YARDX

Yield and Reliability Demonstrated in Xeriscape

Final Report

Metro Water Conservation, Incorporated (MWCI)

December 2004

Cover: Photo courtesy of David Winger, Denver Water, Denver, Colorado.

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YIELD AND RELIABILITY DEMONSTRATED IN XERISCAPE

Final Report

Prepared for

Bureau of Reclamation

And

Metro Water Conservation, Incorporated (MWCI)

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by

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Abstract

Metro Water Conservation, Inc. (MWCI) of Denver, Colorado, in partnership with the Bureau of Reclamation, conducted a water conservation study known as the Yield And Reliability Demonstrated in Xeriscape (YARDX) project to estimate the benefits of water-conserving landscaping known as Xeriscape. Benefits to be assessed were seasonal water savings, landscape installation, and annual maintenance costs. Seven municipalities from Fort Collins, Colorado, to Colorado Springs, Colorado, participated in the study. The YARDX project is one of five field projects of Reclamation's National Xeriscape Demonstration Program (NXDP) established to study the benefits of installing Xeriscape under differing climatic and other potentially impacting conditions.

YARDX was conducted from 1997 through 2002. The project included seven field demonstrations, each with some differing attributes, including Xeriscape application type (retrofits or new starts), application level (high or moderate water savings designs), yard size, irrigation method, socio-economic level, and soil type. In seven demonstrations, control groups of traditional high water use turf were established with similar characteristics to Xeriscapes, except for landscape type. Participants had to install Xeriscapes, except at one demonstration. All participants had to maintain them with no major revision during the study period. Xeriscape participants were provided a small rebate to join the study, and were given education on installing and maintaining Xeriscapes. One demonstration involved comparison of older, established Xeriscapes, with comparable control landscapes.

Data analysis of historical water use established the need for sample sizes of approximately 30 properties studied over 4 growing seasons, to have at least a 90-percent chance of detecting a 30-percent change in water use at the 5-percent significance level. The demonstrations yielded high-quality data that generally enabled the estimation of water savings and annual maintenance costs.

Xeriscape installation costs ran a modest $0.90 to $1.45 per square foot, with homeowners in the project contributing a substantial amount of labor. Demonstrations obtained water savings from 18 to more than 50 percent over control samples. Results indicated that relatively consistently, water savings in the 30-percentile range could be obtained for properly designed and maintained Xeriscapes. Annual maintenance costs ranged from $0.34 to $1.33 per square foot. For cost estimation, homeowner labor was computed at $18 per hour. Generally, the maintenance cost of the Xeriscapes sampled, compared to the non-Xeriscaped properties, was found to be less than controls during the plant establishment years, but somewhat more during the plant maturation years. This suggests that as Xeriscapes age, they gradually require more maintenance, compared to traditional landscapes.

Xeriscape participants overwhelmingly expressed satisfaction with their landscapes and would freely recommend this type of landscaping to others. The information gained in the YARDX project should provide an additional alternative in dealing with water conservation needs in the Colorado Front Range.

Acknowledgements

The nonprofit Metro Water Conservation, Inc. (MWCI), located in Denver and consisting of members from several water utilities from the Colorado Front Range, in partnership with the Bureau of Reclamation, U.S. Department of Interior, funded and conducted the Yield And Reliability Demonstrated in Xeriscape (YARDX) project. The YARDX project is one of five field projects that have contributed information to Reclamation's National Xeriscape Demonstration Program (NXDP).

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PURPOSE

In an effort to study the regional effects of water-conserving landscaping called Xeriscape, Metro Water Conservation, Inc. (MWCI) and the Bureau of Reclamation (Reclamation) partnered with nine water utilities along the Colorado Front Range. The study was entitled Yield And Reliability Demonstrated in Xeriscape or YARDX. The YARDX study results were compared to similar studies in four other arid or semi-arid communities in the western United States. The intent was to provide to utility managers a good basis for future decision making about landscape water efficiency programs.

The Colorado project goal was to estimate Xeriscape benefits over a range of landscape and urban environments and within the local climate and weather. Determining benefits involved the study and assessment of landscape water use, installation costs, and annual maintenance expenses. Each of the nine utilities in seven municipalities (Fort Collins, Greeley, Arvada, Wheat Ridge, Denver, Highlands Ranch and Colorado Springs) hosted one or more demonstrations of Xeriscape application. There were 357 landscapes for single-family residential homeowner customers in the study. The study design called for assessment of benefits in retrofits (existing landscapes retrofitted with Xeriscape), new starts (newly constructed homes), and pre-existing Xeriscapes (previously planted Xeriscape). To assess water savings and annual maintenance costs, the new Xeriscape sites were compared with nearby traditional landscape sites, either Xeriscape or traditional landscapes. Project participants installed landscapes from 1997 to early 1999. Operation and monitoring of the project demonstrations occurred over the period 1997 through 2002.

RESULTS

Establishment of study participant samples proved to be challenging. This was due largely to the cost of landscapes, tight schedules (people needed more time to install landscapes and deal with associated expenses), and the necessity to remain within project guidelines for the duration of the project. While installation of Xeriscapes by participants was a lengthy process, installation costs appeared relatively modest, ranging from about $0.90 to $1.45 per square foot (in 1999 dollars). Homeowners contributed all or at least a substantial amount of the labor. Landscapes were completed for as low as $676 and as high as $25,451. Estimated installation labor was an average of 50 to 60 hours per 1000 square feet of landscape with an automatic irrigation system.

Xeriscape annual maintenance costs submitted by homeowners ranged from $0.34 to $1.33 per square foot. For cost estimation, homeowner labor was computed at $18 per hour. Generally, maintenance costs for the Xeriscape sites were less during the plant establishment years, but somewhat more during the plant maturation years, compared to traditional landscapes. This suggests that as Xeriscapes age, they gradually require somewhat more maintenance.

YARDX demonstrated that properly planned and installed Xeriscapes save water. The project Xeriscapes saved from 18 to over 50 percent of the water when compared with paired traditional landscape control groups. On new properties, YARDX results indicate that water savings in the 30-percentile range can routinely be achieved, assuming the property owners are committed to maintaining the savings. New property owners obtained their savings with a design scheme of approximately ¼ the area with low water use plants, ¼ with moderate water use plants, and up to ½ the area with traditional turf. Higher water savings could possibly be obtained with a ⅓-⅓-⅓ design scheme.

The YARDX water savings from retrofits were slightly less than for new properties (generally 28 to 32 percent). Water savings in retrofits appear to vary with the amount of turf that remains in landscapes. Although YARDX retrofit participants were guided toward the ⅓-⅓-⅓ design scheme, the actual water savings did not reach the anticipated savings of 50 percent.

The YARDX project involved the installation and monitoring of landscapes, except for one demonstration (Arvada/Wheat Ridge). In that case, older installed landscapes were only monitored during YARDX. This older landscape study did not yield water savings, and it is not apparent why this occurred. A number of differences other than age of the landscape were apparent. This demonstration consisted of obtaining and comparing the water use of older pre-existing Xeriscapes, with a selected peer control group, as in the other demonstrations. Their watering systems were a mix of manual (also called hose drag) and automated systems. Over the years, there was likely the usual turnover in ownership, so commitment to maintain the existing Xeriscape design might not have persisted with new owners. YARDX did not provide education about Xeriscape as was accomplished with the other demonstrations. More study of this data set is recommended.

The actual data collection for YARDX ended in 2002. A Final Survey was mailed to all project participants to sample their attitudes on their landscapes, installation and annual maintenance costs, and orientation on environmental issues. Overwhelmingly, Xeriscape owners in all demonstrations indicated they were very satisfied with their landscapes, and that they would recommend this type of landscaping to others. Interestingly, Xeriscape owners felt they spent less time on maintenance than with previous traditional landscapes, which did not entirely agree with YARDX maintenance data results.

The information gained in the YARDX project should provide Front Range water managers an alternative in dealing with current and future water demand. The general consistency of water savings in YARDX demonstrations, and the lengthy data collection that occurred, should lend confidence that YARDX results could be consistently achieved.

CHAPTER ONE

Introduction

GENERAL

Population growth on the Colorado Front Range continues at a high level. As a consequence of the semi-arid climate, occasional drought and the continued high growth, Front Range water utilities are accelerating their planning for increasing future water demand.

The Bureau of Reclamation (Reclamation) has a responsibility to help improve water resource management and the efficiency of water use in the western United States. Reclamation recognizes that cooperative efforts with partners facing similar challenges can produce solutions more efficiently to benefit all parties. Consequently, Reclamation pursued several cooperative demonstration projects of landscape water conservation, collectively called the National Xeriscape Demonstration Program (NXDP). The NXDP cooperative studies were conducted at locations in the western United States that experience different climates, including the Colorado Front Range centered at Denver, Colorado; Phoenix, Arizona; Austin, Texas; the Las Vegas area of southern Nevada; and Fargo, North Dakota. Xeriscape ™ [1] landscaping is defined as a set of landscaping principles, including low-water-using plants, efficient watering systems, soil amendments, and proper maintenance practices to create an aesthetically pleasing landscape, while maintaining desired attributes, such as reduced water use, recreation, and cooling.

In January 1996, Reclamation partnered with a Colorado Front Range nonprofit organization, Metro Water Conservation, Inc. (MWCI), to co-

[1]Denver Water, Denver, CO, holds the trademark for Xeriscape.

sponsor the project known as YARDX (Yield And Reliability Demonstrated in Xeriscape), aimed at assessing the benefits of water conserving landscaping. MWCI consists of a group of Colorado water supply agencies and interested stakeholders cooperating to aid planning for future water demand and supply, and to promote water conservation programs. Reclamation, MWCI, and nine water utilities in the Colorado Front Range comprised the group participating in and sponsoring the YARDX project.

STUDY LOCATION

The YARDX project became a 5-year demonstration and evaluation study based on Xeriscapes installed in nonrental, single-family homes along the Colorado Front Range. The area targeted in the Colorado Front Range is the most heavily populated in the state. The study includes landscapes in neighborhoods of Fort Collins and Greeley in the north, Denver and several suburbs in the middle Front Range corridor, and Colorado Springs in the south. Figure 1-1 presents the study locations. This region is considered high plains with a semi-arid climate that receives on average 15 inches of yearly rainfall in Fort Collins and Denver, and 17.5 inches in Colorado Springs (http://www.weatherbase.com).

Specifically, the nine utilities and 357 of their single-family customers that elected to join the YARDX project are the Fort Collins Utilities, East Larimer County Water District (Fort Collins), Fort Collins-Loveland Water District, City of Greeley, City of Arvada, Wheat Ridge Water District, Denver Water, Highlands Ranch Metropolitan Districts with Centennial Water District, and Colorado Springs Utilities.

STUDY GOALS

The YARDX study goals were to develop data and provide evaluation and estimates on the water savings, installation, and annual maintenance costs in implementing Xeriscape. The project was to assess the reliability of landscape water conservation from the application of Xeriscape landscaping.

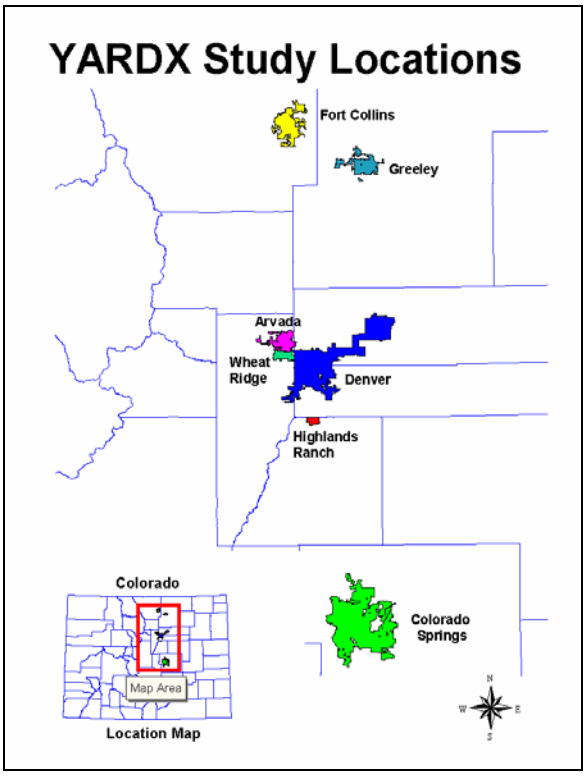


Figure 1-1: Location of cities participating in the YARDX study.

Specifically, the primary study goals of YARDX were:

- Conduct consistent investigations at multiple sites in different geographic and municipal settings.
- Collect data that are uniform in content and method.
- Quantify the range of water savings annually and seasonally when Xeriscape is properly installed and maintained.
- Determine the reliability of Xeriscape water savings (Do water consumption patterns change with the age of the landscape or varying human factors?).
- Calculate the cost of installing Xeriscape landscapes for new construction and for retrofits to existing traditional landscapes (mostly high-water turf landscapes).

- Analyze the cost of maintaining Xeriscape landscapes for new construction, for retrofits to formerly traditional landscapes, and for pre-existing (installed prior to YARDX) Xeriscapes compared to pre-existing traditional Kentucky bluegrass landscapes.

- Identify what marketing strategies affected the implementation of Xeriscape in this study.

PREVIOUS STUDIES

Some results from the other NXDP field studies are now available. The Phoenix project (Stinnett) obtained water savings of 53 percent over control properties with traditional landscaping. This project was similar to a YARDX pre-existing Xeriscape landscape study conducted in Arvada/ Wheat Ridge neighborhoods, except for lack of an observation period. The Phoenix study involved selecting, acquiring, and evaluating landscape historical water use data.

The Southern Nevada project (Sovocool and Rosales) obtained water savings of 39 percent (summer) over control properties. Xeriscape maintenance was estimated to be about ⅓ less than for control properties.

The Austin Xeriscape project (Gregg, 1994) obtained water savings of 31 percent during summer months. Nelson (1994), in preliminary results of the North Marin Study, obtained a 25-percent water savings from Xeriscape. Testa and Newton (1993) obtained a 33 percent water savings in a Mesa, Arizona, study of Xeriscape.

Xeriscape participants in all projects of the NXDP have overwhelmingly expressed satisfaction with their landscapes and indicated they would freely recommend this type of landscaping to others.

The above studies have provided evidence suggesting that Xeriscaping can reduce landscape water usage by 20 to 50 percent during peak irrigation months, as compared to traditional turf landscapes. Those water-use evaluations dealt with water use in single-family residences, as did YARDX.

WHY YARDX IN THE FRONT RANGE

Motivation for incorporating the Colorado Front Range in the NXDP national study included: (1) the high-growth characteristic of the area, (2) concerns over prolonged drought in the state, (3) urban landscapes accounting for approximately 50 percent or more of the water used by residences in this region (Winger), and (4) the citizenry's familiarity with Xeriscape. As people continue to select Colorado for its moderate climate, variety of outdoor recreation, jobs availability, and retirement appeal, water demand will increase. Front Range corridor growth is exemplified by "six counties in the state [making] the census' list of the 100 fastest-growing counties in the nation" and Highlands Ranch in Douglas County, a southern suburb of Denver, Colorado, and part of the YARDX study, "was the third-fastest-growing county in the nation from 2000 to 2003 " (Siebert, Sinisi, B1).

The U.S. Housing Markets, a research firm, announced in 1997 that the Fort Collins/Loveland area (part of the YARDX study) ranked number 9 in the country in residential construction, with the Greeley area (also part of YARDX) holding the number 18 spot in the United States (Cornelius C1+). This Front Range metropolis, from Weld County in the north to Pueblo County in the south, includes about 3,733,308 residents (Romine).

The high growth and difficulty of executing new traditional water projects has motivated water utilities to consider water conservation alternatives to water supply development options, in part, because of the economic and environmental concerns associated with traditional water projects. Landscape irrigation's water use near 50 percent of residential use is an ideal target for water conservation, and offers a potential source for dealing with a major challenge of future Front Range growth.

Front Range landscapes with predominantly thirsty Kentucky bluegrass typically need nearly 30 inches additional water over average rainfall

(Winger) to maintain their health. As suggested in the previous studies discussed above, lower water demand plantings and more efficient irrigation methods could potentially decrease outdoor watering by 30 to 50 percent, or about 10 inches less irrigation. Noticeable water savings are obtained when viewed over the many landscapes of the Front Range.

The extreme Front Range drought of 2002 (exceeding 100-year records) and the continuing dry years have contributed to increasing interest in water conservation approaches. The 2002 drought persuaded utilities to enact watering restrictions. These restrictions apparently impacted the 2002 water savings by YARDX Xeriscapes in Colorado Springs (discussed in *Water Use Results*). Drought remains an ongoing concern in Colorado.

Xeriscapes are a familiar sight in Colorado Front Range municipalities, rendering the area a likely candidate for Xeriscape research. In new neighborhoods, there are indications of increasing use of lower water demand plantings and mulched areas without plantings. This landscaping approach is particularly being utilized in moderate and higher priced properties. Positive results from YARDX and readily available educational materials from water utilities (for example) could further promote the installation of water conserving plantings.

Following in this report are descriptions of the YARDX project and the results obtained. Chapter Two discusses the project design, Chapter Three covers the promotion efforts to recruit homeowners to join YARDX and install a Xeriscape. A summary of the Xeriscape installation costs is given in Chapter Four. Chapter Five presents water use results, and Chapter Six covers landscape maintenance costs. Chapter Seven presents the YARDX participants' responses to a Final Survey that included questions on satisfaction with their landscape and query for pro-environmental tendencies that may have influenced their water use. Finally, Chapter Eight presents a summary and conclusion of primary results.

CHAPTER TWO

Project Design

INTRODUCTION

A proper evaluation plan and data sampling design was required to accomplish the goals established for YARDX. However, design features would need to function within demonstration logistics. The desired sampling scheme was random allocation of the treatment (Xeriscape) and control (traditional landscape) to lessen possible bias. From a large pool of willing participants, homeowners would be assigned to treatment and control groups at random. Treatment participants would install Xeriscapes and control participants would install traditional landscapes. It was also determined to sample only owner-occupied, single-family properties to reduce noise that may occur from rentals or multiple-family housing. To encourage participation, a rebate was established of $300 to new starts (newly constructed homes), and $600 to retrofits (Xeriscaping a portion of an established high-water use landscape). Also, Xeriscape participants would be provided 2.5 hours of professional landscape design assistance, educational seminars on Xeriscaping, and one-on-one consultation upon request during the study period.

In the initial stages of the project, it became apparent that establishing a treatment group with random selection would not be possible, despite the benefits provided by YARDX. There was inadequate participation to install Xeriscapes. The primary barrier appeared to be Xeriscape installation cost and time, though other concerns voiced included conforming to the rigor of participation (e.g., reporting requirements) and structured Xeriscape design features and irrigation type selected for particular demonstrations.

Elimination of random allocation to the treatment group forced development of a new Xeriscape

sampling plan, possibly introducing more data noise.

That nine utilities expressed interest in joining YARDX also impacted the study design. Large participation presented an opportunity to develop seven demonstrations, each with at least one unique variable factor setting (such as large yard or sandy soil).

The project covered approximately 6 years of information gathering, as a consequence of the landscape enlisting and installation process becoming rather time consuming. The YARDX project began enlisting properties in 1997. Xeriscapes were installed from 1997 through the first half of 1999. Field data collection continued until the end of 2002. Data responses from participants continued well into 2003.

DEMONSTRATION CHARACTERISTICS

Consideration was given to the various variable factor influences (Gregg, et al.) on study sample establishment, including project duration and available funding. Table 2-1 lists the YARDX seven demonstrations along with their primary influence factor and logistic characteristics. In general, a mixture of three retrofit, three new starts and one pre-existing (Xeriscape landscapes installed prior to YARDX, by the spring of 1996) demonstrations was developed for YARDX. Marketing failed to convince more homeowners to participate in additional demonstrations, except possibly for additional high-priced properties that may have joined if pursued. The table shows the demonstration in Greeley as a mix of retrofits and new starts. This occurred because few people joined the project.

Demonstrations were designed to address variables that appear to impact water use. Previous studies (Gregg, et al.) have identified variables that are correlated with water use. Accordingly, the YARDX field demonstrations were structured to yield data on eight seemingly correlated variables, including the primary response variable, water use.

STUDY VARIABLES

1. Water use (primary response variable)
2. Xeriscape application type (retrofit, new start or pre-existing)
3. Xeriscape application level (landscape designed for 30-40 percent or 60-70 percent water savings)
4. Yard size
5. Irrigation method (manual hose drag or automatic sprinkling system)
6. Family income level (home values were used to approximate income levels)
7. Soil type (loam, sand, or clay)
8. Precipitation

The first variable, water use, is the key response (dependent) variable of the study. The other listed variables, operating in combination, are considered to substantially impact water use. YARDX collected data on some secondary variables, including exposure of a landscape to wind (a categorical variable as defined by YARDX), degree of shadiness (more important in retrofits that had pre-existing plants remaining and providing shade), and area with 15-degree slope or greater. A variable not listed above that certainly impacts water use, but is difficult to assess, is landscape maintenance. YARDX collected related information via an assignment of a landscape or turf health score (see appendix C). While the health score assignment was subjective (by the person conducting the field audit), there may be some useful maintenance level assessment in the scores.

Table 2-1 shows the various influences of factor settings by demonstration. Because landscape water use is the end result of a number of operating and interacting factors such as weather and climate, soil type, yard size, and home occupant attitude, individual neighborhoods of differing demographics may yield different water use savings.

Xeriscape application type refers to a Xeriscape new start, retrofit, or a pre-existing type.

Xeriscape application level relates to the presumed water savings level of the Xeriscape design, based on the area ratio landscaped in high-, moderate-, or low-water plants (see Glossary) plus the area amount of hardscape. For YARDX, two

application levels were selected: 30-40 percent water savings design (used in the new start demonstrations) and the higher water savings of 60-70 percent (used in the retrofit demonstrations). The 30-40-percent design consisted of ¼-¼-½ area ratio of low, moderate, and high water use. The 60-70-percent design used corresponding area ratios of ⅓-⅓-⅓. The pre-existing landscapes were taken "as is." Consequently, a combination of different potential water savings landscape plans existed in these yards.

The water savings estimation levels (Xeriscape application levels) could possibly be achieved under proper designing and installing, watering and performing general maintenance (such as thinning plants). Landscape designs were structured to specify certain water-hardy plants and grasses, density level of installation, proportion of turf to nonturf area, and landscape preparations that included soil preparation, mulches, and hardscape.

The variable yard sizes were categorized into small, medium, and large. The classification was relative to each city, so that category size cut-offs, from city to city, varied minor amounts. Thus, large yards in Fort Collins tended to be larger than large yards in the Denver demonstration area. The study in Fort Collins was structured to include larger properties and more affluent owners. Table 2-1 presents the yard size cut-offs. Approximately, the three size categories that described one-half of the "landscapable area" (square footage to be formally landscaped) were: low-sized yards up to about 2750 square feet, medium sizes from approximately 1000 to 4000 square feet, and large sizes with over 2500 square feet. The Xeriscape landscape had to encompass 50 percent or more of the landscapable square footage. This area did not include dryland area (natural vegetation surviving solely on rainfall). Only one YARDX property involved dryland area.

Only two types of irrigation systems were studied in the project: automatic sprinklers on a clock and timer that would start and stop the watering as programmed, and hose dragging. In each demonstration, all participants (both treatments and controls) had the same type of irrigation system with the exception of the pre-existing demonstration. In this case, YARDX accepted whatever type of irrigation system had been installed, and thus a mixture occurred in this group.

Home value was used as a surrogate for attitudinal variables of family income levels that some previous studies (Gregg, et al.) suggested could affect household water use. The home value representation varied by region. One value that may seem low in one locale could reflect a high-priced home in another city. A relative comparison system on a local basis was used. Three general classes of home values are identified on Table 2-1: low, medium, and high.

The soil types also fell into three main groups: loam, clay, and sand. In some demonstrations, there were some properties with mixes, but generally there was a predominant soil type.

Lastly, three groupings of relative precipitation were prevalent during the growing season of April through October in YARDX demonstrations. The relative code of "low" indicated about 8 inches or less, "moderate" reflected more than 8 and up to about 11 inches, and "wet" indicated 12.5 inches or more of rainfall.

SAMPLING PLAN

Because random allocation of the treatment was not possible, a new sampling plan was needed, at least for establishing the Xeriscape sample. For each demonstration, the goal was still to have the treatment and control group properties as similar as possible, except for random assignment of the treatment. After some consideration, the sampling plan was developed that involved:

- Only certain households were willing to participate in the project. The greatest difficulty in obtaining participants was in the Xeriscape group.
- Willing Xeriscape participants were surveyed to conform to settings of the relevant demonstration. Participants (and properties) that satisfied their demonstration settings were invited to join the study.

Table 2–1: YARDX demonstrations and primary characteristics.

Demo	Demo Type [1]	Xeriscape Level (%)[2]	Soil	Rainfall [3]	½ Yard Size (ft²)	Home Value	Irrigation	Periods of Water Data Analyzed
Arvada/ Wheat Ridge	PX	Any [4]	Clay	8" (Moderate)	1000-4000 (Medium)	$150-275,000 (Medium)	As Is	9/99 -- 12/02
Colorado Springs	RT	60-70	Clay	12.5" (Wet)	1000-3750 (Medium)	$150-200,000 (Medium)	Auto	2/99 -- 12/02
Colorado Springs	NS	30-40	Sand / sandy loam	12.5" (Wet)	1000-3750 (Medium)	$150-200,000 (Medium)	Auto	2/99 -- 12/02
Denver	RT	60-70	Clay	9" (Moderate)	up to 2750 (Low)	up to $200,000 (Low)	Manual	5/98 -- 12/02
Ft. Collins / Loveland	NS	30-40	Clay	9" (Moderate)	>2500 (High)	>$175,000 (High)	Auto	9/98 -- 12/02
Greeley	RT & NS	60-70	Loam	8" (Low)	1000-3750 (Medium)	$80-200,000 (Medium)	Auto	2/98 -- 12/02
Highlands Ranch	NS	30-40	Clay / clay-sand	11" (Wet)	1000-4000 (Medium)	$150-250,000 (Medium)	Auto w/ submeter	2/98 -- 12/02

[1] NS= New Start; RT= Retrofit; PX=Pre-existing

[2] Xeriscape application level was designed for a 30-40% or 60-70% water savings over traditional landscapes.

[3] May to September average rainfall

[4] The Arvada/Wheat Ridge demonstration was not a YARDX-designed project, and Xeriscape application levels were not specified.

- With knowledge of Xeriscape participant characteristics, a pool of properties with traditional landscapes was surveyed for matching the treatment characteristics. A random sample was selected of the acceptable control pool, in excess of treatment numbers.

- Those randomly selected were contacted for joining the control group of the particular demonstration. Not all contacted agreed to join the study. Upon enlisting the desired number of control participants, the contacting ceased.

- Information conveyed to control participants consisted of only stating that they would belong to a local landscape water-use study of traditional landscapes (to avoid potential influence on water use). No education on landscaping was provided to control participants by YARDX.

The restricted population of willing Xeriscape participants could lead to some bias in the samples obtained. The project also used a rebate to aid in obtaining adequate numbers of participants, which could introduce some bias. The rebate undoubtedly motivated some participation (see Chapter Seven, *Final Survey*). Finally, new home construction leads to the need for new landscapes (neighborhood covenants usually require homeowners to install a landscape). The type and amount of bias resulting from these initial conditions was difficult to foresee. In particular, the rebate could lead to specific types of water users. However, the project team realized that some participants may simply want to conserve water. Others seemed attracted to the aesthetics of Xeriscape.

Efforts made to investigate bias consisted of studying responses in a survey administered at the end of the project by YARDX (see Chapter Seven, *Final Survey*). Specific questions on the survey suggested the environmental inclination by participants and the primary motivation for joining the study. Results in Chapter Seven suggest some bias of Xeriscape participants toward pro-environmental orientation over control groups. However, this result may have occurred as a result of several circumstances. It is not clear that pro-environmentalism always leads to higher water conservation.

SAMPLE SIZE ESTIMATION

Sample sizes must be large enough to enable the detection of a treatment effect (Xeriscaping in this study) on water savings anticipated from Xeriscape application. The natural "noise" levels of the local water-use data must be assessed to estimate sample sizes. Data noise sources can occur from influential elements changing with time (such as effects of weather) and influences varying across households. Real water-use historical data offer an opportunity to estimate sample size requirements.

Several years of water-use data were obtained from the city of Boulder, Colorado, for some 26,000 homes. The project team agreed that the Boulder data were well representative of wide socio-economic, educational, and other water-use-impacting variables. Given this assumption, the Boulder water data would be a suitable candidate for sample size estimation for YARDX demonstrations.

Computer software was developed that utilized a resampling technique similar to bootstrap (Manly) that uses random selection of samples, which can be compared. This technique was used to study the detection of different water amount savings in different sample sizes from samples without water savings. For example, a 30-percent increase in water use was applied to each of 100 randomly selected samples of residential water use and compared with 100 unaltered samples, using a nonparametric test at the 5-percent significance level. By studying the proportion of comparisons over and under the 5-percent significance level, an estimate of probability of detecting the inserted water amount change was obtained.

Results of applying different water amount changes in different sample sizes indicated that to achieve the 90-percent detection level, water use from about 30 homes for approximately 25 growing season months would be required to detect a 30-percent water savings. This meant

that water data should be collected from about 30 homes per sample for four growing seasons in the YARDX demonstrations. The growing season selected was April through October. This sample size included about 10 percent overage for participant dropout during the study. The sample estimate would accommodate typical data noise caused by varying climate effects, property characteristics, irrigation systems and management, and homeowners' varying behavior.

FIELD DATA

For their customers in the YARDX study, the participating utilities routinely collected monthly or bimonthly water-use information. This information was provided to the YARDX project for analysis over the course of the study. Table 2.1 shows the periods of water data for each utility. The water data required substantial manipulation for the final tabulation. The final tabulation consisted of calendar monthly totals (obtained from reporting period average daily usage) per participating property. The estimated monthly totals became the water-use basic database for treatment and control sample comparisons.

Generally, water-use data were available from mid-1998 or early 1999 through 2002. Water-use data files were constructed with complete records through 2002 for all participants. A few properties underwent major landscape revisions no longer in character with the particular demonstrations. These records were adjusted for a partial study time period and included in the analysis.

To estimate outdoor use, winter use was subtracted from summer meter readings. Winter use was estimated by averaging water use for January, February, November, and December. These were considered the core winter months most likely to include little or no outdoor use. The project team decided that using the average of "encircling" months best represented indoor use. For winter comparisons between samples, the water use in March was included with the above 4 months.

The growing season months were designated as April through October. Estimation of growing season water use, with the exception of the Highlands Ranch demonstration, had to be derived from readings from the utility-provided home water meter. In the case of Highlands Ranch, an additional meter was installed to measure only the landscape water use. These data were available for the last two growing seasons only (2001 – 2002).

COST ESTIMATION

Xeriscape Installation

One of the primary goals of YARDX was to estimate the cost of installation of Xeriscapes. Data were obtained from six demonstrations. The seventh demonstration, the Wheat Ridge / Arvada study, did not involve the installation of landscapes, but rather the study of existing Xeriscapes and traditional landscapes. See Chapter Four for a detailed discussion of installation costs.

Maintenance

Annually, both the treatments and controls received a maintenance log to record their time and expenses on their landscapes. Segregated by major landscape area (e.g., turf, groundcover plants and perennials, irrigation, etc.) and by three seasons (spring, summer/fall, and winter), these data were tabulated annually from 1997 through 2002. A discussion of maintenance costs can be found in Chapter Six, *Maintenance Costs*, and the form can be found in Appendix E.

In addition to studying the maintenance costs, the effect of providing landscape maintenance education was also considered. Xeriscape maintenance training was provided to the new start and retrofit treatment groups but not to the pre-existing sample. By isolating the pre-existing group, the effects of maintenance training could be better observed between the "trained" and "untrained" groups.

ANNUAL SURVEYS

Also annually (from 1997 through 2002), both the treatments and controls received a survey. The purpose of this survey was to identify the age of the property and indoor water-usage factors such as the number of adults and

children, the number of low-flow toilets and showers, etc. At the conclusion of the study in 2002, the survey was expanded to determine attitudes toward their landscapes and environment. The results of this survey can be found in Chapter Seven, *Final Survey*.

EXAMPLE OF DESIGN

Figure 2-1 presents a sample plan designed for a study participant. Figure 2-2 depicts the completed Xeriscape 4 years after installation. Other homeowners' landscape photographs, before and after installation, can be found in Appendix J.

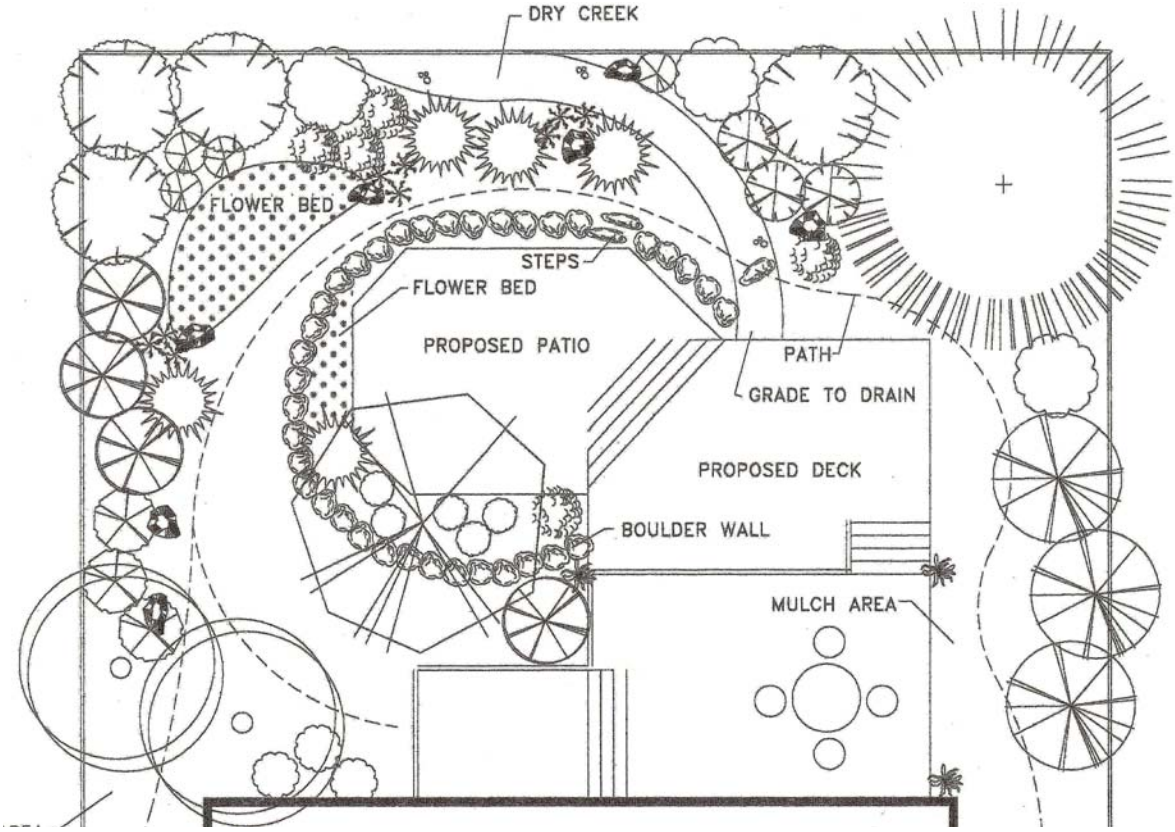


Figure 2-1: Xeriscape design, Colorado Springs, CO. Design created by Joelle Dunaetz, Designs by Dunaetz.

Figure 2-2: Photograph of the Xeriscape 4 years after installation in Colorado Springs. Photo courtesy of participant.

CHAPTER THREE

Promotion

INTRODUCTION

The YARDX project was designed to study owner-occupied, single-family residential homes. Project participants would be homeowners willing to install a new Xeriscape landscape (treatment) or maintain a traditional landscape (control) throughout the study. YARDX offered a rebate to treatments to participate in the study (except for the pre-existing demonstration). Most of the cost of installing Xeriscape would be borne by those willing to participate.

In each demonstration, approximately 45 to 55 homeowners were targeted for each of the treatment and control groups. The team planned to enlist about 40 participants, nearly 20-percent over subscription, to deal with anticipated attrition. The sample size estimation of Chapter Two indicated the need for about 30 participants per sample group completing the study. Accordingly, five of the seven demonstrations achieved the desired number of signups at the onset.

Table 3-1 indicates a total of 294 Xeriscape participants signed up and paid a $100 commitment check (where required). Participants were given time schedules for completing their Xeriscapes. A total of 170 Xeriscape participants of the original 294 that initially joined YARDX (58 percent of 294) completed the study.

Thus, 124 Xeriscape participants failed to complete YARDX. Each demonstration was designed with pre-specified criteria of participation. Failure was caused by violation of criteria, such as failing to install a required automatic watering system. Even with high attrition, all but the Greeley demonstration had

Table 3–1: Number of participants who signed up, completed or dropped from the YARDX project.

Demonstration	No. of Treatment Signups	No. that Completed Project to the End [1] (% of Signups)		No. of Treatments Dropped from Project (% of Signups)
		Treatments	Controls	
Arvada/Wheat Ridge (PX)	30	26 (87%)	28	4 (13%)
Colorado Springs (NS)	52	27 (52%)	37	25 (48%)
Colorado Springs (RT)	64	27 (42%)	32	37 (58%)
Denver (RT)	63	34 (54%)	31	29 (46%)
Fort Collins (NS)	46	34 (74%)	38	12 (26%)
Greeley (NS & RT)	13	6 (46%)	4	7 (54%)
Highland Ranch (NS)	26	16 (62%)	17	10 (38%)
Total	294	170 (58%)	187	124 (42%)

Legend:
RT = Retrofit Xeriscape **NS** = New Start Xeriscape **PX** = Pre-existing Xeriscape
[1] The project was able to use only partial data on 12 treatments and 8 controls due to changes to their landscapes late in the study.

adequate participation for conducting data analysis.

Appendix A presents drop-out numbers with breakdown by city and reason for leaving the project.

PROMOTING XERISCAPE PARTICIPATION

The YARDX Project used several different avenues to elicit homeowner participation in the Xeriscape group. The primary approach was a direct mailing campaign to preselected neighborhoods that fit the criteria for the demonstration (home value, soil type, etc.), and to new water tap permittees (for homes recently built for the new start demonstrations). Over 19,600 letters were mailed to prospective participants by 9 utilities on utility letterhead.

Table 3-2 shows homeowner approximate response to the Xeriscape direct mail campaign. About 5 percent or 965 prospective participants responded with interest. Second requests were used at times. Included in the mailing was a colored flyer with Xeriscape landscapes, a brief letter, and an application form. When a homeowner called or returned an application form, YARDX responded with an additional letter covering more details about the project, including costs of installing a Xeriscape. Applicants were then asked to confirm their interest with a mail-back form. Lastly, the project team prequalified the interested homeowners with a drive-by audit checking for approximate home value and age, irrigation system, yard size, soil type, etc., for matching the demonstration's study settings.

At each level of scrutiny, homeowner response levels dropped. Participation confirmation requests were below expectations. Approximately 234 homeowners (24%) of the original 965 who expressed interest in installing a Xeriscape responded favorably to our confirmation request. Of the original 19,600 homeowners that were contacted, 1.2 percent replied that they wanted to proceed with

Table 3–2: Example of Xeriscape signup results from a direct mail campaign.

Demonstration	No. of Invitations Mailed	No. of Applications Received (% of Invitations)	No. of Qualified Homes (% of Invitations / % of Apps)	Signups			
				No.	% of Invitations	% of Applications	% of Qualified
Arvada (PX)	664	54 (8%)	24 (4%) / (44%)	20	3	37	83
Boulder (NS)	143	14 (10%)	cancelled demonstration	cancelled demonstration			
Colorado Springs (NS & RT)	7,305	360 (5%)	280 (4%) / (78%)	81	1	23	29
Denver (NS)	586	23 (4%)	cancelled demonstration	2	0.3	9	—
Denver (RT)	1,524	246 (16%)	not available	63	4	26	—
Ft. Collins (NS):							
Ft. Collins Utility	355	31 (9%)	28 (8%) (90%)	13	4	42	46
Ft. Collins-Loveland	160	27 (17%)	not available	10	6	37	—
East Larimer County	38	16 (42%)	not available	6	16	38	—
Ft. Collins Total	553	74 (13%)	not available	29	5	39	—
Greeley (NS & RT)	7,058	194 (3%)	135 (2%) / (70%)	13	0.2	7	10
Highlands Ranch (NS)	544	not available	not available	26	5	—	—
Subtotal	18,377	965 (5%)	--	234	1	24	—
Various	1,223	not available	not available	not available			
Grand Totals	19,600	965 (5%)[1]	--	234	1	24	—

Legend:
RT =Retrofit Xeriscape **NS** =New Start Xeriscape **PX** =Pre-existing Xeriscape
[1] Calculated without Highlands Ranch results

installing a Xeriscape. These results forced a prolonged marketing effort.

Besides mailing invitations to prospective participants, several other marketing campaigns were added to help enhance YARDX credibility and circulate availability more widely. Additional marketing included:

- Approximately 19 newspaper articles highlighting the project and its benefits were circulated in various papers and cities.
- About seven paid newspaper ads were printed in local newspapers.
- Denver Water sponsored several TV news bites about Xeriscaping on a local TV news station. This publicity helped educate the citizenry about the overall benefits and aesthetics of Xeriscape, but did not specify information on YARDX.
- The government channel on cable TV promoted the project in Colorado Springs and Greeley.
- Newsletter articles were published and/or presentations made to such organizations as the Home Builders Association, real estate agent groups, homeowner associations, environmental groups, garden centers, Colorado State University Extension, the Horticulture Arts Society, the Associated Landscape Contractors of Colorado, and the Nurserymen's Association. These groups were in contact with the public

and likely enhanced promotion of YARDX.

- Letters were sent regarding YARDX to more than 100 builders and Home Builder Association members in the Colorado Front Range. In addition, YARDX representatives visited or called several homebuilder sales offices to utilize their contacts with the public. These efforts produced varying degrees of support for YARDX.

- Flyers were deposited at single-family residential homes, at libraries, and at homeowner associations in Fort Collins, Greeley, and Highlands Ranch. The Colorado Springs Xeriscape Demonstration Gardens passed out YARDX flyers to their visitors.

- Some utilities mailed inserts with water bills.

- The Fort Collins Utility taped a video of the YARDX introductory Xeriscape seminar for distribution to interested homeowners.

- For locating pre-existing Xeriscapes in Arvada, a mailing was conducted to participants in the city's previous Xeriscape rebate program. Also, Arvada and Wheat Ridge representatives assisted in identifying areas of existing Xeriscapes in their neighborhoods.

The Xeriscape marketing effort started late in the summer of 1996 and continued through the winter of 1998, exceeding the original time schedule and plans. YARDX spent at least an additional year on marketing due to initial low sign-up rates.

Mass marketing techniques were not used to elicit homeowners for the control role. Chapter Two presents procedures for selecting control properties. Promotion consisted of personal door-to-door contact on randomly selected properties that were determined to closely match treatment properties of the demonstration. The control sign-up process started in 1998 and continued into 1999.

XERISCAPE SEMINARS

Homeowners who confirmed their interest to participate in YARDX were subsequently invited to a 2½-hour Xeriscape seminar in their neighborhoods. At these seminars, members of the project team discussed the requirements of the project, the benefits, preparation for a private design session with a landscape architect/designer, the seven principles of Xeriscape, and the procedures and costs involved with installing a landscape. At the seminar conclusion, the team signed up participants, which required a $100 commitment check. These monies helped to subsidize the homeowners' private design sessions. In some cases, YARDX representatives met with homeowners who were unable to attend scheduled seminars.

RESTRICTING YARDX PROMOTION

YARDX established standards and related expectations of treatment and control groups. These demands may have contributed to the slow signup rate. However, obtaining high quality data demanded rigor in the conduct of the project.

Standards required of new start and retrofit Xeriscapes were similar. The pre-existing Xeriscapes had less demands, as those Xeriscapes were already established and the interest was to evaluate the water savings of older Xeriscapes. The following lists some landscape requirements established for YARDX:

- The retrofit and new start homeowners had to commit with a $100 nonrefundable check, which would be returned to them through project benefits. This fee was enacted to help determine participants likely to complete their installations.

- Retrofit and new start homeowners also had to have their landscape plans approved and installed by June 1, 1999. The plan had to encompass over

50 percent of their landscape. For new starts, they could not have an existing landscape older than 6 months in at least 50 percent of the yard. Conversely, the retrofit demonstrations had to have an existing landscape. Both groups had to track their installation work time and expenses and submit copies of all invoices to YARDX.

- Annually, the homeowners were to report landscape maintenance including tracking their time and expenses, completing an annual survey, and providing YARDX with photos of their yard. The project supplied a maintenance tracking form. The pre-existing Xeriscapes were not required to submit photos.

- Homeowners were asked not to significantly alter their landscape during the study (concluding December 31, 2002) and to allow project staff to occasionally view the progress of the Xeriscape.

- Participants had to own their home (no renters); not be an employee of their utility, Metro Water Conservation, Inc., or Reclamation; and have no expectation of moving in the next 3 to 5 years.

- For the Highlands Ranch demonstration only, Xeriscape participants were required to install a submeter on their irrigation line to measure outdoor watering. The submeter was provided by the utility, but the homeowners were responsible for its installation.

PROJECT BENEFITS

The total benefit package offered to the treatment group encompassed:

- Receive a rebate of $\$0.45/ft^2$, up to a maximum of $300 for new starts and $600 for retrofits, depending on the size of the Xeriscape installed. No rebate was disbursed to pre-existing Xeriscape homes, since they had already completed their installations. Almost 100 percent of those completing their installations received the maximum rebate allowed.

- Participate in YARDX-exclusive discounts negotiated with 25 vendors in 5 cities throughout the study region. These discounts averaged 10 to 20 percent and included nurseries and garden centers, irrigation suppliers/contractors, soil amendment providers, hardware stores, and hardscape suppliers.

- Receive a 2½-hour private session with a landscape architect or designer paid for by the YARDX Project. Participants were given a simplistic homework assignment to complete before their design session: photograph their yard, complete a questionnaire about their desires, and draw a schematic of their property with measurements.

- The YARDX Project provided one free maintenance seminar in four demonstration cities (Greeley, Fort Collins, Denver, and Colorado Springs). Additionally, an annual newsletter with maintenance tips was mailed to all the Xeriscape participants except for the pre-existing group in Arvada and Wheat Ridge. The plan was to observe what the pre-existing demonstration would do without any formal maintenance education from the project.

- At the conclusion of the study, the YARDX project team is to provide each homeowner with a personalized analysis of their water use, installation costs, and maintenance expenses, comparing their results to those of other project participants.

- Some general benefits include increased home value through an attractive landscape, and reduced water bills by saving water. Homeowners would be helping the environment by creating microclimates and reducing energy needs, reducing wastewater through reduced water applied to landscapes,

maintaining higher water quality return flows (assumed less pesticides and fertilizers), and assisting utilities to better deal with future water demand planning and demands. Water conservation can provide immediate benefits without requiring environmentally sensitive water projects.

The promotion campaign advertised project benefits to entice homeowners to join YARDX. The value of the provided landscape design, installation discounts, and project rebate were assessed as high as $1000 for the higher rebated properties.

The main benefits for the control group were the personalized analysis of their water use and maintenance expenses, and the comparison to other participants in the project. They also gained the satisfaction that they were helping their utility better determine the water use of traditional landscapes.

Two pre-existing Xeriscape demonstrations were dropped: Boulder and Colorado Springs. Boulder switched from being a new start demonstration to a pre-existing demonstration. They received a poor response from letters sent to homeowners who had previously been identified as having a Xeriscape landscape. Since Colorado Springs was already hosting two demonstrations, a retrofit and new start, they decided not to pursue a pre-existing demonstration as well.

OBSERVATIONS

During the promotion campaign, some success and lack thereof became apparent. The following lists some observations on these issues:

- The utilities with dedicated staff on the Project had better signup results.
- Signups for the retrofit treatment group progressed better than for the new starts (about 13 percent better) despite marketing for only two retrofit demonstrations compared to three new start groups. The smaller population of new homeowners (compared to the number of homeowners with existing landscapes) indicated they were overburdened with new home expenses and tasks and thus were reluctant to commit to a new type of landscape. Often their builders provided Kentucky bluegrass in parts of their yard, diminishing the need for a complete landscape. Additionally, many homeowners had small children who needed grassy areas for play and chose mostly turf landscapes.
- After newspaper articles were published about YARDX, the utilities were inundated with inquiries (Denver about 150 phone calls and Colorado Springs about 1400). Most of these callers lacked sufficient interest to proceed.
- The Fargo, North Dakota, Xeriscape study also experienced new start signup rates less than initially anticipated, despite using a higher rebate amount of $1200, or four times the YARDX new start rebate of $300 and twice the retrofit rebate of $600. However, the Fargo rebate did contribute to an increased interest in the retrofit demonstration.

CHAPTER FOUR

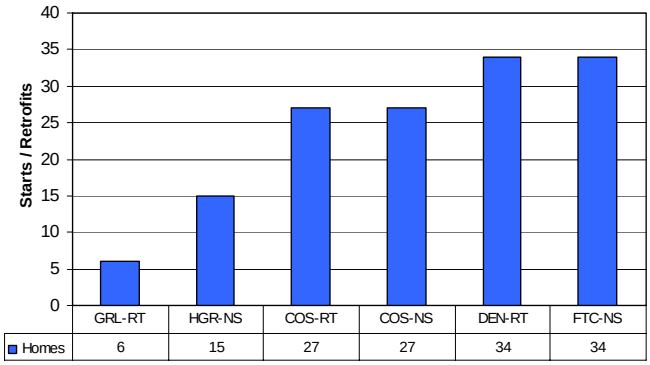
Installation Cost of Xeriscape

INTRODUCTION

Estimation of the cost of installing Xeriscape was one of three major goals of the YARDX study. The cost of Xeriscape will likely impact its level of implementation. Participants in Xeriscape samples of six demonstrations (excluding the pre-existing group) were asked to submit receipts of costs of materials and labor pertaining to installation of their landscapes. Because many homeowners provided some or all of the installation labor, they were asked to track their work hours as well as expenses. YARDX tabulated participant information. Similar information was not requested from control properties, so as not to potentially influence their water use. As a result, no treatment/control installation cost comparison was conducted.

COST DATA QUALITY

To ensure a high response and data quality, Xeriscape participants were not given a cash rebate until they had submitted a list of all of their expenses along with receipts and a total of their related work hours broken down by irrigation and other construction work. YARDX reviewed all participant-submitted paperwork and categorized expenses into 11 groups, including plants, hardscape, mulch, walls or drainage, irrigation, home labor hours, contractor hours, contractor costs, non-Xeriscape costs, other Xeriscape expenses, and discounts received. A total of 143 participants from 6 demonstrations submitted landscape cost data. Figure 4.1 shows data contribution by demonstration.



COS-NS = Colorado Springs new start
COS-RT = Colorado Springs retrofit
DEN-RT = Denver retrofit
FTC-NS = Fort Collins new start
GRL-RT = Greeley combined new start & retrofit
HGR-NS = Highlands Ranch new start

Figure 4-1: Number of new start (NS) and retrofit (RT) Xeriscapes providing installation costs.

COST ESTIMATION

Determining the average cost of a Xeriscape was a goal of YARDX. Categorization of cost data also enabled determination of the costs of different landscape components. Studying cost data suggested that extraordinary costs associated with substantial land preparation be analyzed separately from other invoice costs. These include costs such as grading that generally is conducted by builders, retaining walls, drainage issues, and non-Xeriscape expenses such as fences, dog runs, playgrounds, birdbaths, storage sheds, and large equipment or tools.

Homeowners received substantial discounts from nurseries and other providers of landscape materials as a result of participation in YARDX. As a consequence, one-half of vendor discounts were considered extraordinary and added to invoice costs to simulate typical cost. The special vendor discounts had been negotiated specifically for YARDX participants and were not available to the general public. The vendor discounts were an additional benefit to participants for joining YARDX. One-half of discounts for YARDX were considered a reasonable estimate of discounts obtainable by the general public.

YARDX properties varied in area. Consequently, cost per square foot was computed to compensate for area differences. Figure 4-2 presents the average area of landscapes in each Xeriscape sample. This figure shows the relative size of landscapes on average. Property landscape size was reduced by "dryland" area where appropriate. Dryland is defined as an area with sparse, native vegetation that receives only natural precipitation and has no irrigation system. Only one retrofit property area (in Colorado Springs) was impacted by this adjustment.

The retrofit landscapes of demonstrations in Greeley, Colorado Springs, and Denver contained areas of pre-existing plants not replanted. Consequently, nonreplanted areas did not contribute to landscape costs. This suggested adjustment of area used in computations, for nonreplanted area. However, only the Denver demonstration pre-existing area measurements were consistently logged, adequate for making adjustments. Some retrofit homes retained existing turf in their landscapes in small, separate areas difficult to accurately measure. No adjustment was made in Table 4-3 for nonreplanted areas in the remaining two retrofit demonstrations, Colorado Springs and Greeley. The adjustment effect on installation cost per square foot for the Denver demonstration is an increase of 7.9 percent. An estimate of the underestimate of cost per square foot for the Colorado Springs and Greeley retrofit demonstrations is Denver's 7.9 percent

increase. The average area given for Denver in Table 4-2 does not contain the correction of 222 square feet (reduction) for removing nonreplanted area to obtain cost per square foot.

The majority of the installations were completed in 1998 with a few extending into 1999. For an estimate of installation costs in 2005, an inflation adjustment would need to be applied. Appendix D discusses an estimate of the multiplication factor, 1.1543, that can be applied to current estimates to obtain approximate 2005 installation costs.

AVERAGE INSTALLATION COSTS

Figure 4-3 presents the average Xeriscape installation costs per square foot for each new start and retrofit demonstration. The figure indicates a relatively narrow installation cost range from $0.83 to $1.43 per square foot. The figure shows a $0.60-per-square-foot difference between the costliest demonstration average in Highlands Ranch (a new start demonstration) and the least expensive average for the Colorado Springs retrofit. It is noted that applying the Denver factor estimate of 7.9 percent (more costly) for excluding pre-existing area to the Colorado Springs and Greeley retrofit costs of Figure 4-3, would adjust their costs to $0.90 and $1.06 per square foot, respectively.

For comparisons, homes were grouped into three categories: new starts with automatic irrigation, retrofits with automatic irrigation and the Denver retrofit group with manual irrigation. Regarding the two groups with automatic irrigation, the difference in installation cost is about $0.38 per square foot less costly for the retrofits. This difference is about 25 to 30 percent less expensive for installing retrofits. Other average cost outcomes include:

- The Colorado Springs new start cost is $0.40 per square foot more than its companion retrofit (adjusted by excluding pre-existing area).
- The hose-drag Denver retrofit cost is $1.12 per square foot, $0.22 more per square foot than the Colorado Springs retrofit (adjusted) with automatic irrigation. It is not clear what caused this noticeable difference.
- New starts with automatic irrigation cost about $1.36 per square foot.
- Irrigation system costs in retrofits averaged $0.14 per square foot (30 homes).
- New start irrigation systems averaged $0.29 per square foot (74 homes).

Overall, lower cost averages for the retrofits suggest some financial benefit by having an existing landscape. The retrofitted homes may have modified an existing irrigation system, kept part of their turf, or transplanted some existing plants to save costs. Also, retrofits only occasionally needed to deal with retaining walls and drainage issues. Hardscape may already have been in place, or could have been enhanced inexpensively.

The Denver retrofit group did not install irrigation systems, yet they had higher install costs than their retrofit counterparts with automatic irrigation. The Denver landscapes were smaller than those in other demonstrations, and perhaps this caused some loss of economy.

The Fort Collins new start average installation cost of $1.34 fell within the average cost of the other new starts, despite involving large properties and higher family affluence. Perhaps homeowners in Fort Collins benefited from some economy of large properties. On the other hand, Highlands Ranch, with smaller properties, may have lost economy, yielding the highest average install cost of $1.43 per square foot.

When installation costs were stratified by considering only properties classified as full Xeriscapes, differences between retrofits and new starts narrowed. Data were pooled across demonstrations for these computations.

- Based on 22 properties, the retrofit average cost per square foot was $1.26.

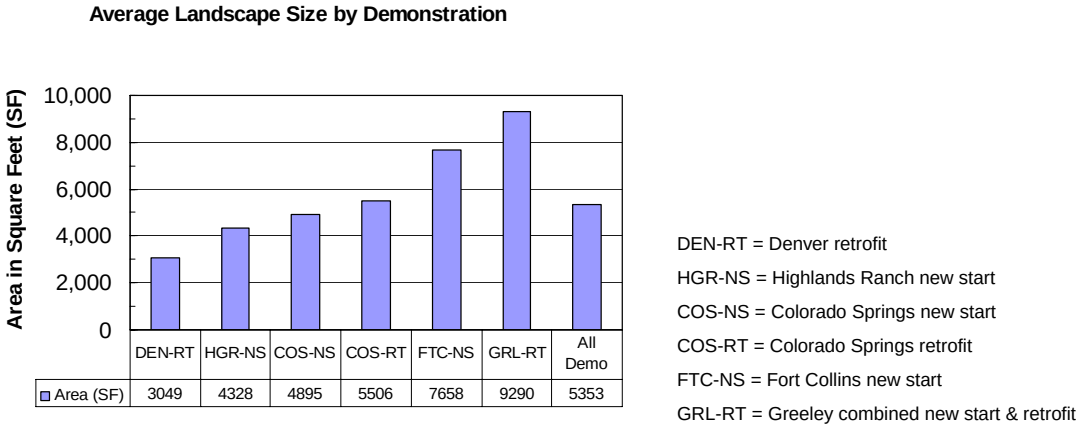


Figure 4-2: Average landscape size by demonstration.

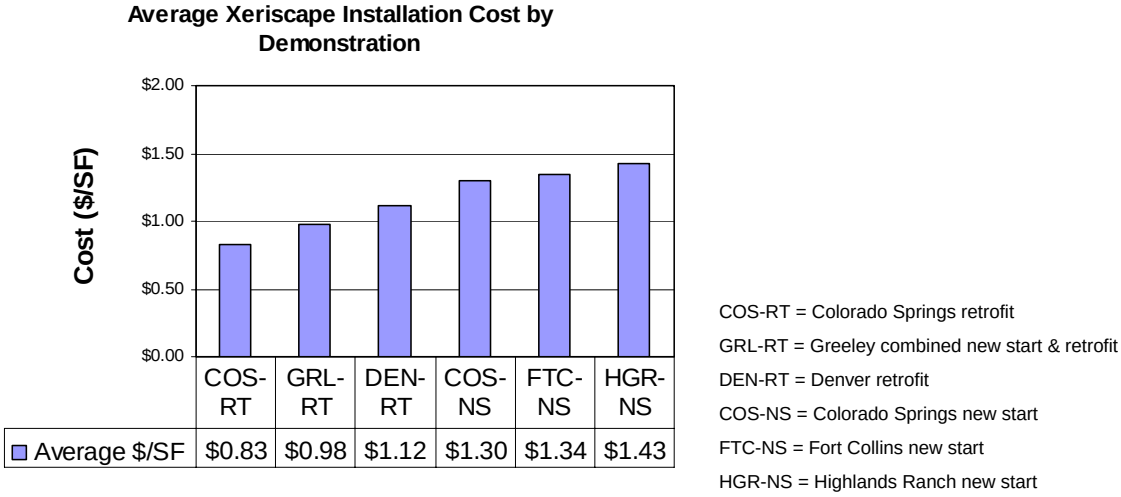


Figure 4-3: Average Xeriscape installation cost per square foot by demonstration.

- Considering 53 properties, the new start average cost per square foot was $1.36.

Because of the difficulty in estimating the area not planted for YARDX in properties, estimates given in Figure 4-3 for retrofits are smaller than the $1.26 given above estimated from full Xeriscapes. Because of the estimation difficulty for those properties not fully (newly) Xeriscaped, the $1.26 is considered a more realistic estimate of cost per square foot for retrofits. This retrofit cost and the $1.36 per square foot for new starts show minor cost differences. This outcome is plausible and not surprising.

The project's range of average Xeriscape installation costs is considered relatively

Costs were determined for extraordinary landscape items for 40 participants who incurred these costs. These numbers show that retrofits spent almost double the average amount spent by the new start owners (87 percent more). Nevertheless, these numbers provide useful guidance.

- Considering retrofits, the average extraordinary Xeriscape expenses per home were $1,432 (12 homes).
- Considering new starts, the average extraordinary Xeriscape expenses per home were $768 (28 homes).

Over twice the number of new start homes incurred extraordinary costs than did the retrofits. Presumably, many of the retrofits had already addressed these issues in their pre-existing landscape. There is the possibility that sample size effects of 12 homes may have partly led to the higher value of $1,432. Also, the retrofit yards tended to be larger than the new starts, possibly increasing costs for more materials.

INSTALLATION LABOR

The cost figures in Figure 4-3 and of extraordinary costs discussed do not include a cost estimate for homeowner labor input to installations (but do include any out-of–pocket labor costs).

The relatively modest cost per square foot may be due to substantial homeowner labor contribution to installation. Labor costs were analyzed when homeowner receipts allowed categorization. Labor costs were designated as mixed if (1) the homeowner hours or contractor hours and cost information were not discernable from the paperwork, or (2) the contractor costs were less than 75 percent of the total installation cost and no homeowner hours were logged.

- Five percent of homeowners hired contractors to do 75 percent or more of the installation (7 homes).
- Twenty-seven percent of homeowners performed all the work (38 homes).
- Sixty-eight percent of homeowners hired contractors to do some of the work (98 homes).

The average installation cost per square foot was calculated for the above three labor breakdowns: mostly contractor installed, homeowner installed, and mixed labor installed. Considering only nonextraordinary installation costs, contractor-installed landscapes were most expensive, followed by mixed labor, followed by homeowner installed, as would be expected. Costs increased approximately 85 percent per square foot from homeowner to mixed labor and about a 66-percent increase from mixed labor to mostly contractor-provided labor. Costs nearly tripled from homeowner-provided labor to mostly contractor labor.

- Landscapes installed mostly by contractors cost $2.16 per square foot (7 homes).
- Mixed-labor-installed landscapes cost $1.30 per square foot (98 homes).
- Homeowner-installed landscapes cost $0.70 per square foot (38 homes).

Further analysis of homeowner labor input can be seen in Figure 4-4. This figure shows the relative homeowner labor contribution to landscape construction and irrigation system installation, stratified by demonstration retrofit and new starts. The chart statistics represent only installations by the homeowner. Because the data would not allow separation of contractor labor hours from total contractor costs, properties were selected without contractor costs to estimate the number of hours to install a Xeriscape.

- New start homeowners spent about 40-percent less time on construction of landscapes than retrofits.

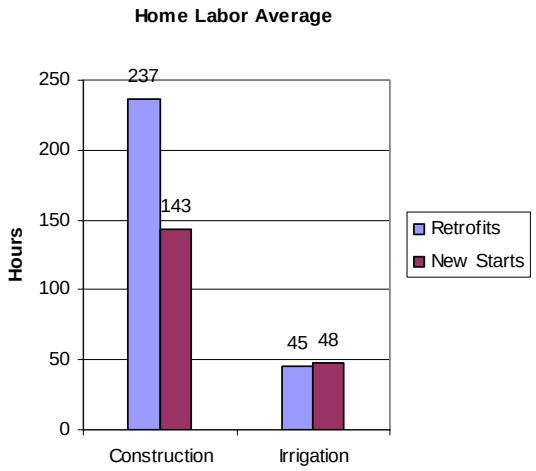


Figure 4-4: Installation hours by homeowner labor only.

- New start owners spent an average 143 hours per property in construction (11 homes).
- Retrofit owners averaged 237 hours per property in construction (27 homes).
- Retrofits (18 homes) and new starts (11 homes) spent about the same amount of time installing their automatic irrigation systems (45 and 48 hours).
- The new start group spent an average of 25 percent of their total installation time on irrigation systems.
- The retrofit group spent an average of 16 percent of their total installation time on irrigation systems.

The difference in construction time between retrofits and new starts is not easily reconciled. Perhaps retrofits spent more time removing the old landscape and in the land preparation phase. Also, retrofit groups may have included more retired homeowners with more time to spare.

It is instructive to estimate the Xeriscape construction time per 1000 square feet of landscape. Estimates were made solely for the homeowner-provided labor cases. The landscape area used is that used previously to calculate the average installation cost per square foot.

- The retrofits spent an average of 59 hours per 1000 square feet to install their Xeriscape (18 homes).
- The new starts spent an average of 50 hours per 1000 square feet to install their Xeriscape (11 homes).

These numbers provide useful estimates of homeowner Xeriscape installation time.

COSTS OF PLANTS AND HARDSCAPE

The installation costs were stratified into 11 major landscaping categories. Two categories consisted of plants and hardscape. The average cost per square foot was determined for each category, by retrofit and new start stratum. The plant calculations included all types of plants (including turf).

Documenting cost per square foot was the desired goal. To calculate average cost of plants per square foot, the project team subtracted from the total landscape area these components: the area covered by pure mulch, all hardscape, and any dryland. The averages were computed for only those homes that had identifiable expenses for the category of interest. Data were pooled across demonstrations.

Plants

- For retrofits, the average cost was $0.38 per square foot (65 homes).
- For new starts, the average cost was $0.49 per square foot (75 homes).

Hardscape

- Average cost was $1.74 per square foot (38 homes) for retrofits.
- Average cost for new starts was $4.63 per square foot (51 homes).

On average, the cost per square foot for plants and hardscape was noticeably higher in the case of new starts.

CHAPTER FIVE

Water Use Comparisons

INTRODUCTION

A prominent goal of the YARDX project was to assess whether Xeriscape landscapes save water over traditional landscapes. Determining this involved comparing water use between treatment (TR) samples and their counterpart control (CN) samples. Comparisons were needed for each demonstration. Cross-demonstration comparisons were also of interest.

Demonstration sample selection procedures were aimed at reducing within-demonstration variation, except for landscaping type (Xeriscape or high-water-use turf). Cross-demonstration differences involved different settings of some demonstration characteristics, such as soil type. Within-demonstration comparisons of TR and CN samples, or within-sample comparisons between individual landscapes, were less likely to have water difference estimates masked by high variability. Impacts on water use assessment caused by differing weather, soil type, and family affluence were lessened by the substantial efforts expended by YARDX to enlist control properties with characteristics similar to the companion Xeriscape yards.

Efforts were made to minimize companion sample differences in several subtler variables, such as landscape exposure (effects of wind), shadiness, and area of landscape on steep slopes (15 degrees and steeper). These data were collected on all YARDX properties.

Several water use relationships were also of interest. These included water use amount versus Xeriscape age, or whether water application per unit area of landscape seemed to

differ according to landscape size or family affluence.

WATER DATA

Utilities routinely collect water use information monthly or bimonthly. Water meter readings were provided to the YARDX project for analyses. Table 2-1 shows the periods of water data obtained by YARDX.

The water data possessed a number of differences. Landscapes differed in month and day-of-month of initiation of irrigation. The differing number of properties per sample, using water in the initial months of each demonstration, was important. Because the monthly water use per square foot was the basic assessment of interest, the initial month was eliminated for a property when more than the initial 4 days (of the month) had missing data. If the number of properties in the initial months of incomplete samples (CN and TR) of a demonstration, differed by more than three properties beyond full sample difference, months were truncated until samples were within three properties difference of their full sample configuration.

Meter readings occurred on differing days of months. Consequently, average water use per day was computed for each metering period, using the water use total and the day count per period. Water use rates were used to compute monthly total use. Monthly water use totals were then divided by landscapable area to obtain monthly water use per square foot. These values became the basic data analyses unit for conducting TR and CN sample comparisons.

Generally, water use data were available from mid-1998 or early 1999 through 2002. The growing season months were selected as April through October. Estimation of growing season water use, with the exception of the Highlands Ranch demonstration, had to be derived from readings from the single utility-provided home water meter. The home meter registers indoor plus outdoor water use. Outdoor monthly water use was estimated by subtracting the average winter monthly use from growing season monthly computed values. For these adjustments, the indoor use average was computed from January, February, November, and December monthly computed values encompassing each growing season. The project team felt that using the average of "encircling" months best represented indoor use for each growing season.

The water utility at Highlands Ranch offered a second water meter for their demonstration participants, to assess the outdoor water use. Homeowners of TR and CN landscapes installed the meters. For the growing seasons of 2001 and 2002, outdoor water use readings were incorporated into the database for Highlands Ranch. The outdoor readings more accurately determined the landscape water use than winter-corrected house meter readings. The data were incorporated with winter corrected data for the 1998 through 2000 growing seasons. As the number of participants in the Highlands Ranch demonstration was less than the desired 30, the more accurate summer data for 2 years seemed to somewhat offset the impact on data variability caused by the smaller data samples.

Yearly winter water use for comparisons between samples was estimated by the average of monthly estimated values for January through March and November and December. In making winter use comparisons, the water data were not divided by landscape area, because outdoor watering was not involved. In YARDX demonstrations, March can be a transition month, during which minor outdoor watering may occur in some years. In the Front Range, March is, on average, a snowy month.

Other adjustments were applied to water use data samples as necessary. Data truncation occurred when a participating property was sold and the new owner altered the landscape with revisions no longer in character with the particular demonstration. In a few cases, owners abandoned care of the landscape. The level of landscape revisions generally considered excessive for YARDX purposes was established at 30 percent of area of the water use zone in question. Such revision would likely impact landscape installation costs, maintenance and water use. Water use data sets were truncated at the estimated date of revisions.

WATER USE COMPARISONS

Water use data for an individual homeowner typically consisted of 45 to 65 monthly values, depending on when landscape irrigation and meter readings began. Thus, the database for a demonstration sample of 25 participants could contain over 1200 monthly water use readings.

Pooling the monthly values for TR and for CN separately, and computing basic statistics for each group, indicated the data to be positively skewed. In such circumstances, averaging may provide an unrealistically large estimate of centrality. An alternative estimate, the median, is often preferable. Consequently, the medians of the pooled samples are used here for comparisons.

Figure 5-1 presents a plot of Denver homeowner average monthly water use during summer, versus landscapable area, over all growing seasons. This figure shows the within-demonstration variation of Denver participant water use with corresponding landscapable area. The curve represents the application of the Lowess (Cleveland, 1979, 1981) moving-window smoother. The figure is an example of how water use may vary with landscape area. The plot shows the tendency of higher water application in the smaller landscapes regardless of CN or TR properties. Computing water use per unit area for comparisons was aimed at removing some effects of differences in watering area. Demonstration sample average property area is given in Table 5-1.

Figure 5-2 presents table values and a pictorial comparison of growing season median monthly water use in gal/ft², applied in outdoor use for the TR and CN groups for each demonstration.

The median is obtained from pooled April through October monthly, indoor-adjusted water use for all years of data. The water use units are monthly values, so the median represents the middle monthly value (similar to the average monthly use during the growing season). The results, either evident or suggested, in Figure 5-2 are:

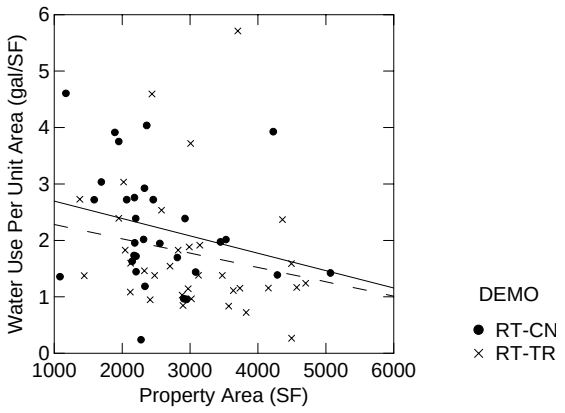


Figure 5-1: Denver water use per unit area (ft^2) versus landscape area in Denver. (RT-CN = Retrofit Control, RT-TR = Retrofit Treatment).

- Control median water use ranged from a low of 1.8 gal/ft^2 in the Denver and Colorado Springs retrofits, to a high of 2.9 gal/ft^2 in the Greeley demonstration of 4 control properties.
- The new start CN traditional landscapes used more water than the established older CN landscapes selected for the retrofits.
- Xeriscape median water use ranged from 0.8 gal/ft^2 at the Highlands Ranch new start demonstration to 1.9 gal/ft^2 at the Arvada/Wheat Ridge pre-existing demonstration.
- TR median water use was consistently lower than the corresponding CN use, except in the case of the Arvada/Wheat Ridge pre-existing study.

Table 5-1 gives percentages of growing season water use savings using sample group, median monthly water use computed per square foot of landscapable area, using growing season values adjusted for winter. Figure 5-2 presents a pictorial of the growing season results. Sample medians were computed from all seasonal monthly values from all properties per sample.

For the 2002 growing season, Xeriscapes in the Colorado Springs demonstrations indicated greater seasonal water use in Xeriscapes than respective control properties. As a consequence, year 2002 single season results, and project period results without 2002 data were separately

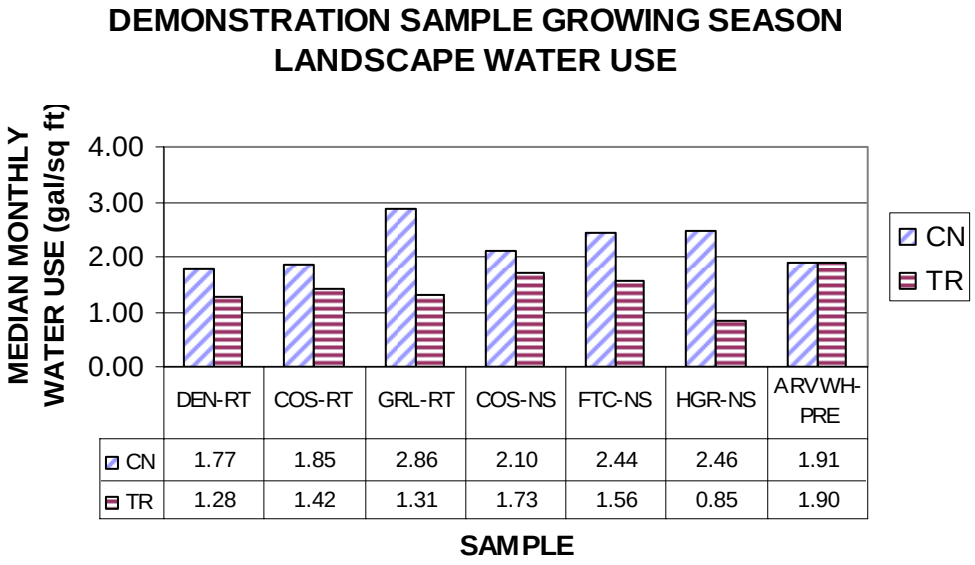


Figure 5-2: Water Use for the demonstration sample.

computed and are given in Table 5-1 and Figure 5-3.

Plausible explanations for the Colorado Springs year 2002 results include unrestricted watering regulation of Xeriscapes during the drought year. Xeriscape owners apparently hand watered their plants or used their drip irrigation systems allowable under the restrictions. Watering turf was more restricted and thus affected the controls more severely.

Table 5-1 and Figure 5-4 present winter median daily water use in gallons per day, computed from winter months January, February, March, November, and December. These values are not adjusted for differences in landscape area, as outdoor watering is very low during winter. Figure 5-4 indicates somewhat higher control winter use, but only minor treatment-control differences except for Arvada / Wheat Ridge and Highlands Ranch.

Table 5-1 also contains P-values, the probability that sample differences could have occurred by chance. The generally accepted significance value range is 0.05 or smaller for so-called significant difference. Because samples were large (except for 2002 water use examined separately and data from too few Greeley homes) and differences versus controls were large, the versatile, nonparametric, Wilcoxon (1947) two-sample rank test was applied to determine P-values.

Because the probability of detection of differences in small samples of water use data is undesirably small, P-values were not calculated for 2002 data solely, or for Greeley data comparisons.

Computation of water use savings between Xeriscape samples and respective control properties ranged from 18 percent savings in the Colorado Springs new start demonstration (28 percent in data without year 2002 water use values) to 63 percent water savings in the Highlands Ranch new start demonstration. All comparisons tested with the Wilcoxon method yielded P-values less than 0.01. The retrofit demonstration in Colorado Springs yielded a water savings of 23 percent (32 percent excluding year 2002 data) while the Denver retrofit demonstration (hose drag) produced a 28-percent savings. The new start demonstration in Fort Collins, consisting of large area, and more expensive properties, produced a 36-percent savings.

Table 5–1: Water use comparisons between Xeriscape and traditional landscape samples.

	Seasonal (Apr-Oct) water use savings (%) per square foot of landscapable area, using growing season values adjusted for winter[1] average use[2]			Seasonal savings without adjustment for area	Winter[1] median daily water use (gal/day) N=number of properties Landscape average area (A) in square feet	
Demonstration	**All project years**	**Years except 2002**	**Year 2002 only**	**All years**	**Xeriscapes**	**Control group**
Colorado Springs new start	18 savings P<0.01	28 savings P<0.01	50 increase	22 savings P<0.01	169 (N=27) A=4608	182 (N=37) A=5190
Colorado Springs retrofit	23 savings P<0.01	32 savings P<0.01	34 increase	24 savings P<0.01	194 (N=27) A=5374	191 (N=32) A=5472
Denver retrofit	28 savings P<0.01	26 savings P<0.01	33 savings	17 savings P<0.01	146 (N=34) A=3047	152 (N=31) A=2537
Fort Collins new start	36 savings P<0.01	39 savings P<0.01	29 savings	32 savings P<0.01	191 (N=34) A=7583	182 (N=38) A=8859
Highlands Ranch new start	63 savings P<0.01	69 savings P<0.01	63 savings	50 savings P<0.01	165 (N=13) A=3971	218 (N=17) A=3576
Greeley retrofit	54 savings	56 savings	30 savings	40 savings	130 (N=6) A=9290	185 (N=4) A=9348
Wheat Ridge & Arvada pre-existing Xeriscapes	1 savings P>0.05	1 savings P>0.05	3 savings	25 savings	164 (N=26) A=4068	198 (N=28) A=5558

[1] Winter months included January, February, March, November and December.

[2] P-values (probability that sample differences could have occurred by chance) are not given for small samples.

The water savings in the Arvada/Wheat Ridge demonstration was less than 1 percent (not statistically significant). The limited data samples from Greeley suggested water savings of 54 percent. The estimated high water savings of 63 percent in the Highlands Ranch demonstration appeared out of range with the other new start comparisons. The results could have been somewhat influenced by the occurrence of an imbalance in samples of zero water monthly values possibly caused by the drought. Determination of the possible influence of this feature called for in-depth investigation and analysis outside the scope of this study.

The retrofit demonstrations did not achieve water savings levels consistent with expected savings from the Xeriscape design developed for retrofits. This design called for Xeriscape plant area according to ⅓ low (or no), ⅓ moderate, and ⅓ high water use, and overall water savings of about 60 percent. Water savings may have been negatively impacted by some participants employing greater than ⅓ high water use area (of total landscape).

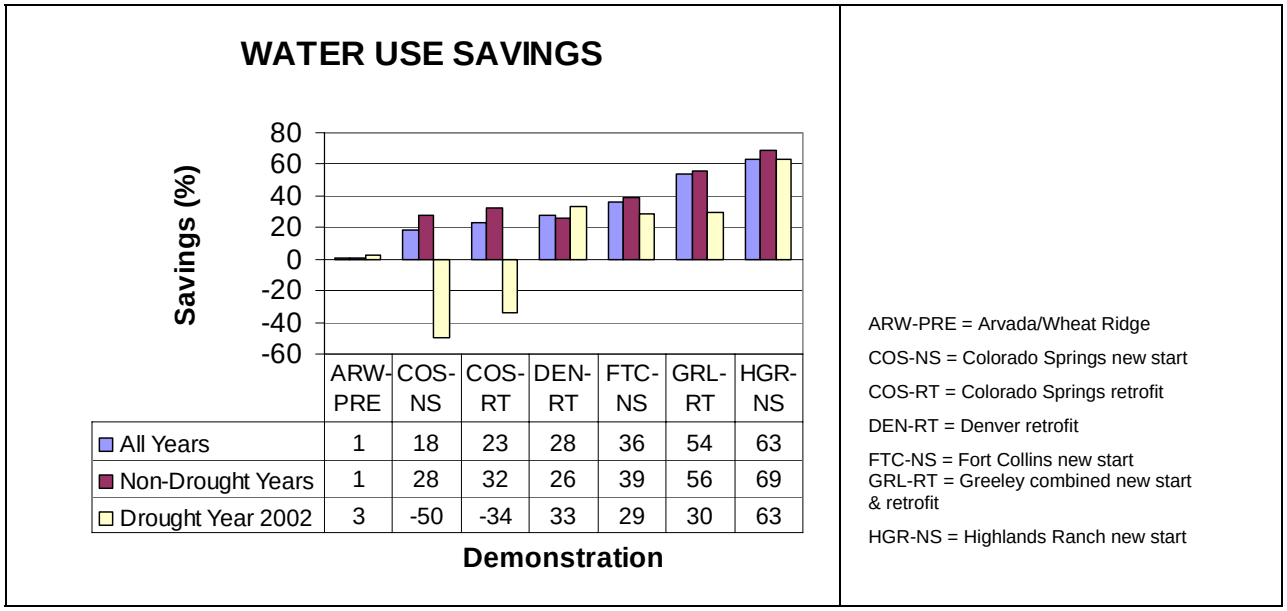


Figure 5-3: Demonstration water use savings by Xeriscape group over respective control group.

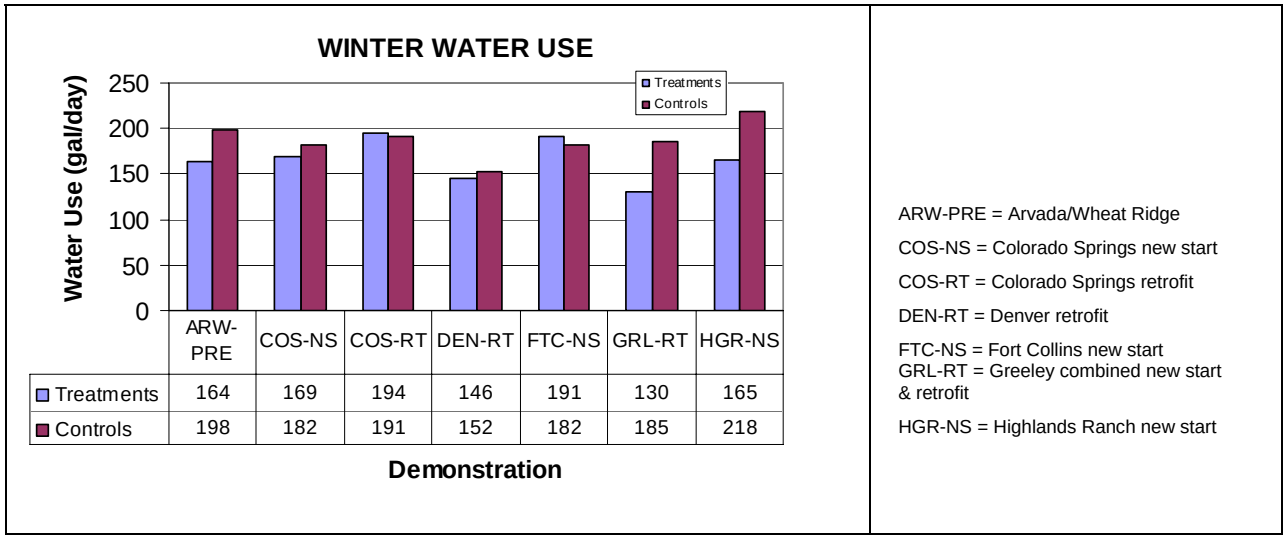


Figure 5-4: Winter water use.

The apparent lack of water savings in the Arvada/Wheat Ridge demonstration was surprising. These landscapes were estimated to be 5 years or older than landscapes of other YARDX demonstrations. Lack of water savings suggests savings may eventually decrease with landscape aging, unless proper maintenance and homeowner education is maintained. Plots of monthly water use with time, of other YARDX Xeriscape samples did not indicate a reduction in savings with time over the duration of YARDX. Figures 5-5 and 5-6 show, for the Denver and Colorado Springs demonstrations, the water use per square foot over time, month by month. The Lowess curves for water use in Denver show the water savings (amount of separation of curves) and the downturn in water use in 2002 by both TR and CN. The Lowess curves for Colorado Springs present the pattern of higher water use by TR in 2002.

Possible causes for nil (1%, statistically insignificant) water savings in the Arvada / Wheat Ridge demonstration include inadequate thinning of plants, occurrence of increasing plant root structure that required additional watering, and lack of knowledge by new owners on proper maintenance. Such detriments can be overcome by careful selection of plants upon installation, proper landscape maintenance, and the continuation of education programs on water-conserving landscaping.

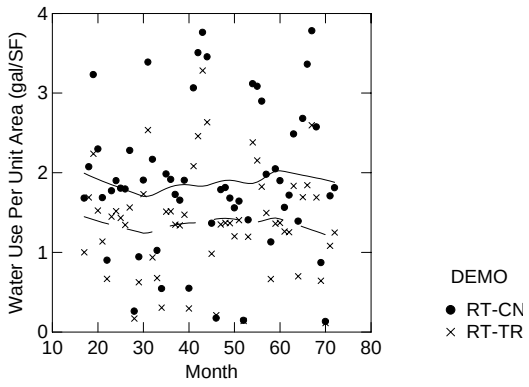


Figure 5-5: Denver water use in time for April 1999 – January 2002. (MONTH = Months since start of data [April 1999], RT-CN = Retrofit Control, RT-TR = Retrofit Treatment).

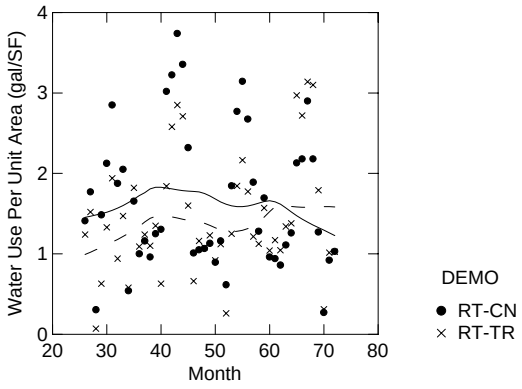


Figure 5-6: Colorado Springs water use in time for April 1999 – January 2002. (MONTH = Months since start of data [April 1999], RT-CN = Retrofit Control, RT-TR = Retrofit Treatment).

PRECIPITATION

It is well known that precipitation usually impacts landscape irrigation, particularly in properties using manual irrigation. Often, automated system properties do not benefit as well, because most irrigation systems do not include a rain sensor that can reduce irrigation when rainfall occurs, or property owners fail to temporarily shut off automated systems. Figure 5-7 presents annual rainfall at locations of the YARDX demonstrations (or nearby as in Cherry Creek and Lakewood). The figure indicates 1999 as the wettest year with most locations receiving 20 inches of precipitation or more (as in Colorado Springs). The driest year was 2002 with all locations receiving less than 10 inches. The difference between these extreme years is about one-third of the growing season requirement of Kentucky bluegrass. Average growing season precipitation varies from about 9 inches in Arvada and Greeley to about 13.5 inches in Colorado Springs, a relatively narrow range. Precipitation extremes of 1999 and 2002 and water restrictions due to drought influenced irrigation water demand.

Without question, the YARDX Xeriscapes saved water over their counterpart controls. These results suggest water savings in the 30s percentage should be readily achievable if Xeriscapes are properly planned, installed, and maintained. New start water savings appeared greater than those for retrofits, but attention to amount of turf in retrofits and appropriate irrigation could overcome this difference.

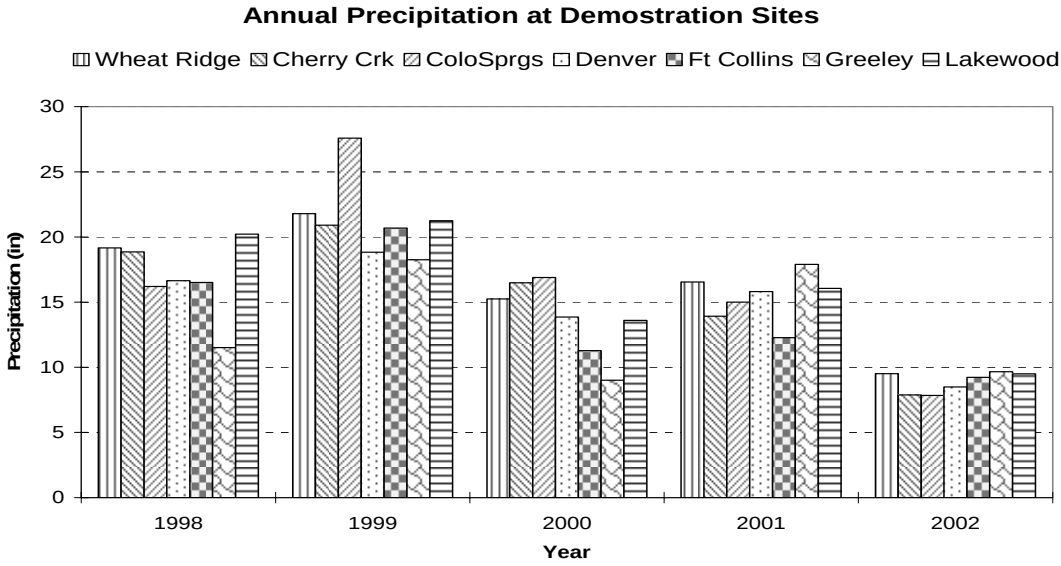


Figure 5-7: Annual precipitation at demonstration projects.

CHAPTER SIX

Maintenance Costs

INTRODUCTION

Estimation of landscape annual maintenance costs was one of three major goals of YARDX. Whereas installation costs were incurred up front, maintenance costs accrued over the duration of the project. YARDX did not have adequate funding of rebates to encourage tracking and periodic submission of costs. YARDX developed the forms shown in Appendix E for participants to tabulate costs and submit information after each growing season, November through February. Control participants were also provided cost data forms and encouraged to log and provide maintenance information. The control form was identical to that for treatments, other than the word "YARDX" was removed. Again, control participants were not told their information would be compared to that of Xeriscape samples to lessen the possibility of influencing control water use. YARDX mailed a second request for information in January to those homeowners who had not yet responded.

DATA QUALITY

Overall, response from Xeriscape samples for maintenance cost information was less than desired. Xeriscape participants had a 46-percent response rate, while controls managed only a 23-percent response. In combination, the response rate was 34 percent.

Reporting of maintenance information during the project was erratic. Participants reported at some times and not others. Some never turned in a report. Very few turned in all requested reports.

MAINTENANCE COST CALCULATIONS

As with installation costs, it was desirable to factor out the disparity in landscape area differences by estimating the annual maintenance cost per unit area. Participant landscape area was reduced by dryland area and "pure mulch" area (generally a rock area without vegetation and irrigation). Little or no maintenance is applied to dryland areas, especially if a fabric weed barrier is installed (recall that dryland impacted only one retrofit home in Colorado Springs). The pure mulch area was subtracted, because minimal or no maintenance is required, especially during the first several years, and pure mulch areas are sometimes quite sizeable (as in area between houses), which could improperly distort average annual maintenance cost per square foot. Remaining landscape area was that area requiring routine maintenance and irrigation. Table 5-1 gives the adjusted average area per demonstration for comparison with average areas of Figure 4-2 that include pure mulch.

To accurately calculate all maintenance, an accounting procedure of time spent was required. After some discussion with YARDX utility representatives, the project team decided to apply a rate of $18 per hour for noncontract labor provided by homeowners. The $18 rate was intermediate between an unskilled labor rate and a professional contractor rate.

All maintenance reports were scanned for comments that suggested an inappropriate entry. Occasionally, an expense was claimed that was clearly a capital expenditure, such as a new fence. These were removed when they could be clearly identified. Also filtered out were installation costs, mostly recorded in the early years (1997-1999) while many homeowners were still completing their landscapes. Only 12 homes were found to have apparent installation costs recorded on their maintenance reports. Most of these costs were either already included in the installation costs or were capital expenditures that occurred after installations were completed and thus were not routine maintenance items.

As a final adjustment, maintenance surveys were eliminated that came from participants who were dropped from the project. Drops generally occurred because of noncompliance with project guidelines, such as property conversion to a rental, or substantial alteration of the landscape or irrigation type. There were 12 drops in 7 demonstrations.

To calculate the demonstration's average annual maintenance cost per square foot, the following steps were performed:

- A participant's annual maintenance cost per adjusted square foot was determined for each year reported. A time average of interest, such as the first 3 years and the last 3 years, was obtained by averaging over the years within the specific time period of interest. Two time periods of interest, 1997-1999 and 2000-2002, were individually averaged to obtain two values for each participant. These two periods allowed comparison of plant establishment maintenance versus the mature plant phase.

- A group or demonstration sample average was obtained by averaging over the individual time average that was each "report weighted." The individual weights were determined by dividing an individual's number of reports in a period of interest by the total number of reports for all in that period. The "report weighted" averages for a demonstration sample were summed over the individuals in that group to obtain the (weighted) average annual maintenance cost per square foot per demonstration.

No adjustments were made for inflation.

MAINTENANCE COST RESULTS

Maintenance data were stratified according to the periods 1997-1999 and 2000-2002 to examine whether maintenance costs increased from the plant establishment period to the mature plant phase. Figure 6-1 presents average annual maintenance costs for each demonstration,

stratified by timeframe. It should be noted that the Greeley demonstration consisted of too few participants to conduct desired data comparisons.

The following discusses the results given in Figure 6-1:

- Treatment average annual maintenance costs other than Greeley ran $0.34 to $1.33 per square foot, yielding a range of about $1.00.
- Controls average annual maintenance costs other than Greeley ran $0.27 to $1.44 per square foot for a range of $1.17.
- During the first time period (1997 – 1999), five of six treatment demonstrations yielded average annual maintenance costs less than their control counterparts.
- In the latter time period (2000 – 2002), three of seven treatment demonstrations yielded average annual maintenance costs less than their control counterparts.

On the other hand, comparing the treatment and control groups within their own peer group (treatment groups, control groups), yielded the following:

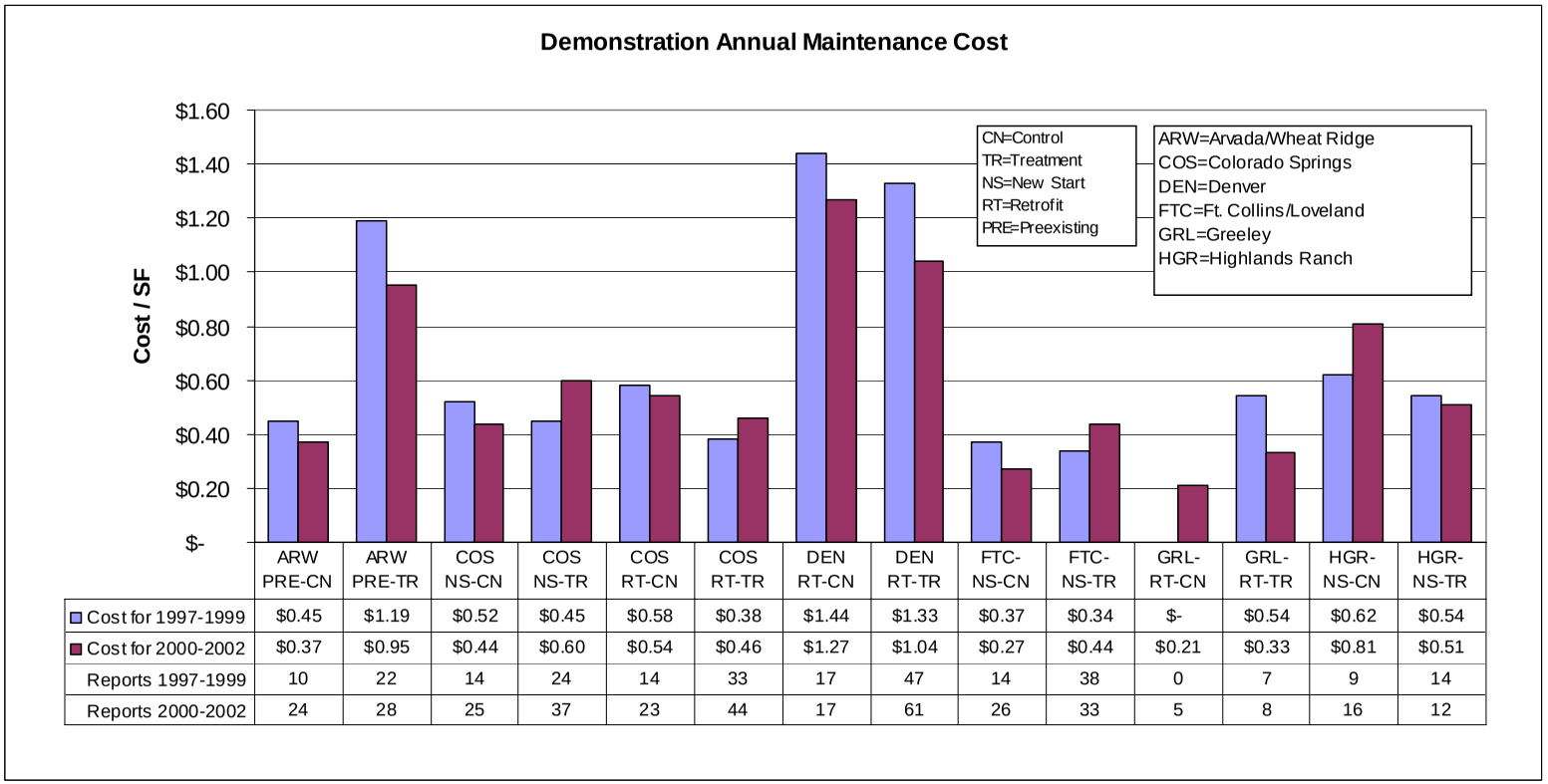
- During the second time period (2000 – 2002), four out of seven treatments experienced a decline in their average annual maintenance costs from the first period. This is a fairly likely outcome if in fact no difference exists between period maintenance (similar to obtaining four heads in seven tosses of a fair coin).
- Control demonstrations experienced a decline in annual maintenance costs in five of six demonstrations, from the first period through the second period. This is a far less likely outcome if controls do not, in fact, experience declining maintenance after plant establishment.

These results show that treatment maintenance costs were lower than those for traditional landscapes during the establishment period, but become comparable or greater thereafter. In three of the treatment demonstrations (both Colorado Springs groups and Fort Collins), the maintenance costs increased from the first period to the second period, possibly reflecting an increasing need for weeding and thinning of those Xeriscapes. Only one control group showed an increase (Highlands Ranch).

There are two other interesting trends of note. First, the older, pre-existing Xeriscapes in Arvada/ Wheat Ridge tended to have relatively high average annual maintenance costs compared to most other treatment groups with the exception of Denver. The Denver Xeriscapes and controls had the highest maintenance costs of any group during the early and later years. The Denver treatment group had high environmental orientation as indicated in Figure 7-2. Denver treatments also indicated spending more time on maintaining their Xeriscapes over previous traditional landscapes (Appendix G, question 20).

Two demonstration design features were shared by the Denver and Arvada/Wheat Ridge demonstrations: "hose drag" (manual) watering, and older landscapes. Denver was the only hose drag watering system demonstration in YARDX. Both treatments and controls had to manually water their landscapes. In the Arvada/Wheat Ridge study, the project team accepted whatever type of watering system was in place. A few homes had manual systems, while a larger number had automated spray heads in their turf, but hand watered their flower beds and vegetable gardens. Still others had fully automated systems for their entire landscape. After reviewing their installation audits, about 50 percent (14 out of 28) of the Arvada/Wheat Ridge controls had some aspect of manual watering, as did the Xeriscapes (13 out of 26). However, high annual maintenance costs are only seen in the Arvada/Wheat Ridge treatment group.

The Arvada/Wheat Ridge controls had costs comparable to other control demonstrations in the study. In fact, they had lower maintenance



	ARW PRE-CN	ARW PRE-TR	COS NS-CN	COS NS-TR	COS RT-CN	COS RT-TR	DEN RT-CN	DEN RT-TR	FTC-NS-CN	FTC-NS-TR	GRL-RT-CN	GRL-RT-TR	HGR-NS-CN	HGR-NS-TR
Cost for 1997-1999	$0.45	$1.19	$0.52	$0.45	$0.58	$0.38	$1.44	$1.33	$0.37	$0.34	$-	$0.54	$0.62	$0.54
Cost for 2000-2002	$0.37	$0.95	$0.44	$0.60	$0.54	$0.46	$1.27	$1.04	$0.27	$0.44	$0.21	$0.33	$0.81	$0.51
Reports 1997-1999	10	22	14	24	14	33	17	47	14	38	0	7	9	14
Reports 2000-2002	24	28	25	37	23	44	17	61	26	33	5	8	16	12

Figure 6-1. Demonstration maintenance cost and number of maintenance reports from all homeowners per each demonstration

costs than the Colorado Springs retrofit controls (also with somewhat older landscapes but with automated irrigation) and several of the new start control groups as well (Colorado Springs and Highlands Ranch).

It is not clear why there are higher maintenance costs in only the pre-existing treatment group. One possibility is that the care of older Xeriscapes takes more time. Perhaps, more weeding and thinning of plants, transplanting, and pruning add up to more maintenance. This could have also been a contributing factor in the Denver demonstration's high costs, since the landscapes were older and some pre-existing landscape was left unchanged. However, in the Colorado Springs retrofit demonstration, homeowners did not report these high maintenance costs. Further study may be able to shed light on these discrepancies.

Yet another possibility is that data quality may have played a role in the maintenance cost results of Denver and Arvada/Wheat Ridge. It is possible that some hose drag homeowners recorded the time their sprinklers operated rather than their personal time in accomplishing the watering. One may speculate that homeowners willing to install Xeriscape as a retrofit or those who installed Xeriscape years ago, tended to be more environmentally conscious and more prone to enjoy gardening. Cross-referencing results here to the Final Survey outcomes are discussed in Chapter Seven. Study of homeowner maintenance labor hours, versus contractor time, versus material costs compared with Final Survey responses may shed more light on environmental inclination.

MAINTENANCE EDUCATION

Two types of maintenance education were conducted throughout the study timeframe. First, maintenance seminars were held for all the Xeriscape homeowners except those in the Arvada/Wheat Ridge pre-existing study. Secondly, an annual newsletter was sent out each fall to this same group of Xeriscape homeowners.

Three maintenance seminars were held in YARDX municipalities after landscape installation. One seminar was held in Fort Collins for the Fort Collins and Greeley homeowners, a second one was presented in Denver for the Denver and Highlands Ranch groups, and one was held in Colorado Springs for the two demonstrations there. Overall, the maintenance seminars were poorly attended.

The seminars lasted approximately 2 hours and covered topics such as lawn care, irrigation, trees and shrubs, and perennials. Homeowners were also given handouts, including those compiled by the Colorado State University (CSU) Cooperative Extension on various landscape-related subjects. The local CSU Cooperative Extension phone numbers were also made available for future homeowner questions.

The annual newsletter included an update on the project, but most importantly, landscape maintenance tips. These tips were focused on problems that the field auditors saw during their site visits. A sample newsletter can be found in Appendix I.

No discernible trend in maintenance costs was apparent between the YARDX-trained Xeriscape participants and the untrained Arvada/Wheat Ridge Xeriscape homeowners. Several items may have contributed to these indistinct results on maintenance training. The training effect signal may be small and be easily confounded by other influential factors. How many participants read the newsletters and/or training materials is unknown.

The person(s) actually performing the maintenance may have had little exposure to education on maintenance. The poor attendance at the YARDX maintenance seminars suggests less than desired training was absorbed. Lastly, response to the maintenance information requests was low.

CHAPTER SEVEN

Final Survey

INTRODUCTION

A Final Survey was mailed to all participants of the YARDX project. The survey was conducted during the October 2002 to February 2003 period. Its purpose was to sample participants' attitudes toward Xeriscape, the environment in general, and water conservation at project end. The Final Survey developed for controls did not include questions relating to Xeriscape landscapes (installation costs, maintenance, training, rebates, etc.). Also, the control form did not reference "YARDX". In the Final Survey for pre-existing Xeriscapes, two questions were eliminated regarding project rebates and instructional seminars in which they did not participate.

Figure 7-1 presents participant response rates to the Final Survey. Response rates varied from 16 percent to 58 percent of total participants in the various sample groups. These overall results excluded the Greeley control group, which was very small and replied 100 percent to the Final Survey.

Generally, the controls were less faithful at responding to the Final Survey. The controls' response rates were lower than their treatment group in all demonstrations except two, Greeley and Highlands Ranch. The overall response rate for all the controls in YARDX was 33 percent, and for the treatments it was 50 percent.

Summarized Final Survey results for all demonstrations can be found in Appendix G.

Questions 1 through 8 included queries on water-saving appliances and number of people living in the home, etc., which were not used to gauge attitudes but did assist in the property's water use analysis. These eight questions were sent to all participants annually. Questions 28

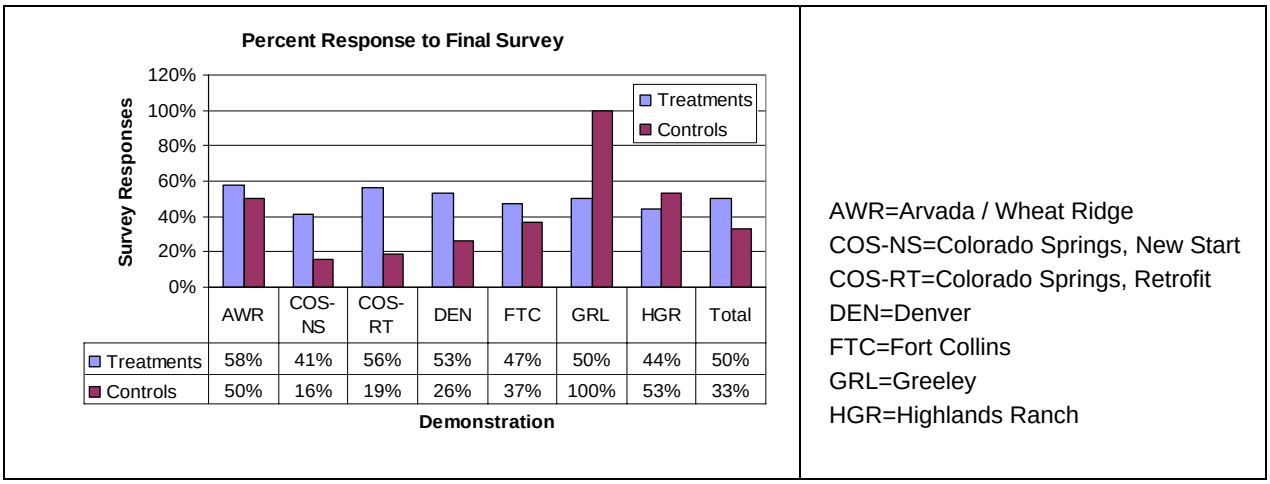


Figure 7-1: Response rate to Final Survey of all participants per sample group.

and 30 requested verbal responses. Responses are given in Appendix G. Survey question 30 requested that participants provide comments that they considered helpful to improving water conservation through lawn and landscaping practices.

The percentage response rates noted for each question relate to the number of homeowners who responded to the survey question, as a percentage of all who responded to a question (not a percentage of all study participants). Homeowners who were dropped retroactively to the beginning of the study were deleted from the survey results. Homeowners who had at least partial involvement in the project were kept in the Final Survey.

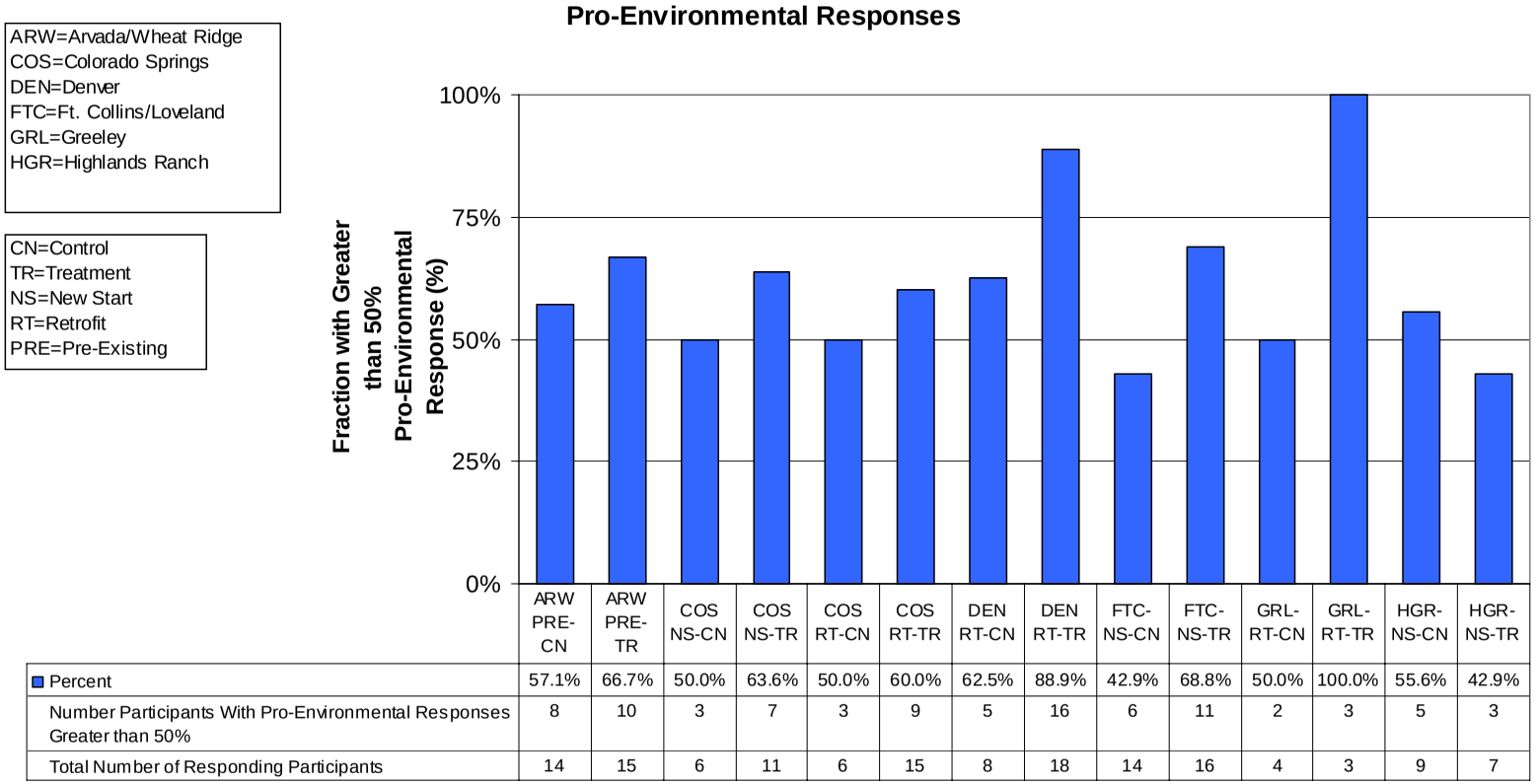
On scoring the Final Survey, each response was worth one point, except in the case of question 10 (see Appendix F). Question 10 queried participants on why they chose to join YARDX. If a participant selected multiple answers where only one was supposed to be designated, fractional values of equal weighting were assigned to each answer so their total equaled one. For question 10, multiple answers could be selected and prioritized as to the level of importance to the responder. A percentage response for each priority was calculated based on the number of selections of that level divided by the number of participants who responded to this question. If the homeowner did not prioritize their responses to question 10, each selected choice was given equal value.

Figure 7-2 presents the estimated environmental characterization of participants by sample group. Environmental orientation was determined by reviewing responses to survey questions 10, 19, 22, and 25 through 29. For each participant, eight possible points were assigned (nine points for the new start and retrofit treatments) from responses to the eight questions to determine an environmental score computed as a percentage of the maximum eight points. A pro-environmental orientation was determined if the score was 0.50 or greater. Figure 7-2 presents the number of participants of the responding total whose scores were 0.50 or greater. This procedure was applied to all responders.

Figure 7-2 shows that the number of responders varied from 3 at Greeley to 18 for the Denver Xeriscape group. Overall, pro-environmental scores (listed as percentages in the figure) varied from 42.9 to 100 percent.

Only for the Fort Collins controls and the Highlands Ranch treatments were scores below 50 percent. Clearly, in this scoring system, there was a strong pro-environmental bent in treatment and control participants.

This should not be surprising, given that the Final Survey was given in the end of 2002, a severe drought year.



	ARW PRE-CN	ARW PRE-TR	COS NS-CN	COS NS-TR	COS RT-CN	COS RT-TR	DEN RT-CN	DEN RT-TR	FTC-NS-CN	FTC-NS-TR	GRL-RT-CN	GRL-RT-TR	HGR-NS-CN	HGR-NS-TR
Percent	57.1%	66.7%	50.0%	63.6%	50.0%	60.0%	62.5%	88.9%	42.9%	68.8%	50.0%	100.0%	55.6%	42.9%
Number Participants With Pro-Environmental Responses Greater than 50%	8	10	3	7	3	9	5	16	6	11	2	3	5	3
Total Number of Responding Participants	14	15	6	11	6	15	8	18	14	16	4	3	9	7

Figure 7-2: Pro-environmental responses by demonstration.

The environmental orientation of participants was important, because it could possibly impact water savings as well as other aspects of the study, such as maintenance time in the yard. Environmentally inclined participants might be high water savers without Xeriscape and also enjoy working in their landscapes.

Figure 7-2 results indeed suggest more environmentally inclined participants in treatment groups with values of 43 to 100 percent. All of the treatment demonstrations show higher pro-environmental response rates than their control group except for Highlands Ranch. Controls showed a lower tendency to be pro-environmental (42 to 63 percent). Generally, this result would cause some concern that water savings' comparisons may have been impacted. Several attending factors diminish this possibility. Xeriscape training provided to treatment participants could have increased environmental awareness. A limited number of participants responded to the Final Survey, quite possibly the more environmentally oriented (Colorado Springs' two control groups had less than 20 percent response).

SPECIFIC SURVEY QUESTIONS ANALYZED

Several survey questions are analyzed in more detail below. Some of these questions could be helpful to a utility trying to gauge whether a Xeriscape rebate is helpful and whether homeowners are pleased with their landscapes.

Question 12 asked if the homeowner would have installed a Xeriscape without the rebate. This question was only presented to the new start and retrofit Xeriscape properties, because they received a project rebate.

Overwhelmingly, the majority from each demonstration answered that they would have installed their Xeriscape without a rebate. The percentage who responded affirmatively to this question ranged from 56 to 83 percent. Interestingly, two of the new start demonstrations, Colorado Springs and Highlands Ranch, had the highest favorable responses (80 and 83 percent). One might read into this that the retrofits need a little more prodding to rip out an existing landscape, and the rebates may have helped sway their decisions to go forward. The final answer suggests that rebates are helpful, but not critical, and they may not have to be large dollar amounts.

When the treatments were asked if they would recommend Xeriscape to others based on their current knowledge and experience, the majority of each demonstration answered "definitely" (question 15). The answers ranged from 80 to 100 percent, which are extremely strong responses, implying a sound satisfaction with the results of their landscape. Curiously, the demonstrations on the low end of this response were two of the three retrofits (the small Greeley group excluded) and the pre-existing demonstration (Colorado Springs and Arvada/Wheat Ridge at 80 percent and Denver at 83 percent). This could insinuate that a small fraction of retrofits and pre-existing participants were less happy with the results of their landscapes compared to what existed before. However, these satisfaction numbers, while lower, are still very high. Although, it should be noted that not one Xeriscape participant selected the answer "not at all." The synthesis of these results shows that homeowners were overall quite satisfied with their landscapes.

When question 15 above is examined with question 16, "do you like your landscape now?" there are similar compelling, positive responses from the homeowners with Xeriscapes. The treatment groups ranged from 61 to 88 percent for a "very much so" answer, outperforming each of their control groups. The controls only responded 13 to 57 percent with "very much so." This suggests there may be potential for swaying those with traditional yards into changing to a more interesting Xeriscape landscape.

The topic of landscape maintenance came up in several questions. Question 18 queried, "What is your opinion on the cost of maintenance of your landscape?" Unanimously, the majority for each Xeriscape group said "not at all expensive" with the majority in each control group saying "moderately expensive" with one control group's majority saying "noticeably expensive" (Colorado Springs new start control).

Therefore, in each demonstration, the treatment group thought their maintenance was less expensive than did their control peer group.

Question 20 asked homeowners to compare maintenance time on Xeriscape with maintenance time on their previous, traditional landscapes. Only the Xeriscape homeowners were given this question, and the majority for each demonstration said "somewhat less" to "substantially less" was spent on their Xeriscapes than on a traditional landscape. The answers to questions 18 and 20 show strong evidence that the Xeriscape homeowners believe their maintenance is less than that of a traditional landscape.

The next step is to compare these maintenance questions with the actual maintenance time and expense results stated previously in Chapter Six.

Even though the perception of the Xeriscapes was that they spent less time and money, which was generally true in the early years (1997 – 1999), it was not always true in the latter years (2000 – 2002). Eighty-three percent of the treatment groups did indeed have lower costs than their control counterparts in the plant establishment period, but 57 percent of the control groups actually had lower annual maintenance costs than did their treatments in the maturing period. Perhaps the treatments enjoyed working in their yards more than the controls and saw more positive benefits from their labor, so that possibly the time and money spent did not seem as costly.

In retrospect, more information could have been obtained by interviewing all participants in person. However, this was beyond the scope of YARDX.

CHAPTER EIGHT

Summary and Conclusions

Photo: Courtesy of David Winger, Denver Water, Denver, Colorado.

PREFACE

Metro Water Conservation Inc. (MWCI) and the Bureau of Reclamation (Reclamation) formed a temporary partnership in 1996 to create the YARDX (Yield And Reliability Demonstrated in Xeriscape) project. The main purpose of the project was to study the benefits of water-conserving landscaping called Xeriscape. The primary goals of YARDX were to develop reality-based estimates of water savings, and installation and annual maintenance costs in implementing Xeriscape.

The YARDX project is one of five cooperative demonstration projects on landscape water conservation pursued by Reclamation, collectively called the National Xeriscape Demonstration Program (NXDP). The NXDP cooperative studies were conducted at locations in the western United States that experience different climate, including the Colorado Front Range, centered at Denver, Colorado; Phoenix, Arizona; Austin, Texas; the Las Vegas area of southern Nevada; and Fargo, North Dakota.

The Colorado Front Range's high population growth, concerns over prolonged drought, and urban landscapes accounting for 50 percent or more of residential water use, have raised the level of concern of meeting current and future water demand. Water conservation offers an alternative to new traditional water development projects that are difficult to execute because of economic and environmental concerns. Water conservation through Xeriscape may offer at least a partial solution to the growing municipal water demand on the Colorado Front Range. In addition, the citizenry's familiarity with Xeriscape made the

Front Range a likely candidate to conduct YARDX.

Nine water utilities along the Colorado Front Range, and their 357 single-family customers chose to participate in YARDX. Seven demonstrations of Xeriscape, using a mix of settings of eight impacting variables, were initiated and conducted for nearly 6 years. The demonstration sites were located in Arvada/Wheat Ridge, Colorado Springs, Denver, Fort Collins, Greeley, and Highlands Ranch. The demonstrations consisted of three landscape retrofits; three new starts, and one pre-existing Xeriscape. The eight variables included water use, Xeriscape application (retrofit, new start, or pre-existing), Xeriscape application level (landscape designed for 30-40 percent or 60-70 percent water savings), yard size, irrigation method (manual or automatic), family income, soil type, and precipitation. Over the 6 years of fieldwork (1997 – 2002), YARDX developed and analyzed data on the water savings, and installation and annual maintenance costs in implementing Xeriscape.

RESULTS

ENLISTING PARTICIPANTS

Analysis on real water use data had shown that about 30 participants per sample, monitored over 4 growing seasons, were required to detect a 30-percent water savings. This suggested that seven demonstrations would require over 400 participants (treatments and controls). However, it was not easy to enlist 400 homeowners to participate. Although homeowners (treatments, except pre-existing) were charged a $100 commitment fee up front to participate in the project, they were compensated with a $300 rebate for a new landscape or $600 for a retrofit. All homeowners (except the control groups and the pre-existing demonstration) received design and educational support, as well as discounts on Xeriscape plants and other landscape materials.

YARDX encountered substantial difficulty in completing sampling needs. The main obstacles appeared to be cost of installing a landscape, and meeting requirements of participation (including completion of installation by set date). One demonstration (Greeley) was unable to obtain adequate numbers of participants. Another demonstration (Highlands Ranch) enlisted about 60 percent of desired numbers, somewhat less than desired. Of Xeriscape enlistees, 58 percent completed the study. Attrition appeared mostly caused by financial and time constraints. Sample sizes of the remaining demonstrations were adequate to support preferred data analysis.

XERISCAPE INSTALLATION COSTS

Participants of YARDX were required to submit receipts and a listing of hours of labor expended in installing their Xeriscapes. Costs were stratified by demonstration and estimated per square foot.

Overall, the installation costs ran $0.83 to $1.43 per square foot, a rather narrow range. A prominent factor in costs was that participants provided most of the installation labor. In general, homeowner-installed landscapes cost about one-third the cost of contractor largely-installed Xeriscapes. The Highlands Ranch demonstration logged the highest cost per square foot, but exceeded others (new starts) by only $0.10 to $0.15 per square foot. Automated watering systems added about $0.14 to $0.29 per square foot. Installation costs for new properties ran $1.36 per square foot and $1.26 for retrofits. The lower retrofit averages suggest some financial benefit by having an existing landscape and being able to modify irrigation systems and simply replant some plants.

Estimates were obtained of labor hours required for Xeriscape installation, from properties for which owners conducted installations. The labor effort to install Xeriscapes was estimated at 50 to 60 hours per 1000 square feet of landscape, including time to install automatic irrigation systems. Automatic irrigation system installation required 46 hours per property on average.

WATER USE RESULTS

A major goal of the YARDX project was to estimate the water use savings of Xeriscape over traditional landscape water use. The study was

designed with each demonstration consisting of treatment pairs (Xeriscape/traditional landscape) of similar property and landscape features, except for landscape type.

Water utilities provided the meter readings of participants. YARDX converted the water data to monthly amounts applied per square foot of landscapable area. To estimate the outdoor use, average winter monthly (January, February, March, November, and December) use was subtracted from each growing season (April through October) month's water. The Highlands Ranch demonstration added water meters to measure strictly the outdoor use. This feature was expected to lower water data noise, so that fewer properties (than 20) could produce useful assessments. The study focus was on comparing the growing season water use.

Comparing Xeriscape samples with respective control properties yielded water savings ranging from 18 percent in the Colorado Springs new start demonstration (28 percent in data without year 2002 values), to 63 percent savings in the Highlands Ranch new start demonstration. All comparisons tested with the Wilcoxon method yielded P-values (see Glossary) less than 0.01, a value generally considered highly significant.

The study period included the severe drought year of 2002. Front Range water utilities imposed watering restrictions that varied from municipality to municipality. Some municipalities allowed Xeriscape owners to water as needed. In extreme summer conditions similar to a 2002 drought year, traditional landscapes as well as Xeriscapes would likely require more water than in years with normal rainfall.

The demonstrations in Colorado Springs were most impacted by the drought and the imposed watering restrictions. During the growing season of 2002, YARDX Xeriscapes in Colorado Springs used twice the amount of water used by the corresponding control groups. Other demonstrations appeared with little impact, except that of Arvada/Wheat Ridge. This demonstration did not yield water savings, according to calculations.

The Denver retrofit demonstration produced a 28-percent water savings. The retrofit demonstration in Colorado Springs yielded a water savings of 23 percent (32 percent excluding year 2002 data). The new start demonstration in Fort Collins, consisting of large area and more expensive properties, produced a 36-percent savings. The limited samples from Greeley suggested water savings of 54 percent. The high water savings indicated in the Highlands Ranch demonstration may have been caused by the occurrence of an imbalance in samples of some zero water use monthly values.

MAINTENANCE COSTS

Another goal of the YARDX project was the estimation of landscape annual maintenance costs. After each growing season, YARDX participants were asked to report their maintenance-related expenses and time expended. As a means of developing a cost for homeowner labor input, their hours were charged at $18 per hour. To estimate maintenance costs over time, results were estimated separately for the periods 1997-1999, and 2000-2002. The low and high average annual maintenance costs per square foot of all Xeriscape samples and separately, the control samples, yielded the treatment range of $0.34 per square foot to $1.33 per square foot and a mid-range of $0.84, and similarly for the control the range of $0.27 per square foot to $1.44 per square foot and a mid-range of $0.86.

The Xeriscape maintenance costs generally tended to be lower than their controls during the plant establishment period (first time period), but somewhat higher during the plant maturing years. This suggests that older Xeriscapes take more work to maintain than for a traditional landscape. And, the two Xeriscape demonstrations that most dealt with hose dragging (Arvada/Wheat Ridge and Denver) had the highest annual maintenance costs per square foot, possibly indicating the extra effort needed to hand water. The Denver control group that also hose dragged, had the highest cost of any demonstration group, suggesting the traditional landscapes took more watering effort, perhaps needing more frequent watering.

However, the Arvada /Wheat Ridge controls that also did some hose dragging did not follow this pattern.

There was no discernable difference in maintenance costs between those who received education on good maintenance practices and those who did not.

FINAL SURVEY RESULTS

At the project's conclusion in 2002, a Final Survey was mailed to all participants to sample their attitudes toward Xeriscape, maintenance, landscape installation and their environmental orientation, which could possibly impact their water savings and maintenance efforts.

The Final Survey results show a somewhat stronger pro-environmental orientation in Xeriscape groups than control groups. However, many Xeriscape participants indicated they joined the project because they needed a landscape.

Overall, the Xeriscape groups in all demonstrations were very satisfied with their landscapes (more so than controls) and would recommend Xeriscape to others. The treatment groups thought their maintenance was less expensive than did their control peer groups. Homeowners with Xeriscapes thought they were contributing less maintenance time and money to their landscapes than with prior traditional landscapes. This perception, though, did not completely match up with the actual maintenance costs logged in the project.

REFLECTIONS

- For a water utility to motivate more customers to save water through Xeriscape, a variety of measures may need to be used to target different types of customers based on their values. For example, low-income customers may not be able to afford to change out a landscape, even with the benefit of a small to medium rebate. Customers who cannot physically handle the rigors of maintaining a Xeriscape may not choose to embrace it. Some water utilities are already finding that to be true. Other customers may have other priorities than spending time maintaining their landscapes. Thus these people may choose to keep a predominantly turf landscape for the simplicity of maintenance. If water utilities are to achieve savings from these customers, there must be incentives, or perhaps disincentives, stronger than current values.

- Since so few participants attended the maintenance seminars, water utilities need to find ways to make learning about maintenance more enticing. Scintillating presentations or seminars on weekday afternoons or evenings may help. Perhaps a credit on the customer's water bill for attending and demonstrating water savings over time might bring in more people.

- Since there are few professional landscape contractors in Colorado who maintain Xeriscapes, perhaps utilities could join with landscape trade associations in creating an incentive program for the contractors. Otherwise, those who cannot maintain landscapes for themselves will have strong disincentive to change to Xeriscape.

- MWCI is committed to making all the data from the study available for further research.

- One big question not addressed in the YARDX study, but needing to be addressed soon, is "How does a water provider motivate more customers to have Xeriscape on their properties and maintain it?" The answer to this question will be the key to water savings sustainable in the future. Results of the YARDX approach are given in Table 3-2. The table suggests a YARDX success enrollment rate of 5 percent. However, this enrollment rate may not be transferable to other areas, given the changes in the inflation rate, water rates in general, and other factors.

- Overall, the YARDX study shows that Xeriscape saves water, and saves the most water when all seven steps are included:
    - Design
    - Soil amendment
    - Limited turf areas
    - Mulches
    - Appropriate irrigation
    - Appropriate plant selection
    - Appropriate maintenance

MWCI recommends that water providers and other water-related organizations continue to look at Xeriscape as one of the many water-savings tools in an effective water management program.

RECOMMENDATIONS

- Additional investigation of the water savings by older Xeriscapes is needed.
- YARDX produced a rich data set. Additional studies could reveal additional beneficial information. Current resources did not allow additional study.

CONCLUSIONS

- Xeriscape installations cost $0.90 to $1.45 per square foot if homeowners are willing to supply part of the labor. About 50 to 60 labor hours per 1000 square feet are required for installation.
- Xeriscapes save water. YARDX results indicated a savings from 18 to over 50 percent in comparison to traditional landscapes.
- One demonstration on pre-existing older landscapes indicated no water savings.
- Xeriscape annual maintenance costs generally tended to be lower than their control counterparts during the early establishment period, but somewhat higher during the maturing years.
- Overall, Xeriscape owners in all demonstrations were very satisfied with their landscapes, and would recommend this type of landscaping to others.

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Glossary

TERM		DEFINITION
Control (CN)	=	Properties in the study with mostly bluegrass turf in the landscape
Dryland	=	Area in a landscape that is planted in sparse, native vegetation that exists on natural precipitation and is not irrigated
ft²	=	Square feet
Hardscape	=	1) Patios and decks that are not attached to the house or attached patios and decks that have plants growing within the structure (e.g., ground cover planted between the flagstone in a flagstone patio) 2) Retaining walls, decorative pathways, and sitting areas. Hardscape does not include playgrounds, dog runs, or vehicle parking areas for purposes of YARDX calculations.
Landscapable	=	Area that is to be formally landscaped. It does not include dryland area.
New start	=	Single-family residences in the study with a newly installed Xeriscape landscape. At the start of the study, these properties did not have any prior landscape.
P-value	=	Probability that differences in samples could have occurred by chance.
Plants, high water-use	=	Plants that require moisture similar to Kentucky bluegrass turf
Plants, low water-use	=	Plants that require ¼ or less of the moisture of Kentucky bluegrass turf
Plants, moderate water-use	=	Plants that require ½ the moisture of Kentucky bluegrass turf
Pre-existing	=	Single-family residences in the study with a pre-existing Xeriscape landscape. At the start of the study, these properties had a Xeric landscape that was installed by the spring of 1996.
Pure mulch	=	A rock area, or infrequently a wood-chip area without vegetation and irrigation
Retrofit	=	Single-family residences in the study with a newly installed Xeriscape landscape. At the start of the study, these properties had a previous non-Xeric landscape.
Submeter	=	A separate water meter from the whole-house water meter that monitors water used outdoors, primarily to irrigate the landscape. Sometimes called an irrigation meter.
Traditional landscape	=	A landscape with mostly high water turf such as Kentucky bluegrass.
Treatment (TR)	=	Properties in the study with Xeriscape landscaping in at least 50 percent of the landscapable area.

TERM		DEFINITION
Xeriscape	=	Xeriscape is a set of seven principles of sound landscaping for water conservation. The seven principles are: • Plan and design for water conservation and beauty from the start. • Create practical turf areas of manageable sizes, shapes, and appropriate grasses. • Select low-water-requiring plants and group plants of similar water needs together. Then experiment to determine how much and how often to water the plants. • Use soil amendments like compost or manure as needed by the site and the type of plants used. • Use mulches such as woodchips, to reduce evaporation and to keep the soil cool. • Irrigate efficiently with properly designed systems (including hose-end equipment) and by applying the right amount of water at the right time. • Maintain the landscape properly by mowing, weeding, pruning and fertilizing properly