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Outdoor Water Efficiency Offers Large Potential Savings, But Research on Effectiveness Remains Scarce

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Abstract

This article summarizes the work completed in Phase 1 of the Alliance for Water Efficiency's (AWE) Outdoor Water Savings Research Initiative. Phase 1 was a review, analysis, and synthesis of published and pending research on outdoor water use and water savings. In particular, studies that documented water savings were reviewed. The research in Phase 1 was conducted specifically to identify the area(s) of greatest need for future research. Key findings are:

- Outdoor water savings are achievable and can be significant.
- Quantifying water savings from outdoor programs and measures is challenging.
- Cost savings of any kind are rarely documented.
- Standardized approaches and methods for measuring and evaluating outdoor water efficiency programs are needed.

Introduction

Improving outdoor water use efficiency is an essential goal for urban water providers facing supply constraints and costly infrastructure expansion. While per capita indoor water use continues to decline across the US, outdoor irrigation stands as the largest end use of water and thus will be the focus of many urban water efficiency programs in the coming years (DeOreo 2014, Coomes 2010). While much is known about indoor water savings and how to reduce indoor demand, effective methods for increasing the efficiency of outdoor water use are less certain and the potential for water savings untested through rigorous scientific evaluation.

To address this critical knowledge gap, the Alliance for Water Efficiency created a comprehensive Outdoor Water Savings Research Program with the intent of producing actionable information and data on the savings potential and actual water savings from a variety of outdoor conservation measures. The goal of this research program is to provide relevant, statistically validated, and peer reviewed information on water savings and costs from different outdoor measures and programs, regional differences, and evaluation methods, and

to provide key inputs for the AWE Conservation Tracking Tool and other demand forecasting models. This article presents the results from Phase 1 of the AWE Outdoor Water Savings Research Program.

Phase 1 – What is Known and Unknown?

Phase 1 of the AWE Outdoor Water Savings Research Initiative was a review, analysis, and synthesis of published and pending research on outdoor water use and water savings. The research in Phase 1 was conducted specifically for the purpose of informing the direction of the AWE Outdoor Water Savings Research Initiative so that the limited research budget can be focused on the area(s) of greatest need.

Key elements of Phase 1 include:

- Definition of five distinct outdoor research topic areas.
- Description of relevant research and findings on water savings.
- Identification of gaps in topic areas where additional empirical research is needed.
- Identification of the best/most useful research completed to date.
- Useful results applicable for use in the AWE tracking tool.
- Ongoing and upcoming research yet to be published.
- Bibliography of published research.

Research Methodology - Five Areas of Investigation

The Alliance for Water Efficiency (AWE) identified five distinct areas of research for this project's focus. These areas were deemed the most useful characterizations of need in utility planning of outdoor savings measures. They are described briefly below:

1. **Restrictions, Rates, Education, and Information:** Top down irrigation management including irrigation restrictions, efficiency oriented water rates, water budgets, education, and information programs.
2. **Landscape Transformation:** Creating landscapes that require less water, based on local and regional conditions. Includes new landscapes, renovated landscapes, alternative landscapes, voluntary hands-on education programs, and regulations, codes, and standards that mandate and/or restrict landscape design and installation.
3. **Irrigation Management:** Technology, information, methods, and projects to optimize and improve irrigation management. Includes: smart controllers, soil moisture sensors, rain shutoff devices, irrigation management training programs, audit recommendations, and contractor and customer education.
4. **Landscape and System Efficiency:** Improving the performance and efficiency of landscapes and irrigation beyond the control device. The right plant in the right place and with the right amount of water. Includes research on the inherent characteristics of plants, landscapes, and irrigation systems.

5. **Monitoring and Verification:** Tracking and verification of landscape water use and savings.

Literature Review

The research team rigorously explored national and international research on outdoor water use, outdoor water use efficiency, and the impacts of or programs created to reduce outdoor water use, including conservation oriented rate structures designed to target outdoor demands. Using the five proposed areas as a guide, the research team assembled published research on outdoor water savings. A matrix of research reports was prepared that allows for basic comparison of research studies and results.

The research team sought out instructive examples from the US, Canada, and countries like Australia that have addressed water supply shortfalls implementing rigorous outdoor demand management programs as well as encouraging technological innovation.

The literature review examined both published research and un-published utility sponsored research as well as conference proceedings and internet resources. The research team worked to identify the studies that are most relevant and that offer the best data and examples for consideration.

Interviews with Irrigation and Outdoor Use Experts and Practitioners

The research team conducted a series of short interviews with noted irrigation and outdoor water use experts and utility practitioners to further identify research and data. The interviews were conducted via telephone and via email. In some cases, researchers were simply asked to review the bibliography and provide any additional research not already included.

Outdoor water use experts that the research team interviewed for this project included: Michael Dukes, Kelly Kopp, Dennis Pittenger and Joanna Endter-Wada. Other experts were contacted by email, provided a copy of the bibliography and asked to

Outdoor Use Experts

The research team consulted the following irrigation and outdoor water use experts and utility practitioners to further identify research and data.

- Dr. Michael Dukes – University of Florida
- Dr. Kelly Kopp – Utah State University
- Dennis Pittenger – University of California, Riverside
- Dr. Joanna Endter-Wada – Utah State University
- Dr. David Zoldoske – Fresno State University
- Brent Mecham – Irrigation Association
- Dr. Tony Koski – Colorado State University
- Dr. Roger Kjelgren – Utah State University

recommend changes and additions. These experts included: Dave Zoldoske, Brent Mecham, Tony Koski, and Roger Kjelgren.

The personal interviews helped the research team identify additional studies and data for the literature review as well as to establish what gaps exist in understanding and measurement of outdoor water use and savings.

Analysis of Assembled Research and Data

The research team organized the most useful information and data into a summary matrix to help improve understanding of outdoor water use and savings potential in each of the five different topic areas. This process was extremely useful in identifying areas where significant research gaps exist.

Summary of Findings

The key findings from the AWE Outdoor Water Savings Research Initiative Phase 1 are summarized here.

Outdoor water savings are achievable and can be significant. Numerous recent studies documented outdoor water savings from specific measures such as conservation oriented rates, xeriscape, or soil moisture sensors that reduced outdoor water use by 15 – 65% or more. The research shows that successful approaches to reducing outdoor water use are available and are in fact being implemented across the U.S.

Quantifying water savings from outdoor programs and measures is challenging. Remarkably few studies quantify water savings from measures such as xeriscape or landscape contractor training and certification. Many studies that originally sought to measure water savings instead report "hypothetical" or modeled savings results because of data collection problems or climate variability.

Reporting of outdoor water savings in research varies and there is a lack of geographic and climate variability in the research. Many studies report savings as a percentage, but the basis of the percentage is not consistent across all studies. Some studies reported savings in gallons per square foot of landscape impacted. Much of the urban landscape outdoor water savings research to date of real significance has been conducted in Florida, California, and Nevada. Except for Florida, outdoor water savings research east of the Mississippi is hard to come by.

Cost savings are rarely documented. Water savings are documented in some good studies, but cost savings – from either the customer perspective or the utility perspective - are documented in very few of the studies. If cost savings are documented, it is almost always based on water reductions only. Very few studies consider the time and maintenance costs associated with a landscape and how these may be impacted by the efficiency program.

Standardized approaches and methods for measuring and evaluating outdoor water efficiency programs are needed. Work has begun on establishing conservation metrics, and robust methods for measuring changes in water use are available. Developing standardized approaches and performance indicators, similar to what has been accomplished for water loss control, could be highly beneficial for water utilities in measuring their progress.

Identified Research Needs

The following were identified as the areas of greatest need for additional research on outdoor water savings and costs:

- Impact of native, water-wise, and xeric landscapes vs. turf on water use and cost.
- Impact of water rate structures on demand, particularly inclining block rate structures.[1]
- Impact of various drought restrictions on demand. The best/only research on this topic is now 10 years old.
- Water requirements and drought tolerance of landscape turfs and plants under different climate and drought conditions. Water requirement should be based on acceptable appearance rather than maximum growth.
- Impact of landscape contractor training, education, and certification.
- The human element of landscape water management – how people manage and interact with the entire irrigation system and the installed landscape.
- Impact of improving system efficiency through audits, tune ups, sprinkler-head retrofits, and other measures.
- Reasons and rationale for customer landscape choices.
- Cost-effectiveness and cost savings of various outdoor water saving programs.
- Impact of regional variability (climate, soils, demographics, etc.) on outdoor water demand and savings, with a standard measure for comparison across regions.
- Standard methods for monitoring and verifying water savings.
- Long-term reliability and projected lifetime of outdoor water savings.

Identified Areas Where Sufficient Research Exists

The following were identified as areas where more and potentially sufficient research and information are already available:

- Impact of water budget-based rates.
- Irrigation control technology including weather-based controllers and soil moisture sensors.

[1] Simply measuring elasticity is not sufficient to inform water utilities about the likely impacts of different rates and rate structures. The water savings from water budget-based rates have been studied more recently and better than other rate forms.

Additional research in these areas would be welcome, but these are not currently the areas of greatest need.

Data to Improve Demand Forecasts

Care should be taken when applying results from the research studies identified in this report to demand and water savings forecasts. The applicability of each study reviewed differs significantly and few of the studies cited were designed specifically with the goal of providing broadly generalizable results. Regional variability is a significant issue that has not been well addressed in research to date, and thus this lack of localized information can impair the accuracy of long-term outdoor water use demand planning by water utilities in varying climate zones.

A summary of the water savings measured from different outdoor water conservation programs are presented in Table 1. Differences in research methods, location, timing, and numerous other factors should be considered before applying any of these results in demand forecasting models. There is no accepted standard 'baseline' from which outdoor savings are measured. Actual savings may vary.

Table 1: Summary of water savings by measure

Measure	Lower Bound of Water Savings	Higher Bound of Water Savings	Best Available Estimate of Water Savings*
Water budget-based rates	10 %	20%	18% (Barenklau et. al. 2013)
Mandatory drought irrigation restrictions	18%	56%	Varies by severity of restriction. More severe = more savings.
Voluntary drought irrigation restrictions	4%	12%	Varies.
Customized mailed home water use reports		5%	5% (Mitchell et. al. 2013)
Conservation education programs	2%	12%	Varies.
Florida-Friendly Landscaping	50%	76%	50% (Boyer, et. al. 2014)
Xeriscape rebates (NM)		33%	Varies (Price, et. al. 2014)
Xeriscape conversion (NV)	34 gpsf	60+ gpsf	55.8 gpsf savings (Sovocool, et. al. 2005)
Urban densification (MA)		5%	5% (Runfola, et. al.)
Natural and manufactured shade (Israel)		50%	50% (Shashua-Bar, et. al. 2009)
Soil moisture sensor-	24%	92%	65% (Haley, et. al. 2012)

based control (FL)			
Residential weather-based control (CA)	6%	9.4%	9.4% (MWDOC 2011)
Commercial weather-based control (CA)	8%	27.5%	27.5% (MWDOC 2011)
ET signal-based control (FL)	23%	34%	Varies. (Davis, et. al. 2014)
Rain switch and pause (FL)	25%	41%	Varies. (Rutland et. al. 2012)
Weather-based control (NM)	34%	54%	Varies. (Al-Ajlouni, et. al. 2012)
Weather-based control (NV)	4.6%	68%	Varies. (Devitt, et. al. 2008)
Rotating sprinkler heads	0 or negative	31% (hypothetical)	Unknown

*Some savings estimates did not differentiate between indoor and outdoor reductions, but in all cases the primary focus was on outdoor.

The full Phase 1 report is available for free download from the Alliance for Water Efficiency – www.allianceforwaterefficiency.org.

Next Steps

Using the results from this Phase 1 effort, the AWE is designing Phase 2 of the Outdoor Water Savings Research Initiative. Phase 2 will:

- Propose outdoor water savings research in the areas of greatest need identified through Phase 1.
- Solicit funding to support the proposed research.
- Develop and issue requests for proposals (RFPs) to conduct the work.
- Select highly qualified research teams.
- Manage the research efforts.
- Disseminate the results.

The ultimate goals of this effort are to identify the most effective methods for successfully reducing outdoor water use and sustaining those reductions over time. Improving outdoor water use efficiency could be a real game-changer for water utilities across North America, offering potentially huge cost savings on future infrastructure expansion and extending scare supplies.

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