Assessment of the viability of xeriscaping to reduce water consumption in Sacramento

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Abstract
With drought conditions in Sacramento, methods to reduce residential water consumption could prove extremely beneficial. Current residential outdoor water usage is compared to possible savings following xeriscape methods to pinpoint effective areas to save water. The average single family household is found to use 135,000 gallons of water per year on irrigation. At a cost of $4300, switches to xeriscape through a “cash for grass” program could shave 30% off of yearly usage. Soil moisture sensor controllers are determined to save 60% and cost only $219; solving a common issue of irrigation efficiency, which is lacking with popular automatic irrigation systems supplying twice the amount of water needed to sustain cool-season turf. Investment in irrigation efficiency is determined as the cheapest, most effective, and fastest method of water conservation; giving it the highest expected acceptance from consumers based on the popular acceptance of turf.

Background/Goal/Significance
Residential water usage can be seen as a major factor in total water usage for California. (Hanak et al. 2008). Practices that have become normal are wasting large amounts of water in a time when water is a scarce resource (ConSol 2010). Only 2.5% of the water on earth is fresh. Of this freshwater, less than 1% is accessible for human consumption. This 1% must then support Earth’s population as it moves past 7 billion. With our increased population, water supplies can become stressed. An example of this stress is the struggle between northern and southern California for the contents of the American and Sacramento River. Two major aspects in the struggle for water is knowledge regarding water consumption and the relationship of visual appeal versus the perceived value placed on different landscapes in the home environment.
(Clayton 2007, Blaine et al. 2012). This has led to the average home garden becoming wasteful with outdoor irrigation taking up 58% of residential water use (ConSol, 2010).

Xeriscaping is a design strategy, that when followed, can drastically lower water consumption (Addink 2014 and Mojave 2011). By definition, xeriscaping means dry scene (California Recycle 2013). The concept of xeriscaping is simple; it involves redesigning a yard based on maximizing water efficiency with consideration focused on the types of plants that should be grown based on climate conditions of a given area and using efficient watering techniques.

The goal of this paper is to determine if xeriscaping is an effective technique to reduce water consumption in Sacramento. Through research and inspection of many applicable journals, data will be accumulated to find standard Sacramento and xeriscaping water usage, which will be compared to illuminate solutions to Sacramento’s high water consumption. Feasibility will also be examined on the ability of techniques to be economically practical based on return on investment statistics; this includes the cost associated with the conversion to xeriscape, cost of irrigation updates, and the savings expected from each.

**Sacramento Standards**

Evapotranspiration, which is the amount of water lost from evaporation and transpiration, can be used to determine the amount of water necessary to sustain different plants based on climactic zone (Hanak et al. 2008). Based on this, an equation has been developed to assess the amount of water required by a residential home.

**Equation 1:** Landscape water = \((ET_0) \times 0.62 \times \text{Area} \times \text{ETAF}\)

(ConSol 2010)
The ET₀ value for Sacramento is listed at 52 inches per year and 0.62 is a conversion factor to convert the result to gallons per year (ConSol 2010). Landscaped surface area for a single family home is listed between 3000 and 5000 square feet, for the purposes of this paper, an average of 4000 square feet will be used (Baumann et al. 1998, Hanak et al. 2008). The adjusted ET value, ETAF, is based on irrigation efficiency, with lower efficiency rates increasing the amount of water required to sustain residential gardens.

Irrigation efficiency is the last aspect revolving around Sacramento’s residential water usage. The more efficient an irrigation system, the less water is wasted; a perfect system would operate at 100% efficiency, which would mean that no water is wasted. The standard irrigation efficiency for California is 62.5%, meaning that 37.5% is wasted as excess, which is due to the misuse of automatic sprinkler systems (Hanak et al. 2008, Haley et al. 2012). These systems are commonly adjusted in ways that operate much more frequently than is needed based on a plant’s specific ET.

To demonstrate this inefficiency the Mojave Water Agency (2011) compared the amount of applied water from 231 residential properties and 7 golf courses to the required ET for turf. Results show the residential participants overwatered by over twice the required ET amount while golf courses on average only marginally overwatered (Figure 1).
This large amount of wasted water gives rise to an adjusted $ET$ value for residential homes in Sacramento of 105%, found from equation 2.

**Equation 2:** Adjusted $ET = \frac{\text{Average plant ET requirement}}{\text{Irrigation efficiency}}$

(Hanak et al. 2006)

This is based on an ET requirement of 65%, which spurs from a mixture of high ET turf and medium ET shrub, and California’s statewide irrigation standard of 62.5% (Hanak et al. 2008, Table 1). Plugging this number into Equation 1 as follows: $(52)(0.62)(4000)(1.05)$, gives an average single family home in Sacramento using 135,000 gallons of water per year. This value is higher than that of ConSol (2011), determined to be 115,000 gallons, because of a higher adjusted ET factor from Hanak et al. (2008).
<table>
<thead>
<tr>
<th>Irrigation Efficiency</th>
<th>Average Plant ET Requirement</th>
<th>High (80%)</th>
<th>Medium (50%)</th>
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</tbody>
</table>

Table 1: Plant adjusted ET based on irrigation efficiency (Hanak et al., 2008)

Xeriscape Standards

A major goal of xeriscaping is to replace high ET plants (80%), such as turf, with native plants commonly having an ET of only 20%. Eliminating turf grass would drop Sacramento down from an average plant ET of 65% to 32%, assuming the rest of the landscape remained 40% shrub. Adjusted ET is then shifted from 105%, to 51%. Substituting this factor into equation 1 gives a total of 66,000 gallons per year, a theoretical savings of 69,000 gallons per year or 51% from the current estimate of 135,000. This theory that replacing turf with lower ET plants will reduce water usage drives “Cash for Grass” programs which offer cash incentives for homeowners to replace turf with native low ET plants; almost all require irrigation updates as well (Figure 2). These programs are structured to pay residents between $0.50 and $1.00 per square foot of turf removed and upon completion see theoretical savings of 51%.
Figure 2: Pre and post “cash for grass” program (Mojave, 2011)

The real life savings from these programs prove to be much lower than the theoretical savings of eliminating turf grass. Mojave Water Agency (2011) held a program including 231 properties in which a reduction of 37% was recorded, resulting in a turf water usage of 8.94 feet per year. This study compared pre and post usage amounts, the difference being reduction from the program. Comparisons to the ET for cool-season turf grass of 4.0 feet per year shows a very large irrigation inefficiency that remains even after the “cash for grass” program. Somewhat similar data were evaluated in comparing four different “cash for grass” programs; North Marin Water District, Albuquerque, New Mexico, Southern Nevada Water Authority, and El Paso Texas. From these four programs, savings averaging around 30% were also seen, but the majority of savings became linked to irrigation upgrade, most customers opting for drip systems (Addink 2014). This was exemplified by the El Paso, Texas example, showing comparatively low numbers due to the lack of rules stipulating requirement of irrigation upgrade.
Data from “cash for grass” programs point towards irrigation inefficiency as being a common denominator between water usage issues. A study was done in southwest Florida testing the efficiency of different watering techniques (Haley et al. 2012). Through a 26 month study, 58 homes were watered using devices ranging from automatic timer (MO), automatic timer with rain sensor capable of stopping watering cycles based on precipitation (RS), automatic with rain sensor and scheduling which moderates water cycling according to weather conditions programmed into it (EDU), and automatic timer with soil moisture sensor control system which is an underground unit that overrides scheduling based on soil moisture content (SMS). After the 26 month period, automatic timer (MO) was used as a standard to compare the savings of each option. From this standard, SMS saved 65%, EDU 30% and RS 20% (Figure 3). The high savings of the SMS were also consistent with other studies. Cardenas et al (2008) found savings of 70% in an initial study testing the effectiveness of SMS. This study was repeated again in 2010 with drier conditions resulting in a savings of 54% (Cardenas et al. 2010). A savings of 60% would cut yearly water usage from 135,000 to only 54,000 gallons, which is even lower than the theoretical savings of a “cash for grass” approach, and no turf must be removed.
Figure 3: Comparisons between amounts of irrigation and precipitation from SMS (soil moisture sensor), EDU (rain sensor and scheduling), RS (rain sensor), and MO (automatic timer) (Haley et al. 2012)

Feasibility

The water savings of a xeriscape approach to home landscaping comes with a cost. The incentive to participate in “cash for grass” programs ranges from $0.50 to $1.00 per square foot of grass, and in fact Sacramento has recently been reporting an approval of a program that is reported in various news websites at $0.50 per square foot of grass with a maximum of 1000 feet or $500. The standard yard being 4000 square feet and 60% turf would amount to 2400 square feet of turf for the average single family home. This would mean that the average single family home would have to pay full price to remove the remaining 1400 square feet of turf. Hanak et al. (2012) quotes Tracy Bower from the Southern Nevada Water Authority on prices for the
homeowner of $2 per square foot. The cost to homeowner at this price, with the “cash for grass” incentive, would be $4300. Investing this amount would then lead to a 30% reduction, which based on a metering price between $0.61 and $2.36, quoted from the Rancho Cordova Water District (http://www.ranchowater.com/DocumentCenter/View/16), equivalates to a savings between $33 and $128 a year. At this price it would take between 35 and 136 years for a return on the investment of $4300. This would not count for the parts of Sacramento which are still on a flat rate system however. The Sacramento Water District states that retrofitting meters is expected to finalize by 2025 (http://sswd.org/index.aspx?page=181).

The investment for an SMS irrigation system is much lower with the entry level Acclima brand, referenced by Haley et al. (2012), being $219. For this price, one soil sensor is included, but the machine is capable of utilizing six, each additional sensor priced at $169. The Acclima SC6 SMS sensor can be directly installed to current timer irrigation systems which would lead to an expected reduction around 60%. Return on investment would be much quicker based on a yearly savings ranging from $66 to $256, with a maximum return on investment of only three and a half years. Once again, this would not be relevant to non-metered customers.

**Discussion**

There is no doubt that replacing high ET plants with native low ET plants saves water. However, the transition process involved with converting a yard to xeriscape can be expensive, even with the expected savings and incentives. Beyond that, a large part of Sacramento is still paying a flat rate for water, which would take away the incentive to invest in water conservation.

Money aside, removing turf from residential gardens is an extremely unpopular decision. Acceptance of turf removing programs is extremely low at only 5%, with a survey consisting of
1800 participants in Phoenix yielded 70% who listed turf as an integral part of their landscape (Addink 2014). Similarly, a study of 432 residents of Ohio listed turf as representing social status; assuming a dearth of it would represent a family’s welfare poorly (Blaine et al. 2012). This feeling towards turf is an integral part of American landscape practice, and is likely to be seen everywhere, including Sacramento.

Investment in irrigation efficiency devices, costing 95% less than the expected cost of xeriscape transformation, and saving 50% more without the loss of any turf, has the ability to draw a much larger percentage of the population. The water savings for this type of conservation has also been proven to be more consistent with theoretical amounts. This shows that irrigation efficiency should be the focus of water conservation campaigns, especially with subjects of many studies overwatering by twice as much as the required ET.

Moving forward, to prioritize water conservation, metering must be introduced to the entire population, which would give incentives for customers with savings on irrigation amounting to money back in their pocket, especially as the cost of water rises. Also educational materials detailing possible savings based on investments in irrigation efficiency products, such as SMS, which would pay for themselves within a few years. Beyond that, rebates for SMS products could also be used to point customers in the right direction, which could replace and draw from the budget of the newly announced “cash for grass” program.

Moving towards a full xeriscape is not impossible for Sacramento. However, steps towards the replacement of turf cannot be compared to the removal of a band aid, and an all-or-nothing approach, such as “cash for grass” programs, will not hold strong support with residents who are at this point too passionate towards landscapes containing turf. A drastic increase in
irrigation efficiency is possible with limited investment, which would garner strong support from turf lovers and grant large reductions in current water usage in Sacramento.
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