Stretching Urban Water Supplies in Colorado
Strategies for Landscape Water Conservation

by
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with assistance from
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Colorado Water Resources Research Institute

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Executive Summary

During the 2002 drought in Colorado, municipalities relied on a variety of drought response strategies to temporarily and significantly curtail water use. Faced with declining water supplies, municipalities in Colorado primarily used outdoor watering restrictions to decrease demand during the 2002 drought. The rather sudden reduction in water available for landscape water use created a significant economic impact on the landscape (green) industry and water utilities. As might be expected, the negative economic impact on the landscape industry resulted in some tension between the landscape industry and municipal water providers. Now that the drought has somewhat subsided, municipal water providers are seeking improved conservation strategies to mitigate the severity of water reduction impacts and better prepare for future drought episodes.

The purpose of the study was to enhance the dialogue between municipal water providers and the green industry by identifying strategies for landscape water conservation that are acceptable and reasonable to both industries. In an attempt to define a Colorado context for examining these strategies, the study synthesized existing knowledge on the range of options available for reducing landscape water use and reviewed literature regarding the advantages and disadvantages of each option.

In the study, conservation strategies are categorized as price and non-price strategies. Non-price strategies include outreach and education as well as policy and regulation. Price strategies include inclining block rates, water budget based rate structures, and seasonal rate structures. Each strategy was explored in depth for purposes of extracting conservation options that may be beneficial in Colorado. A review of these strategies and an analysis of the advantages, disadvantages, and effectiveness of strategies are provided in the study.

Non-price Strategies

Outreach and Education

There are a variety of outreach and education measures used to conserve water on landscapes. These measures are primarily used to convey information to water users so they can make informed decisions on how to efficiently manage water for landscapes. These strategies generally target one of two approaches to landscape water conservation: (1) improving the efficiency and management by which water is applied to landscapes, and (2) changing landscapes to those that require less water. Education and outreach measures are widely used by water providers and landscape industry professionals, yet not much is known about their direct influence on water conservation beyond the general understanding that they are essential to any conservation effort.

Policy and Regulation

Policy and regulation are typically more effective water conservation strategies than outreach and education strategies. However, education and publicity are needed to inform the public about water conservation policies and regulations. Policy strategies are long-term and include measures such as landscape ordinances and codes. Much is still to be understood about how policy strategies affect water conservation efforts. Regulation strategies are commonly used in the short-term for drought response and include measures such as mandatory water use restrictions. One of the major concerns about using policy and regulation strategies for conservation is the negative impact that ordinances and restrictions have on the landscape industry and local and state economies.

Price Strategies

Even though financial strategies for water conservation are probably the most studied strategy, they are still not widely understood. In employing pricing policies for conservation, municipalities generally have concerns regarding public responsiveness to price increases and the ability to manage these policies with other water provider objectives. Nonetheless, conservation-oriented rate structures can be used to send strong messages for water conservation. Conservation-oriented rate structures considered in the study include inclining block rates, water budget based rate structures, and seasonal rate structures.

Inclining Block Rates

Inclining block rates are designed to encourage water conservation by increasing water charges for high consumption users; thus providing an incentive to be more efficient. Literature reviewed in the study shows that the effective use of inclining rate structures for landscape conservation requires a consideration of some key issues: price sensitivity, marginal cost pricing, price signaling, and block thresholds.

Water Budget Based Rate Structures

Water budget based rate structures are inclining block rates linked with individualized volumetric allotments of water to customers. Water budget based rate structure theory holds that these rate structures: (1) are more equitable than other conservation-oriented rates because costs are allocated according to individual water needs or budgets, not average customer classes, and (2) are more efficient because they provide an individualized water allotment that is based on conservative resource standards. Proponents of water budget based rate structures state other benefits including: improved customer acceptance, low and consistent water bills, and improved drought response. Both water managers and customers also see water budgets as an equitable way to share limited water supplies, while preserving some amount of customer choice.

Several concerns regarding the effectiveness of using water budget based rate structures are discussed in the study, including the tendency to base individual allotments on averages and the subjectivity that may be involved in defining conservation standards for allotments. Despite these concerns water budget based rate structures have the potential to promote long-term conservation and to serve as a drought response tool. The green industry recognizes this approach to conservation as very viable and sustainable for the industry. As a relatively new concept that has not been widely used in Colorado, it has yet to be fully developed and understood.

Seasonal Rates

Seasonal water rates are another type of conservation-oriented rate structure that can be used to curtail water use for landscapes. Under this type of rate structure, surcharges are used to cover or limit the costs that are driven by peaking requirements or times of high outdoor water use. There are relatively few studies that show the effectiveness of seasonal surcharges for landscape conservation because they have not been widely used for the purposes of curtailing outdoor water use during times of drought.

Study Findings

The findings of this study indicate that, in general, there is not sufficient peer-reviewed literature to scientifically evaluate the effectiveness of urban landscape water conservation strategies. While there have been studies of basic urban water conservation principles, applications of water conservation practices by municipalities are highly site specific, are often inconclusive due to confounding factors, and lack a strong backing of scientifically defensible information.

With the above as a caveat, there are several specific conclusions that can be stated as a result of this study:

- Overall, there is a lack of information available regarding the implementation of non-price conservation programs and a lack of detail and consistency of water use information necessary to evaluate changes in demand.
- More research is needed to understand how the interaction of conservation strategy incentives influences the overall reduction in water consumption.
- Failure to account for non-price conservation efforts, primarily outreach and education programs, may result in an overestimation of the effectiveness of price strategies for conservation.
- Education and outreach conservation programs tend to be a part of all conservation efforts and are generally believed to be very important in all conservation programs.
- A majority of conservation studies are site-specific and are not necessarily applicable in all settings.
- There is very little consistency in terminology used by various water managers and members of the green industry regarding water conservation for landscapes.

Because there is a lack of scientific certainty in the existing literature, the study does not recommend specific water conservation strategies that are believed to both reduce water use and protect the financial integrity of water utilities and the green industry. Although water managers have already employed strategies for reducing water use during the drought in Colorado, most have done so without the benefit of strong, scientifically defensible strategies.

While the study does not provide a definitive set of water conservation recommendations, it does provide insight into options that municipalities and the green industry might consider as they seek new and mutually agreeable approaches for urban landscape water conservation.

This study recommends that a more scientific, collaborative approach be employed to document water conservation programs and to reduce water use and minimize the impacts to both Colorado's landscape industry and Colorado municipal water providers.

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INTRODUCTION

In drought situations, urban water supply is first allocated to indoor residential water use, then non-landscape commercial use, and finally irrigation of landscapes. Landscape is often viewed as the lowest priority in a drought situation and the first target of urban water conservation efforts. Not only are landscape water requirements large in arid areas, where droughts and dry conditions frequently occur, but such use is also considered, under severe drought conditions, non-essential compared to indoor uses for health and sanitation.

In most urban areas, residential communities and their landscapes represent a majority of water use and land area in a municipality. Commercial, industrial, and institutional landscape water uses may also be significant since most landscaped areas are devoted to turfgrass. City landscapes are very important to urban communities because they are often the only way that people come into contact with nature on a daily basis, even if that nature is unnatural for the local climate (Martin et al., 2003). In addition, landscapes help to increase the aesthetic surroundings in communities, thereby increasing property values. Because landscapes in Colorado serve these purposes, it is understandable that efforts to promote landscape water conservation have encountered resistance.

On April 15, 2003, the Colorado State University College of Agricultural Sciences, Department of Horticulture and Landscape Architecture, and Cooperative Extension, in collaboration with the Green Industries of Colorado and the Colorado Water Resources Research Institute, sponsored a conference on water management strategies to sustain the beauty and value of Colorado's urban landscapes. Part of the dialogue that emerged from the conference was the need for the development of best management practices for urban landscape water use, including conservation pricing and water budgeting. Currently, the literature presenting urban landscape water use practices is highly varied in its scientific detail, urban context, and technical/management focus. Therefore it is often difficult to compare landscape best management practices across different water infrastructure configurations, institutional arrangements, urban landscape practices, and land use strategies.

Study Objectives

In response to the suggestion for a consistent comparison of urban landscape water conservation practices, this study examines commonly accepted and emerging strategies for landscape water conservation.

The study attempts to enhance the dialogue between the landscape industry in Colorado and the municipalities that supply water for urban landscapes by systematically, and where possible, scientifically defining options for managing urban landscape water use. The study synthesizes existing knowledge on the range of options available for reducing landscape water use; reviews the literature regarding the advantages and disadvantages of each option; and attempts to define a Colorado context for examining urban landscape water conservation strategies.

The study does not attempt to provide technical and scientific details on all urban landscape water conservation strategies. It is the dialogue that results from this study that will, hopefully, identify the strategies that deserve an in-depth examination for potential use in Colorado.

Study Methods

Information used in this study was obtained through interviews with landscape professionals, municipal water managers, and water conservation consultants. Literature in both peer-reviewed scientific journals[a] and case studies documenting past experiences of other municipalities were reviewed. From this body of information, a series of strategies were examined and are presented to assist municipalities as they continue to make decisions about conservation and drought preparedness. Due to the complexity of water issues and the diversity that exists among municipalities in Colorado, this study does not recommend strategies for municipalities to employ nor detail the

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[a] Peer-review literature is literature that is reviewed by "peers" of the author. Peers are expected to have comparable academic or professional experience and to provide a meaningful critique of the literature.

process of implementing these strategies. Rather, the study attempts to provide municipalities with an overview of key strategies available so that they can make decisions that incorporate the concerns of the landscape industry.

Much of the information available on landscape water conservation options comes from peer-reviewed literature in the late 1980's and early 1990's, which corresponds to one of the worst droughts in recent California history. More recent literature on landscape water conservation strategies for municipalities is found in a variety of American Water Works Association (AWWA) publications and conference proceedings. Perhaps proceedings at AWWA conferences contain the largest amount of recent information on landscape water conservation strategies. Unfortunately, aside from these proceedings and some sporadic case studies on conservation projects throughout the 1990's, recently peer-reviewed literature on the "latest" strategies for landscape conservation is limited. Despite limited peer-reviewed literature, new strategies for water conservation are being considered by municipalities throughout Colorado as a result of the recent drought.

This study is organized to first present the water supply and demand context within Colorado's semi-arid climate – a context that is critical to understanding the need for municipalities to conserve water, in all dimensions of urban living. This study then describes the urban landscape's use of water, which, in turn, points to the need for landscape water conservation in Colorado. Water conservation strategies are categorized, for purposes of systematically presenting them, into three categories. Finally, the advantages and disadvantages of the various water conservation strategies are summarized, hopefully in a manner that facilitates constructive dialogue for agreement on the best landscape water conservation strategies in Colorado.

COLORADO IS A GROWING, SEMI-ARID STATE

Annual precipitation in Colorado averages only 17 inches statewide (McKee et al., 2000). The variability of precipitation is quite high, with the San Luis Valley in south-central Colorado receiving only seven inches and the mountains receiving more than 25 inches annually. Despite somewhat abundant precipitation in the mountains of Colorado, a majority of the state is semi-arid and heavily dependent on annual snowmelt and runoff from the mountains to the plains, where a majority of the water is used.

Through creative and diligent management, Colorado provides water to a large agricultural industry, a number of growing urban population centers, and downstream states as governed by interstate compacts. In addition, Colorado has been able to provide water for newer, legally accepted uses including fish and wildlife habitat needs, snow making, and river and reservoir recreation. Although Coloradoans enjoy a high quality of life and growing economy, they cannot continue to do so without being aware that they play a crucial role in the periodic management of drought in this semi-arid environment.

Colorado's population continues to grow rapidly. Of concern is the fact that Colorado's population has grown considerably since the last major statewide drought in 1981. Moreover, the last two decades provided Colorado with the most reliable precipitation since before the "dust bowl" drought of the 1930's (McKee et al., 2000). What this means is that many Coloradoans are now accustomed to sufficient water supply and little social, economic, and political pressure to curtail high water use. As Colorado continues to see the gap between growing water demand and shrinking water supply narrow, Coloradoans will be asked to consider the tradeoffs between their personal needs for water and the personal lifestyle and choices that they make.

Limited Supply and Growing Demand

All new water supplies in Colorado result from precipitation, in the form of rain, hail, and snow. As a headwater state,[b] Colorado on average has 15,600,000 acre-feet of surface water runoff, consumptively uses approximately 6,000,000 acre-feet, and can deliver the remaining water to downstream states, primarily those in the southwestern

[b] Meaning all rivers in Colorado flow out of the state. There are no major rivers that flow into Colorado providing water for use in the state.

United States.[c] Most of the precipitation in Colorado does not fall on the populations that use the water or at times when it is needed most. Despite the relatively large volume of water that originates in the state, drought and limited supply conditions are very much apart of Colorado's history and future.

Definitions: *Some common terms used to describe surface water supply*
Native Surface Supply - undepleted, unregulated available surface water.
Diversion – the removal of water from any body of water by canal, pipe or other conduit (some of which may become return flow).
Consumptive Use – amount of water that is consumed and lost to the system while applying water to a beneficial use (diversion with no return flow).

Source: CWCB, 2003.

Although urban water uses in Colorado account for less than 5% of total water use in the state, it is the top priority use and must be used wisely to allow for expected growth (Figure 1) (USGS, 1999). Compared to the amount of water used for irrigation, urban water conservation may appear insignificant, but the importance of water conservation in the urban sector should not be overlooked. Because there is a large cost associated with the treatment, distribution, and disposal of urban water supplies it is as important to use water efficiently in urban settings as it is in agricultural settings. The demand for potable water supplies will continue to grow as the statewide population steadily increases.

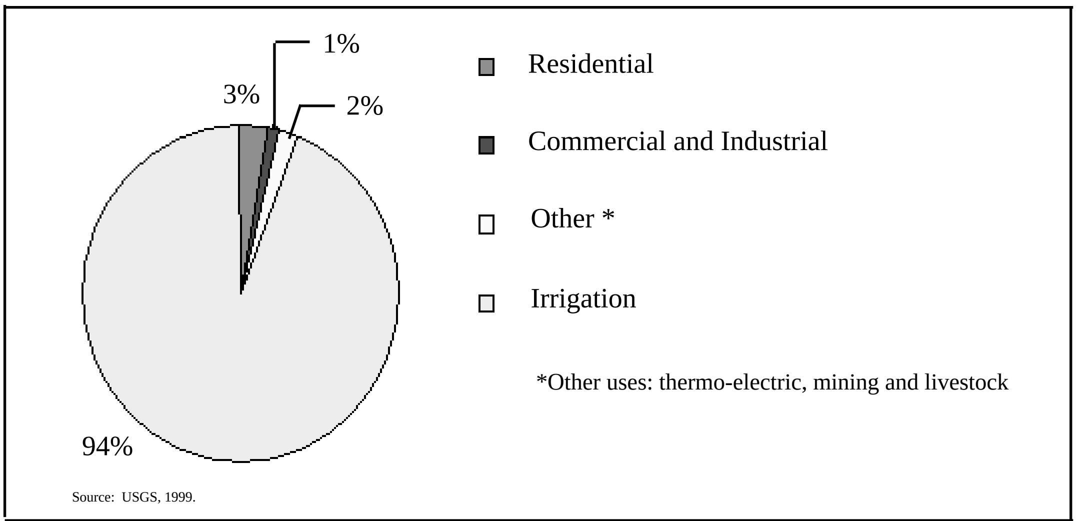


Figure 1. Colorado Water Use for 1995

The state demographer predicts significant growth in the state, from 4,350,000 as estimated by the 2000 Census, to 6,000,000 by 2025 and 10,000,000 by 2100. Statewide municipal and industrial use is expected to increase from one million acre-feet in 1998 to 2.7 million acre-feet by 2100 (Colorado Farm Bureau, 1999).

In the United States, an estimated 7.8 billion gallons per day (about 30% of total residential water demand) on average is used for outdoor purposes (Solley et al., 1998). Figure 2 shows that residential outdoor water use varies significantly by region, with percentages as low as 10% for cool, wet climates to as high as 75% for hot, dry climates. Almost all outdoor water uses are attributed to the irrigation of landscapes. Indoor use of water is relatively constant between regions and throughout the year.

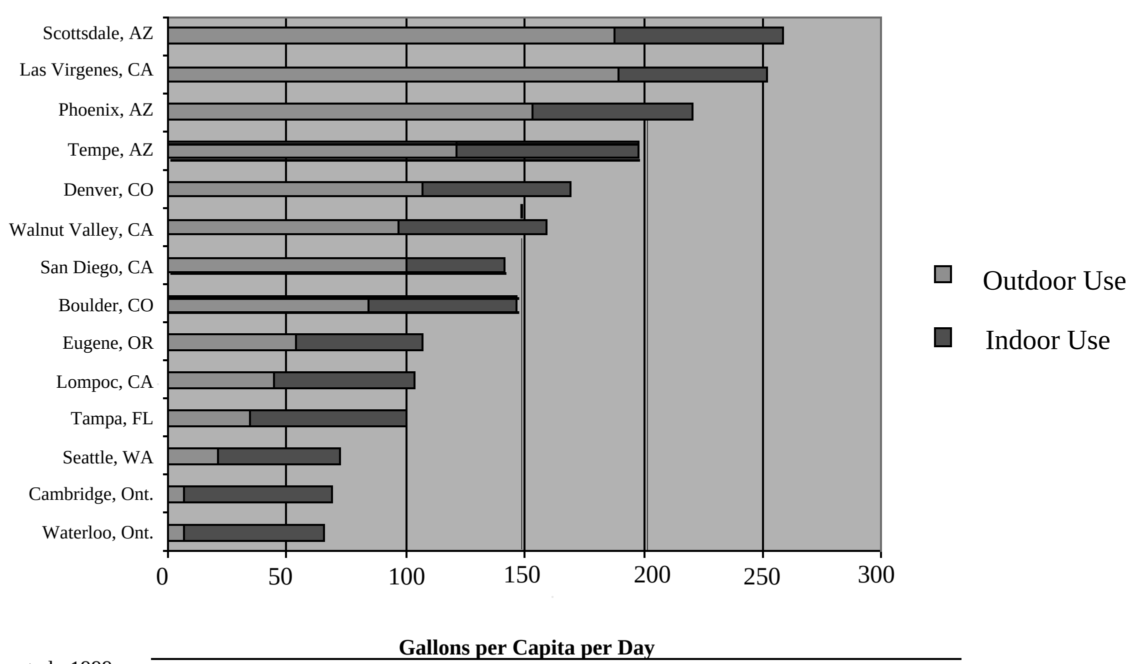
[c] Approximately 100,000,000 acre-feet of precipitation fall in Colorado, of which 15-16 million acre-feet results in surface water runoff. Colorado also pumps 2.4-2.5 million acre-feet of groundwater annually, Colorado Water Conservation Board.

Outdoor water use also varies significantly throughout the state of Colorado. Approximately 40% to 60% of annual residential water use in urban areas of Colorado is attributed to outdoor water use, which is primarily used to supplement landscapes (Mayer et al., 1999). As the population in Colorado grows, we will continue to see a large percentage of urban water supply devoted to landscapes.

Message Box: *How much water is consumptively used?*

Water consumers do not often know where their water supply comes from beyond the sink tap or where it goes beyond the sink drain. The city of Fort Collins in Northern Colorado receives its urban water supply from the Cache La Poudre River, a tributary to the South Platte, and the Colorado-Big Thompson Project. In Fort Collins, single family and duplex homes, multifamily homes, and commercial and industrial water uses account for 43%, 13% and 38% of total treated water respectively. Of the total water use, it is estimated that indoor water use accounts for 59%, while outdoor use accounts for 41%. Approximately 95% of indoor water use is returned to the Cache La Poudre through the City's water reclamation facilities, where it becomes available for other uses downstream. Of the outdoor use, it is estimated that 80% of water is consumptively used by landscapes, while the remaining 20% returns to the river system.

Source: Fort Collins Utilities, 2003.



Source: Mayer et al., 1999.

Figure 2. Average Indoor and Outdoor Water Use for Single Family Residences in 14 Cities

THE URBAN COLORADO LANDSCAPE

Colorado landscapes provide a variety of physical and aesthetic benefits. Landscapes provide appealing environments for humans and wildlife; provide some amount of microclimate control through tree shading and wind blocking; improve air and water quality, protect from soil erosion; and increase the property value of homes. In addition, development and maintenance of landscapes constitute a significant portion of the economy (estimated to be on the order of $2.2 billion per year employing 40,000 people) by supporting a variety of businesses and organizations in the green industry.[d] Landscapes in Colorado's urban areas are diverse and include turfgrass, woody plants such as trees and shrubs, herbaceous perennials, flowering annuals, vegetable gardens, hardscapes such as rocks and mulches, low water use plants, and native plant species.

Message Box: *Drought Response vs. Water Use Efficiency*

Drought response strategies initiated by municipalities are often short-term efforts aimed at minimizing the impacts of drought, relieving temporary water shortages, and reducing peak demand requirements. For example municipal drought plans often stipulate that water restrictions may be used as a response tool during severe drought episodes (often droughts more severe than a 1-in-50 year event).

Water use efficiency refers to a longer-term conservation effort that permanently changes the behavior and technology used to apply water in a more efficient manner. Municipalities often set target conservation levels based on water savings programs that are only achievable under drought situations. Experience has shown that such savings are not typically sustainable and can actually increase water use as soon as drought management restrictions are lifted. Now as municipalities struggle to develop water supply projects, they are realizing the benefits of long-term water use efficiency to reduce system demand.

As municipalities begin to rethink their approach to managing water demand, they must distinguish the difference between short-term drought response strategies and long-term conservation strategies, as they have different planning approaches, achievable outcomes, and public response. While some water managers caution that long-term water conservation will reduce the cushion between water supply and demand when future drought episodes occur, growing demand and limited water supply is inevitably the future and conservation will continue to be important.

Turfgrass for residential lawns, corporate, government, and roadside areas covers an estimated 30 million acres in the United States (Vickers, 2001; Borman et al., 2001). Throughout the United States, green, well-groomed lawns are a mainstay in our culture and are typically expected in most suburban communities. In fact, many community covenants actually require that lawns and landscapes maintain a certain traditional character and a degree of "greenness." Colorado is no exception to this trend, as turfgrass represents the largest percentage of urban landscaped area in Colorado. Most Colorado lawns are comprised of a mixture of cool season grasses, primarily Kentucky bluegrass, which requires supplemental irrigation in summer months. It is during the months of high landscape irrigation that most municipalities experience peak demand and shortages of water supply. In addition to the fact that landscapes represent a significant urban consumptive use in Colorado, peak demand for landscape irrigation is also a reason why municipalities first emphasize landscape water conservation programs during times of drought.

Landscape Water Uses

A brief review of landscape water uses is needed to fully understand the need for conserving water in urban

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[d] Green industry professionals include horticulturalists, landscape architects, retail and wholesale nurseries, irrigation system designers, contractors and landscape maintenance managers.

environments. Quantifying water requirements for landscapes is a complex science. Unfortunately, efficiently maintaining healthy landscapes is not as easy as applying a certain amount of water every week. The amount of water required for urban landscapes cannot be simply understood through a review of crop water requirements alone, because water use also depends on a variety of weather factors, plant characteristics, soil type, topography, degree of sun exposure or shade, root depth, efficiencies of watering devices, uniformity of water application, expected turf visual quality, and cultural practices such as mowing height.

Perhaps the most influential factor in determining water use for landscapes is the human factor, or how people choose to or are informed about managing water for their landscapes. While the science for determining water requirements is quite advanced, the human element is complex, difficult to control, and not commonly understood. Landscape performance is measured by how well it meets the expectations of the user, not by any objective measure. Therefore, it should be recognized that because people's expectations vary significantly, water use for our landscapes will as well (Kjelgren et al., 2000).

Evapotranspiration (ET) is the combination of two separate processes whereby water is lost from the soil surface by evaporation and from the crop by transpiration (Allen et al., 1998). Plant water requirements or ET rates are primarily a function of weather parameters and plant characteristics. The principle weather parameters that affect ET are air temperature, solar radiation, wind speed, and humidity. All plants at different development stages have unique transpiration rates. These differences are a function of plant height, plant roughness, reflection, ground cover and rooting characteristics. Because there are so many factors that influence ET, it is highly variable by location. There have been many, localized studies nation wide on evapotranspiration rates for naturally occurring and landscape plants (Johns, 1989).

It is commonly understood that cool season grasses such as Kentucky bluegrass have larger water requirements than warm season turfgrasses.[e] Although woody plants may have nearly the same water requirements on a per plant canopy area base, they can provide a water savings in landscapes because they are not typically planted to provide full ground cover and can be easily irrigated with efficient drip irrigation methods (Qian, 2003). Water requirements for herbaceous perennials, flowering annuals and vegetable gardens may also be significant depending on weather conditions and crop type, but generally constitute a smaller percentage of landscaped area in Colorado than turfgrass.[f] Although there is not a significant amount of research that addresses specifically the water needs of native and low water use plants, they are generally believed to require less water than cool season turfgrasses.

Message Box: *Urban vs. Agriculture water uses*

In Northern Colorado, an acre of irrigated corn uses approximately the same amount of water as four single-family residences on that same acre, if traditional indoor and landscape water uses are considered. Under these circumstances as agricultural land is converted to urban residential areas, the amount of water consumed does not change significantly.

Turfgrass is classified as either cool season or warm season. Common cool season grasses in Colorado include Kentucky bluegrass and turf type tall-fescue.[g] Cool season grasses maintain their highest quality in moderate

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[e] Average annual water requirement (May to October) for Kentucky bluegrass is 21-24 inches of water for an efficient and uniform irrigation system. Some warm season grasses such as buffalo grass can use 30% less water than cool season grasses (Qian, 2003).

[f] Trees, shrubs, and perennials generally avoid drought more effectively, and respond to drought more acceptably than turfgrass (Kjelgren et al., 2000).

[g] Several studies have shown that tall-fescue is more drought tolerant than Kentucky bluegrass (Ervin, 1995). Recent research by CSU found that under moderate drought conditions when water is available in the deep soil profile (>1 foot), tall fescue required less water than Kentucky bluegrass to maintain an acceptable quality. However, under severe drought conditions,

temperatures and will go dormant when temperatures become too high. Warm season grasses such as buffalograss and blue grama grass green up only when temperatures are warm and can remain green without water for weeks even in the hottest of summer (Koski and Skinner, 1998). Although Kentucky bluegrass has acquired a negative reputation in arid areas because of its high water use requirements relative to other landscape plants, it is still the most popular turfgrass. Several reasons for this include its nice appearance and texture, adaptability to the Colorado climate, resistance to dying after short periods of drought, and high traffic durability (Mecham, no date).

Warm season grasses are considered to be more drought tolerant than cool season grasses because they require less water. However, warm season grasses can be difficult to establish and maintain. Kentucky bluegrass is also drought tolerant in the sense that it can withstand dormancy in hot summer months and green up when temperatures begin to moderate in spring and fall, thus providing significant water savings (Brown et al., 2002; Wilson, 2002). It has also been shown that cool season grasses can be deficit irrigated between 60-80% of full ET and still maintain an acceptable appearance (Feldhake, 1981).

An evaluation of the advantages and disadvantages of various landscape plant materials is beyond the scope of this study. Because there are significant differences of opinion concerning the appropriateness of various landscape materials and because there are a tremendous amount of variables involved in evaluating appropriateness, this study recognizes the need for more information and does not try to address these issues in detail.

Table 1 provides water use estimates for a variety of landscape conditions.

Table 1. Water Needs for a Variety of Landscape Conditions (Koski, 2003; Gardener, 2004)[h]

Landscape	Annual Water Need [inches]
Adequate for healthy bluegrass	24
Maintenance level for healthy bluegrass	18
Recommended amount for healthy Xeriscape	17.7
Recommended amount for healthy bluegrass	28.9
Single Family Residential (SFR) average	35
Average for SFR with clock-controlled sprinkler	39
Average for SFR with manual watering (hose)	32

Cool season grasses do require more water than many common landscape plants, but it is not for this reason alone that landscapes constitute a majority of our urban water uses. Mismanagement and uninformed decisions about landscapes are as much a reason for high water use as is cool season turfgrass. There is often little consideration put into limiting turfgrass to practical turf areas, or those areas where lawns serve a functional or practical use. Instead society tends to place turfgrass throughout cities, even on medians and along roadways because it aesthetically appealing and is relatively inexpensive to install. In addition, very few people are informed about how much water turfgrass needs to maintain a healthy, green lawn.

A significant conservation issue associated with using water for turfgrass and landscapes is that they tend to be overwatered. Poor irrigation scheduling, or watering too often or for too long, is the primary source of water waste in landscapes. It has been suggested that the average landscape is overwatered by more than 10% to 50% (Reed, 2002; Ash, 2002; Kjelgren et al., 2002). A majority of overwatering occurs through the mismanagement of some of he more technically advanced irrigation systems. It has been found that residential landscapes with automatic

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when water was depleted in the deep soil profile, tall fescue did not show drought tolerant advantages over Kentucky bluegrass. (Qian, 2003).

[h] The last five numbers reported in this table were obtained from Liz Gardener, Denver Water. These numbers are based on experience by sod growers in Colorado during the recent drought period and are not published. The first two numbers reported in this table were obtained from Tony Koski, Colorado State University.

requirement (Keiffer and Dziegielewski, 1991). It should be noted that droughts occurred in 2002 in Colorado and in 1991 in California, which may have influenced people's traditional watering practices. Despite the mixed results concerning water use on landscapes, there are always instances of excessive water use on landscapes. Therefore, there will always be a need to address landscape water conservation issues.

Colorado's Changing Landscape

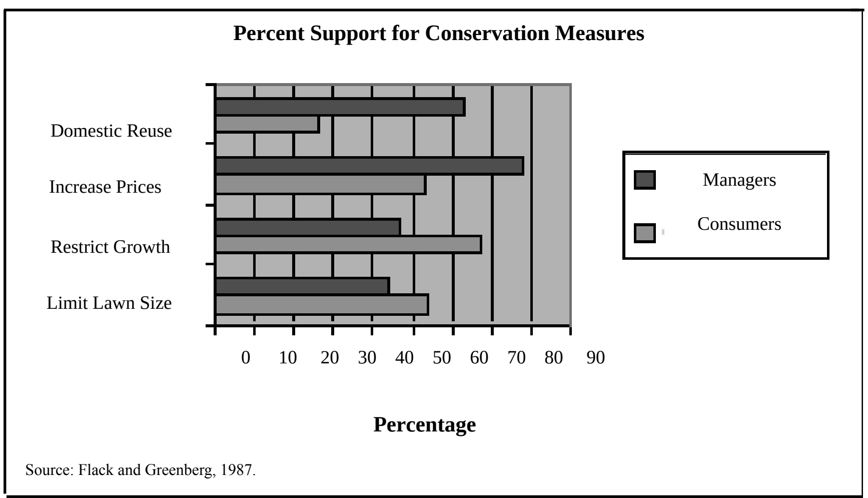
Whether or not landscapes are over watered, a large percentage of urban water supplies are devoted to the irrigation of landscapes. As water supplies continue to diminish and population grows, Colorado will be forced to make water conservation choices. Municipalities will encourage and employ different demand management strategies, the green industry will become more conservation oriented, and the public will change their perception of what is an acceptable and responsible landscape. This study hopes to facilitate this inevitable change.

How will conservation programs change Colorado's landscapes? The answer to this question is complex, difficult to predict, and highly dependent on the conservation programs that municipalities choose and the public accepts. In some cases, municipalities may choose to increase the price of water so there is a financial incentive to efficiently use water on existing landscapes. Increases in efficiency will require not only new technology, but more importantly, better water management. Other municipalities may choose to implement landscape ordinances such as limiting the amount of turfgrass planted, requiring a greater percentage of low water use plants, or requiring ET controllers or rainfall sensors on all automated sprinkler systems. Regardless the programs that municipalities choose for conservation, Coloradoans will be asked to better manage water use on their landscapes and be willing to accept the social, political and economic responsibilities that are associated with diminishing urban water supplies.

As municipalities begin to make decisions about what conservation programs are most beneficial to them, they will have to consider the results of their decisions on the public and the green industry. Perhaps all municipalities can benefit from a brief overview of the California drought in the late 1980's and early 1990's.

Case Study: *Public Attitudes Towards Water Conservation*

Consumer and manager attitudes towards water conservation were surveyed in seven northeastern Colorado communities in late 1980's. Results of this survey showed that consumer and water manager opinions vary significantly and should be considered during the conservation decision-making process.



THE CALIFORNIA EXPERIENCE

In the United States, urban water conservation has primarily been addressed at the state and regional level, with few federal laws addressing conservation on a national level.[i] California has aggressively addressed urban water conservation issues over the last several decades. At the root of more recent conservation efforts in California was the six-year statewide drought that began in 1987. It was this experience that ultimately convinced California that water conservation was a political as well as an environmental and financial necessity (Dickinson, 2000). The California experience with drought provides valuable information for Colorado as municipalities begin to explore strategies for landscape water conservation.

California has only 6% of the nation's available water, but 8% of the nation's rapidly growing population (Dickinson, 2000). Limited water supply and years of below average rainfall depleted California's reservoirs and aquifers in the late 1980's and early 1990's to the point that urban and agricultural water users were required to curtail use by 10% to 75% (Argent and Wheatley, 1992). In addition, water supplies were further restricted by the need to provide for environmental uses such as federally endangered and threatened wildlife species. To conserve water in the urban sector, municipal water providers employed a variety of strategies including outreach, education and public awareness campaigns, economic incentives, water waste penalties, metering and regulations, voluntary and mandatory water use restrictions, conservation water pricing, drought related technology and policy changes, and statewide cooperative efforts.

Recognizing the need to coordinate conservation efforts between the municipal water providers and public and private interest groups, California enacted a "Memorandum of Understanding (MOU)" in 1991 among 100 stakeholders.[j] The California Urban Water Conservation Council (CUWCC) was created in response to the MOU to foster these statewide partnerships and promote efficient urban water use. A major goal of the CUWCC has been to develop, monitor, and evaluate Best Management Practices (BMPs) for urban water conservation among those members of the MOU.[k] BMP No. 5, Large Landscape Conservation Programs and Incentives, is the only BMP that specifically addresses water conservation for landscapes. This BMP requires that water budgets be prepared for 90% of all commercial and industrial accounts with landscape only (dedicated) meters and provide irrigation surveys to 15% of mixed-metered customers. The remaining BMPs address indoor water conservation issues and more general conservation programs.

More specific to landscape water conservation in California is the Model Water Efficient Landscape Ordinance, which went into effect in 1993 under the Water Conservation in Landscaping Act of 1990 (OWUE, 2003). The ordinance was created by a taskforce of stakeholders including landscape and construction industry professionals, environmental protection groups, water agencies, and state and local governments. Managed through the Office of Water Use Efficiency in the California Department of Water Resources, the state ordinance recognizes the importance of landscapes in California, but also promotes water use efficiency for landscapes. The ordinance requires that new or redesigned landscapes be given a water use target if the project is undertaken by a public agency, business or installed by a developer at a new apartment complex or housing subdivision. The ordinance does not apply to landscapes under 2,500 square-feet and homeowner installed residential landscapes. The effectiveness of the landscape ordinances in reducing water use for landscapes has not yet been evaluated relative to pre-drought water use conditions (California Department of Water Resources, 2000).

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[i] Some national policies addressing water conservation include: Energy Policy Act of 1992 and the 1996 Reauthorization of the Safe Drinking Water Act.

[j] The MOU now includes 290 members from a variety of interest groups including: municipal water providers, public advocacy organizations, environmental organizations, private consultants, and green industry associations and industries (see list at www.cuwcc.org). Includes about 41% of urban water providers in the State of California.

[k] Those signing the MOU do so voluntarily and pledge to develop and implement fourteen BMP's (CUWCC, 2003).

Message Box: *California Success Stories*

A report by the Pacific Institute titled *Sustainable Use of Water: California Success Stories*, identifies, describes and analyzes examples of sustainable water policies and practices. These stories show how water managers, policymakers, and the public have worked in collaboration to move California towards more equitable and efficient water management and use. Several lessons and recommendations that have evolved out of this compilation are listed below:

- The most successful water projects have individuals and groups with different agendas working together to meet common goals.
- Existing technologies for improving water-use efficiency have enormous untapped potential. Smart water policies will unleash this potential.
- Regulatory incentives and motivation are effective tools. Smart regulation is more effective than no regulation.
- The power of the proper pricing of water is underestimated.
- Economic innovation leads to cost-effective changes.
- In the water area, ignorance is not bliss. The more water users know about their own water use and the options and alternatives available to them, the better decisions they make.
- "Waste not, want not." The potential for improving the efficiency of water use is greatly underestimated.
- Environmental and economic goals are increasingly being recognized as compatible rather than conflicting.

Source: Owens-Viani, et al., 1999.

URBAN WATER CONSERVATION STRATEGIES

Conservation strategies are categorized as price and non-price strategies in this study. A review of these strategies and an analysis of the advantages, disadvantages, and effectiveness of strategies are provided to bring forth key issues for landscape conservation.

Water conservation is any beneficial reduction in water use, waste or loss (Baumann et al., 1998). As defined in this study, water conservation *strategies* are programs employed by urban water providers that strategically incorporate a combination of water conservation *incentives* and *measures*. A water conservation *incentive* promotes customer awareness about the value of reducing water use and motivates customers to adopt specific water conservation measures. A water conservation *measure* is an action, behavioral change, device, technology, or improved design or process implemented to reduce water loss, waste or use.[1]

The two categories of strategies identified by this study are: (1) non-price strategies and (2) price strategies.

- Non-price strategies addressed include:
  - Outreach and education to raise public awareness about the importance in conserving water.
  - Policy and regulation to establish water use requirements and restrictions.
- Price strategies addressed include:
  - Inclining block rates
  - Water budget based rate structures
  - Seasonal rate structures

[1] Incentive and Measure as defined by Vickers (2001). Vickers (2001) states incentive categories as educational, financial and regulatory, but this study defines these as strategies because they are programs that include both incentives and measures.

Municipal water providers typically employ more than one of these conservation strategies simultaneously, which makes separate evaluations and impacts difficult to discern. Water providers may also employ other conservation strategies that are not discussed in this study such as metering, indoor water conservation strategies, wastewater reuse, system pressure reduction, and leak detection and repair. These strategies can also effectively reduce water use and loss, but do not specifically relate to decreasing water use for landscapes.

Before the various water conservation strategies can be discussed, it is important to recognize the lack of consistency in terms used across several disciplines to discuss landscape water conservation. Water conservation issues addressed by municipal water providers have been used in conjunction with terms such as policies, programs, plans, tools, management strategies, approaches, mechanisms, instruments, measures, practices, options and methods among others. In the plant care and landscape discipline, water conservation is often associated with terms such as best management practices, procedures, technologies, principles, and guidelines. To the general public, these terms may be confusing or one in the same. The lack of consistency of terms used to discuss water conservation within and between disciplines has the potential to cause misunderstanding. As water providers, green industry professionals, the public and other interest groups engage in discussions about water conservation, these differences should be recognized and reconciled to the extent possible.

NON-PRICE CONSERVATION STRATEGIES

Outreach and Education Strategies

There are a variety of outreach and education measures used to conserve water on landscapes. These measures are primarily used to convey information to water users so that they can make informed decisions on how to efficiently manage water for landscapes.

Some of the more common measures include: media information and advertisements, bill inserts, internet information, demonstration projects and gardens, informative water billing for customers, public events, public informational meetings, school programs and curriculums, conservation hotlines, speaker bureaus, new homeowner outreach programs, evapotranspiration programs, best management practices, voluntary water use curtailments, distribution of water saving devices, landscape audits, community based social marketing, and workshops for alternative landscape options, better landscape management, and efficient landscape technologies. These strategies generally target one of two approaches to landscape water conservation: (1) improving the efficiency and management by which water is applied to landscapes, and (2) changing landscapes to those that require less water.

Effective outreach and education conservation measures will require cooperation and communication with the green industry because of their involvement with the design, construction, maintenance, and management of a majority of Colorado landscapes. Conflicting information and objectives that may exist between water providers and the green industry can send mixed messages to the public and defeat conservation efforts. From a public standpoint these entities have a symbiotic relationship, because municipalities provide water for landscapes and the green industry supports and encourages the efficient use of water on landscapes.

Message Box: *Alternative Landscapes*

Several landscape design and management approaches that emphasize low water use plants and native plants and other water saving practices, have gained popularity in recent years. *Water-wise* landscaping, *Xeriscaping*, and *natural landscaping* are some of the more common alternative landscapes. These landscaping methods have different conceptual approaches, but all promote the common goals of reducing water use, decreasing maintenance time and cost, and reducing or eliminating the use of chemicals. These methods of landscaping have not been promoted to their fullest extent in Colorado, primarily because there is concern regarding the public acceptability of different landscapes. Fortunately, more urban water providers, government agencies, and Green Industry members are promoting alternative landscapes by exhibiting the beauty and water conservation benefits associated with these landscaping methods.

1. *Water-wise* landscape planning and design involves careful consideration of site characteristics, climate and rainfall characteristics, and native and low water use plants. The fundamentals for *water-wise* landscaping are expressed in the following eight steps: group plants according to their water needs, use native and low water use plants, limit turf areas to those needed for practical uses, use efficient irrigation systems, schedule irrigation wisely, insure healthy soil, use mulches, and provide regular maintenance.

2. The term *Xeriscape* has acquired many definitions over the years since its inception by Denver Water in 1981. Simply defined, *Xeriscape* is a method of landscaping that promotes water conservation. There is much information available on the principles, uses and successes of *Xeriscape* for water conservation. The seven fundamentals of *Xeriscape* are as follows: planning and design, create practical turf areas, select low water requiring plants, use soil amendments, use mulches, irrigate efficiently, and maintain the landscape properly.

3. The purpose of *natural landscaping* is to promote and reintroduce the use of plants that are indigenous to a region so as to virtually eliminate any need for supplemental irrigation.

The most misunderstood notion about alternative landscapes that promote water conservation is that they require eliminating and replacing turfgrass with hardscapes and dry climate plants such as cacti. It should be emphasized that the success of these landscaping methods lies not only in the choice of plants, but mainly the management and cultural practices that people use in designing and maintaining these landscapes.

www.drought.colostate.edu
www.denverwater.org/xeriscapeinfo/xeriscapeframe.html
www.xeriscape.org
www.awwa.org/community/links.cfm
http://aggie-horticulture.tamu.edu/extension/xeriscape/xeriscape.html
http://cwcb.state.co.us/owc/freefa.htm
www.greenco.org
www.ext.colostate.edu

Source: Vickers, 2001.

timers for irrigation, in-ground sprinklers, drip irrigation systems, and gardens use 47%, 35%, 16%, and 30% more water than residences without these systems respectively (Mayer et al, 1999). People who use hand held hoses to irrigate landscapes have been show to use 33% less water than other users. These results suggest that users with automatic systems tend to “set it and forget it,” while “hose draggers” tend to irrigate only when necessary to minimize the work associated with setting and moving sprinklers.

Although some studies have shown that landscapes tend to be overwatered, several studies have also shown that lawns are often underwatered or deficit irrigated in some instances. A 2002 Fort Collins study found that 65% of lawns were underwatered (Fort Collins Utilities, 2003b). A majority of the 35% of landscapes that were overwatered were associated with newer homes that had automatic sprinklers and fewer mature shade trees. It was estimated that over-watering savings could be as much as 12% in this municipality. Another study in California conducted in the summer of 1991 concluded that 60% of households applied less water than the theoretical water

Case Study: *Cary, North Carolina*

Cary, North Carolina is a suburban residential town facing an explosive population growth. To delay the construction of another water treatment plant, Cary invested in a variety of water conservation strategies with the goal of reducing per capita water use by 20% by the year 2020. Since the mid-1990's, the town has employed incentive, regulation and education programs to help achieve this goal. Central to all conservation strategies is their extensive and continuous customer outreach and education campaign. Education measures include a beat the peak campaign to promote water-wise outdoor irrigation; block leader campaigns to provide neighborhood information on efficient landscape water use; school programs that promote use of catch-cans to measure amount of water applied to landscapes; printed materials on best management practices; and free workshops for efficient landscape irrigation technologies, scheduling, maintenance, management, and design.

According to estimates, current water conservation efforts in Cary will reduce total water use 16% by the end of 2028. Public education strategies for conservation alone will account for a total water savings of nearly 4%, about one-quarter of all conservation strategies employed by the town. However, public education and awareness are a part of every conservation strategy employed in the town of Cary.

Source: Platt and Delforge, 2001

Case Study: *Durham, Ontario, Canada*

The municipality of Durham has used Community-Based Social Marketing (CBSM) techniques to reduce excessive use of water on landscapes. CBSM is an alternative to information based education campaigns for water conservation. CBSM claims that behavior change (which is rarely a result of providing information alone) is most effectively achieved through initiatives delivered at the community level, which focus on removing barriers to an activity while simultaneously enhancing the activities benefits.

Since 1997, Durham has employed college-aged students to discuss lawn and gardening information with customers on the neighborhood level. The students were trained to challenge customer's current habits and misconceptions about water use for landscapes. CBSM methods are designed to give customers a chance to understand and embrace the need for conserving water for landscapes. Between 1997 and 2001, over 1,400 households participated in the program at a cost of $45/household for an average irrigation reduction of 32%.

Source: Pleasance, 2002

Table 2 shows advantages, disadvantages, and water conservation effectiveness, if available, for some water conservation measures achieved through outreach and education. Water conservation values were obtained from a variety of studies, both peer-reviewed and non peer-reviewed.

Table 2. Education and Outreach Conservation Measure Effectiveness

Conservation Measure	Advantages	Disadvantages	Percent Water Conservation *Peer reviewed Literature*	Percent Water Conservation *No Peer reviewed Literature*
Voluntary water use restrictions	Easy to implement, no enforcement necessary	Doesn't send a strong message to conserve, water use can be increased[/8/7/14/15]	22% in San Diego, CA[/b]	4-12% in Front Range, CO[/a]
Alternative landscapes	Lower maintenance required, high potential water savings, no significant cost difference, provides a regional and natural attractiveness, more drought tolerant, reduced chemical requirements, green industry participation	Requires significant effort to inform, customer preference for traditional plants- not aesthetically pleasing to some, knowledge and availability of plants limited, does not conform to conventional landscape styles	43% in Austin, TX[/j] USBR Study in process	Highly Variable 10% in Seattle, WA[/k] 42% in Oakland, CA[/l] 33% in Mojave Desert, NV[/m]
Efficient landscape water use management and technology	Soil probes, ET controllers, deficit irrigation all have potential to increase efficiency if used properly, green industry participation	Must be properly coordinated with management, new technologies may be more expensive and difficult to operate, incentives for use and distribution are difficult	Highly variable and not well studied	14% for soil probes[/g] 16-58% for ET Controllers in CA[/h] 10-15% for landscape audits[/n] 25% in Tampa, FL[/e]
Public Education	Can change long-established habits, can achieve long lasting results by influencing younger generation, can achieve conservation on a voluntary basis, has the potential to help with other conservation measures, green industry participation	Requires a long-lasting, well planned and coordinated effort, is not extremely effective as a stand alone measure, requires change in human behavior	5% for education alone[/d] 4% for education alone[/f] 5-15% with modest price increases[/o]	32% for CBSM[/i]

/a Kenney and Klein, 2003
/b Shaw et al., 1992 (outdoor water use outreach: increased advertising and information, conservation hotline, large water use customer (audits))
/c Gilbert et al., 1990
/d Grisham and Fleming, 1989
/e EPA, 2002
/f Platt and Delforge, 2001, data produced by Raftelis Consulting and are estimates, not actual but projected savings.
/g Ash, 1999
/h Ash, 2002 and Ash, 2003 (Santa Barbara Water District)
/i Pleasance, 2002
/j Fuller et al., 1995
/k Shridhar, 1999
/l Vickers, 2001
/m Sovocool et al., no date
/n CUWCC, 2003
/o Renwick and Green, 2000

There are very few scientific studies that have isolated the effectiveness of outreach and education strategies for landscape water conservation. There are several reasons for this lack of information.

- Outreach and education programs are typically a part of all conservation efforts used by municipal water providers and are therefore difficult to analytically isolate when determining program effectiveness.
- Studies have shown that there is an overall lack of information available regarding the implementation of "non-price" conservation programs and a lack of detail and consistency of information necessary to evaluate changes in demand (Renwick and Green, 2000; Michelsen et al., 1998a).
- Most analyses of water demand have placed emphasis on price policy influences on water use, while largely ignoring the outcomes of alternative or "non-price" policies (Michelsen et al., 1998a).

Education and outreach measures are widely used by water providers and landscape industry professionals, yet not much is known about their direct influence on water conservation beyond the general understanding that they are essential to any conservation effort.

Message Box: *Best Management Practices*

Best Management Practices (BMPs) for landscapes are generally accepted practices that result in beneficial and cost-effective water savings. BMPs are considered a type of conservation measure under outreach and education strategies because their main purpose is to provide information on efficient water use to those who design, manage, and maintain landscapes. There are several BMPs specifically designed for Colorado landscapes.

1. Green Industries of Colorado (GreenCO)
www.greenco.org/bmps.htm
Includes a set of 29 guidelines, directed at the landscape industry, on how to reduce water consumption and protect water quality, while producing, designing, installing and maintaining healthy landscapes.

2. Irrigation Association
www.irrigation.org/conservation.htm
Includes five voluntary irrigation practices for turf and landscape that reduce water consumption, protect water quality, and are economical, practical and sustainable. In addition, these BMP's provide the tools needed to create active partnerships between water purveyors, property owners and the green industry.

3. Northern Colorado Water Conservancy District (NCWCD)
www.ncwcd.org/ims/ims_turfandurban_tech_rep.asp
Includes several recommended BMP's for urban turfgrass in Colorado.

3. Colorado State University Cooperative Extension
www.ext.colostate.edu
Includes fact sheets and management suggestions for both urban and agricultural uses of water.

Policy and Regulation Strategies

Policy and regulation are typically more effective water conservation strategies than outreach and education strategies[m] (Kenney and Klein, 2003). Policy strategies are long-term and include measures such as landscape ordinances and codes. Regulation strategies are short-term and include measures such as mandatory water use restrictions. Water restrictions are typically more effective in the short-term or for drought response because it is difficult for water providers to maintain enforcement and engage public cooperation for prolonged periods (Grisham and Fleming, 1989). Landscape ordinances and codes are more appropriate for long-term conservation

[m] Renwick and Green (2000) have shown that relatively moderate water demand reductions (5-15%) can be achieved through modest price increases and voluntary strategies, such as public information campaigns. Larger demand reductions (>15%) will require larger price increases, mandatory or regulatory strategies, or a package of strategies and will depend on the effectiveness of other conservation measures used.

goals and programs. The relative success of both policy and regulation strategies is highly dependent on the level of public awareness and cooperation, which is directly a result of the outreach and education measures used to promote water conservation.

One of the major concerns about using policy and regulation strategies for conservation is the negative impact that ordinances and restrictions can have on the landscape industry. It is estimated that 11,000 employees in the green industry lost jobs during the drought of 2002 in Colorado, which is believed to be in part a result of water restrictions imposed by municipalities. Because regulation strategies can be effective tools for water conservation, especially during times of drought, municipalities will continue to use them. Fortunately, increasing policy changes and regulations by municipalities are now being coordinated closely with the green industry, thus resulting in effective and enforceable programs that have a positive economic and environmental impact on the green industry and the public. This has been the case for some municipalities in California and Texas as they have already identified the importance of stakeholder involvement and the public review process in implementing ordinances and restrictions (Good, 1998; CUWCC, 2003).

Landscape ordinances and codes have been used and implemented for landscape water conservation at the state and local level.[n] Some common landscape ordinances and codes include: rainfall shutoff devices for sprinkler systems, site preparation requirements for new landscapes (soil amendments, aeration, and mulching), limits on portion of landscape devoted to turf and high water use plants, requirements for low water use plants, efficient irrigation systems for medians and right of ways, time and day limitations on landscape watering, prohibitions on wasteful water use, prohibitions on restrictive covenants and “weed” ordinances, restrictions for turf in narrow strips (along sidewalk and highways), and requirements for efficient irrigation systems for new landscapes among others.

The effectiveness of ordinances and codes for water conservation has not been widely evaluated. There are likely several reasons for this:

- Landscape ordinances are relatively new approaches to conservation and few have been active for the time period required for analysis.
- It is difficult to analyze this type of information.
- Ordinances and codes typically accompany other conservation measures and are therefore difficult to analytically isolate.
- Emphasis has primarily been placed on short-term regulatory measures such as water use restrictions.
- Ordinances are typically difficult to implement and enforce.

Mandatory water use restrictions have been shown to effectively reduce water demand in the short-term (see Table 3). Water use restrictions are typically used to reduce water use during peak demand times and during times of drought. Some common water use restrictions include: odd-even watering days, designated watering times and watering lengths during the day, every third day, twice a week, once a week, or no watering days, and prohibitions on water waste. In some cases water quantity restrictions based on past water uses have also been used to curtail water use for landscapes (Narayanan, et al., 1985; Pint, 1999).

Table 3 shows the advantages, disadvantages, and potential for water savings expected under policy and regulation conservation strategies. Much emphasis has been placed on the effectiveness of regulatory measures for landscape water conservation, while little information has been reported on the long-term results of landscape ordinances on water use. Water use restrictions can be effective in the short term but are not typically recommended for long-term conservation.

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[n] Some examples include: California State (Model Water Efficient Landscape Ordinance), Florida State (Florida Model Landscape Code), Albuquerque, NM, Marin and North Marin Municipal Water Districts, CA, Colorado Springs, CO, Boulder, CO, Aurora, CO, Tucson, AZ, Phoenix, AZ and several Texas municipalities.

Table 3. Policy and Regulation Conservation Measure Effectiveness

Conservation Measure	Advantages	Disadvantages	Percent Water Conservation *Peer-reviewed Literature*	Percent Water Conservation *Non Peer-reviewed Literature*
Mandatory water use restrictions	Effective in reducing outdoor use especially in the short term or for a drought/ 1, clearly communicates a conservation emergency message to public, easy and inexpensive to implement, publicly acceptable and understood	Requires customer cooperation and is hard to enforce/1, Quantity restrictions are often based on past levels of use/21, may increase water use in some cases when users apply more water than required, not a long term conservation measure, can lead to utility revenue shortfall, not good for green industry, customer responsiveness subsides with time	10-20% of residential use[/a] 19.7% in Fort Collins, CO[/c] 25% in LA, CA[/d] >15% in CA[/g] 18-56% for Front Range, CO[/e]	14% in Cary, NC for total ban on turf watering -6% to 10% in Cary, NC for alternate day watering[/b]
Landscape ordinances	Policy guideline for utilities, sends a clear message to public about what is a conservative practice, in theory has the potential to conserve significant water, enforcement mechanism	Possible resistance by customers, managers, and landscape industry, politically difficult to implement, not much is known about its effectiveness as a conservation measure, enforcement mechanism required	Highly variable and not well studied	Proposed Denver Water ordinances, greater than 10%[/f]

/a Grisham and Fleming, 1989

/b Platt and Delforge, 2001, data produced by Raftelis Consulting and are estimates, not actual but projected savings.

/c Anderson et al., 1980 for odd/even address watering schedule

/d Shaw et al., 1992

*outdoor water use restrictions and strict enforcement were part of conservation program

** outdoor water use outreach: increased advertising and information, conservation hotline, large water use customer (audits)

/e Kenney and Klein, 2003

/f Denver Water, 2003
Estimated water savings quotes for various proposed ordinances including: rain sensors, soil preparation, turf limitations, waste of water ordinance, median sub-surface irrigation, restrictive covenants.

/g Renwick and Green, 2000

With extensive public outreach and awareness campaigns, water use restrictions can quickly and significantly reduce water use without much additional input from municipal water providers. However, the success of maintaining or further reducing water demand through restrictions is limited because there is often no enforcement mechanism to continually encourage conservation. In addition, restrictions tend to evoke a sense of emergency to save water among the public, which subsides over time or as restrictions are relaxed. The 2002 drought in Colorado has shown that municipalities must exercise caution when using water use restrictions for future drought episodes, as these strategies can negatively impact the green industry. The use of landscape ordinances and codes should also be exercised with caution, because much is still to be understood about how these strategies affect water conservation efforts. Additionally, the green industry should focus on eliminating over-watering of landscapes even during non-drought years.

Case Study: *Front Range, CO*

A study conducted in 2002 by the Center for Science and Technology Policy Research at the University of Colorado sought to document and evaluate the effectiveness of voluntary and mandatory water use restrictions employed by various municipal water providers on the Front Range of Colorado. Municipalities used a variety of approaches during the study period, all yielding significant findings. The primary results of the study were that mandatory restrictions were effective in reducing water use, voluntary restrictions were of limited value, and the greatest water savings were found in the cities that used the most aggressive and stringent water restrictions. The percent water savings under mandatory watering restrictions for the municipalities is presented in Table 3.

Municipal Water Provider	Water Restriction/2	Percent Water Savings/1
Thornton	None	None/3
Aurora	Once every 3 days (2-1/3 per week)	18
Denver Water	Once every 3 days (2-1/3 per week)	21
Westminster	Once every 3 days (2-1/3 per week)	27
Fort Collins	Twice per week	24
Boulder	Twice per week	31
Louisville	Twice per week	45
Lafayette	Once per week	56

/1 Comparison of actual per capita use (deliveries) in 2002 with that level of use anticipated in 2002 had water restrictions not been in effect and given the adverse climatic conditions associated with drought.

/2 most municipalities also had voluntary restriction period as well (4-12%).

/3 Thornton did not have mandatory watering restrictions.

Other cities in the Front Range did not experience these results (Howe and Goemans, 2002). Colorado Springs and Aurora experienced initial curtailments in water use due to restrictions but were then followed by small increases in use. The city of Trinidad reportedly experienced a 13% increase in water use over the previous year.

Source: Kenney and Klein, 2003 and Howe and Goemans, 2002

PRICE CONSERVATION STRATEGIES

While financial strategies for water conservation are probably the most studied strategy, they are by no means the most understood. The relationship between water consumption and water use fees, the concern regarding public responsiveness to price changes, and water provider objectives all influence how municipalities incorporate financial strategies into conservation efforts.

Research has shown that when the price of water increases, consumption decreases but at a lower rate than the increase in price (Jordan, 1994). For this reason water is often considered an inelastic good such that a one percent increase in price results in a less than one percent decrease in the quantity consumed (Michelsen et al., 1998). One explanation for the inelasticity of water is that it is believed to be a necessity to life and therefore cannot be treated as an economic good subject to price controls. Although it is true that water is a necessity to human survival, some urban uses of water, such as water use for landscapes, are not essential. For this reason, it is commonly believed that pricing strategies can be used for landscape water conservation. In addition, numerous studies (see Table 4, next page) have shown that conservation-oriented rate structures can be used to send strong messages for water conservation, if applied correctly.[o]

Pricing strategies for landscape water conservation are rapidly spreading as an effective way to increase the efficiency by which water is applied to landscapes, while still maintaining the quality of our landscapes. Compared to other conservation strategies, pricing strategies are the only method that can send a message to all users about the real value of water and the need for conservation. The most appealing characteristic of financial strategies to the green industry and municipal water providers is that they convey the message of conservation and maintain the public right to use water as long as they are willing to pay for it. However, this may be considered inequitable because higher income customers will pay less for water relative to lower income customers. For this reason among others, there are still issues that will need to be considered when employing financial strategies for landscape conservation. Issues of affordability and equitability between various customer classes will greatly influence the degree to which financial strategies can be used.

Financial strategies for landscape conservation are the most popular method being considered by municipalities in Colorado after the 2002 drought and are therefore emphasized in this study.

Review of Utility Water Pricing

A review of utility (municipal water provider) water pricing and rate structures is fundamental to the understanding of financial strategies for water conservation. A utility rate structure is a set of fees designed to recover a water utility's fixed and variable costs (LaFrance, 1995). Fixed costs (often reflected in bills as a base rate or service charge) typically represent the largest portion of a utilities total cost and are independent of the amount of water consumed by customers. Variable costs (often reflected in bills as a consumption charge) are relatively small and depend on the amount of water consumed by customers. A water utility creates rate structures to: (1) generate revenue from customers, (2) allocate fixed and variable costs to customers, and (3) provide incentives for efficient water use (Collinge, 1996).

- Revenue generated from rate structures should sufficiently recover costs and should be stable and predictable over time and during times of consumption change (e.g. in a drought or during conservation efforts). For many water utilities, the objective is to maintain revenue neutrality.
- Rate structures should apportion costs of service among different users in a way that is fair and in a manner that avoids the subsidy of one group of users at the expense of another. The cost of service,[p] water rate affordability, and public acceptability are often concerns that utilities have when allocating costs.
- Rate structures should provide price signals to customers, which may serve as incentives to increase efficiency or reduce peak loading.

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[o] No peer-reviewed article concludes that price does not affect urban water use (Baumann et al., 1998).

[p] Cost of Service means that each class of customers (e.g. residential, commercial and industrial) is allocated costs based on their contribution to causing the cost (cost follows cost causers).

Table 4. Financial Conservation Measures Effectiveness

Conservation Measure	Advantages	Disadvantages	%Water Conservation *Peer-reviewed Literature*	%Water Conservation-*Non Peer-reviewed Literature*
Inclining Block Structures	Sends clear message for conservation, increases in revenue used to support other conservation efforts, delay the need for new water supplies, can encourage conservation in the long term, considered equitable among users, can represent the true value of water, maintains customer choice, supported by green industry	Not always publicly acceptable, revenue stability issues, can be ineffective if designed improperly, many other factors influence conservation, long and short term response difficult to discern, income & affordability issues, public outreach required, public relatively unresponsive unless blocks are very steep, requires better billing/information system	10%[/a], 5%[/b], 10% (for 40% increase in price)[/20], 16%[/h], 7% in Tucson, AZ[/i], 33% in AZ[/j]	25% in CO[/d], 11% in Cary, NC[/e]
Water Budget Based	Potential to be more equitable & fair, potential to decrease water use, appears to use science, markets well as customized use, good for cost recovery, provides public with reasonable goal, sends a clear over consumption message, supported by green industry, punishes excessive water users, potential drought mechanism, can be altered to meet community goals, revenue stability is possible	Relatively new concept & not much is known, requires a decision on what is a conservative resource standard, science is typically based on averages, requires a major effort to change pricing structure, not cost of service, requires significant public outreach, difficult to obtain customized information, may be difficult in non-homogenous communities, hard to use in commercial settings, requires allotments to be generous for public acceptability, subsidizes users who have been less conservative in the past	Not well studied	12%(residential)[/f], 20-37%[/g]
Seasonal Surcharges	Relatively easy to implement, public understands the need, can curtail landscape water use, revenue stability possible, specifically targets landscape water use, potential to be an effective tool	Not much research available, does not encourage conservation if designed improperly, requires public outreach, requires change in billing structure	10% decrease in use for 35% increase in price[/c]	Seattle, WA 4.5%[/i]

/a Grisham and Fleming, 1989

/b Jordan, 1994

/c Moncur, 1987 (residential only)

/d Flack et al., 1977 (for 2X increase in price)

/e Platt and Delforge, 2001, data produced by Raftelis Consulting and are estimates, not actual but projected savings.

/f Ash, 2002b

/g Pekelney and Chesnutt, 1997

/h Pint, 1999

/i Cuthbert, 1999

/j Billings and Day, 1989 (price effects not isolated from other factors)

There are four general types of pricing or rate structures used to generate revenue by municipal water providers: uniform rates (the same price for each unit consumed), declining rates (the more units consumed the lower the price), inclining rates or inverted rates (the more units consumed the higher the price), and seasonal rates (different prices based on seasons). Inclining and declining rate structures are also called tiered or block structures because different prices are often applied to different quantities or tiers of water consumed.

Theoretically, inclining, uniform and seasonal rate structures are more conservation-oriented than declining rate structures because customers are charged the same or increasing rates for higher water consumption. Seasonal rate structures are designed specifically to address peak demands associated with seasonal outdoor water use through the addition of surcharges to water bills. Another more recent conservation-oriented rate structure combines inclining block rates with individualized water budgets. Inclining block rates, water budget based rate structures, and seasonal rate structures are emerging as the most popular conservation oriented rate structures available for municipal water providers to curtail landscape water use.

To achieve stable and neutral revenue streams, municipal water providers traditionally employed declining rate structures because the unit costs for providing water decreased as supply increased. Because these rate structures send mixed signals to customers about the need for water conservation and appear to discount high water use customers, many municipalities have now converted to conservation-oriented structures.[q] While conservation-oriented rates signal the message of conservation to customers, they tend to increase revenue volatility for utilities, increase the frequency of rate adjustments, and decrease equity by placing individual customers into rate tiers that are based on average class uses (Teodoro, 2002; Vickers and Markus, 1992).

Selecting and creating conservation rate structures is a difficult task because there are many, often conflicting, objectives that must be achieved. Utility objectives, such as revenue stability and conservation for example, may be conflicting because higher rates that encourage conservation may increase revenue streams if water curtailment is not significant (Cuthbert, 1999); or can lead to revenue shortfalls if customers significantly curtail water use in response to price increases (Thimmes, 2001; Teodoro, 2002). Further complicating the process, utilities, customers, and society often have different community goals and opinions regarding the role of water pricing (Cuthbert, 1999). Utilities should incorporate a public review process and education campaign while they consider and implement alternative rate structures (Reed and Johnson, 1994).

Some important issues to consider for conservation-oriented rate structures:

- The quantity of water demanded by customers is influenced by the price of water, climate conditions, household income, number of people per household, and number and efficiency of water using appliances among others (Cuthbert, 1999).
- Approaches to pricing based on the future costs of water, provide signals to customers about the consequences to their water use decisions (Chesnutt and Beecher, 1998).
- Water has historically been under-priced and is often viewed as a right and not a resource subject to large or frequent fluctuations in price.
- Since fixed service charges typically represent the bulk of a customer’s utility bill relative to variable or consumption charges, relatively large decreases in water consumption do not reflect as equally as large decreases in customer’s water bills (Cuthbert, 1999).
- Conservation pricing strategies maintain customer choice while holding customers economically accountable for their choice.
- Long and short-term responses to water rate increases are difficult to discern.
- A majority of the public perceives that water use for landscapes is a right as long as users are willing to pay for that use.
- Large increases in the price of water are not politically and publicly acceptable.

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[q] Changes in water rate structures in the United States from 1986 to 1994: Declining-from 61% to 39.2%, Inclining-from 7% to 22.7% and Uniform-from 32% to 38.1% (Ernst and Young, 1994).

- Water customers fill a wide range of socioeconomic classes. Income and affordability must be considered while constructing rate structures (Jordan, 1994).
- Conservation pricing requires an extensive public outreach and education campaign to signal and explain price increases for water conservation purposes.

Inclining block rates, water budget based rate structures and seasonal rates are the most common conservation-oriented rate structures considered by utilities for purposes of reducing water use on landscapes. These will be considered in detail.

Inclining Block Rates

Implementing inclining rate structures may or may not be a panacea for water conservation concerns. Although inclining blocks rates are conservation-oriented in the sense that they send the message, "the more you consume the more you pay," they do not always send a strong enough message to significantly change a majority of people's behavior in favor of conservation. The theory behind using inclining block rates for landscape water conservation is that increased rates will encourage those users with high landscape water consumption, and thus high water bills, to be more efficient. The effective use of inclining rate structures for landscape conservation will require a consideration of some key issues: price sensitivity, marginal cost pricing, price signaling, and block thresholds.

Price Sensitivity

The effectiveness of inclining block pricing for reducing water consumption depends on how sensitive water users are to price increases (Michelsen et al., 1998c). Income, personal choice, and access to information are some of the more common factors that can influence the public's sensitivity to price. Price elasticity of demand is a measure of consumer responsiveness of changes in the quantity of water consumed to changes in price. Water use is price inelastic meaning customers, for the most part, are relatively unresponsive to small increases in water price. Many studies have attempted to determine the price elasticity of water, but these results are quite variable and dependent on a complex interaction of factors.

Marginal Cost Pricing

Marginal cost is the price of the next unit of water consumed. To be effective, conservation rate structures require that customers be charged a price for water that reflects the value of developing the next increment of supply needed (marginal cost). The idea behind conservation-oriented pricing is to charge customers for the full cost of water service and over the long-term to bring supply and demand into balance (Reed and Johnson, 1994). Whether or not customers respond to the average of marginal cost of water is another issue that is beyond the scope of this study.

Price Signaling

The need to conserve water and the connection to increasing prices must be adequately signaled to water users for inclining block rates to be effective. It is difficult for utilities to send price signals for conservation because customers receive bills after they have consumed water. In addition, utility bills are often difficult to understand and the connection between quantity of water consumed and the price for that consumption may be difficult to discern.

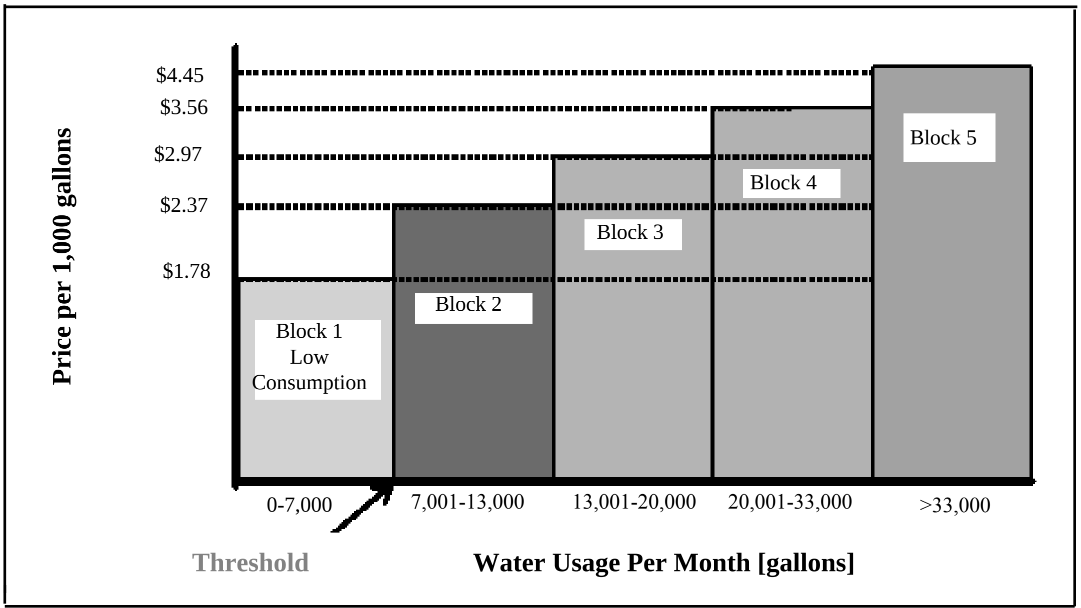
Block Thresholds

Figure 3 shows an example of an inclining block (tier) rate structure for the City of Fort Collins, Colorado (May 2003). Similar to most inclining block rates, customers are charged a low rate per 1,000 gallons up to a threshold amount (15,000 gallons per month).[r] Water consumption above this threshold is subject to progressive rates for increasing consumption.

These rate structures require utilities to assign a use allotment or consumption threshold for each block. The first threshold distinguishes the low consumption block and provides a "reasonable" quantity of water at a minimum rate to recover utility costs. Thresholds are discretionary and difficult to determine because they are based on what the utility believes, on average, adequately meets the needs of its customers, at a reasonable price. They are typically based on average consumption levels of a customer class, not on individual water needs.

Some problems associated with setting thresholds is that in some instances, low rate block quantities are so large, that only excessive water users are affected by the high rates associated with higher blocks. In addition, there is little financial incentive for conservation by those users consuming within low-rate blocks.

Figure 3. City of Fort Collins Inclining Block Rate Structure (May, 2003)



Case Study: *Effectiveness of water rate increases following watering restrictions*

Drought conditions in Colorado during the summer of 2002 forced the town of Boulder, Colorado to initiate twice per week, 15-minute per zone outdoor watering restrictions. Although watering restrictions and public education and awareness campaigns were effective in reducing water demand in Boulder, utility managers have explored alternative price structure as options for further reducing water use. Of concern to Boulder utility managers during this process was how large a price increase was necessary to reduce water use below those already imposed by restrictions.

To answer this question, an economic analysis was performed and showed that for a significant percentage of households in Boulder, price increases would yield no further reductions in water use beyond the amount caused by restrictions. Estimated price increases for Boulder's rate structure block 2 (5,001 to 17,500 gallons per month) would require a >100% price increase and >200% price increase for rate structure block 3 (17,501 gallons per month and up). The success of using pricing strategies to achieve water conservation in addition to watering restrictions may be much lower than expected.

Source: Howe and Goemans, 2002

[r] Consumption charge is in addition to some fixed rate of service or base rate ($11.82 for Fort Collins). www.ci.fort-collins.co.us/

Water Budget Based Rate Structures

Water budget based rate structures are inclining block rates linked with individualized volumetric allotments of water to customers based on conservative resource standards (Aquacraft, Inc. and A&N Technical Services, Inc., 2003). Volumetric water allotments can be based on a variety of characteristics including number of persons per household, lot size, percentage of landscaped area, and water use requirements for landscapes (Ash, 1999). The theory behind water budget based rate structures for conservation is that they: (1) are more equitable than other conservation-oriented rates because costs are allocated according to individual water needs or budgets, not average customer classes, and (2) are more efficient because they provide an individualized water allotment that is based on conservative resource standards. Proponents of water budget based rate structures state other benefits including: more stable revenue generation (when fixed costs are separated from variable costs), improved customer acceptance, low and consistent water bills, and improved drought response (Aquacraft, Inc. and A&N Technical Services, Inc., 2003).

Water budget based approaches to conservation have grown in popularity since their implementation by several California municipal water providers in the early 1990's.[s] The Irvine Ranch Water District (IRWD) in California was the first utility to fully implement the water budget concept in 1991. The success associated with IRWD's approach to providing financial incentives for conservation has gained some attention in Colorado, particularly after the drought of 2002. The IRWD estimates a 12% reduction in total residential water use with the adoption of water budget based rates structures and a 43% decrease in landscape water use between 1991 and 1997 (Ash, 2002b). While support for water budget based rate structures is growing in Colorado, so too is skepticism towards its applicability in Colorado.

Most municipal water providers that have adopted the water budget based approach follow three steps: determination of utility costs, water allocation to customers, and an economic incentive through pricing blocks or tiers (Ash, 2003).

Utility Costs

Water service providers must determine fixed and variable costs so a rate structure can be designed to insure revenue stability. To assure revenue stability, fixed costs should be recovered through a fixed service charge and variable or consumption related charges should be recovered by an inclining rate structure. Excess revenues generated from high consumption blocks should be used to pay for outreach and education programs that promote conservation. In order to stabilize revenue using this pricing strategy, fixed costs should be separated and charged for independent of the variable costs.

Water Allocation

Water allocation is the process of determining how much water customers need. This process is typically performed first for dedicated landscape meters, then single-family residences, and finally commercial landscape uses, since water use within this last class of customers is highly variable and difficult to determine.

Allocations include an estimate for indoor water demand and outdoor water requirements. Indoor water needs are usually based on the number of residents per dwelling and per capita water consumption. The number of residents per dwelling can be based on averages or can be determined for each individual dwelling.

Outdoor water requirements are based on the amount of landscaped area, an estimate of irrigation efficiency, and an evapotranspiration rate. Landscaped area can be determined a number of ways including: aerial images of landscapes, actual measurements of irrigated area, total area of property, or some percent area of property. Local

[s] Irvine Ranch Water District, City of San Juan Capistrano, Otay Water District, and Eastern Municipal Water District among others.

evapotranspiration rates for cool-season grasses are then used to determine the water needs over the landscaped areas throughout the year. A combination of indoor water demands and outdoor water requirements determines an individualized water budget.

Economic Incentive

The third step is to create a rate structures that reflects the water allocation, encourages conservation, and covers a utility's costs. Water budget based rate structures are typically designed to cover variable costs or costs associated with water consumption. Fixed costs are charged to each customer through an additional flat rate to insure revenue stability.

Water allocations are typically represented as the first or base block.[t] Water consumption within this block is charged at a reasonable base price. For water consumption above water budget allocations, customers are charged steeply increasing water rates. Steep increasing rates are designed to send a strong message to customers to not over-consume. Excess revenue generated from high consumption customers is used directly for education and outreach conservation programs.

Colorado Experience With Water Budget Based Rate Structures

Conceptually water budget based rate structures make sense for landscape water conservation. The water budget concept is not only used to charge higher prices for high water use, but it also is used to provide an efficient water allocation target that customers can reasonably achieve. The science and technology is now available to provide an efficient estimate of the amount of water an individual household should use. In addition, enough is known about pricing mechanisms for conservation and revenue stability that it is relatively easy to incorporate water budgets into a rate structure. Both water managers and customers also see water budgets as an equitable way to share limited water supplies, while preserving some amount of customer choice (Chesnutt and Pekelney, 2002). Although it has not yet been used as a drought management tool, water budgets have the potential to quickly reduce demand during drought situations by reducing water allocations (Ash, 2003).

Despite the intended benefits of water budgets and the relative amount of success that IRWD and others have achieved, there is still much to be understood about water budgets. The relatively new concept is being implemented throughout California and in parts of Colorado, yet there are relatively few studies that have fully evaluated this concept and there are no studies that have explored its applicability in Colorado. While municipal water providers in Colorado continue to explore options for landscape conservation, they should consider some key issues concerning water budgets.

Allotments Based on Averages

Although it appears that the water budget concept is more fair and equitable by allocating water budgets based on individualized or customer specific rates, it has not been implemented strictly in this manner.

Unfortunately, the resources needed and the difficulty in obtaining individualized information on a per customer basis requires utilities to rely on averages for customer use information. This is the case for traditional water rate structure design, which relies on customer class averages to set thresholds for rate blocks. Currently, water allocations determined through the water budget approach have also relied on averages such as the number of people per household, average landscaped area, and landscape type. The individualization of water budgets only occurs when customers request variances from these averages because they have received high water bills for any number of reasons including more people per household or greater landscaped area.

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[t] In the case of IRWD, the first block is a low-volume discount if 0-40% of water allocation is used. The base rate or conservation-based rate is the second block and represents 41-100% use of water allocation.

The issue of basing "individualized" water budgets on averages has not been a major problem for IRWD. Fortunately for IRWD, the city of Irvine is a relatively new homogeneous residential community. In communities where residential accounts may vary significantly, it may be more difficult to base water allocations on averages. This may very well be the case for some communities in Colorado.

Conservation Standards for Allotments

In theory, the determination of a water allocation is based on conservative resource standards. For example, this means that per capita indoor water use is based on consumption levels for households that have efficient indoor appliances. Setting conservative resources standards is relatively straightforward for indoor uses of water because use does not vary significantly per capita or with time of year. Setting conservative resource standards for outdoor water use is not as straightforward.

Creating allotments for outdoor water use requires a utility to make a judgment as to what is "conservative" water use or what is believed to be "appropriate" water use. To be fair to the public and preserve the notion of customer choice in landscapes, utilities tend to be quite generous with their allotments by basing all landscape water requirements on those for high water use, cool season turfgrass. In doing so, utilities do not provide a strong incentive to customers to use water below their allocation because these users are already in the reasonably priced, base rate consumption block (tier). Outreach and education efforts may convince water users of the need to further reduce water consumption.[u] Although utilities have tended to be quite generous in their allotments, they do have the ability to set more conservative water allotments it they choose to do so, for example by limiting the amount of landscape planted in turfgrass.

It can be argued that water budgets tend to subsidize those water users who have tended to be less conservative in the past. Because water allocations are based on individualized needs, customers with higher water use landscapes will be given a higher allocation than those customers with lower water use landscapes. Therefore, customers with high water use landscapes will be charged water at the same rate per unit consumed as those users who have chosen to have a more conservation-oriented landscape. Water budget based rates structures are useful in that they encourage water use only to the degree needed for efficient use on existing landscapes. However, if water needs for existing landscapes are inappropriate during periods of drought then the issue becomes not one of just efficiency on existing landscapes but one of long-term sustainability for the community.

Aside from the concerns discussed in this study, water budget based rate structures have the potential to promote long-term conservation and to serve as a drought response tool if conservative resource standards are appropriately defined. The green industry recognizes this approach to conservation as very viable and sustainable for their industry. As a relatively new concept to Colorado, it has yet to be fully developed and understood. Water budgets have not been scientifically supported as an effective tool for landscape water conservation in Colorado, but that does not mean that it isn't a viable strategy for conservation. As the concept is improved and more fully understood, it may serve as important tool for the future management of water for urban landscapes.

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[u] If there is a low water use discount in water rates, there may be an additional incentive to conserve further. Otherwise, those users who select low water use plants are still paying the same rate per unit of water consumed as those users who select cool season turfgrass (a higher water use plant).

Case Study: *Irvine Ranch Water District, California*

Located in Irvine California, the IRWD serves a population of approximately 150,000 in a 78,000-acre service area. IRWD manages over 70,000 water connections or accounts, of which 60,000 are in the residential customer class.

IRWD implemented a water budget based rate structure in 1991 to curtail water use during one of California's most devastating droughts. With extensive outreach and education campaigns, this effort reduced water use in 1991/1992 by 19% as compared to 1990/1991. Between 1991 and 1997, landscape water usage dropped from an average of 4.1 acre-feet to less than 2 acre-feet and total residential water use dropped a total of 12%. Since 1990, water usage is on average, 9% less per residential household. In addition, surveys conducted in 1997 and 1998 indicate that 85% of customer believe the water budget system is fair, 95% understand the rate structure system, and 92% believe it accurately reflects their water use.

IRWD bases residential allocations on a sum of indoor water demand and outdoor water requirements. For each individual residential household, IRWD assumed an average of 4 people per dwelling at a rate of 72 gpcd. Based on a relatively homogenous residential character in Irvine, IRWD was able to assume an average landscaped area of approximately 1,300 square-feet for each dwelling. Assuming 100% of this landscaped area to be cool season turfgrass (ET measured by three local weather stations on a daily basis) and 80% irrigation efficiency, IRWD is able to calculate landscape irrigation demand on a daily basis. Residential households that do not meet these allocation standards (e.g. more people per household or larger landscaped area) are encouraged to contact IRWD so water allocations can be adjusted to better reflect their water use needs.

The IRWD residential water rate structure:

Block/Tier	**Rate (per ccf*)**	**Use % of Allocation**
Low Volume Discount	$0.59 (3/4 base rate)	0-40
Conservation Base Rate	$0.75 (base rate)	41-100
Inefficient	$1.50 (2X base rate)	101-150
Excessive	$3.00 (4X base rate)	151-200
Wasteful	$6.00 (8X base rate)	>201

*1 ccf = one-hundred cubic feet=748 gallons

In addition to consumption charges above, customers are billed a fixed water service fee based on meter size, which insures revenue stability, regardless the amount of water sales. IRWD also holds a different water budget based rate structure for commercial class customers.
For more information on IRWD: www.irwd.com

Source: EPA, 2002; Ash, 2002b; Ash, 2003

Case Study: *Centennial Water and Sanitation District, Highlands Ranch, Colorado*

Highlands Ranch, developed in the 1980's, is a rapidly growing planned community of about 75,000 residents and 26,000 water service accounts. In response to the drought of 2002 and the desire to explore new rate structures, the Centennial Water and Sanitation District, which services Highlands Ranch, implemented a water budget based rate structure in the spring of 2003. To promote conservation and inform the public about changes in the rate structure, Centennial used 20 to 30 different public relation activities including bill stuffers, workshops, hearings and newspaper articles during the spring of 2003.

To determine an individualized water budget for residential customers, Centennial assumed an average household size of three people; a 42% landscaped area from individual parcel size data, and an evapotranspiration rate typical of cool season turfgrass in the area. Indoor per capita consumption was assumed to be 65 gpd. An analysis of approximately 1,000 households in the region was used to determine the average percent of irrigable area on residential lots, which was determined to be approximately 42%. Data obtained from county records were used to determine individual lot sizes. Over 2,400 individualized water budgets were performed for commercial customers because the large degree of variability in this class of customers did not allow for use of averages.

At the time this study was conducted, Centennial water customers had received only one bill under the new rate structure. Under the first billing cycle, less than 5% of customers received very large water bills. Aside from strong political reaction to the new rate structure, not much is known at this point about its effectiveness in reducing water consumption or customer satisfaction. As municipalities in Colorado begin to consider options, Centennial will be of some interest.

Source: McLoud, R., personal communication, 2003

Seasonal Rates

Seasonal water rates are another type of conservation-oriented rate structure that can be used to curtail water use for landscapes. Under this type of rate structure, surcharges are used to cover the costs that are driven by peaking requirements or times of high outdoor water use (Chesnutt, 2000). Aside from covering costs associated with peak demand, seasonal rates also have a conservation justification because they communicate the additional cost associated with meeting the peak demand of outdoor uses (Mann and Clark, 1993). Like other conservation-oriented rate structures, seasonal surcharge structures should use marginal cost pricing to signal the consequences of consumers continuing their pattern of consumption. Surcharges are frequently used by utilities because they are relatively easy to implement, are understood by water customers, can reduce water consumption during peak periods, and can be designed so revenues remain relatively stable over time. An example of a surcharge rate structure for the Denver Water Department is shown in Table 5.

Table 5. 2003 Summer Surcharges for Denver Water

Block	**Threshold (1,000 of gallons)**	**Surcharge per 1,000 gallons***
Minimum Use	0-18	No surcharge
1	19-22	$0.80
2	23-28	$1.39
3	29-34	$2.05
4	35-40	$3.00
5	41-46	$4.41
6	47-52	$6.47
7	53-60	$9.50
8	>61	$11.85

Source: Denver Water, 2003b

* Surcharges are rates in addition to normal inclining block rates.

There have been relatively few studies that have shown the effectiveness of seasonal surcharges for landscape conservation. As with most conservation efforts, pricing strategies are typically used in conjunction with other conservation strategies so to isolate seasonal surcharges from other efforts to measure conservation effectiveness is quite difficult. In addition, seasonal surcharges have primarily been used in the past to reduce peak demand and have not been widely used for the purposes of curtailing outdoor water use in times of drought. A study in Honolulu, Hawaii suggests that drought surcharges can induce conservation, especially when used in conjunction with education and outreach conservation programs (see Table 4, presented earlier) (Moncur, 1987). The Seattle Water Department has also implemented seasonal surcharges in the form of an inclining seasonal rate structure in the summer and a uniform rate structure in the winter. Adoption of the seasonal inclining rate structure is believed to be responsible for a decline in water use (see Table 4) (Cuthbert, 1999).

Table 5 also shows the advantages, disadvantages and potential for water savings expected under conservation oriented rate strategies. While there are numerous peer-reviewed studies that have shown the effectiveness of inclining block rates for conservation, there are currently very few studies that have shown effectiveness for water budget based rate structures and seasonal surcharges. An essential component to the success of any conservation oriented rate structure requires an extensive outreach and education program. Many studies, both peer-reviewed and non-peer reviewed have failed to consider the role of other conservation programs used simultaneously.

Message Box: *Financial Rebates*

Financial rebates are another financial conservation measure that can be used to reduce water demand. While pricing measures tend to send price signals to water-wasters, rebates are used to financially reward efficient water users. Rebates for indoor water efficient appliances are the most common rebate incentive programs used by municipal water providers. However, rebates options also exist for promoting efficient water use on landscapes. Rebates for converting to efficient landscapes, performing landscape audits, and using efficient water devices are some of the more common rebates that promote landscape water conservation.

Several cities in Texas offer financial rebates to promote the efficient use of water on landscapes. The San Antonio Water System Watersaver Landscape program offers $0.10 per square foot credit to water customers for the installation of water-wise landscapes up to 5,000 square-feet of converted landscape. In 2001, the program saved approximately 300 acre-feet of water at a cost of $253 per acre-foot. Similarly, the Environmental and Conservation Service Department in Austin, implemented the Xeriscape It! Program that offered $0.08 per square foot credit for landscape conversion up to 3,000 square-feet. Between 1993 and 1997, 469 projects were completed for an average summer water savings per project of 214 gpd and total project cost of $77,620.

Source: Vickers, 2001 and Gerston et al., 2002

CONCLUSIONS

While there is considerable information developed over the years regarding water savings from conservation strategies, overall, there is not sufficient *peer-reviewed* literature to scientifically evaluate the effectiveness of urban landscape water conservation strategies. While there have been studies of basic urban water conservation principles, such as underlying economic theory of water pricing and best management practices for landscape irrigation, applications of water conservation practices are highly site specific, which often confound efforts to extract broadly applicable concepts. Water conservation practices tend to be studied from the point-of-view of specific applications – the results of which are presented in the "gray literature" (non peer-reviewed technical reports, case studies, and educational documents).

Given the wide range of community needs, citizen desires, and municipal water provider circumstances, urban landscape water conservation strategies are typically tailor-made for a specific city and include a combination of conservation practices. Data documenting the success of a municipality's total urban water conservation program are recorded, but it is difficult to tease out the effectiveness of any one conservation measure.

More specific conclusions are:

- Overall, there is a lack of information scientifically documenting the performance of non-price conservation programs and a lack of detail and consistency of water use information necessary to evaluate changes in demand (Renwick and Green, 2000). Until recently, many water utilities failed to document and maintain consistent records of conservation program activities and scope, specific periods of program implementation, measurable levels of effort and follow-up evaluations of non-price program participation and responses (Michelsen, 1998).
- Since water utilities typically adopt more than one conservation strategy during droughts or for long term conservation planning, more research is needed to understand how the interaction of strategy incentives influences the overall reduction in water consumption (Renwick and Green, 2000).
- Failure to account for non-price conservation efforts, primarily outreach and education efforts may result in an overestimation of the effectiveness of price strategies for conservation.
- Research has tended to ignore the effects of non-price programs for conservation.
- Education and outreach conservation programs tend to be a part of all conservation efforts and are generally believed to be very important in all conservation programs.
- A majority of conservation studies are site-specific and are not necessarily applicable in all settings.
- There is very little consistency in terminology used by various water managers and members of the green industry regarding conservation for landscapes.

RECOMMENDATIONS

Due to scientifically inconclusive findings in this study, it is suggested that additional literature is needed in order to define strategies that can reduce water use and minimize negative economic impacts to Colorado's landscape industry. The outcome of this study cannot recommend specific conservation strategies that are believed to both reduce water use and protect the financial integrity if water utilities and the green industry.

It is possible to share several insights gained from this research as municipalities and green industry seek new approaches for conservation. Specific insights include:

- Involving stakeholders is an important component to the success of any conservation program. Stakeholders should include water managers, the green industry, and the public.
- A suite of conservation strategies, including public outreach and education, regulatory measures, and pricing mechanisms, has the potential to be an effective approach for many municipalities.
- Forming coalitions to study, manage, and improve conservation efforts among a variety of interests has been successful in other states.
- New approaches to conservation, such as water budget based rate structures, should not be overlooked based solely on the fact that there is currently little research on the topic. Rather, these new approaches should be studied in greater detail to more fully understand their role in future conservation policy. For example, is it possible to define a conservation oriented standard that is acceptable to the public and helps Colorado during times of drought?

As the drought unfolded in 2002 and municipalities were forced to restrict landscape water use, the assumed relationship between the homeowner and their landscape began to be questioned. In many ways, the sharp memory of 2002 water reduction impacts on landscapes is causing a rethinking of the general approach to urban landscaping most appropriate to Colorado.

While questions are being raised about the appropriateness of landscape materials traditionally used in urban Colorado landscapes, the green industry, water providers, and water consumers must be prepared to defend their preferences by employing the most appropriate strategies for landscape conservation, or they will need to be willing to rethink the very nature of landscapes in Colorado. It is likely that a combination of these two movements will ultimately provide a balance in Colorado's landscape community.

Such examination will require new information and knowledge about soil, plant, and water relationships and the interface between people and their landscapes. The fallout of the recent drought may be felt long into the future as the green industry and its clients in Colorado attempt to better position the urban landscape to survive future droughts.

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