COST-BENEFIT ANALYSIS OF XERISCAPING: A COLORADO COLLEGE CASE STUDY

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By
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COST-BENEFIT ANALYSIS OF XERISCAPING: A COLORADO COLLEGE CASE STUDY

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Economics

Abstract
Xeriscaping, a landscape technique geared towards water conservation, can reduce water consumption by 10% to 50%. The cost of xeriscaping ranges from $0.90 per square foot to $1.45 per square foot. Most studies on xeriscaping examine the issue from a homeowner’s perspective, whereas, relatively few people have explored the issue from an institutional standpoint. Making landscape decisions for semi-public lands, like a college campus, is complicated because there are multiple users. This thesis looks at the potential of xeriscaping on the Colorado College campus. A financial analysis is used to determine how much various xeriscaping projects would cost. To understand how or if the student body would benefit from xeriscaping, a survey was used. Xeriscaping could be an educational tool and help promote a sense of place among the student body. Xeriscaping would save Colorado College water, but how the students would benefit is still unknown.

KEYWORDS: (Xeriscaping, Landscaping, Water conservation)
ON MY HONOR, I HAVE NEITHER GIVEN NOR RECEIVED UNAUTHORIZED AID ON THIS THESIS

Phillip Babbitt
____________________
Signature
Acknowledgements

I would like to thank my thesis advisor, Professor Mark Smith. Throughout the process, Mark provided sound advice and needed encouragement.
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Introduction

With class sizes capped at 25, and an acceptance rate of 16% and falling, Colorado College is a competitive liberal arts institution (Colorado College, 2016). The school boasts a pristine, luscious, campus that rivals those of its New England counterparts. Only, Colorado College benefits from the breath taking view of Pikes Peak. What should serve as a reminder of Colorado College’s bio-geographic location, Pikes Peak and the native landscapes surrounding it, are merely an afterthought to the greenery on campus. The Colorado College campus seeks to mirror what east coast schools obtain quasi-naturally. The green grass and tall trees paint a picture of a lush, east coast liberal arts school, which, unfortunately, does not belong in the arid west.

The future of Colorado water is bleak. Complex water laws coupled with an increasing demand and decreasing supply of water have created uncertainty for future Colorado water users, and therefore, Colorado College (Jones & Cech, 2009). The problem intensifies when considering that “over 80 percent of Colorado’s population resides east of the Rocky Mountains, while 80 percent of the state’s water supply is west of the Continental Divide” (Jones & Cech, 2009). The Front Range is, arguably, already over populated, and the problem is going to intensify. Jones states that “it is predicted that by the year 2030 the state will have 7,156,400 residents” (Jones & Cech, 2009). That is a significant increase from the roughly 5.5 million inhabitants currently stretching the uses of Colorado’s water resources.

This thesis focuses on Colorado College’s landscaping practices, and how these practices should evolve with the rising concern of water scarcity. Specifically, the practice of xeriscaping. Xeriscaping is a landscape management technique designed with
water conservation in mind. Through the use of native and drought resistant plants, xeriscaping has demonstrated significant water saving potential (Gregg, et al. 1994; Sovocool, et al. 2006; Medina & Gumper, 2004; Nelson, 1991). Not all turf areas should be converted to xeriscape. As a result of the high frequency of use for recreation, and aesthetic value, Kentucky bluegrass is the most effective landscape for the large quads on campus. In areas that receive less foot traffic and are less central to campus, Kentucky bluegrass wastes water, and therefore, money.

There are two components to determining whether or not Colorado College should invest in a xeriscaping project. First, what are the costs of implementing new xeriscapes? This question is answered through a financial analysis. Second, a xeriscaping project should only be undertaken if the student body, and therefore the college as a whole, would benefit from an increase in xeriscaping. Xeriscapes could serve as educational tools, informing students of local ecosystems and their issues.

A proper financial analysis must first define which costs and benefits should count. We must also determine a time frame for the analysis of a xeriscape project. Initially, this project will not pay off, but in the long run it may. Accordingly, we must determine a discount rate to use, since the money put into a xeriscaping project could have been alternatively invested. The most accurate discount rate to use for Colorado College is the return on the endowment. This is the opportunity cost of the project. Essentially, is the net present value of water savings greater than the net present value of the costs?

The costs of such a project are the manual labor required in converting a turf landscape to xeriscape, the cost of updating the irrigation system, the cost of the plants
and materials used, and the opportunity cost of the money spent on the project. For simplicity of this analysis, the benefit considered is the dollar value attributed to the amount of water saved per year. The data on both the costs and the benefits come from a review of the literature surrounding xeriscaping. Specifically, the “Yield and Reliability Demonstrated in Xeriscape” study (Medina & Gumper, 2004).

A survey was implemented to determine if the student body and college would benefit from an increase in xeriscaping. To avoid bias the survey was randomly distributed among the student body. The survey instrument was designed to gauge student perception surrounding the current landscaping policies at Colorado College and the importance of a campus aesthetic that promotes a sense of place. This information is an important complement to the financial analysis. The cost of xeriscaping alone does not encompass the complexity of the issue.
Literature Review

Xeriscaping the Colorado College campus presents the problem of making landscape decisions for semi-public lands used by many people. The literature surrounding xeriscaping is extensive, but there is lack of research examining public parks. The majority of research in the field of landscaping focuses around residential uses (Gregg et al., 1994; Sovocool et al., 2006; Medina & Gumper, 2004; Nelson, 1991). This literature review will also address the research undertaken on consumer preferences towards water wise landscapes, and the cultural and political elements influencing these practices (Larsen & Harlan, 2005; Larson & Brumand, 2014; Lockett et al., 2002; Hurd, 2006; Larson et al., 2009). Another aspect of landscape choice is sense of place, and the implications of bioregional awareness on landscape attitudes (Garcia-Llorente et al., 2012; Hausmann et al., 2016). This review attempts to provide clarity on the topic of xeriscaping, but also point towards the importance of further investigation into institutional landscaping practices for public and semi-public open spaces.

Advantages of Xeriscape

Population growth and diminishing water resources have created a need for water conservation programs in the arid western U.S (Spinti, 2004). As a result, numerous studies have been undertaken in Arizona, California, Colorado, Nevada, New Mexico, Texas, and Utah explore the feasibility of xeriscaping as a water conservation method. Many of these studies take shape in the form of “Cash For Grass” programs, in which cities offer rebates for the conversion of turf landscapes to xeriscape. Addink (2005)
summarizes the findings of such studies, and reveals that the rebates offered ranged from $0.40 per square foot of bluegrass turf converted to xeriscape in Albuquerque, New Mexico to $1.00 per square foot of conversion in El Paso, Texas.

In 1989, the North Marin Water District pioneered one of the first studies on the potential of xeriscaping (Nelson, 1991). Homeowners received a rebate of $0.50 per square foot of newly converted xeriscape. To take part in this study participants were required to update their irrigation systems. An effective xeriscape garden requires an efficient irrigation system. Hilaire (et al., 2008) discusses the importance of irrigation systems for efficient water use in residential landscaping. Landscape irrigation uniformity and smart water application technologies, such as soil moisture sensors play a critical role in water savings (Hilaire et al., 2008). Participants in the North Marin Water District predominantly implemented drip irrigation systems. Of the 73 applicants, 46 decided to take part in the study. Data analyzed from the 46 properties revealed annual water savings of 33 gallons per square foot (Nelson, 1991).

One of the most exhaustive studies on xeriscape was conducted by the Southern Nevada Water Authority. This study monitored the water use and landscape practices of 1,393 properties over a five year span from 1995-2001 (Sovocool et al., 2006). The properties were separated into three groups: the comparison group, the turf group, and the xeriscape group. The 472 properties in the xeriscape group were “eligible for an incentive of up to $900, calculated at $0.45/sq ft” (Sovocool et al., 2006). Of the 472 properties, 102 installed new xeriscapes from no existing landscape, and the other 370 converted at least 500 sq ft of turf to xeriscape (Sovocool et al., 2006). To avoid bias, a control group of 668 properties was selected but not contacted. These landscapes were similar to the
253 properties who self-selected to represent the turf group. Monthly water consumption was observed through utility meter readings for all three groups.

The main objectives of Sovocool’s study were to determine water reductions, the variability of water savings across time and seasons, evaluate both capital and maintenance costs of xeriscaping, and “estimate the incentive levels necessary to induce a landscape conversion to Xeriscape” (Sovocool et al., 2006). In the eyes of Sovocool (et al., 2006), a successful “Xeriscape incorporates seven key principles:

1. sound landscape planning and design; 2. limitation of turf to appropriate, functional areas; 3. use of water-efficient plants; 4. efficient irrigation; 5. soil amendments; 6. use of mulches; and 7. appropriate landscape maintenance.”

The results of this study show that a xeriscape is cost effective and beneficial to the environment and water suppliers. Homes that converted from turf grass to xeriscape experienced 30 percent annual reductions in total household water use. Cost reductions accompanied water reductions. The typical home from this study realized savings of 54 percent in total annual water charges. Furthermore, xeriscape produced savings arising from decreased maintenance costs. The participants who did convert to xeriscape benefited from 26.4 hours of reduced labor per year, as well as savings of $206 per year on maintenance necessities, like fuel for a lawn mower. (Sovocool et al., 2006). Sovocool alludes to the benefits that water suppliers may experience as a result of xeriscaping. Utilities providers incur large costs attempting to meet the demands for water during peak seasons such as summer. “Per unit area, xeriscape reduced the winter-to-summer peak demand ratios by 48%” (Sovocool et al., 2006), which would allow water demand schedules to become more predictable, and therefore, more efficient.
In 1997, Metro Water Conservation, Inc of Denver, Colorado undertook a study known as the “Yield and Reliability Demonstrated in Xeriscape” (YARDX). The study was conducted across seven municipalities (Fort Collins, Greeley, Arvada, Wheat Ridge, Denver, Highlands Ranch and Colorado Springs) (Medina & Gumper, 2004). 357 landscapes of single-family homes were studied to determine the benefits of three types of landscapes: (1) xeriscape conversions (2) new landscapes designed specifically for xeriscape, and (3) pre-existing xeriscapes (Medina & Gumper, 2004). During the period between 1997 and 1999, project participants converted and installed xeriscapes. Data was collected over a five year span between 1997 and 2002. The study outlined eight variables under consideration: water use, xeriscape application type (retrofit, new or pre-existing), xeriscape application level (landscape designed for 30-40 percent savings or 60-70 percent savings), yard size, irrigation design (manual hose or automated sprinkler system), family income level (estimated through home values), soil type (loam, sand, or clay), and precipitation (Medina & Gumper, 2004). Water use was the dependent variable and all other variables were expected to influence water consumption.

The findings of the study reinforce the promises of xeriscape. Water savings were significant, ranging from 18-50 percent. In terms of costs, if homeowners were willing to partake in the conversion process, xeriscape installments cost $0.90 to $1.45 per square foot. To account for homeowner labor, a wage rate of $18 per hour was factored into total costs. The study also strengthened the argument that xeriscape gardens lower maintenance costs for homeowners, although the researchers did find that while the xeriscape garden is maturing, maintenance costs may exceed those of the control groups. Customer satisfaction with the various landscape designs was gauged through a survey.
Participants with xeric landscapes demonstrated higher levels of satisfaction with their landscapes than their control counterparts. The YARDX study concluded that xeriscapes are a viable water conservation measure and well suited for the Front Range (Medina & Gumper, 2004).

In 1991, the Texas Water Development Board conducted a comparative study of residential water consumption with the goal of achieving a 10 percent water reduction by the year 2000. Phase I of the study concluded that xeriscapes could result in savings of up to 40 percent (City of Austin, 1991). Phase II of the study was conducted to confirm the 40 percent water savings estimate, examine underlying factors that may constrain or increase water savings such as social and economic factors, and test the possibility that xeriscaping results in higher water quality (Gregg et al., 1994). The study used a multivariate regression analysis to interpret data received from: observation, water consumption, a questionnaire, and house value and lot size. Key findings revealed that the reduction in observed water consumption was actually 30 percent as opposed to the previous findings of 40 percent. Additional factors influence water consumption savings from xeriscape. Increased house values, automatic irrigation systems, swimming pools, and large landscape expenditures were shown to increase water consumption. The findings on whether or not xeriscaping reduces chemical use were inconclusive (Gregg, et al., 1994). More studies are needed to evaluate the confounding factors present in xeriscape water reductions debates.
Drawbacks of Literature Surrounding Xeriscape

Critics of xeriscaping point to the lack of literature and research devoted to understanding the true costs of xeriscaping absent of rebate programs. Most, if not all, studies pertaining to xeriscape (Gregg et al., 1994; Sovocool et al., 2006; Medina & Gumper, 2004; Nelson, 1991) explore the topic through the lens of a water supplier. These studies evaluate the costs of xeriscapes to consumers when a rebate program is offered. It is possible that water suppliers introduce bias into such studies by elevating the attractiveness of xeriscapes. Rebates incentivize people to convert to xeriscape, which in turn would reduce the costs to suppliers by reducing water demand, without regard to the true costs (in lieu of a rebate program) that may fall on the consumers.

Addink (2005) identifies studies rarely cited amongst xeriscape advocates. An Arizona State University study concluded that water consumption increased under xeriscapes as compared to conventional turf grass landscapes. In Phoenix and Tempe, xeriscapes used 10 percent more water than control landscapes (Addink, 2005). A study on xeric gardens from Albuquerque, New Mexico demonstrated “water savings of 19 gallons per square foot of bluegrass turf converted to Xeriscape” (Addink, 2005). Further analysis reveals that not all xeriscape participants experienced such benefits. 17 percent of households used more water after converting from turf to xeriscape (Addink, 2005). In this study, participants were not required to update their irrigation systems.

Dr. Douglas Welsh, the former president of the National Xeriscape Council, expresses his concerns with xeriscape studies in his paper “Practical Turf Areas: The Controversial Xeriscape Guideline” (1990). Welsh advocates the use xeriscapes, but is critical of the lack of emphasis placed on irrigation systems and human capital as a major
determinant of water savings. Welsh believes 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” (Welsh, 1990). Knowing when a plant needs water is an important, and often overlooked, aspect of landscape management. Welsh is not the only critic of blind acceptance of xeriscaping. The importance of a well-planned and well maintained xeriscape garden is often neglected under the false pretense that simply selecting drought resistant plants will reduce water consumption (Martin, 2003).

Traditional grass landscapes provide benefits, but this rarely considered. For example, Kentucky bluegrass is a resilient plant and can take abuse before withering and dying. Thus, if the homeowner intends to use their landscape for recreation, turf grass would be more efficient than xeriscaping. Scott Yabiku (et al., 2008) hypothesizes that households with small children will gain more utility from turf landscapes than xeriscapes. Turf landscapes also provide a microclimate cooling effect. McPherson (et al., 1989) suggests hot climates may benefit from turf landscaping in the form of decreased cooling expenditures. The literature inadequately addresses elements that impact landscape conversion.

Consumer Landscape Preferences

Although there is a void in research that specifically addresses consumer preferences towards xeriscaping, literature on landscape preferences more generally exists (Larsen & Harlan, 2005; Larson & Brumand, 2014; Lockett et al., 2002; Hurd,
2006; Larson et al., 2009). While costs and water savings do influence homeowner’s landscaping practices, there are also social, political, and aesthetic considerations that promote or restrict xeriscape conversions.

To understand the difference between formal and informal rules shaping landscape choices, Larson and Brumand (2014) instituted an interview based case study in Phoenix, Arizona. According to the study, many Phoenix residents are aware of water scarcity, but their landscape practices do not always align with their beliefs. Individuals allow their personal preferences and social norms to dictate their landscape choices (Larson & Brumand, 2014). Social norms pertain to the neatness of landscapes and the manner in which a landscape fits with the historic traditions of a neighborhood. This study concludes that social norms influence landscape design more than formal norms (codes, restrictions, rules).

Today, society is more mobile, and as a result, people are living in places with unfamiliar environments and plant communities (Larsen & Harlan, 2005). These new neighborhoods reshape the social norms surrounding landscapes. The study conducted by Larsen and Harlan (2005) focused on the differing norms between backyards and front yards. Front and back yards serve different purposes. The front yard functions as a “visible symbol of self,” while backyards are “a personal pleasure ground” (Larsen & Harlan, 2005).

Larson (et al., 2009) studied the underlying factors that shape personal preferences for various landscapes. Differing landscape choices were shown across two survey samples. Personal preferences were primarily shaped by appearance, maintenance, environment, recreation, microclimate, familiarity, and health/safety (Larson et al., 2009).
Often times, water conservation measures “are likely to be unsuccessful because: other social priorities often take precedence, multifaceted ecological benefits are associated with different yard types, and residents tend to cognitively construct landscape values in diverse ways while rationalizing their decisions” (Larson et al., 2009).

Successful water conservation programs rely on two things: public education, and awareness. Lockett (et al., 2002) studied Texas resident’s attitudes towards water conserving landscapes. Data was collected through a survey and then analyzed using Chi-square approximations. The study concluded that education was a significant predictor of opinions on water conserving landscapes and native plants. Respondents with higher education levels were more likely to approve of water conserving landscapes, and were more likely to use native plants (Lockett et al., 2002). Hurd’s (2006) study found a similar relationship between public education and water conservation. Public education and awareness were found to be significant predictors of less turf grass landscapes (Hurd, 2006).

Awareness of an individual’s place in ecosystems has been shown to promote environmental stewardship. Most of the literature surrounding this topic is relatively recent (Garcia-Llorente et al., 2012; Hausmann et al., 2016). Hausmann (et al., 2016) suggests that a sense of place positively affects human well-being and biodiversity conservation. In another study examining sense of place, bioregional awareness significantly impacted individual’s willingness to pay for landscape conservation (Garcia-Llorente et al., 2012). Although these result are promising, there is no conclusive evidence linking sense of place and environmental protection. Moreover, literature examining how xeriscaping influences one’s sense of place is needed.
Xeriscapes can reduce water consumption by 10% to 50%. Most studies focus on residential xeriscaping. In terms of xeriscaping, institutions face different circumstances. For example, college campuses have many different users. These users may have different landscape values. Also, college campuses have more land than the typical homeowner. Larger xeriscapes could be more or less effective at conserving water, but no studies exist to reinforce this idea. There is a lack of research on institutional landscaping practices, and in particular, institutional xeriscaping.
Background

Colorado College used roughly 69 acre feet of water last academic year to irrigate the various turfs and vegetation on campus (Ferguson, 2016). Since non-potable water is used multiple times, essentially recycled, it is cheap. Total irrigation costs last academic year were only $58,862.00 (Ferguson, 2016). This value does not adequately address the true cost of water consumption in the western United States. Furthermore, water rates have consistently trended upwards over the past decade. With the impacts of climate change manifesting, and the uncertainty of Colorado’s water future, it is vital to consider less water intensive landscaping practices.

Figure 1 illustrates how much Colorado College pays for irrigation and how much water Colorado College uses for irrigation. There was a significant drop in irrigation water use from 2013 to 2014. This drop can be attributed to two factors. 2013 was a notable dry year in Colorado Springs, and after 2013, the Colorado College grounds crew began implementing weather monitors to avoid unnecessary excess watering (J. Ortiz, personal communication, January 1, 2017).

![Figure 1](Image)
The greenery around campus is irrigated with non-potable water through a Colorado Springs Utilities exchange program. Non-potable exchange water is beneficial because “exchanges provide system flexibility by placing water where the demand exists” (Colorado Springs Utilities Water Tour, 2016). Exchanges allow for the repeated use of water resources. Often, the same water resource may be used two or three times. Even so, consumption of non-potable water is still less sustainable than a reduction in water usage as a whole.

Over the past few years, Colorado College has made significant strides towards more sustainable landscaping practices. This includes the transition from potable to non-potable water, the reduction in water consumption, and an increase in xeric gardens on campus. Figure 2 shows the varying types of landscapes on campus, including the gardens highlighted in purple. For the sake of this paper, all demonstration gardens will be classified as xeriscape gardens.

![Figure 2](image)

Colorado College Master Plan

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1 The Colorado Springs Utilities exchange program returns used water to the stream after the treatment process. This returned water is then exchanged for reuse. This system allows Colorado Springs to stretch their existing water rights. Non-potable water is water that is reused after it is treated. Non-potable water accounts for 13 percent of Colorado Springs’ total water portfolio (Colorado Springs Utilities Water Brochure).
Most of the gardens on campus are not strictly xeriscapes, but many implement native plants and xeric principles. In 2015, roughly 2.2 acres of the total 38 acres of landscaped area on campus contain xeric principles.

Moving forward, the Colorado College master plan outlines locations for new xeriscape gardens. Figure 3 provides a map of the proposed master plan for the campus landscape. As is the case currently, many of the proposed xeric gardens will be placed near entrances to high frequency buildings on campus. Many people come and go from these buildings, indicating that the college cares about placing these new xeriscapes in high visibility areas. Aesthetically, they are pleasing, and they also provide a sense of place.

Creating a sense of place is an important aspect of a college experience, particularly for Colorado College. Colorado College offers “sense of place” field trips and workshops. Moreover, there is an entire Colorado College webpage dedicated to
furthering the sense of place on campus. Located in the Pikes Peak region, Colorado College is set upon a unique short-grass prairie. Few other liberal arts colleges can say the same. As Colorado College sought to build a reputation, the campus attempted to emulate the looks of other liberal arts colleges: tall trees and grass quads. Now, Colorado College has a reputation of its own, and there are benefits to having a unique campus. Principle two of the Colorado College master plan states: “reinforce Colorado College’s sense of place and unique position in the west” (Colorado College Master Plan, 2015).

As concerns for environmental sustainability continue to rise in the public eye, elite liberal arts schools will continue to compete for the title of most environmentally friendly. Theoretically, if costs were not an issue, every school would build new net zero buildings, develop renewable energy systems, and create sustainable landscapes. However, these projects come with costs. How much money is Colorado College willing to spend for a sustainable landscape? Xeric gardens will save money through water savings, but installing them is expensive.
Analysis

Survey Analysis

What is important at Colorado College is not only the books read, the equations examined, or the plants dissected, but it is also the space in which we reside and the messages of which we promote. The focus that Colorado College places on climate change and the importance of sustainability is contradicted by the irrigated turf on campus. A survey was distributed to the Colorado College student body to determine student perception surrounding Colorado College’s current landscaping policies and the future possibilities of landscaping practices on campus.

The survey was designed to answer the following question:

Ignoring costs, do Colorado College students believe that there should be an increase in xeriscaping around campus?

Many students were unfamiliar with xeriscaping and the implications of undertaking a new landscape policy. Therefore, the question of xeriscaping could not be asked explicitly. Instead, the survey questions sought to surmise the answer to the question. Three categories of survey questions were asked. First, questions determining how the respondent currently uses the green space (e.g. how often, for what purposes, etc.). Questions aimed at understanding what the respondent believes the function of a landscape should be. Finally, questions pertaining to Colorado College specifically. This third category included questions about water scarcity issues in Colorado Springs, the obligation of a college to provide a sense of place, and the sustainability of Colorado College’s current landscaping practices.
The survey population was the student body at Colorado College. To avoid bias, the survey was distributed to all students. A link was sent via email to the entire student digest and posted in Colorado College’s many student Facebook pages. A financial incentive of five dollars, awarded to the first 100 respondents, was used to decrease bias. This ensured that students with all different interests, not just those interested in environmental issues or landscaping, were motivated to partake in the study.

166 survey responses were received. Table 1 provides descriptive statistical results for the majority of the survey questions. Two questions were left out of the table: “please rank, in ascending order, the functions you believe a landscape should serve,” and “for what purposes do you use the campus quads? Highlight all that apply.” The results to the first omitted question are summarized in table 2. The second question only received 137 responses, and therefore, could not be included in this analysis. Most likely, respondents found the question format difficult to comprehend.
Table 1: Descriptive statistics of survey responses

<table>
<thead>
<tr>
<th>Question</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
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<tbody>
<tr>
<td>Are you aware of the various xeriscaped projects located around campus? (1=yes; 2=no)</td>
<td>1.00</td>
<td>2.00</td>
<td>1.55</td>
<td>0.50</td>
</tr>
<tr>
<td>How often do you use the grass quads on campus? (1=once per week; 8=more than seven times per week)</td>
<td>1.00</td>
<td>8.00</td>
<td>2.19</td>
<td>1.59</td>
</tr>
<tr>
<td>Prior to applying to Colorado College, did you visit campus? (1=yes; 2=no)</td>
<td>1.00</td>
<td>2.00</td>
<td>1.14</td>
<td>0.35</td>
</tr>
<tr>
<td>If you answered yes, how important was the campus aesthetic in your decision to attend CC? (1=extremely important; 5=not at all important)</td>
<td>1.00</td>
<td>5.00</td>
<td>2.75</td>
<td>0.92</td>
</tr>
<tr>
<td>How important was the campus irrigated greenspace (trees, fields, shrubs, etc.) in your decision to attend CC? (1=extremely important; 5=not at all important)</td>
<td>1.00</td>
<td>5.00</td>
<td>3.26</td>
<td>1.14</td>
</tr>
<tr>
<td>On a scale from 0-10, how important do you consider the issue of water scarcity in Colorado Springs? (0=not at all important; 10=extremely important)</td>
<td>0.00</td>
<td>10.00</td>
<td>7.15</td>
<td>1.88</td>
</tr>
<tr>
<td>On a scale from 0-10, how important do you believe it is that a college campus promote a sense of place among its student body? (0=not at all important; 10=extremely important)</td>
<td>0.00</td>
<td>10.00</td>
<td>8.26</td>
<td>1.73</td>
</tr>
<tr>
<td>Do you believe a visible increase in the level of xeriscaping and native gardens around campus would provide students with a greater sense of place? (1=yes; 2=maybe; 3=no)</td>
<td>1.00</td>
<td>3.00</td>
<td>1.66</td>
<td>0.65</td>
</tr>
<tr>
<td>How sustainable do you consider Colorado College’s current landscaping practices? (1=extremely sustainable; 4=not at all sustainable)</td>
<td>1.00</td>
<td>4.00</td>
<td>3.00</td>
<td>0.74</td>
</tr>
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<td>How important do you believe it is that a college adopt practices that are sustainable for its location? (1=extremely important; 4=not at all important)</td>
<td>1.00</td>
<td>4.00</td>
<td>1.45</td>
<td>0.59</td>
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Table 2: Please rank, in ascending order, the functions you believe a landscape should serve.

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<th>#</th>
<th>Field</th>
<th>Ranking</th>
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<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>Aesthetic value</td>
<td>8.16%</td>
</tr>
<tr>
<td>2</td>
<td>Provide recreational space</td>
<td>44.03%</td>
</tr>
<tr>
<td>3</td>
<td>Educational opportunities (e.g. Tutt Science learning gardens)</td>
<td>8.16%</td>
</tr>
<tr>
<td>4</td>
<td>Ecosystem services (e.g. carbon sequestration or habitat restoration)</td>
<td>39.62%</td>
</tr>
</tbody>
</table>

Students were asked: on a scale of 0-10, how important do you consider the issue of water scarcity in Colorado Springs? 0 being not at all important and 10 being extremely important, the mean response value was 7.15 with a standard deviation of 1.88. This indicates that 68 percent of responses landed between 5.27 and 9.03. An answer of 5 indicates a response of moderately important and an answer of 9 indicates a response of very important. Therefore, these results lead to the conclusion that, on average, the Colorado College student body considers the issue of water scarcity important.
When asked, how sustainable do you consider Colorado College’s current landscaping policies, students were given four possible options: extremely sustainable, sustainable, moderately sustainable, and not at all sustainable. The mean response calculated from this question was a 3 with a standard deviation of 0.74. The mode response was moderately sustainable, which received 85 responses. The next most popular response, with 42 responses, was not at all sustainable. “Sustainable” received 36 responses, whereas the response of extremely sustainable received only 3 responses. The majority of students consider current Colorado College landscaping practices sustainable,
but these results indicate that, from the perspective of the student body, the college could be more sustainable in its practices.

Figure 5: *How sustainable do you consider Colorado College’s current landscaping policies?*

Respondents were asked: How important do you believe it is that a college adopts practices that are sustainable for its location? The possible answers were: extremely important, important, slightly important, and not at all important. 1 being extremely important and 4 being not at all important, the mean value of responses was 1.45 with a standard deviation of 0.59. 99 respondents answered extremely important, 61 respondents answered important, 5 answered slightly important, and 1 answered not at all important.
These responses suggest that Colorado College students understand the importance of local sustainability.

Figure 6: How important do you believe it is that a college adopts practices that are sustainable for its location?

Due to the use of native plants, xeriscaping at Colorado College should increase the sense of place the campus provides. To determine whether or not students believed an educational institution should promote a sense of place among its student body, the following question was asked: On a scale from 0-10, how important do you believe it is that a college campus promote a sense of place among its student body? 0 being not at all
important and 10 being extremely important, these responses yielded a mean of 8.26 with a standard deviation of 1.73. Overwhelmingly, students believe a college campus should provide a sense of place. As of now, the Colorado College campus fails to provide a sense of place.

Figure 7: On a scale from 0-10, how important do you believe it is that a college campus promote a sense of place among its student body?

The student body recognizes issues of water scarcity in Colorado Springs, recognizes that, in reference to Colorado College landscaping practices, issues of sustainability exist, believes it is important that a school provide a campus that promotes a sense of place, and believes that a college campus should be sustainable in its location.
All of these responses allude to the potential of xeriscaping. An increase in xeriscaping on the Colorado College campus would make it more sustainable. However, it cannot be concluded that an increase in xeriscaping would provide a substantial increase in the sense of place felt by students.

**Financial Analysis**

Undergoing major xeric landscape retrofits on the Colorado College campus would require a large upfront cost. It is important to perform a financial analysis. A financial analysis allows the decision makers to understand what the costs of a xeriscaping project would be relative to the benefits. A financial analysis also provides the decision maker with the net present value of the investment.

The equation for this financial analysis is:

\[
NPV = \sum_{t=0}^{30} \frac{(Benefit_t - Cost_t)}{(1 + r)^t}
\]

The payback period for this financial analysis has been set at 30 years. The discount rate selected was the 10 year average of the return on the Colorado College endowment, which was 7.8% (Colorado College, 2017). Therefore, \(r=0.078\). This figure represents the college’s opportunity cost. The money that went into a xeriscaping project could alternatively be invested in the endowment.

To run this financial analysis, three assumptions were made. It was assumed that all plots of irrigated land on campus receive the same amount of water per year, per
square foot. It was assumed that water rates would remain the same for the time period in question. It was assumed maintenance costs are zero. In reality, maintaining a xeriscape is not free. The YARDX study estimates that annual maintenance costs range from $0.34 to $1.33 per square foot (Medina & Gumper, 2004). However, these maintenance costs are not as straightforward to calculate as installation costs. Moreover, traditional turf grass landscapes incur maintenance costs. In fact, the YARDX study concluded that “during the first time period (1997–1999), five of six treatment demonstrations yielded average annual maintenance costs less than their control counterparts” (Medina & Gumper, 2004). As xeriscapes age, maintenance costs go down. Since it is difficult to confidently determine the difference between maintenance costs for xeriscapes versus grass landscapes, the financial analysis ignores both.

Table 3: Cost Data

<table>
<thead>
<tr>
<th>Cost per square foot</th>
<th>0.50 acres</th>
<th>1.00 acres</th>
<th>1.50 acres</th>
<th>2.00 acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.90</td>
<td>$19,602</td>
<td>$39,240</td>
<td>$58,806</td>
<td>$78,408</td>
</tr>
<tr>
<td>$1.00</td>
<td>$21,780</td>
<td>$43,560</td>
<td>$65,340</td>
<td>$87,120</td>
</tr>
<tr>
<td>$1.10</td>
<td>$23,958</td>
<td>$47,916</td>
<td>$71,874</td>
<td>$95,832</td>
</tr>
<tr>
<td>$1.20</td>
<td>$26,135</td>
<td>$52,272</td>
<td>$78,408</td>
<td>$104,544</td>
</tr>
<tr>
<td>$1.30</td>
<td>$28,314</td>
<td>$56,628</td>
<td>$84,942</td>
<td>$113,256</td>
</tr>
<tr>
<td>$1.40</td>
<td>$30,492</td>
<td>$60,984</td>
<td>$91,476</td>
<td>$121,968</td>
</tr>
<tr>
<td>$1.45</td>
<td>$31,581</td>
<td>$63,162</td>
<td>$94,743</td>
<td>$126,324</td>
</tr>
</tbody>
</table>

The cost and benefit data was taken from the Yield and Reliability Demonstrated in Xeriscape (YARDX) study. To this date, the YARDX study is the most comprehensive study on xeriscaping. Furthermore, part of the YARDX study required data gathered in Colorado Springs. For the cost of installing a xeriscape garden, the study concluded a
range of values between $0.90 per square foot and $1.45 per square foot. Table 3 summarizes how much different xeriscape installations would cost. For the benefit, which is the amount of water saved, the study concluded that, in Colorado Springs, homes with xeriscapes used 32% less water as opposed to homes with traditional landscapes (Medina & Gumper, 2004). Colorado College uses roughly 69 acre feet of water a year to irrigate the roughly 38 acres of turf around campus. This costs $58,862. Thus, it costs $0.01962 per cubic foot of water. Assuming all land plots are watered equally, each acre of land receives 78,947 cubic feet of water per year. If xeriscapes have a water conservation rate of 32%, each acre of land converted to xeriscape will save 25,263 cubic feet, which, at a rate of $0.01962, has a monetary value of about $496 per acre. These values were used to perform financial analysis for varying levels of xeriscape conversions.

Table 4: Net present value of xeriscape installations

<table>
<thead>
<tr>
<th>Cost per square foot</th>
<th>Acreage of new xeriscape</th>
<th>0.50 acres</th>
<th>1.00 acres</th>
<th>1.50 acres</th>
<th>2.00 acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.90</td>
<td>$-16,882</td>
<td>$-33,688</td>
<td>$-50,658</td>
<td>$-67,537</td>
<td></td>
</tr>
<tr>
<td>$1.00</td>
<td>$-19,060</td>
<td>$-38,044</td>
<td>$-57,192</td>
<td>$-76,249</td>
<td></td>
</tr>
<tr>
<td>$1.10</td>
<td>$-21,238</td>
<td>$-42,400</td>
<td>$-63,726</td>
<td>$-84,961</td>
<td></td>
</tr>
<tr>
<td>$1.20</td>
<td>$-23,416</td>
<td>$-46,756</td>
<td>$-70,260</td>
<td>$-93,673</td>
<td></td>
</tr>
<tr>
<td>$1.30</td>
<td>$-25,594</td>
<td>$-51,112</td>
<td>$-76,794</td>
<td>$-102,385</td>
<td></td>
</tr>
<tr>
<td>$1.40</td>
<td>$-27,772</td>
<td>$-55,468</td>
<td>$-83,328</td>
<td>$-111,097</td>
<td></td>
</tr>
<tr>
<td>$1.45</td>
<td>$-28,861</td>
<td>$-57,646</td>
<td>$-86,595</td>
<td>$-115,453</td>
<td></td>
</tr>
</tbody>
</table>
These results indicate that implementing new xeric gardens would be more expensive than the business as usual scenario. In a 30 year period, the money saved from water reductions will not pay back the cost of installing a new xeriscape. To an individual, these costs are significant, but an institution, like Colorado College, has more available capital. If the size of the college remains constant, with roughly 550 new students entering each year, 16,500 students will pass through the school in a 30 year period. Colorado College could xeriscape two acres of campus, at a cost of $1.45 per acre, for $7.00 per student, and in the process save 35 acre feet of water. This project would have an initial cost of $126,324.00. After adjusting for the water savings, this project would have a net present value of negative $115,452.00. Total water savings for this project would amount to $27,360.00. However, the net present value figure is not $100,000.00 because of the high discount rate used. The return on the endowment is quite substantial, and therefore, these xeriscape projects have high opportunity costs. At minimum cost, the college could install half of an acre of cheaper xeriscapes for roughly $1.00 per student. This financial analysis does not address many of the benefits of xeriscaping; for more information, see the limitations section located in the conclusion.
Conclusion

Xeriscaping the Colorado College campus presents a solution to two existing issues with the current landscaping practices. The campus green space uses too much water, and the campus fails to provide students with a sense of place. Studies on xeriscaping show that this technique can dramatically reduce water consumption. Unfortunately, no research has addressed xeriscaping semi-public lands. This thesis addressed, from two perspectives, whether or not Colorado College should xeriscape. The survey analysis presented the issue from the student’s point of view, while the financial analysis evaluated the costs.

The argument to xeriscape more of Colorado College goes beyond the issue of water scarcity. An important aspect of the educational experience provided by Colorado College is a sense of place. The survey results indicate that the student body believes a sense of place is an important aspect of a college education. Xeriscaping presents a promising avenue for increasing the sense of place felt by the student body, but this study cannot definitively conclude that.

The survey results suggest that the student body believes that Colorado College landscaping techniques could and should be more sustainable. Overwhelmingly, students responded that it was very important that a college’s landscaping practices be sustainable in their location. While students did respond that Colorado College’s current landscaping practices are moderately sustainable, relatively few ranked the practices as sustainable or extremely sustainable. Realistically, current Colorado College landscaping practices are quite sustainable. The grounds crew uses smart technologies like moisture sensors and weather monitors to cut back on unnecessary water use. The turf on campus is also
irrigated using non-potable water. If the college did desire to adopt more sustainable practices, using less water is their only option, and xeriscaping is proven to reduce water consumption. The student body responded that the issue of water scarcity in Colorado Springs is important. Therefore, it may be in the college’s best interest to cut back on water consumption.

Reducing water consumption does come with costs. Non-potable water provides a cheap source of water for irrigation. Financially, the college does not have an incentive to xeriscape. Even though it would cost money to implement new xeriscapes, and the cost would not be recovered through the financial value of the water savings, Colorado College should still consider a future landscape that implements xeric principles. A new library costs money, but there is a reason the school decides to make the investment. Further research is needed to determine the other benefits the College may experience from xeriscaping.

This research has been important in highlighting the promises and pitfalls of xeriscaping. Xeriscaping will save Colorado College water. Xeriscaping will also cost Colorado College money. The student body feels xeriscaping is important. Ultimately, this research serves only as a guide for those making decisions about the future of the Colorado College landscape. Students and decision makers alike will be more informed about the possibilities of xeriscaping, but also its drawbacks.
Limitations

This thesis is not a comprehensive cost-benefit analysis of xeriscaping on the Colorado College campus. Because of limited time to complete the research, the true costs of xeriscaping on campus could not be calculated. There was insufficient time to collect independent data on what a xeriscaping project would cost at Colorado College. For example, it is possible that if the college did wish to engage in a xeriscaping project, more grounds crew employees with knowledge in horticulture may need to be hired.

The benefits that xeriscapes provide were underestimated. Considering only the value of the water saved from xeriscaping does not account for the other benefits the student body, environment, and college may experience. For example, xeriscape gardens could provide educational benefits, like a knowledge of local ecosystems or awareness of water scarcity, to both the college and student body. The best way to account for these benefits would have been to estimate the student’s willingness to pay for xeriscapes on campus. This is possible through the contingent valuation method, where the researchers set up hypothetical scenarios in order to deduce a person’s willingness to pay. This strategy is often employed to value the uses of public and semi-public goods. Unfortunately, in this case, a CVM would not have worked. Many students do not pay for their time spent at Colorado College, and therefore, could not properly gauge their own willingness to pay. Furthermore, attending Colorado College is expensive, and therefore, students would be reluctant to pay a premium for landscape changes. These limitations resulted in an oversimplified cost-benefit analysis.
References


Austin, City of (1993). Quantifying the Effects of Xeriscape Landscaping on Outdoor Water Use (PhaseI).


Appendix

Survey

This survey was designed with the intention of determining student perception surrounding Colorado College landscaping practices. In 2016, it took 3,029,173 cubic feet (22,718,798 gallons) of water to irrigate the 38 acres of landscaped land on campus, which cost the school $59,000.00 annually. Specifically, this survey addresses the use of native and xeric (drought resistant) plants to reduce water consumption. The following questions aim to deduce the benefits alternative landscape techniques may provide to the environment, the student body, and Colorado College.

Your responses will be kept completely anonymous. By participating in this survey, you confirm that you are 18 years or older.

Q1. Are you aware of the various xeriscaped projects located around campus (e.g. Tutt Science gardens, Palmer gardens, Cutler Hall Gardens, Shove Chapel Gardens, etc.)?
   ○ Yes
   ○ No

Q2. How often do you use the grass quads on campus?
   ○ Once per week
   ○ Twice per week
   ○ Three times per week
   ○ Four times per week
   ○ Five times per week
   ○ Six times per week
   ○ Seven times per week
   ○ More than seven times per week

Q3. Please rank, in ascending order, the functions you believe a landscape should serve
   _____ Aesthetic value
   _____ Provide recreational space
   _____ Educational opportunities (e.g. Tutt Science learning gardens)
   _____ Ecosystem services (e.g. carbon sequestration or habitat restoration)
Q4. For what purposes do you use the campus quads? Highlight all that apply.

1: Intramurals
2: Picknicking/sunbathing/reading
3: Frisbee/soccer/etc.

Q5. Prior to applying to Colorado College, did you visit campus?

☑ Yes
☑ No

Q6. If you answered yes, how important was the campus aesthetic in your decision to attend CC?

☑ Extremely important
☑ Very important
☑ Moderately important
☑ Slightly important
☑ Not at all important

Q7. How important was the campus irrigated greenspace (trees, fields, shrubs, etc.) in your decision to attend CC?

☑ Extremely important
☑ Very important
☑ Moderately important
☑ Slightly important
☑ Not at all important
Q8. On a scale from 0-10, how important do you consider the issue of water scarcity in Colorado Springs?
   - 0
   - 1
   - 2
   - 3
   - 4
   - 5
   - 6
   - 7
   - 8
   - 9
   - 10

Q9. On a scale from 0-10, how important do you believe it is that a college campus promote a sense of place among its student body?
   - 0
   - 1
   - 2
   - 3
   - 4
   - 5
   - 6
   - 7
   - 8
   - 9
   - 10

Q10. Do you believe a visible increase in the level of xeriscaping and native gardens around campus would provide students with a greater sense of place?
   - Yes
   - Maybe
   - No
Q11. How sustainable do you consider Colorado College's current landscaping practices?

- Extremely sustainable
- Sustainable
- Moderately sustainable
- Not at all sustainable

Q12. How important do you believe it is that a college adopts practices that are sustainable for its location?

- Extremely important
- Important
- Slightly important
- Not at all important

Q13. Please specify your class level

- Freshman
- Sophomore
- Junior
- Senior

Q14. Please list the State and Country from which you come.

Q15. Please state your major or intended major.

Q16. Please state your name. This information will exert no influence over your survey answers, nor will it be published. Your name is needed to ensure that, if you were one of the first 100 respondents, you receive your 5 dollar reward.