Buffalo Grass as a Means of Water Use Reduction on the UC Davis Campus

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Abstract

As global water demand continues to rise, improving water-use efficiency becomes increasingly crucial to achieving hydrologic sustainability. Ornamental lawn irrigation remains one of the largest water use inefficiencies in the United States, but altering public perceptions about the desirability of lawns remains a challenge from a strictly narrative standpoint. The paradigm of market forces acting as deadweight to changing the status quo when it comes to conservation efforts may be shaken, though, if it can be demonstrated that individual actors can benefit from environmentally conscientious actions. The aim of our study is to see if the replacement of turf grass with UC Verde Buffalo Grass could substantially reduce the water use of the University of California, Davis while maintaining economic and logistic feasibility.

Spatial analysis of lawns maintained by UC Davis was performed to assess potential scenarios for turf grass replacement. Water-use calculations were then executed to estimate the amount of water the campus would use under conditions of no change and of each of the scenarios provided by the spatial analysis. Lastly, each scenario was assessed for its economic viability under current market conditions.

While our more conservative model showed the potential for 46.6% reduction in annual irrigation water use, even the most favorable cost of implementation showed a time of 29.8 years until the water savings alone paid for the lawn replacement, excluding the time value of money, making current market conditions unlikely to favor turf grass replacement alone. The low return is largely the product of the relatively small effect the reduced irrigation will have on total water costs faced by UC Davis (10.59%-13.64%) and the relative cheapness of water compared to the price of grass replacement.

While our hypothesis of economic feasibility was not met, the results of our data show that significant water reductions can be made by switching to a less water-intensive variety of grass. A more graduated process such as replacing lawns only when they would need to be replaced anyway could help lower the cost of replacement. Also, when taking into account the high externalities of water scarcity and principles of environmental ethics, the decision to switch or not may not only be a question of dollars and cents.

Introduction

Using satellite imagery to quantify impervious surfaces across the United States and applying the average lawn-to-impervious-surface ratio in urban areas, Christine Milesi at NASA's Ames Research Center predicted that lawns cover 128,000 km^2 of the United States, making grass the number one irrigated crop in the country, about three times as abundant as area dedicated to corn production (Lindsey, 2005). Americans spend a lot of water and CO_2, in the form of the energy cost to pump irrigation water, just to keep their lawns green. The American fixation on the lawn as an aesthetic decoration and status symbol has not relinquished despite growing concerns about water scarcity and conservation. The University of California, Davis, a leader in research in the environmental sciences, is currently no exception to the great American ritual of water sacrifice, although researchers at UC Davis in collaboration with UC Riverside have recently developed a variety of grass that may serve as a water-saving replacement to traditional turf grass (University of California Cooperative Extension, 2012).

This non-invasive variety of grass is known as the UC Verde Buffalo Grass. Preliminary studies have shown that it uses 50-75% less water than common turf grass (University of California Cooperative Extension, 2012). Benefits of this grass include high competitiveness with weeds, disease resistance, and lower pollen production (University of California Cooperative Extension, 2012). Competitiveness with weeds should make the variety of grass easy to maintain, disease resistance will lower lawn treatment and replacement costs, and lower pollen production will limit the negative effects of allergens. Downsides to this grass transition include full winter dormancy of the Buffalo Grass, meaning a loss of color during months with frost, and less resilience to excessive use or precipitation (University of California Cooperative Extension, 2012). A non-organic but harmless colorant can be applied during the winter if desired (University of California Cooperative Extension, 2012), though that would dampen the economic benefits from the transition.

The aim of this research is to assess whether replacement of traditional turf grass with the UC Verde Buffalo Grass could substantially reduce the university's water budget and to see if such a transition would be economically feasible. As global water demand continues to grow and water-dependent ecosystems continue to be degraded, finding ways to reduce water waste becomes imperative, and the University, the hub of science and philosophy, need to take up that mantle to encourage sustainable water use.

Objective

The main objective of this project was to see whether or not switching from turf grass to UC Verde Buffalo Grass will significantly reduce water use. Additionally, we assessed the viability of native landscaping as a sustainable economic alternative to the status quo. Based on our findings, we explored two management scenarios for UC Davis as well as issues involved in using native landscaping as a water conservation measure.

To begin, we contacted Joshua Morejohn, the Energy Manager at the UC Davis Facilities Management, to get an estimate of how much water is used around the campus. This helped us establish a baseline of current water use. Through research, we were able to determine the crop coefficient of the grasses to calculate the crop evapotranspiration (Etc = Kc * ETo, where Etc=crop evapotranspiration, Kc=crop coefficient, ETo=reference evapotranspiration). We came up with our own scenarios to see what would happen if we replaced the turf grass with the UC Verde Buffalo Grass. For Scenario A, we only replaced ornamental lawns. This left us with a mixture of both grasses. We figured out how much water is used per year and then added up both numbers to get the total water use. For Scenario B, we replaced all lawns on campus with the UC Verde Buffalo Grass. Like Scenario A, we have to find out the total water use for the year. We will then compared both numbers with the baseline, which is having only turf grass.

In our study performed spatial analysis of the UC Davis campus for our predictions of current water use and native landscaping water use using GIS software. We used ArcGIS computer software to run estimates to find the spatial extent of watered lawns on campus and to develop plans for how and where techniques in native landscaping can be applied to reduce water use.

Finally, we developed a water management recommendation based on our findings, including uncertainties in our estimation and potential challenges in implementation.

Hypothesis

We hypothesize that replacing turf grass with native landscaping can result in a net reduction in annual water use. Additionally, and more pertinently, we hypothesize that the cost of implementation will pay for itself in water savings within a short enough to be economically feasible. We define the period of economic feasibility as $t<10$ years.

Data Sources

Areal imagery for the spatial analysis was obtained from CalAtlas, using the Digital Orthophoto Quarter Quads n38121e6sw, “Davis,” and n38121e7se, “Merritt” (CalAtlas, 2010).

Land-use overlay shapefile (vector data) was obtained from Chris DiDio in his role as GIS Analyst for UC Davis (Chris DiDio, personal communication, Nov. 27, 2012). This data was essential for determining lawns maintained by UC Davis and in the spatial aggregation of scenario-appropriate lawns and fields.

The input variables for the water-use calculations came from the California Irrigation Management Information System for the standardized ET_0 values (CIMIS, 2012) and from research published to the web by University of Arizona’s Paul Brown for crop coefficients for standard C4 grasses (Brown, accessed 2012). Using data from studies that experimentally varied ET_0 conditions (University of California Cooperative Extension, 2012), the crop coefficient for UC Verde Buffalo grass could be calculated, allowing for the water-use calculations to be made.

Retail price estimates of the UC Verde Buffalo Grass were obtained on the web from “ucverdebuffalograss.com” and “naturehills.com.”

Water use data for the UC Davis campus was obtained through personal communication with Joshua Morejohn, an Energy Manager for UC Davis Facilities Management. This data was imperative for determining the overall impact on the UC Davis water budget, and the amount of water that would be saved by both scenarios.

The figures for labor and water rates came from “campus-care.ucdavis.edu,” a website run by UC Davis Facilities Management. From that, the average cost per gallon could be calculated and in turn the cost of the water savings could be determined.

Methods and Assumptions

To estimate the total amount of water used by UC Davis in irrigation of turf grass, spatial analysis of the property maintained by UC Davis was performed using ArcMap 10 by ESRI. Digital Orthophoto Quarter Quads (DOQQs), aerial photography maintained by the USGS, were used as a basemap for the analysis and were obtained from CalAtlas, a geospatial information hub maintained by the State of California. The two DOQQs used, "Merritt" and "Davis," were from flights between 1996-1999 and have a resolution of one meter, making their spatial and temporal scale acceptable for this analysis. Land-use data identifying lawns maintained by the campus was obtained from Chris DiDio, a GIS Analyst at UC Davis in the form of a vector-based shapefile and its associated projection files, which had been converted from the campus geodatabase data and is as recent as 2010. This data was overlaid on the DOQQs and compared to the imagery data to determine where turf grass replacement could occur on campus. Two major divisions in turf grass were apparent in the campus's database structure, namely lawns and athletic fields. The land-use polygons were evaluated against the basemap to determine their suitability to our analysis. The Aggie Football Stadium field was removed from our analysis,

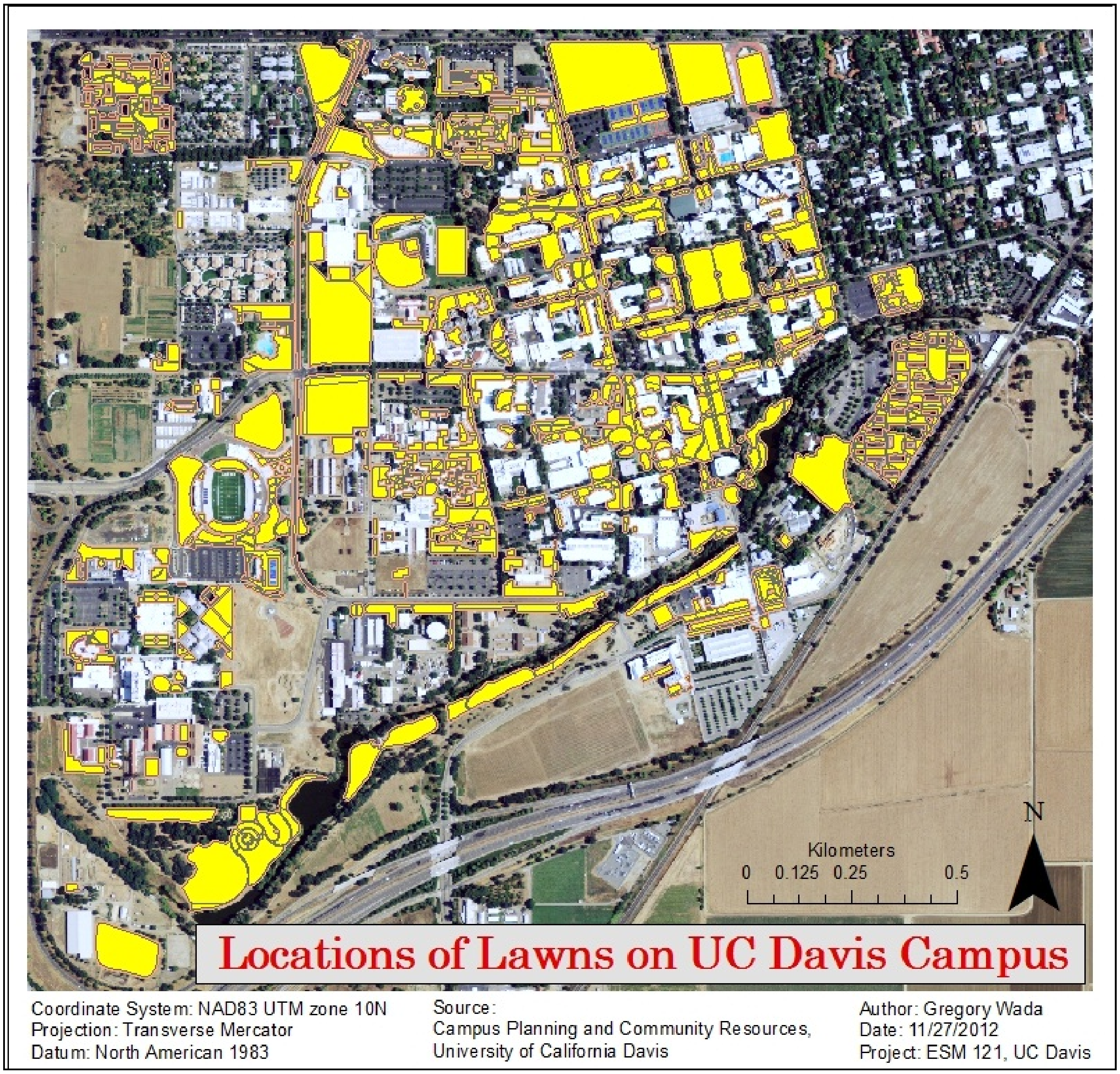

Figure 1: Map of Lawns Managed by UC Davis

though it is classified as an athletic field, as it is a synthetic turf (UC Davis Department of Athletics, 2008). We considered two scenarios for turf grass replacement. Scenario A considers the replacement of ornamental lawns but not athletic fields. This includes all lawns, dividers, and medians not intended for sports as well as grass in housing areas maintained by UC Davis. This scenario also includes grass in areas under construction. Scenario B includes both the replacement of athletic fields and ornamental lawns, which account for all non-agricultural grass maintained by the campus (Figure 1). Both do not include the Aggie Stadium field. The additional plots considered in the second scenario but not in the first are the Hutchinson and Russell intramural sports fields, the A-street football field, the baseball field, the softball field, and the soccer field. The areas of the polygons that meet the conditions of each scenario were aggregated to calculate a total area for each scenario.

To calculate the water demands for the grass on the UC Davis campus, a crop evapotranspiration value was derived based on a known reference evapotranspiration value for Davis and known experimental crop coefficient values for C4 grasses via the relationship $Et_c=K_{c\text{-}adjusted}(K_s)(ET_0)$ (Morgan et al., 2006) (CIMIS, 2009). The reference evaporation value for Davis used was 57.97 inches per year, based on data collected by the California Irrigation Management Information System, managed by the California Department of Water Resources (CIMIS, 2012). The crop coefficient was experimentally derived by Paul Brown at the University of Arizona to be 0.65 for C4 grasses of the traditional turf grass variety (Brown, accessed 2012). The UC Verde Buffalo Grass was experimentally shown to survive at 40% ET_0 conditions and still function well as a lawn (University of California Cooperative Extension, 2012), therefore we applied a K_s value of 0.40, resulting in a functional *K_c of 0.26* for the UC Verde Buffalo Grass. This conversion was necessary as ET_0 is a reference value from crops compared to ground covered by grass.

These values were used in the analysis of monetary values and were crucial to determining economic viability of each project. After obtaining the necessary water rate and cost information from Joshua Morejohn and the Campus Care website, the water savings calculations were performed in Excel through a series of formulas and computations. Additionally, further sub-scenarios were explored with regards to source of UC Verde Buffalo Grass plugs, bulk/public university discount rate and amount of labor necessary. The same computations were repeated for each sub-scenario. With all sub-scenarios taken into account, 36 possible outcomes were presented. For each possible outcome, we calculated the total cost, the dollar amount saved, the percent of the overall UC Davis water budget that would be saved, and the amount of time it would take to start saving money after the initial water savings made up for the cost of the project.

Scenario	Descrption	Size
Scenario A	Ornamental	123.408 acres
Scenario B	Athletic and Ornamental	158.995 acres

Table 1: Scenario Description

Calculation/Results

The results of the area aggregation of potential turf grass to be replaced by the UC Davis campus resulted in *123.408 acres for Scenario A*, the replacement of ornamental lawns only, and *158.995 acres for Scenario B*, the replacement of athletic fields and ornamental lawns (Table 1). Scenario B has *35.586 additional acres* than Scenario A, which accounts for *22.4% of the grass maintained by the campus*. If the UC Verde Buffalo Grass proves to be unsuitable for athletics, *77.6% of the grass on campus could still be converted to the buffalo grass*. This is telling of the fact that most of the grass on campus is located in smaller patches, resulting in a rapidly declining fat-tailed distribution (Figure 2).

Using the $ET_c = K_c \times ET_o$ equation and the parameters discussed in the methods section, ET_c was calculated for both the current turf grass and the UC Verde Buffalo Grass. The ET_c for traditional turf grass was calculated to be *38.727 inches of water per year*. The ET_c for the UC Verde Buffalo Grass was calculated to be *15.491 inches of water per year*. When applied to the area estimates from the GIS analysis, this translated to *274.156 acre-feet of water/year for Scenario A (114.836 acre-feet of water/year from traditional turf grass and 159.320 acre-feet of water/year from UC Verde Buffalo Grass)*, which was replacement of ornamental lawns only.

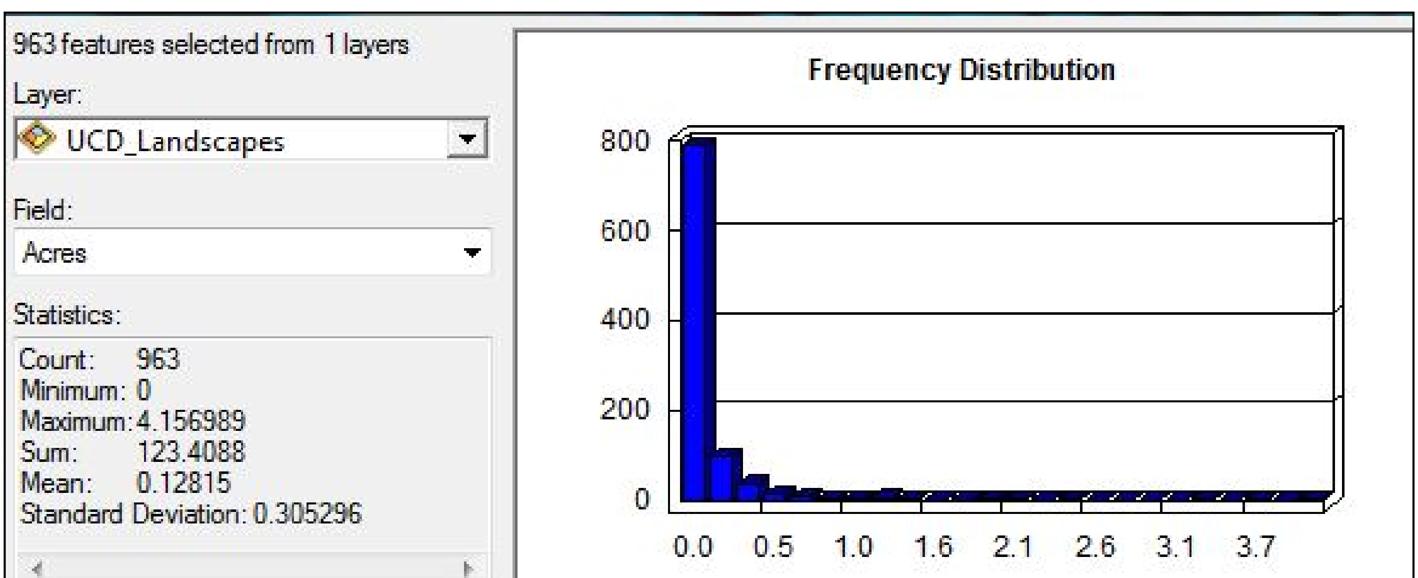

Figure 2: Histogram of Lawn Size

Scenario B had water use of 205.156 acre-feet of water/year, considering the entire 158.995 acres of UC Davis grass transitioned to UC Verde Buffalo Grass. The baseline water usage per year *with no grass transition was found to be 513.007 acre-feet of water/year*. From the baseline, *Scenario A saves 238.851 acre-feet of water/year, or a 46.6% reduction in water use*. Replacement of all maintained grass showed that *Scenario B saves 307.851 acre-feet of water/year, or a 60.0% reduction in water use* (Table 2).

			Table 2	
	area replaced	water use	water savings from baseline	savings as percent
	acres	acrefeet/year	acrefeet/year	%
Scenario A	123.408	274.156	238.851	46.6%
Scenario B	158.995	205.156	307.851	60.0%

To determine the water savings of both Scenario A and Scenario B, the respective water consumption rates of 46.6% and 60% were multiplied by the total water used. The monetary value of this water saved was calculated by taking the cost per CCF, $0.17, and dividing it by the conversion factor, 748.052 (Campus Care, accessed 2012). *This gave the cost per gallon, $0.000227*, which was then multiplied by the amount of water saved for each scenario. *Scenario A gave 186,400,000 gallons saved and $42,360.69 saved per year. Scenario B gave 240,000,000 gallons saved and $54,541.66 saved per year.*

The total cost of the project is an important metric to consider as well. To find the cost of labor of installation, we multiplied the estimated number of workers by the number of weeks by 40 hours per week by $62, the cost per hour (Campus Care- Labor, accessed 2012). See Table 3 for the rates for each sub-scenario.

Estimated Labor	Cost
120 hours, 20 people	$148,800.00
160 hours, 20 people	$198,400.00
200 hours, 20 people	$248,000.00

Table 3: Estimated amount of labor necessary and respective cost

To find the total cost, we converted acres to square feet, assumed 1 grass plug per square foot and then input the number of plugs for *Scenario A and Scenario B into the website: 5375652.48 and 6925822.20 square feet, respectively.* However, for naturehills.com, the number input exceeded the amount in stock, so instead, 500 was input as the number of plugs, and the cost was extrapolated. The shipping and handling was calculated by the websites (UC Verde Buffalo Grass, accessed 2012; Nature Hills, accessed 2012). This was then added to the cost of labor to give the total cost of grass installation.

To determine the amount of time it would take to make this project worthwhile, the amount of water saved is divided by the total cost of the project. Here, the largest variable is the

Scenario	Labor	Years		Scenario	Labor	Years
Scenario A ucverdebuffalograss.com	120 hours, 20 people	73.61		Scenario A naturehills.com	120 hours, 20 people	77.23
	160 hours, 20 people	74.78			160 hours, 20 people	78.14
	200 hours, 20 people	75.95			200 hours, 20 people	79.05
25% discount	120 hours, 20 people	56.09		25% discount	120 hours, 20 people	45.44
	160 hours, 20 people	57.26			160 hours, 20 people	46.34
	200 hours, 20 people	58.43			200 hours, 20 people	47.25
50% discount	120 hours, 20 people	29.8		50% discount	120 hours, 20 people	112.48
	160 hours, 20 people	30.97			160 hours, 20 people	113.65
	200 hours, 20 people	32.15			200 hours, 20 people	114.82
Scenario B ucverdebuffalograss.com	120 hours, 20 people	72.87		Scenario B naturehills.com	120 hours, 20 people	77.96
	160 hours, 20 people	73.78			160 hours, 20 people	79.14
	200 hours, 20 people	74.69			200 hours, 20 people	80.31
25% discount	120 hours, 20 people	55.34		25% discount	120 hours, 20 people	46.19
	160 hours, 20 people	56.25			160 hours, 20 people	47.36
	200 hours, 20 people	57.15			200 hours, 20 people	48.53
50% discount	120 hours, 20 people	29.03		50% discount	120 hours, 20 people	111.76
	160 hours, 20 people	29.94			160 hours, 20 people	112.67
	200 hours, 20 people	30.85			200 hours, 20 people	113.58

Table 4: All 36 sub-scenarios and the amount of time it would take to start saving money after initial investment.

Conclusions

If the UC Davis switched from turf grass to buffalo grass then a significant of water could be conserved leading to a substantially reduced water budget. After ample research the hypothesis that buffalo grass would conserve water consumption on UC Davis is true but the financial cost of replacing the turf grass is higher than expected. The best scenario of replacing all the turf grass with buffalo grass would give a break even time of 72.87 years for Scenario A and 73.61 years for Scenario B, not taking into account any bulk/public university discounts. The impact on the total UC Davis water budget by changing to UC Verde Buffalo Grass for Scenario A, the amount of water that would be saved would represent 10.59% of the total water currently used; for Scenario B, that value is 13.64%. Scenario A gave 186,400,000 gallons saved and $42,360.69 saved per year. Scenario B gave 240,000,000 gallons saved and $54,541.66 saved per year. While this is very significant, the cost of the project is most likely out of reach for a public university undergoing budget cuts. Calculating the amount of time, cost, and water saved by replacing the grass it can be concluded that while replacing turf grass with buffalo grass is beneficial but it most likely will not be at the top of the list for projects to do for conserving water.

Recommendation/Limitations

There are several limitations for replacing turf grass with UC Verde Buffalo Grass. Buffalo Grass is not resilient to constant wear and thus would not be suitable for fields used for collegiate or intramural sports. Another hindrance is that during the winter the color of the buffalo grass will turn brown; colorant would have to be applied to keep the grass looking green. The cost of colorant would then have to be taken into consideration when calculating the benefits of using buffalo grass. Even though UC Verde Buffalo Grass conserves 10.59% in Scenario A and 13.64% in Scenario B, the time it takes to break even (at retail price) is astronomical. Thus if UC Davis wanted to design a plan to conserve water immediately then this project could be used in conjunction with other landscape water conservation measures.

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