"CASH FOR GRASS" - A COST EFFECTIVE METHOD TO CONSERVE LANDSCAPE WATER?

By: Sylvan Addink, PhD.
Certified Professional Agronomist

Water districts, municipalities, and states are increasingly confronted with the challenge of finding enough water to sustain their growing and thirsty populations. In the midst of a drought, the importance of allocating and saving water is of even greater importance. In the search for methods to achieve this goal, a variety of alternatives have been pursued, some more successfully than others.

This paper will not take a comprehensive look at all the options but rather address one question in particular: Whether offering rebates for the conversion of turf to xeriscape is a cost effective and environmentally friendly method to achieve water savings? In pursuit of an answer, we will first look at the effectiveness of several "Cash for Grass" programs.

North Marin Water District

One of the earliest conversion of turf to xeriscape studies was a pilot study by the North Marin Water District (NMWD) in 1989.[1] The rebate offered was $0.50 per square foot of turf removed and replaced with water conserving plant materials with a cap of $310.00 per single family residence. This study also involved the requirement that the participants modify their irrigation system to reduce the water applied to the newly established xeriscape plantings. "The bulk of the applicants opting for drip or drips spitter systems."[1] Participants had to agree to not make any significant changes from xeriscape as long as they owned the property.[1]

There were 73 applications for participation in the study and of these, 46 actually participated in the study and removed turf. Of the 46 participants, half indicated that they were planning on removing turf anyway and that the District's offer was a pleasant coincidence. Individuals that would have removed the turf, even if they had not received the rebate, are termed "free riders".[2]

The annual calculated water savings was 33 gallons per square foot of turf removed. The water savings was partly due to the replacement of the turf, with xeriscape plants, but also due to the installation of a more efficient irrigation system. Properly installed drip-irrigation systems use approximately 20% less water than in-ground sprinkler systems.[3]

Albuquerque, New Mexico

Albuquerque, New Mexico has had a conversion of turf to xeriscape program in effect since 1996.[4] The initial rebate was $0.20 per square foot and by 2004 had increased to $0.40 per square foot of bluegrass turf removed and replaced by xeriscape plants. As with the North Marin program, the Albuquerque participants were also required to replace their sprinkler irrigation systems with more efficient irrigation methods. The xeriscape plants could be watered by hand watering, drip, soaker or bubbler irrigation systems.[5]

It was found that there was an average water savings of 19 gallons per square foot of bluegrass turf converted to xeriscape landscaping. However, "17 percent of the participants in the xeriscaping study found they used more water after putting in drought-tolerant plants."[6]

Southern Nevada Water Authority

A conversion of turf to xeriscape study in Las Vegas offered an initial rebate of $0.45 per square foot of turf converted. The rebate was later increased to $1.00 per square foot of turf converted to xeriscape landscaping. As with the above two studies, the participants were required to install a more efficient irrigation system than the one they were using to irrigate their turf. Most of the turf removed was tall fescue and annual water savings were calculated at 62 gallons per square foot of turf removed.[7]

Participants had to agree that their "xeriscape conversion will remain in place for a period of not less than five (5) years from receipt of the incentive."[8] In each of the above conversion of turf to xeriscape studies, if the participant did replace their xeriscape landscapes, with turf, prior to the end of the agreed upon period of time, then they had to return the rebate.

El Paso, Texas

In 2004, El Paso offered a rebate of $1.00 per square foot of turf converted to xeriscape plantings[9]. "The El Paso Water Utility asserts that this rebate program has involved 385 participants that removed about 29 acres of turfgrass, resulting in a water savings of approximately 23 million gallons."[10] This is equivalent to approximately 18 gallons of water saved per square foot of turf removed, which is not as high as the other studies.

Cost Analysis of Cash For Grass Programs

The best measuring stick in judging whether Cash for Grass programs are an efficient method of decreasing water use is the cost per acre foot saved. Table 1 calculates this cost for the four studies mentioned above (see assumptions in Exhibit 1). The North Marin and Southern Nevada programs have an estimated cost per acre foot of water saved of $512 and $532, respectively. It is estimated that the Albuquerque program cost $718 per acre foot of water saved while the El Paso study was the most costly at an estimated $1,834 per acre foot or water saved.

A key element missing from the El Paso study was the requirement that the participants be required to install a more efficient irrigation system. Lacking an emphasis on good landscape water management, the cost of the program was 312% higher than the average of the other three studies. Although further study is needed, this would indicate that an emphasis on efficient irrigation systems yielded approximately two thirds of the water savings from the programs, while converting from turf to xeriscape yielded only one third of the results.

Further proof that the majority of savings came from emphasis on proper irrigation rather than conversion of turf to xeriscape is seen in the Las Vegas study. Based on water application rates on tall fescue plantings, a water savings of 28% could have been achieved by applying only the

amount of water required by the tall fescue plants (see Exhibit 3). The Southern Nevada Water authority, in their summer 2004 Waterwise publication, stated that, "On average, residents use 40 percent more water on their grass than most turf requires."[11]

When comparing a rebate for an ET Controller with a rebate for the removal of grass the cost per acre foot of water saved is significantly less with the ET Controller studies. As seen in Table 1, the average of the four grass removal studies had an estimated cost per acre foot of water saved of $899. In comparison, the six ET Controller studies, shown in Table 2, had an estimated cost per acre foot of water saved of $350.

Good Landscape Water Management is More Important Than Plant Material Change

As indicated above, a majority of the water savings in the Albuquerque, Las Vegas, and North Marin studies may be attributed to more efficient irrigation practices. Dr. Welsh, past president of the National Xeriscape Council, stated that, "The type of plant materials or irrigation system in the landscape has much less effect on water consumption than the human factor of good landscape water management."[12] Dr. Welsh et. al. also stated that, "By simply using efficient irrigation, you can instantly save 30 to 50 percent on your water bill."[13]

In a water conservation program, established by the Irvine Ranch Water District (IRWD) there was a 50% reduction in water use on non-residential landscapes and "most of the reductions in water use were attributable to improvements in irrigation technology and management, rather than changes in landscape composition."[14]

Dr. Martin stated in Landscape Water Use In a Desert Metropolis that, "factors such as plant spacing, vegetation coverage, plant size, and growth rate can be more important determinants of water use than plant selection."[15] Vickie Driver, a water resources specialist at the San Diego County Water Authority, was quoted as saying, "The behavioral component is the secret to all the landscape stuff. It ultimately is dependent on the human being managing the site."[16]

Acceptance of Cash For Grass Programs

In a cost/benefit analysis of various outdoor water conservation programs, an incentive program for conversion of turf to xeriscape the "customer acceptance rate is assumed to be an average of 5% for existing construction."[17] Of the outdoor water conservation programs listed in the Water Plan the conversion to xeriscape program had one of the lowest assumed customer acceptance percentages.[17]

In a survey of 1800 residential homeowners in Phoenix, "70% of homeowners preferred a landscape dominated by the color green that had at least some lawn area. This finding underscores the importance in Phoenix of turfgrass lawns as an important element of residential landscapes."[15]

In Utah, "citizens have a passion for green lawns with gardening as the number one hobby in the state."[18] If a water district only has a conversion of turf to xeriscape program for outdoor water

conservation, there still is no incentive for the majority of the water users to conserve water outdoors.

Contributing Factors to the High Cost of Cash For Grass Programs

There are some contributing factors, which should be discussed in order to understand why Cash For Grass is a high cost method of saving water. High cost can be in terms of cost per acre foot saved or in terms of cost to the quality of life experienced in metropolitan areas.

1 - Xeriscape landscapes often use more water than "advertised"

An Arizona State University study found that "xeriscapes in Phoenix and Tempe, on average, received at least 10% more water than traditional landscapes consisting of turf and other so-called 'high water-use' plants."[19] As mentioned above in the Albuquerque study, "17 percent of the participants in the xeriscaping study found they used more water after putting in drought-tolerant plants."[6]

Researchers in Phoenix found that "Xeric-landscape plants lose as much or more water than mesic plants when they are not allowed to go dormant in the summer."[20] They comment that "in drip-irrigated landscapes, water-loss rates by 'so-called' low-water plants such as Chilean mesquite and blue palo verde are similar to or even higher than the loss rates of 'so-called' high water-use plants such as the mulberry tree."[20]

To "create a full landscape appearance, residents often prune fine-textured and open-canopied, desert-adapted plants into dense arrangements, negating their water-conserving potential".[15] This was indicated in a study by Dr. Martin, where, "Frequent shearing of two common landscape shrubs reduced plant water use efficiency by as much as 59% relative to unpruned controls."[15]

During the transition from moist to dry conditions, xeriphytic species often shed their leaves to reduce moisture loss and enter dormancy. Drought tolerant species can tolerate drought…but they grow slowly under droughty conditions and often are less aesthetically pleasing. What this means in terms of water management is that xeriphytic landscapes can induce residents to use more water than they would with traditional landscapes."[21]

2 - Drip irrigation systems have low uniformity

Generally, a properly installed drip-irrigation system will use approximately 20% less water than in-ground sprinkler systems.[3] However, after several years of use, drip irrigation systems may lose some of their efficiency advantage over sprinkler irrigation systems. Dr. Waller stated that, "Our evaluation of 38 landscape drip irrigation systems revealed an average uniformity of less than 20%."[22] Many traditional landscape irrigation systems operate at around 65- to 70-percent water-use efficiency.[23] Low distribution uniformity for the drip irrigation systems resulted from "degradation of emitters and lack of adjustment of number of emitters as plants grew resulted in low uniformity."[22]

3 - Negative environmental impacts from the removal of turf

By removing turf, we will be negating the benefits that the turf provides, including the following:

- Turf protects groundwater quality and improves recharge.
- The turf-soil ecosystem entraps and biodegrades polluting organic chemicals.
- "Turf dissipates heat, reducing energy required to cool nearby homes and commercial buildings."[24] (In an Arizona study, it was determined that soil temperatures, at a xeriscape site were generally 8^{o}C higher than soil temperatures under turf.[25] The higher soil temperatures would very likely translate into higher air temperatures).
- Turf abates noise and reduces glare.
- Well-maintained turf and landscaping increase property values.
- Turf is a low-cost, durable, smooth surface for play and relaxation during outdoor leisure activities.
- Natural turf decreases injuries to sports participants.
- "Well-maintained turf and natural scenery have positive therapeutic effects, as measured by heart rate and blood pressure."[24]
- Testing has shown that nitrogen leaching losses are significantly greater on a mixed-species landscape than on turfgrass.[26]

To summarize the benefits of turf, Wynn Anderson, curator of the Chihuahuan Desert Garden at UTEP's Centennial Museum stated, in reference to the conversion of turf to xeriscape program in El Paso that, "We fear that people will be tearing out all of their grass and letting their trees die. We don't want people to stop gardening. More yards with crushed rock could mean a rise in temperature. You're going to have a heat island effect . . . it'll be miserable. That's a big price to pay."[27]

Where Do We Go From Here?

The information above casts doubt on the cost effectiveness and desirability of Cash for Grass programs. Yet, it is important to have a "multi-dimensional conservation program in any particular water district."[10] A brief analysis of other water saving programs is included below:

Option 1 - Information Campaigns
Most water districts are quite active in providing public information to water users on landscape design, plant selection, soil preparation, landscape maintenance and irrigation. "Education programs are by far the most common demand-side water use efficiency measure in the Southwest . . . Two primary reasons are that public education and awareness are the fundamental building blocks to all goals of water use efficiency and public education programs tend to be relatively affordable. Although education and awareness provide a solid foundation for all other demand reduction programs, policies, and regulations, in most cases education alone will not effectively address demand-side water use efficiency."[10]

Option 2 - Water Audits
Due to the time and cost involved in conducting a water audit, there will likely not be a significant impact on total water use in a water district from water audits done on residential landscapes. However, water audits done on large industrial, commercial and public properties may result in significant water savings by a water district, as indicated by the following examples.

"In 1995, SCVWD [Santa Clara Valley Water District] initiated the Irrigation Technical Assistance Program (ITAP) with the goal of helping managers of large landscapes improve their irrigation efficiency."[14] They did an audit and provided recommendations to the landscape managers and the "recommendations were all based on management improvements, such as irrigation scheduling and system maintenance, rather than equipment retrofit or landscape changes, and therefore minimal cost was incurred by customers in adopting these recommendations."[14] At one site, where the SCVWD provided their assistance, the water use declined by "55 percent from the previous year's water use."[14]

In Utah, "The year following a site evaluation, participants were able to reduce their water use by 20-60 percent."[16] Additionally, Marin Municipal Water District has realized substantial water savings by targeting their audit program at the "inefficient water use among the highest water users in each customer class."[28]

Option 3 - Tiered Rate Structures
Today, water districts are starting to implement conservation pricing or tiered rate structures to try reduce the excessive use of water by water users. In some water districts this has been quite successful. "In June of 1991, in response to the drought, IRWD (Irvine Ranch Water District) developed a five-tiered, steep inclining block rate structure . . . The combination of incentive pricing, water budgets, rebate and loan programs, and educational outreach has proven to be very effective…[with] a reduction of 50 percent"in non-residential water use over an eight year period.[14]

IRWD found that, "Five key elements of the rate structure worked to ensure its success: adequate customer information and analysis; structure design; equity and customer acceptance; revenue stability, and coordination with other conservation programs."[29] "IRWD attributes much of the savings in the first five years of the program primarily to improved irrigation practices (better scheduling, less over watering, etc.) and not changes in types of landscaping."[29]

Some water districts, such as Las Vegas, have implemented a four-tiered rate structure, along with other conservation programs, but have not achieved the water savings goals they had set. "The upward conservation trend of the 1990's has not continued, peaking in 1999 at about 17% and declining to a four-year low of 13.5% in 2001.[10] Sometimes, the difference in the success or failure of the tiered rate structure is in the penalty that is assigned to each tier. "…[I]n many cases, the block price increases are not steep enough to get the attention of water users."[30]

Boulder and El Paso "instead of using fixed consumption volumes as thresholds for each block rate, the blocks are determined by the Average Winter Consumption (AWC) of each individual account. This type of price structure serves two objectives. First, as with standard block rate structures, efficient and/or low-use customers pay a low unit rate, while inefficient and/or high-use customers pay a high unit rate. Second, the user of AWC baselines builds an additional incentive into the water pricing."[31] "…[I]t is very likely that the distinct aggressiveness of the rate structures in Tucson, El Paso, and Boulder contribute to the relatively low SFR (single family residence) consumption rates in these water service areas."[31]

With the tier rate structures mentioned above, the water user is allocated a certain amount of water for outdoor use and, if they exceed the base amount they are allocated, they will have to pay a higher rate. An important aspect of this type of program is that the water user makes the decision on what conservation methods they will use rather than having a water conservation method dictated to them by a water district or municipality.

Option 4 - Rebates for Efficient Use of Water

Santa Rosa, California has an irrigation efficiency rebate program that applies to commercial landscapes.[32] "Eligible customers can earn $500 for each acre-foot (325,851 gallons) of water savings below your Efficient Irrigation Goal each year (approximately $1.53 per 1,000 gallons of water saved)."[32] The efficient irrigation goal is based on landscape and weather data. Although Santa Rosa's irrigation efficiency study only applies to commercial water customers, it could be applied to residential customers also and would be a program that would apply equitably to all landscape water users.

The most important aspect of a program such as the one in Santa Rosa is that it would apply to everyone who conserves water outdoors including the 70% of homeowners who prefer turf instead of xeriscape plants. If the homeowners, who have traditional landscapes, would reduce their water usage by better management, installing ET controllers, rain sensors, etc., then they would receive a rebate once their water use is below the 'Efficient Irrigation Goal' for their landscape. This program would motivate all landscape owners to conserve water and should be a very cost effective water conservation program.

The method used to set the "Efficient Irrigation Goal" is extremely important. If the goal is based on a water budget, all outdoor water users would be treated fairly, since the water use goal is based on the landscape area. However, if it is based on a water diet or percent reduction based on historical water usage outdoors, then some water users, even with a reduction in water use, will still be found to use excessive water.

Option 5 - Rebates for the Installation of ET Controllers ™ and/or Rain Sensors

During 2001, residential landscape irrigation studies using Aqua Conserve ET Controllers™ were established with Denver Water and two adjacent water districts in Northern California, the City of Sonoma, Valley of the Moon Water District. The data collected from these studies indicated that participants had a total outdoor water savings of 21%, 23% and 28%, respectively.[33] A similar study in Irvine, California involving conversion from conventional irrigation clocks to "smart" irrigation controllers yielded total outdoor water savings of 16%.[34] See Table 2 for further detail and cost per acre foot of water saved.

Additionally, for a relatively low price, the installation of a rain sensor, with an automatic irrigation controller can provide significant water savings. The water savings will vary based on the average rainfall that occurs at the location site of the irrigation controller. One irrigation consultant has found, based on his own experience, "using rain sensors alone will save about 12 percent of the water that would have been used without a rain sensor."[23]

The combination of the installation of an ET Controller™ and a rain sensor will have an additive effect on the water savings that can be achieved. In a study in Seattle, Washington, conversion to ET Controllers™ with a rain sensor provided outdoor water savings of approximately 45%.[35]

Option 6 – Where Appropriate, Plant More Warm-Season Turf

In southern regions of the United States water could be saved if more warm-season turf was planted rather than cool-season turf. In a study in New Mexico, "the cool season grasses required about 30 percent more water than the warm season grasses to maintain an acceptable appearance."[36] Warm season turf species varieties include bermudagrass, St. Augustinegrass, zoysiagrass, and buffalograss. Cool season turf varieties include tall fescue, Kentucky bluegrass, and perennial ryegrass.

Exhibit 1 – Explanation of Assumptions in Table 1

Rebates - The listed rebates in Table 1 are not necessarily the rebates that were used in the studies but are instead the rebates that are presently offered to participants in each of the water districts or municipalities where the studies on conversion of turf to xeriscape occurred.

Administrative and Site Inspection Costs – In the NMWD study, John Nelson figured the administrative and site inspection cost to be $15.00 per participant.[1] This figured out to be approximately $0.015 per square foot of turf removed with one site inspection. Therefore, in Table 1, the administrative and site inspection costs were set at $0.02 per square foot of turf converted to xeriscape plants for all studies. Likely, the cost today would be higher than the cost John Nelson figured for administrative costs and inspection costs in 1991.

'**Freerider' Costs** - Based upon the North Marin study, 50% of the participants in the study were going to remove turf anyhow, even without the rebate.[1] These participants are termed 'freeriders'.[2] John Nelson accounted for this in the North Marin study since "agencies do not get incremental conservation benefits from serving freeriders because the conservation would have happened irrespective of the program; scarce water conservation program budgets would be more productively spent in other ways."[2] Based on the North Marin data, a conservative figure of 30% was used for 'freeriders' in the calculations in Table 1.

In the Las Vegas study, one superintendent removed 14.1 acres of irrigated rough to qualify for the maximum $300,000 rebate. He stated, "When I see a possible $500,000 surcharge for water costs, that motivates me to look at options".[37] This is another example of the "freerider" effect.

Water Savings Erosion Costs – Several factors contribute to erosion of water savings. First, "if homeowners blindly reduce turfgrass and replace that area with trees and shrubs, the reality is that no savings would be realized in the long run – and, in fact, greater water use would most likely occur."[38] Second, as the xeriscape plants grow, degradation of drip emitters will likely occur,[22] which results in a reduction of water savings. Third, to "create a full landscape appearance, residents often prune fine-textured and open-canopied, desert-adapted plants into dense arrangements, negating their water-conserving potential."[15]

In the Southern Nevada Water Authority Study, over a three year period, there was an increase in water use in the converted xeriscape landscapes. Even though "the authors dismiss concerns over serious savings erosion…,"[7] the erosion in water savings is almost certain to occur. In Table 1 the cost per acre foot of water saved was based on 25% erosion.

Life of the Water Savings – A homeowner may not very quickly replace a toilet, clothes washer or other conserving appliance that they have installed in their home. Thus, a 25 year life for indoor conversions may be reasonable.[4] However, seventy percent of homeowners surveyed in Phoenix indicated they preferred a landscape dominated by green color, with some lawn area[15] and Americans move an average of once every 5 years.[39] Therefore, in Table 1 a 15 year lifetime for water savings was used for a conversion of turf to a xeriscape planting.

Exhibit 2 – Explanation of Assumptions in Table 2

Rebate Cost Per Controller
The Denver Water, Sonoma, and Valley of the Moon studies were conducted with Aqua Conserve ET Controllers. Retail price is approximately $200 for a six to nine station controller. Therefore, this amount was used to compensate for the full cost of a controller.

Administration and Freerider Cost Per Controller
Set at approximately the same percentage as the cash for grass programs.

Exhibit 3 – Estimate of Water Savings from Applying the Proper Amount of Water to the Plant Material – Las Vegas Study

Prior to conversion to xeriscape, the calculated water applied to tall fescue turf was 79.2 gallons per square foot per year,[7] which is equivalent to 127 inches per year. With cool season grasses, a standard recommendation is to apply 0.8 of Reference Evapotranspiration (ETo) for the location. The ETo for Las Vegas is approximately 74 inches per year[40] so tall fescue would require approximately 59 inches per year with 100% distribution uniformity of the irrigation system (DU). With a reasonable DU of 65%, 91 inches of water would need to be applied. Thus, a water savings of 28% could have been achieved, with the applying of the proper amount of water to the tall fescue lawns.

1. Nelson J. O. (1991). "Report on Results of One Year Pilot Project Conversion of Turf to Xeriscape."

2. Whitcomb, PhD., J.B. (2002, December). Freeriders in ULFT Programs.

3. Chapter II Water Use and Conservation: Perception vs. Reality. *Water Right-Conserving Our Water Preserving Our Environment*. 7-10.

4. Friedman, M. S. (2003). Technical and Physical Feasibility Fact Sheet Alternative 22: Conservation Incentives. Retrieved December 12, 2003, from http://www.waterassembly.org/pdfs2/A38.pdf.

5. City of Albuquerque Public Works- Water Conservation Office (2003). Xeriscape. Retrieved December 12, 2003, from http://www..cabq.gov/waterconservation/xericrebate.html.

6. (2000, March 29). City calls xeriscaping a success. *Amarillo Globe- News*. Retrieved amarillonet.com/stories/032900/usn_calls.shtml.

7. Sovocool, K. A. and J. L. Rosales (2001). A Five-Year Investigation Into The Potential Water And Monetary Savings Of Residential Xeriscape In the Mojave Desert.

8. (2003). Water Smart Landscapes-Residential Rebate Conditions. Retrieved December 12, 2003, from http://www.snwa.com/html/ws_landscape_conditions.html.

9. Driver, B. (2002, July). Water Use Efficiency Improvements: A Solution to Colorado's Urban Water Supply Problems. Retrieved January 2, 2004, from www.lawfund.org/media/pdf/efficiency%20White%20Paper.pdf.

10. Western Resource Advocates (2003, December). Chapter 2 Water Use Efficiency: State-of-the-Art. *Smart Water a Comparative Study of Urban Water Use Efficiency Across the Southwest*. 25-54.

11. Waterwise Summer 04. *A Publication of the Southern Nevada Water Authority*.

12. Welsh, D. (1990). Practical Turf Areas: The Controversial Xeriscape Guideline. *Position Paper from National Xeriscape Council, Inc*.

13. Welsh, D. F. et. al. Landscape Water conservation…Xeriscape™. *Texas Agricultural Extension Service*. Retrieved December 12, 2003, from http://aggie-horticulture.tamu.edu/extension/xeriscape/xeriscape.html.

14. Haasz, D. (1999). Chapter 4 Reducing Water Use in Residential, Industrial, and Municipal Landscapes. *Sustainable Use of Water California Success Stories*. 49-67.

15. Martin, C. A. (2003, April). Landscape Water Use In a Desert Metropolis. *Consortium for the Study of Rapidly Urbanizing Regions, Research Vignette No. 1*. Retrieved December 12, 2003, from http://ces.asu.edu/csrur/research%20vignette%201.pdf.

16. Boxall, B. (2003, September 6). Water Conservationists Step on the Grass. *L. A. Times*. Retrieved December 12, 2003, from http://groups.yahoo.com/group/urban-ecology/message/6069.

17. Xeriscaping Residential (1989, October) *WaterPlan*.

18. Jackson, E. K. (2003). Saving Utah Water in the Fifth Year of Drought. *Proceedings, National Irrigation Association*.

19. Chapter V Educational Needs and Opportunities for Water Conservation. *Water Right-Conserving Our Water Preserving Our Environment*. 18-20.

20. Martin, C. A. et. al. Urban Plant Ecology: a Horticultural Perspective. Initial results From a Long Term Ecological Research (LTER) Site. Retrieved December 12, 2003, from http://www.ces.ncsu.edu/fletcher/studys/nursery/metria.metrial2/martinetal/index.html.

21. Chalker-Scott, L. The Myth of Xeriscaping. *Center for Urban Horticulture Ecosystem Sciences College of Forest Resources., University of Washington*. Retrieved December 12, 2003, from http://www.cfr.washington.edu/research.mulch/myths/xeriscape.pdf.

22. Waller, P. (November-December, 1999). To Drip or Not to Drip, That Is the Question. *Arizona Water Resource.* Volume 8, Number 3.

23. Haveruk, L. (June 1, 2002). To the Last Drop. *Grounds Maintenance.*

24. December (2002). Better Turf Thru Agronomics. *UCRTRAC Newsletter*. Retrieved December 12, 2003, from http://UCRTRAC/BTTA/BTTA%20December%202002.pdf.

25. Celestian, S. B. and C. A. Martin (2002). Urban Land Use and Surface Cover: Effects on Soil Temperatures. Retrieved December 12, 2003, from http://caplter.asu.edu/Symposia/Symp2003/CelestianMartin.pdf.

26. Erickson, J. E. et. al. Comparing Nitrogen Runoff and Leaching between Newly Established St. Autustinegrass Turf and An Alternative Residential landscape. *Crop Science 41:1889-1895 (2001).*

27. Gonzalez, M. C. (2003, March 17) Homeowners turn to xeriscaping as water shortage nears. *El Paso Times.* Retrieved December 12, 2003, from http://www.borderlandnews.com/water2003/20030317-88617.shtml.

28. Owens-Viani, L. (1999). Chapter 1 Marin Municipal Water District's Innovative Integrated Resource Management Program. *Sustainable Use of Water California Success Stories.* 11-26.

29. Wong, A. K. (1999). Chapter 2 Promoting Conservation with Irvine Ranch Water District's Ascending Block Rate Structure. *Sustainable Use of Water California Success Stories.* 27-36.

30. Western Resource Advocates (2003, December). Chapter 5 Recommendations. *Smart Water a Comparative Study of Urban Water Use Efficiency Across the Southwest.* 105-114.

31. Western Resource Advocates (2003, December). Chapter 3 Comparative Analysis of Water Providers in the Southwest: Water Use and Demand-Side Efficiency. *Smart Water a Comparative Study of Urban Water Use Efficiency Across the Southwest.* 55-92.

32. Irrigation Efficiency Rebate Study. *City of Santa Rosa Water Conservation Study*. Retrieved December 12, 2003, from http://ci.santa-rosa.ca.us/wc/pdf%20files/irrig%20Effic%20Brochure.pdf

33. Reed, J. (2002). Conservation Specialist, Denver Water, Tom Rodda (2001), City of Sonoma Program Coordinator, and Robert Freeland (2001), Valley of the Moon Water District Program Coordinator, Personal Communications.

34. Hunt, H. et. al. (2001) Residential Weather-Based Irrigation Scheduling: Evidence from the Irvine "ET Controller" Study.

35. Smith, J. and T. Brown (2003) Water Efficient Irrigation Study Final Report. *Seattle Public Utilities, Resource Conservation.*

36. Smeal, D. (Fall 2000). Study Compares Turf Water Needs. *Conservation Current-A Newsletter Published by the New Mexico Water Conservation Alliance*. Retrieved December 12, 2003, from http://wrri.nmsu.edu/wrdis/nmwca/current/fall2000.pdf.

37. Ritter, J. (2003, May 29). Vegas drought may wither growth. *USA Today*. Retrieved December 12, 2003, from http://www.usatoday.com/weather/news/2003-05-29-vegas-drought_x.htm.

38. (1998, June 19). Our Readers Respond. *Las Vegas Review-Journal, Donrey Newspapers*. Retrieved December 12, 2003, from http://www.reviewjournal.com/lvrj_home/1998/Jun-19-Fri-1998/opinion/7684139.html.

39. Moving and Welcoming. *Exodus Network*. Retrieved December 12, 2003, from http://www.exodus.ibelieve.com.

40. Devitt, D. A. (2003). Center for Urban Water Conservation. Las Vegas, Nevada. Personal Communication.

Other Related Reading Information:

Devitt D. A. et. al. (1995). Comparative Water Use of Turfgrass and Ornamental Trees in an Arid Environment. *Journal of Turfgrass Management*, Vol 1(2), 47-63.

Cooper, R. M. and M. K. Owens (2002). How Much Water Do Xeriscape Plants Really Need? *Texas A&M Agricultural Research & Extension Center at Uvalde*. Retrieved December 12, 2003, from http://uvalde.tamu.edu/pdf/2002/024-xeriscape.pdf

Duble, R. D. Water Management on Turf grasses. *Texas Agricultural Extension Services*. Retrieved December 12, 2003, from http://aggie-horticulture.tamu.edu/plantanswers/turf/publications/water.html

Brown, P. W. (2001, December) Turfgrass consumptive Use Values for the Phoenix Area. *Turf Irrigation Management Series V.*

Western Resource Advocates (2003, December). Appendix B El Paso. *Smart Water a Comparative Study of Urban Water Use Efficiency Across the Southwest.* 122-178.

Mecham, B. (2003, March). Conservation Strategies for Lawn Watering During Drought or Water Shortages. *24th Annual International Irrigation Show*.

Table 1. "Cash for Grass" Studies and Cost Per Acre Foot Saved

Study Location	Rebate Cost Per S.F.	Admin Cost Per S.F.	Freerider Cost Per S.F.	Total Cost Per S.F.	Gal. Saved Per S.F.	S.F Needed to Save One Acre Ft./Yr.	Cost Per Acre Foot Water Saved	15 Yr. Cost Per Acre Ft. with 25% Erosion
North Marin	$0.50	$0.02	$0.16	$0.68	33 Gal.	9,874	$6,714	$512
Albuquerque	$0.40	$0.02	$0.13	$0.55	19 Gal.	17,150	$9,433	$718
Southern NV	$1.00	$0.02	$0.31	$1.33	62 Gal. *	5,256	$6,990	$532
El Paso	$1.00	$0.02	$0.31	$1.33	18 Gal.	18,103	$24,077	$1,834

* The Southern Nevada Water Authority, in their summer 2004 Waterwise publication, stated that, "On average, residents use 40 percent more water on their grass than most turf requires."[11]

Table 2 ET Controller Studies and Cost Per Acre Foot Saved

Study Location	Rebate Per Controller	Admin Cost Per Controller	Freerider Cost Per Controller	Total Cost Per Controller	Gal. Saved Per Controller	Controllers Needed to Save One Acre Ft./Yr.	Cost Per Acre Foot Water Saved	15 Yr. Cost Per Acre Ft.
Denver, CO	$200.00	$30.00	$69.00	$299.00	38,486 Gal.	8.5	$2,542	$169
Sonoma, CA	$200.00	$30.00	$69.00	$299.00	23,963 Gal.	13.6	$4,066	$271
Valley of the Moon, CA	$200.00	$30.00	$69.00	$299.00	41,900 Gal.	7.8	$2,332	$155
Irvine, CA	$200.00	$30.00	$69.00	$299.00	13,651 Gal.	23.9	$7146	$476
Seattle, WA Controller Only	$200.00	$30.00	$69.00	$299.00	10,071 Gal.	32.4	$9,688	$646
With Rain Sensor	$250.00	$30.00	$84.00	$364.00	20,735 Gal.	15.7	$5,714	$381