, J.J. (2020, April 8). "Using NDVI sensors to determine the chlorophyll content of *Shepherdia x utahensis* 'Torrey'." Paper presented at Student Research Symposium, Utah State University, Logan, UT.

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

LOCATIONS:

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, curlleaf 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

Released three disclosures (D20048: *Cercocarpus montanus* 'Coy', D20051: 'DoubleDown' Littleleaf Mountain Mahogany, D21021: *Shepherdia xutahensis* 'Torrey').

Discussed licensing four new varieties to Cache Valley Nursery, including *Cercocarpus ledifolius* var. *intricatus* 'Hoodoo' (littleleaf mountain mahogany), *Cercocarpus ledifolius* var. *intricatus* 'DoubleDown' (littleleaf mountain mahogany), *Cercocarpus montanus* 'Coy' (alder-leaf mountain mahogany), and *Shepherdia xutahensis* 'Torrey' (hybrid buffaloberry).

Lawson, K.C., Rupp, L.A., Sun, Y., Newhall, R., & Reid. C. (2020). Propagation of pinyon pine: Selecting and grafting superior *Pinus monophylla* accessions to *Pinus edulis* rootstocks. Prepared for *Native Plants Journal*.

Lawson, K.C., Rupp, L.A., Sun, Y., & Newhall, R. (2020). Propagation of pinyon pine: Topworking *Pinus monophylla* to *Pinus edulis* rootstocks. Prepared for *Native Plants Journal*.

Chen, J., Kratsch, H., Norton, J., **Sun, Y. & Rupp, L.A.** (2020). Nodulation and plant growth of *Shepherdia x utahensis* 'Torrey'. Prepared for *HortScience*.

Paudel, A., Y. Sun, L.A. Rupp, J. Carman, & S. Love (2020). Overcoming seed dormancy in two rocky mountain native shrubs: *Ceanothus velutinus* and *Cercocarpus montanus*. Prepared for *Native Plants Journal*.

Chen, J., H. Kratsch, J. Norton, **Y. Sun, & L.A. Rupp** (2020). Nodulation and plant growth of *Shepherdia xutahensis* 'Torrey' topdressed with controlled-release fertilizer. Prepared for *HortScience*.

Paudel, A., Y. Sun, L.A. Rupp, & R. Anderson (2020). *Cercocarpus montanus* 'Coy': a new Sejo Supreme™ plant. Prepared for *HortScience*.

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

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

LOCATIONS:

UAES Research Greenhouse, Logan, UT, **UAES Greenville Farm**, North Logan, UT, **Austin**, NV; **Hamlin Valley**, UT; **Eureka**, UT; **Raft River Mountains**, UT

UAES Blue Creek Farm, Box Elder County, **USU Botanical Center**, Kaysville, UT

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 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



Transplanting Pinyon pine at the C. Reed Funk UAES Research Farm, Richmond, UT (Spring, 2019).

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. Youping Sun received the 2020 USU Extension Grant to “Establish Pinyon Pine Orchards for Nut Production on Marginal Lands.” With the support, we will establish three additional field-trial sites to evaluate the responses of superior grafted clonal selections of pinyon pine to different climatic zones and soil types. The long-term goal is to cultivate pinyon pine as an innovative, game-changing specialty crop for nut production for marginal lands in Utah and surrounding states. About 300 grafted pinyon pine trees were made using scion-wood collected from Raft River, ID, on February 12, 2020, and are currently grown in a hoop house at the Utah Agricultural Experiment Station.

SELECTED PRESENTATIONS

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

RELATED AND PENDING PUBLICATIONS

Lawson, K. & L.A. Rupp (in press). Selecting and grafting wild *Pinus monophylla* on containerized *Pinus edulis* rootstocks. *International Plant Propagators Society Proceedings* pp. 232-233.

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

Lawson, K.C., L.A. Rupp, Y. Sun, R. Newhall, & C. Reid. Propagation of pinyon pine: Selecting and grafting superior *Pinus monophylla* accessions to *Pinus edulis* rootstocks. Prepared for *Native Plants Journal*.

Lawson, K.C., L.A. Rupp, Y. Sun, & R. Newhall. Propagation of pinyon pine: Topworking *Pinus monophylla* to *Pinus edulis* rootstocks. Prepared for *Native Plants Journal*.



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



Harvesting Bigtooth maple samples at the USU Botanical Center, Kaysville, UT (Fall, 2019)



submitted a manuscript “Vegetative propagation of bigtooth maple by layering” to *Native Plants Journal*.

RELATED AND PENDING PUBLICATIONS

Rupp, L., Dai, X., Richards, M., P. Harris, P. & Anderson, R. (2021). Vegetative propagation of bigtooth maple by layering. *Native Plants Journal* xx:xxx-xxx

WHAT WE DO



Water Conservation Forum tour, Greenville Farm, North Logan, UT (September, 2019).

OUTREACH AND EDUCATION

The Center for Water-Efficient Landscaping's (CWEL) outreach and education programs 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.

PROGRAMS & PROJECTS

- Turfgrass Integrated Pest Management Advisory
- Water Check
- WaterMAPS™
- Qualified Water Efficient Landscaper (QWEL)
- Water Well with CWEL Webinar Series
- Water-Wise Landscape Demonstration Street
- Master of Professional Studies in Horticulture (MPSH) Degree

ADDITIONAL OUTREACH ACTIVITIES

- CWEL Field Day (held every other year)
- Utah Public Gardens (UPG) Network (under normal circumstances CWEL coordinates garden tours with and for network members twice yearly and manages the UPG website)
- Educational publications



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
Zach Schumm – USU Arthropod Diagnostician and Urban 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 December 2020, the listserv has grown to 8,908 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. 13(1), Spring 2020

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

Now that winter has passed in most parts of the state, the focus should be on recovery from damage due to winterkill and other turfgrass diseases, such as snow mold. Spring weeds are also on the horizon.

Letter from the Editor

Dear Readers,

I have never written to you personally before, but feel compelled to do so now given the situation that we currently face as a state, a nation, and a global population with COVID-19.

First, I would like to extend my apologies for the long hiatus of these advisories. I was on sabbatical leave from USU (from August 2018 through July 2019) and it's taken me a few months to regroup. During that sabbatical, I and my family were living outside the U.S., and maintaining many of my normal work tasks was not possible. Having said that, I put together this advisory—the first in more than a year—as one means of maintaining normalcy in my life and, *most hopefully*, yours.

As I work from home and occasionally gaze outside my window, I take comfort in the fact that while so many things are changing, the grass is indeed still growing. And like every year before, there will be insects and diseases and other maintenance challenges, and you will have questions about their management. I will continue to do my best to provide answers.

I would also like to share that USU Extension is rising to meet the challenges that we all now face in countless ways. I have never been prouder to be associated with this fine institution. Related, I would encourage you to access the resources available at USU Extension's [COVID-19 website](#), for answers to questions you may have.

Finally, whether you are a homeowner, a golf course superintendent, a sports field manager, or a landscape contractor, I commend you for your efforts in managing the turfgrass landscapes around us for play, sport and beauty. These places, that we grow and love, will provide the gathering places of our futures.

Please stay safe and stay healthy.

Wishing you all very well,

Kelly Kopp, Editor, Turfgrass IPM Advisories
Extension Turfgrass Specialist
Utah State University

RECENT TURFGRASS IPM ADVISORIES

Kopp, K. (Ed.) (2020, Spring), *USU Extension Turfgrass IPM Advisory*. Utah State University. Vol. 12(1)

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

PEST ADVISORIES



2018- turf



TURF IPM ADVISORY • 2018- TURF

Fall Fertilization

October 25, 2018

[Click here for this issue, which contains updates on: Late Fall Fertilization Overseeding Recommended Cultural Practices for Fall Timely USU Extension Fact...](#)



TURF IPM ADVISORY • 2018- TURF

Ascochyta Blight

July 5, 2018

[Click here for this issue, which contains updates on: Pest Alert: Ascochyta Leaf Blight Summer Patch/Necrotic Ring Spot Complex Upcoming Webinar Highlights USU...](#)



TURF IPM ADVISORY • 2018- TURF

Armyworms, Clover Mites

April 23, 2018

[Click here for this issue, which contains updates on: Armyworms Clover Mites Pink Snow mold Gray Snow Mold New USU Extension fact sheets addressing turfgrass...](#)



WEBSITE: pestadvisories.usu.edu/category/turf/

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.

PROGRAM 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.



Setting up catch cups to perform a Water Check sprinkler system efficiency test (Summer, 2020).

PROGRAM STATUS:

To date, over 15,000 residential and 650 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:

- Water Check participants who reduce water use tend to maintain that reduction for a period of years after participation.
- Over time, water use of program participants has gone from exceeding city-wide average water use to closely reflecting city-wide average water use. This finding may reflect an increasing water conservation ethic in the city and is a trend we are following closely.
- Decreased landscape irrigation water use.

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 now used for developing irrigation system maps for the selected properties.

PROJECT PERIOD: 1999-present



| | | |
|--|--|---|
| <p>Since 1999</p>  | <p>FREE!</p>  | <p>15K+ Residential</p>  |
| <p>650 Commercial/ Institutional</p>  | <p>Offered in 10+ Municipalities & Counties</p> |  |

SELECTED PRESENTATIONS

Kopp, K. (2019, November). “Center for Water-Efficient Landscaping annual Water Check update”. Presented at Metro Metropolitan Water District of Salt Lake and Sandy, UT.

Kopp, K. (2020, November). “Center for Water-Efficient Landscaping Annual Water Check update”. Presented virtually to the Metro Metropolitan Water District of Salt Lake and Sandy, UT.

WATERMAPS™ PROGRAM

PROGRAM INFORMATION

PRINCIPAL INVESTIGATOR

Joanna Endter-Wada – Professor, Water Policy & Social Science, ENVS, CWEL

CO-INVESTIGATORS/COOPERATORS

Chris Garrard – Programmer/Analyst, Remote Sensing/GIS Laboratory

Chris McGinty – Assistant Director, Remote Sensing/GIS Laboratory

Ellie Leydsman McGinty – GIS Specialist, Remote Sensing/GIS Laboratory

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

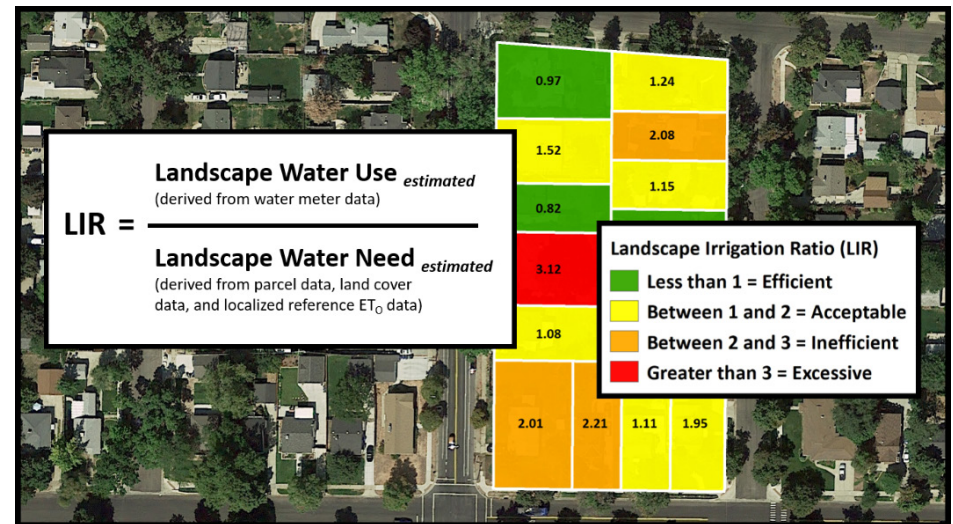
PROGRAM DESCRIPTION

WaterMAPS™ is a custom software application for promoting urban landscape water use efficiency. It was developed by USU research teams over the past 15 years and is led by Dr. Joanna Endter-Wada. In its current third generation form, the software enables users to visualize and interpret the appropriateness of water use on managed urban landscapes using various advanced and customized analytic platforms. WaterMAPS™ was developed as a research, management, and public information tool for urban water systems. WaterMAPS™ helps urban water providers identify and monitor locations with the greatest capacity to conserve water used outdoors in order to more effectively direct and tailor landscape water conservation programs. It also helps them to estimate capacity to conserve water applied to urban landscapes.

PROJECT STATUS

The WaterMAPS™ team works with some of the largest water providers in Utah and has received several awards for excellence.

PROJECT PERIOD: 2005-present



WEBSITE: watermaps.usu.edu/

QUALIFIED WATER EFFICIENT LANDSCAPER (QWEL) PROGRAM

PROGRAM 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

PROGRAM 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.



PROGRAM 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.



Testing water pressure on a sprinkler system (photo taken pre-COVID-19).

PROJECT STATUS

To date, over 450 landscape professionals have been certified through the QWEL training program.

PROJECT PERIOD: 2012-present

'WATER WELL WITH CWEL'

WEBINAR SERIES

PROJECT INFORMATION

ORGANIZERS

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

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

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

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

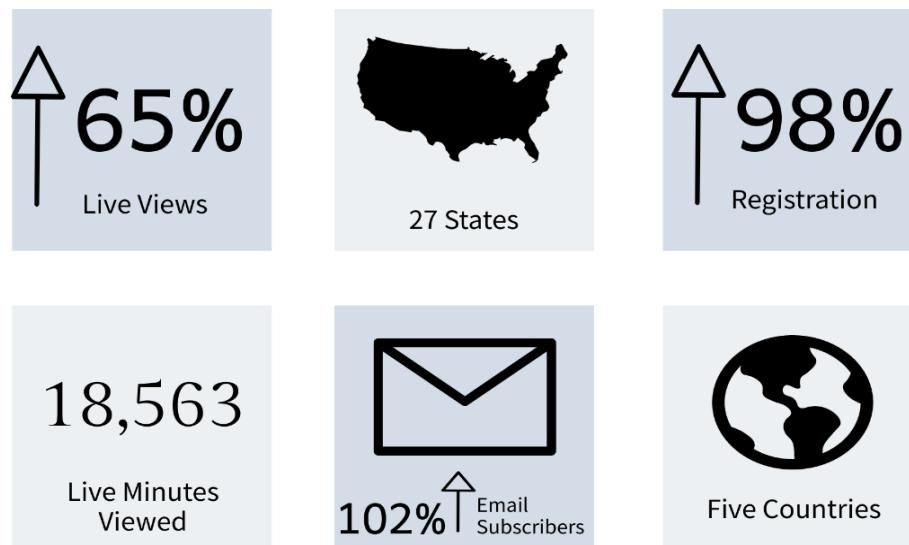
PROJECT STATUS

The 'Water Well with CWEL' webinar series started in January, 2018, and is broadcast live on the second Tuesday of every month at 2 pm MST.

In 2019, CWEL organized & hosted 10 webinars:

- Turned those into 10 YouTube videos
- Increased
 - Facebook engagement by 127%
 - YouTube views by 16%
 - Registration by 98%
 - Live views by 65%
 - A total of 18,563 minutes viewed
 - Email subscribers increased by 102%

In 2020, our live views increased by 19% in comparison to 2019. Our email list increased by 34%, YouTube views by 38%, and we have seen a 40% increase in the live minutes viewed.



2019 highlights



- **Weed Management** (September, 2019) Mike Lorenc, Lead Horticulturist with the Conservation Garden Park.
- **Creating a WaterWise Park Strip** (2019, August). Cynthia Bee, Outreach Coordinator, Jordan Valley Water Conservancy District.
- **Introduction to Localscapes** (2019, July). Cynthia Bee, Outreach Coordinator, Jordan Valley Water Conservancy District.

CWEL YouTube Channel

youtube.com/channel/UCTYegSdKYRMg8tTaeGhOlsw



RECENT WEBINARS

- **Grey Water in Utah** (June, 2020). Roslyn Brain McCann, Utah State University Extension Sustainability & Jeff Adams of Terrasophia, LLC.
- **Water-Wise Demonstration Street** (April, 2020). Jake Powell, Landscape Architecture Specialist, Utah State University.
- **Drip Irrigation 2.0** (March, 2020). Colton Smith, intern for Utah State University, Bridger Park Community Garden.
- **Smart vs. Manually Programmed Irrigation Controllers** (February, 2020). Shane Evans, graduate student, MS plant science
- **Alternate Water Sources** (January, 2020). Lauren Allen, founding member of Greywater Action.
- **Water Well With CWEL** (December, 2019). Larry Rupp, Extension Horticulture Specialist, Utah State University.
- **Drip Irrigation 101** (2019, October) David Rice, Conservation Coordinator with the Weber Basin Water Conservancy District.

WATER-WISE LANDSCAPE DEMONSTRATION STREET

PROJECT INFORMATION

ORGANIZERS

Candace Schaible – Extension Associate Professor, Iron County

Jake Powell – Extension Assistant Professor, ASLA

KEY PARTNERS

Alex Meisner Construction – Cedar City, UT

Cedar Creek Landscaping – Cedar City, UT

ERA Real Estate – Cedar City, UT

Central Iron County Water Conservancy District

PROJECT OBJECTIVES

Our goal is to compare sustainable, water conscious landscaping practices to traditional landscaping practices. We are hoping that this project will demonstrate that sustainable landscape design coupled with climate-appropriate plantings and efficient water management will use significantly less water and have a lower environmental impact when compared to traditional landscapes.

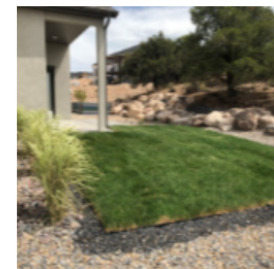
WHERE

- Crescent Hills Subdivision
- Cedar City, UT

FUNDING

- \$75,000 USU Water Initiative funds
- \$77,650 Matching funds from partners

WEBSITE: usudemonstrationstreet.com/



PROJECT STATUS

In 2019, the Iron County Extension office received grant funding through the USU Water Initiative to create a demonstration street showcasing residential low water, low impact, low maintenance, sustainable landscaped front yards.

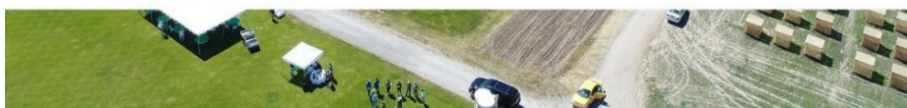
Four landscapes have been installed so far, with one project featured in the 2019 Cedar City Festival of Homes. Funding is available for four more sites. A website, featuring site plans, planting times, and how-to resources is currently in development.

CWEL VIRTUAL FIELD DAY

2020



CWEL *Virtual* Field Day 
 Thursday, June 18, 2-4pm



PROJECT INFORMATION

ORGANIZERS & PRESENTERS

CWEL Faculty: Joanna Endter-Wada, Paul Johnson, Kelly Kopp, Candace Schaible, Youping Sun

CWEL Staff: Susan Buffler, Chris Garrard, Paul Harris, Michael Kilcrease

CWEL Graduate Students: Paige Boyle, Ji-Jhong Chen, Asmita Paudel

LOCATIONS

UAES Greenville Farm, USU Botanical Center, USU campus, Cedar City, UT

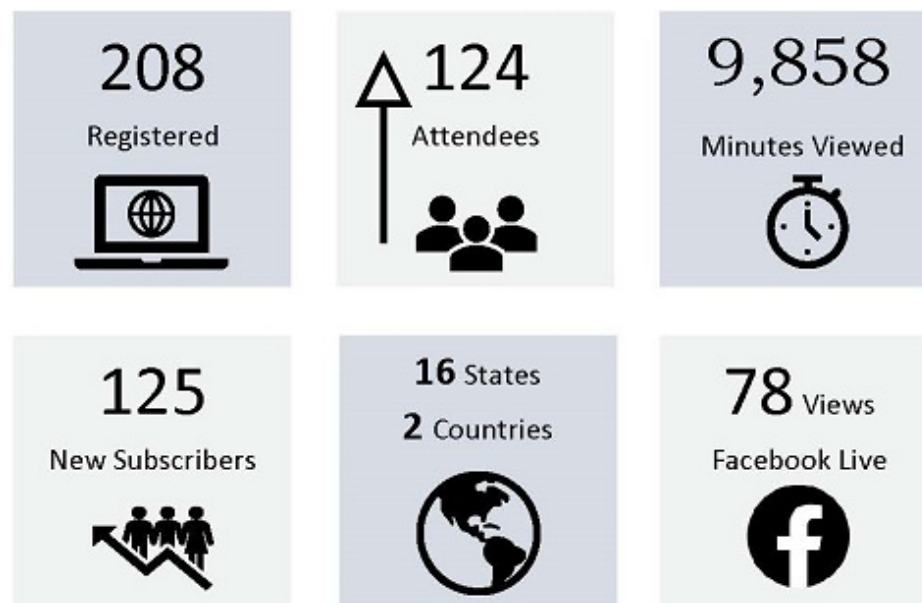
* A special thank you to USU Extension Media Specialist Dennis Hinkamp and PSC/CWEL graduate student Ji-Jhong Chen for the videography and to Candace Schaible for Zoom webinar expertise, presentation logistics, and graphics.

Due to the unusual circumstances caused by the COVID-19 pandemic, the CWEL Field Day normally held every other year at the Utah Agricultural Experiment Station Greenville Research Farm in North Logan, UT and the Utah State University campus in Logan, UT, was held entirely virtually. The Field Day was expanded to include CWEL research and community projects at the USU Botanical Center in Kaysville, UT, the Quinney College of Natural Resources, USU, and Cedar City, UT.

CWEL faculty, staff, and graduate students showcased research, projects, and activities. Topics included water use in urban areas, turfgrass and native plant research, irrigation control systems, and designing water-conserving home landscapes.

See the Field Day playlist on the **CWEL YouTube Channel:**

youtube.com/playlist?list=PLx1adY_0fHx5wvVE0rNaZ7bD7CBg75e1v



*Note: Attendance at the Virtual Field Day was twice that of a typical face-to-face event. A face-to-face field day attracts about 60 participants.

MASTER OF PROFESSIONAL STUDIES IN HORTICULTURE (MPSH) ONLINE DEGREE



MPSH students Nysse Wilson and Moriah Jackson begin a “physically distanced” outdoor tour of the Weber Basin Water Conservancy District’s Water Conservation Garden given by WBWCD lead gardener Janice Terry, center. (August, 2020)

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 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.



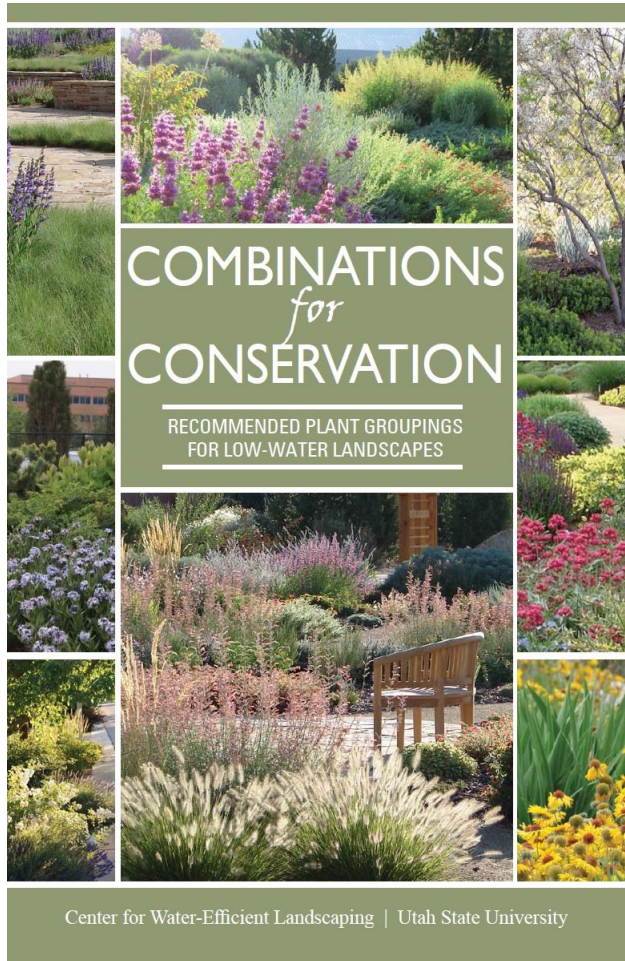
MPSH students visit Red Butte Water Conservation Garden in Salt Lake City during the *Summer Immersion* course. The tour was conducted by Red Butte Gardens lead horticulturist Guy Banner and assistant horticulturist Emily Alworth, at right. (August, 2020)

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 two students actively enrolled in the program.

WHAT WE DO



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 1,000 books sold out by spring 2019 and a second printing was completed in July, 2019.

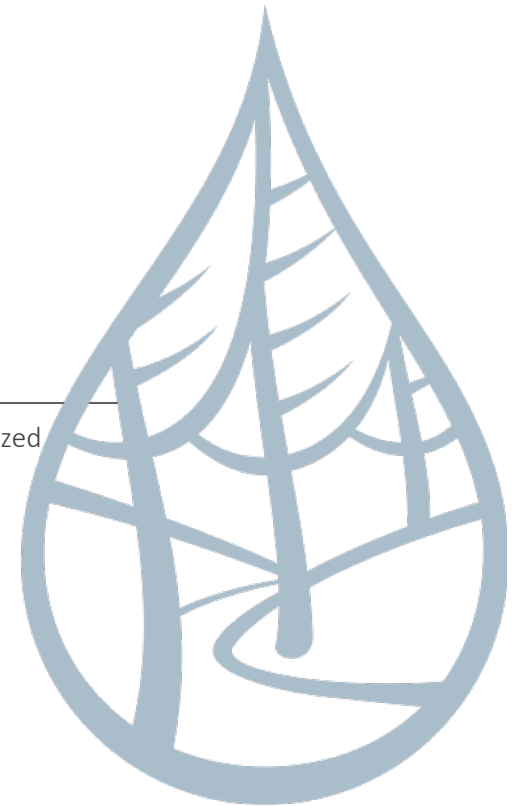
PUBLICATIONS

The Center for Water-Efficient Landscaping's research and outreach materials are disseminated using the following formats.

- Peer-reviewed journal articles
- Presentations at local, national, and international conferences
- Research bulletins
- Research reports, manuals, conference proceedings, and abstracts
- Extension Fact Sheets and articles
- Trade journals
- Website and social media
- Books

STUDENT AWARDS AND SCHOLARSHIPS

CWEL's undergraduate and graduate students are recognized for their outstanding work through prestigious awards, fellowships, scholarships, and grants. (see Student Awards p.60)



PRESENTATIONS

Boyle, P.E. & Kopp, K. (2020, August). "Planting weeds: clover inclusion in urban grasslands." Ecological Society of America (virtual) Annual Meeting (poster).

Boyle, P.E. (2020, June 18). "Planting weeds: Ecolawns in the Intermountain West." Utah State University's Center for Water Efficient Landscaping Virtual Field Day. youtu.be/uDRnp8V0l10.

Boyle, P.E. (2020, May 15). "Earthworms and clover lawns." Cornell Turfgrass Lawn & Landscape Webinar Series. youtube.com/watch?v=a7SNDGIS7Vg&feature=youtu.be.

Boyle, P.E. (2020, May 12). "Women in STEM, academic Twitter, and mind-blowing earthworms." Planthropology Podcast. planthropologypod.com/home/PaigeBoyle.

Chen, J. (2020, April 8). "Using NDVI sensors to determine the chlorophyll content of *Shepherdia × utahensis* 'Torrey'." Student Research Symposium, Utah State University, Logan, UT.

Chen, J. (2020, March 19). "Nodulation of *Shepherdia × utahensis* 'Torrey' topdressed with controlled-release fertilizer." Virtual Intermountain Sustainability Summit, Weber State University, Ogden, UT.

Chen, J. & Sun, Y. (2019, October 4). "Nodulation of *Shepherdia × utahensis*." Annual Meeting of WERA-1013: Intermountain Regional Evaluation and Introduction of Native Plants, Spokane, WA.

Chen, J. & Sun, Y. (2019, July 24). "Comparing the salt tolerance of three landscape plants using near-continuous gradient dosing system." Annual Conference of ASHS, Las Vegas, NV.

Hershkowitz, J. & Sun, Y. (2019, July 24). "Salt tolerance of five spirea species." Annual Conference of the American Society for Horticultural Science (ASHS), Las Vegas, NV.

Kopp, K. (2020, March 9). "Extending the urban water conservation message in the dry western U.S." International Extension Professional Development Program. University of the Philippines, Los Baños, The Philippines.

Kopp, K. (2020). "Identify and treat top turf pests." Utah Nursery and Landscape Association Annual Conference, Sandy, UT.

Kopp, K. (2020). "Necrotic ring spot in turfgrass: Identification and management." Utah Nursery and Landscape Association Annual Conference, Sandy, UT.

Kopp, K. (2020, January 8). "Alternative turfgrasses for pest resistance." Cache County Turf and Landscape Workshop, Logan, UT.

Kopp, K. (2020, Spring). "Turfgrass management." Utah State University Extension Master Gardener Program (9 presentations across the state).

Palmer, A. & Sun, Y. (2019, July 23). "Responses of four ornamental grasses to saline irrigation water." Annual Conference of American Society for Horticultural Science (ASHS), Las Vegas, NV.

Paudel, A. (2020, April 8). "Overcoming seed dormancy in *Ceanothus velutinus* and *Cercocarpus montanus*." Student Research Symposium, Utah State University, Logan, UT.

Paudel, A. (2020, March 19). "Overcoming seed dormancy in *Ceanothus velutinus* and *Cercocarpus montanus*." Virtual Intermountain Sustainability Summit, Weber State University, Ogden, UT.

Paudel, A. (2019, September 28). "Propagation methods for *Cercocarpus montanus*." Annual Conference of International Plant Propagator's Society (IPPS) Western Region, Santa Cruz, CA. (**Asmita Paudel won the First Place Award for Student Poster Competition**)

Paudel, A. & Sun, Y. (2019, July 24). "Salt tolerance of Sejo Supreme™ plants." Annual Conference of ASHS, Las Vegas, NV.

Paudel, A. & Sun, Y. (2019, July 23). "Micropropagation of *Cercocarpus Montanus: Stage II*." Annual Conference of the American Society for Horticultural Science (ASHS), Las Vegas, NV.

Schaible, C. & Powell J., (2020, July 21-22). "Waterwise landscape demonstration street." Utah Association of County Agriculture Agents Summer Meetings, Bicknell, UT.

Schaible, C. (2020, February 6-8). "Irrigation scheduling." Utah Farm Conference, Cedar City, UT.

Schaible, C., & Powell J., (2020, April 14). "Waterwise landscape demonstration street." Water Well with CWEL Webinar Series, online.

Schaible, C. (2020, various dates). "Waterwise landscaping." Utah State University Extension Master Gardener Program, Iron & Kane counties, UT.

Sun, Y. (2019, October 4). "Propagation of *Cercocarpus*" Annual Meeting of WERA-1013: Intermountain Regional Evaluation and Introduction of Native Plants, Spokane, WA.

Sun, Y. (2019, July 24). "Developing a sustainable landscape horticulture program for Utah." Annual Conference of American Society for Horticultural Science (ASHS), Las Vegas, NV. (Four finalists out of nine applicants have been selected for presentation at the Early Career Competition).

PEER-REVIEWED JOURNAL ARTICLES

Chen, J., Y. Wang, Y., **Paudel, A. & Sun, Y.** (2019). Comparing the salt tolerance of three landscape plants using a near-continuous gradient dosing system. *HortTechnology*, 29(5):1-8. doi.org/10.21273/HORTTECH04385-19.

Chen, J., Xing, H., **Paudel, A., Y. Sun,** & Niu, G. (2020, July). Gas exchange and mineral nutrients of twelve viburnum taxa irrigated with saline water. *HortScience*, 55:(8):1242-1250. doi.org/10.21273/HORTSCI14941-20

Barnett, M.J., Jackson-Smith, D., **Endter-Wada, J.** & Haeffner, M. (2020). A multilevel analysis of the drivers of household water consumption in a semi-arid region. *Science of the Total Environment*, 712:136489. doi.org/10.1016/j.scitotenv.2019.136489.

Harris, P., Johnson, P., Kopp, K. & Bushman, B.S. (2020). Inheritance of salt tolerance traits among Kentucky bluegrass (*Poa pratensis* L.) hybrids. (Accepted by *Crop Science*). doi.org/10.1002/csc2.20417.

Paudel, A., Chen, J., Sun, Y., Wang, Y., & Anderson, R. (2019). Salt tolerance of Sejo Supreme™ plants. *HortScience*, 54(11):2056-2062. doi.org/10.21273/HORTSCI14342-19.

Paudel A., Rupp, L.A., & Sun, Y. (2020). *Cercocarpus montanus* 'Coy': a new Sejo Supreme™ plant. *HortScience*, 55(11):1871-1875. doi.org/10.21273/HORTSCI15343-20.

Wang, Y., **Sun, Y.,** Niu, G., Z. Deng, Wang, Y., & Gardea-Torresdey, J. (2019). Growth, gas exchange, and mineral nutrients of ornamental grasses irrigated with saline water. *HortScience*, 54(10):1840-1846. doi.org/10.21273/HORTSCI13953-19.

Qian, X., **Sun, Y.,** Zhou, G., Yuan, Y., Li, J., Huang, H., Xu, L., & Li, L. (2019). Single-molecule real-time transcript sequencing identified flowering regulatory genes in *Crocus sativus*. *BMC Genomics*, 20:857. doi.org/10.1186/s12864-019-6200-5.

Yu, P., **Sun, Y.,** Huang, Z., Zhu, F., & Jiang, L. (2019). The effects of ectomycorrhizal fungi on heavy metals' transport in *Pinus massoniana* and bacteria community in rhizosphere soil in mine tailing area. *Journal of Hazardous Materials*, 381: 1-12. doi.org/10.1016/j.jhazmat.2019.121203.

Hooks, T., Niu, G., Masabni, J., **Sun, Y.** & Ganjegunte, G. (2020). Performance and phytochemical analysis of 22 varieties of pomegranate (*Punica granatum*) in west Texas. *Scientia Horticulturae*, xx:xxx-xxx

Sun, Y., Chen, J. , Xing, H., **Paudel, A.,** & Niu, G. (2020). Morphological responses of twelve viburnum taxa to saline water irrigation. *HortScience*, 55: xxx-xxx

Sun, Y., Li, L., Wang, Y., & Dai, X. (2020). Morphological and physiological responses of spirea species to saline water irrigation. *HortScience*, 55:1-8. doi.org/10.21273/HORTSCI14861-20.

Liu, Q., **Sun, Y.,** Altland, J., & Niu, G. (2020). Morphological and physiological responses of *Cornus alba* to salt and drought stresses under greenhouse conditions. *HortScience*, 55(2):1-7. doi.org/10.21273/HORTSCI14460-19.

BULLETINS

Chen, J. & Sun, Y. (2019). Evaluating physiological responses of viburnums species to salinity stress. *PP System Application Note*. ppsystems.com/application-notes.

Paudel, A., Chen, J. & Sun, Y. (2019). Determining the salt tolerance of two penstemon species using a near-continuous gradient dosing system. *Bulletin of the American Penstemon Society*, 78:29-35.

RESEARCH REPORTS AND MANUALS

Boyle, P.E. (2019, Fall) *Best Management Practices for Utah Golf Courses Manual*. Golf Course Superintendents Association of America. gcsaa.org/docs/default-source/environment/Utah-bmps.pdf?sfvrsn=b24df83e_2.

Endter-Wada, J., Rupp, L.A., Garrard, C., McGinty, E.L., McGinty, C. (2020, June) *Landscape water use analytics for institutional and corporate properties: Final project report*. Delivered to project partner.

Plumb, G. (Project Manager), Brown, C., Burgess, B., Estournes, P., Foley, S., Grogan, J., Hylton, B., Kleinrock, S., **Kopp, K.***, Lane, D., Lee, B., Loomis, K., McNary, C., Michelon, C., Navarra, R., Pollard, C., Rogers, L., **Rupp, L.***,

Schaible, C.*, Schneider, N., Scholte, K., & Vierola, J. (Contributors Reviewers) (2019). *Qualified Water Efficient Landscaper Reference Manual*. Sonoma-Marín Saving Water Partnership. Sonoma, CA. (*CWEL Personnel).

Paudel, A. & Sun, Y. (2020). *Salinity Tolerance of Penstemon Species*. Final report to the American Penstemon Society, University of Wyoming, Laramie, WY.

Sun, Y. (2020). *Salinity tolerance of viburnum species*. Final report to the Center for Applied Nursery Research Grant Program, Dearing, GA.

ABSTRACTS

Chen, J., Wang, Y., Paudel, A. & Sun, Y. (2019). Comparing the salt tolerance of three landscape plants using near continuous gradient dosing system. *HortScience* 54(9): S283.

Hershkowitz, J., Li, L., Wang, Y., **Sun, Y.** & Dai, X. (2019). Salt tolerance of five spirea species. *HortScience* 54(9): S290.

Palmer, A., Wang, Y., & **Sun, Y.** (2019). Responses of four ornamental grasses to saline irrigation water. *HortScience* 54(9): S111.

Paudel, A*., Sun, Y., L. Rupp, L. & Carman, J. (2019, September 28). Propagation methods for *Cercocarpus montanus*, International Plant Propagator's Society (IPPS) Western Region, Santa Cruz, CA. (*Asmita Paudel received the first-place award for Student Poster Competition).

Paudel, A., Snow, N., Sun, Y., Rupp, L. & Carman, J. (2019). Micropropagation of *Cercocarpus Montanus*: Stage II. *HortScience* 54(9): S198.

Paudel, A., Guo, S., Chen, J., Wang, Y., Sun, Y., Rupp, L. & Anderson, R. (2019). Salt tolerance of Sego Supreme™ plants. *HortScience* 54(9): S283.

Sun, Y. (2019). Developing a sustainable landscape horticulture program for Utah. Program of Annual Conference of American Society for Horticultural Science, Alexandria, VA.

Hooks, T., Niu, G., Dou, H. & **Sun, Y.** (2019). Performance and phytochemical analysis of 22 varieties of pomegranate (*Punica granatum*) in West Texas. *HortScience* 54(9): S101.

EXTENSION FACT SHEETS AND ARTICLES

Johnson, K. & Rupp, L.A. (2019, October). *Transitioning trees from traditional to low-water landscapes*. Utah State University Extension Fact Sheet digitalcommons.usu.edu/extension_curall/2061.

Masabni, J., Niu, G., & **Sun, Y.** (2020, February). *Importance of water quality in hydroponic leafy greens production*. Texas A&M AgriLife Extension. College Station, TX. EHT-135.

TRADE JOURNAL ARTICLES

Evans, S., Kopp, K., Johnson, P., Hansen, N., & Hopkins, B. (2020). More “pop” per drop: Smart irrigation. *Sports Field Management*, 36(6), 20-25.

Evans, S., Kopp, K., Johnson, P., Hansen, N., & Hopkins, B. (2020). More “pop” per drop: Smart irrigation. *Outdoor Power Equipment Business (Landscape Business Special Section)*, Summer, 77-82.

UNDERGRADUATE STUDENT AWARDS / SCHOLARSHIPS

Hershkowitz, J. (2020, April 15). ASHS Outstanding Undergraduate Student in Horticulture.

Hershkowitz, J. (2019, July 21). 2019 ASHS Annual Conference Student Travel Grant, Las Vegas, NV.

Hershkowitz, J. (2019, July 25). Second Place Individual Award, 2019 Plant Identification Contest, American Society for Horticultural Science (ASHS) Annual Conference, Las Vegas, NV

Hershkowitz, J., Hill, A., Palmer A., & Jacketta, C. (2019, July 25). Second Place Team Award, 2019 Plant Identification Contest, ASHS Annual Conference, Las Vegas, NV. 25 July 2019.

Hershkowitz, J. has been selected for the 2020 ASHS Scholars’ Scholarship Award.

Palmer, A. (2019, July 21). 2019 ASHS Annual Conference Student Travel Grant, Las Vegas, NV.

Palmer, A. (2019, July 22). 2019 ASHS Scholars’ Scholarship Award, ASHS Annual Conference, Las Vegas, NV.

Palmer, A. (2019). USU Academic Opportunity Funds Team Award. ASHS conference contest, Las Vegas, NV. Palmer, A. took the lead.

Robinson, M.D. (2020, April 15) ASHS Collegiate Scholars.

GRADUATE STUDENT AWARDS AND SCHOLARSHIPS

Boyle, P.E. (2020-2021). Utah State University College of Agriculture and Applied Sciences Elva Acklam & Arvil L. Stark Scholarship.

Boyle, P.E. (2020-2021). Utah State University College of Agriculture and Applied Sciences Apogee Instruments - Campbell Scientific Graduate Fellowship.

Boyle, P.E. (2020-2021). Golf Course Superintendents Association of America Dr. James Watson Fellowship.

Chen, J.J. (2020, April 24). Master's Student Researcher of the Year, College of Agriculture and Applied Sciences, Utah State University, Logan, UT.

Chen, J.J. (2020). AGRI Daniel M. Teng & Lina C. Teng Endowed Fellowship, Utah State University, Logan, UT.

Chen, J.J. (2019, July 21). PP Systems Innovator's Travel Award to attend the ASHS Annual Conference, PP Systems, Boston, MA.

Chen, J.J. (2019). Utah State University Research and Graduate Studies and College of Agriculture and Applied Sciences Travel Grant to attend the ASHS Annual Conference, Las Vegas, NV.

Paudel, A. (2019, September 28). First Place Award, Student Poster Competition Propagation methods for *Cercocarpus montanus*, International Plant Propagator's Society (IPPS) Western Region, Santa Cruz, CA.

Paudel, A. (2019, September 28). Bruce Briggs Memorial Scholarship, International Plant Propagator's Society (IPPS) Western Region, Santa Cruz, CA.

Paudel, A. (2020). Ambassador Ardeshir Zahedi International Endowment Scholarship, Utah State University, Logan, UT.

Paudel, A. (2020). AGRI Elva, Acklam & Arvil L. Stark Scholarship, Utah State University, Logan, UT.

Paudel, A. (2020). AGRI Apogee Instruments - Campbell Scientific Graduate Fellowship, Logan, UT.

Paudel, A. (2019). Utah State University Research and Graduate Studies Travel Grant to attend the ASHS Annual Conference, Las Vegas, NV.

WEBSITE



cwel.usu.edu

SOCIAL MEDIA



facebook.com/USUCWEL/



instagram.com/waterwiselandscapes/



twitter.com/USU_CWEL



youtube.com/channel/UCTYegSdKYRMg8tTaeGhOIsW

EXTENSION 
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