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Landscaping in times of climate change: considerations for water conservation

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Abstract

This work presents an overview of landscaping in times of climate change, proposing some considerations for water conservation. Our main objective is to increase awareness of how good design practices and the use of drought tolerant plants can contribute to a more sustainable and enjoyable environment. First we discuss the water conservation aspect of LEED certification followed by the most popular options for xeriscaping in the United States. Then, we present some basic plant stress physiology concepts such as flowering, photoperiodism and stress, that can aid on designing and maintenance of a more durable and low water input landscape.

Keywords: Xeriscaping. Designs for Drought. Sustainable Landscaping.

Introduction

Sustainable landscaping design is growing in popularity to lessen the impacts of human development on the natural world. Sustainability is an important and essentially integrative concept that has been discussed for decades around the world.

Gibson (2006) points out that such concept has often been depicted as the intersection of social, economic and ecological interests and initiatives, which are considered the three pillars of sustainability. Recent studies have added an institutional pillar to this concept to better represent different spheres and the complexity surrounding this concept (Karlsson and Biggs, 2007). In the search for sustainability, it is important to identify ways in which we can reduce or mitigate the environmental impact caused by human activities while still considering the social and economic impact of such activities.

The use of plants for food and feed production, wood and pharmaceutical products, as well as for ornamental landscaping has always been a facet of human settlements. Currently, plants can also be used in sustainable development projects as part of green roofs and rain gardens towards certifications in Leadership in Energy and Environmental Design (LEED, 2016).

However, most crops typically consume some 500-700 times their dry mass of tissue in water during a growing season (Plaster, 2009). In this sense, drought is one of the most relevant abiotic stresses affecting plant production and it has become one of the major concerns worldwide due to climate instability. Just in the contiguous U.S. a total of 36.8% of land was classified as experiencing moderate to exceptional drought at the end of March 2015 (NOAA, 2015).

Our warming climate and hotter average temperatures frequently leads to more frequent watering of prized landscape plants to sustain the desired appearance of our homes and places of business. This proves to be a wise financial decision as landscaping services and vegetative matter can be relatively expensive. The true cost, however, in this additional watering is beginning to be “paid” by the natural environment with falling water tables, emptying aquifers, and reduced in-stream flows of rivers and creeks in portions of the U.S. That is but one inhabitant of our ecosystem, and for every liter we consume for ourselves and our landscapes, one liter less is available for the remaining inhabitants of that ecosystem.

Leed and water conservation

Several organizations around the world have been trying to promote sustainable development by creating green building standards, such as the U. S. Green Building Council. (USGBC). This council certifies green building projects and it also offers accreditation to people who demonstrate knowledge of the Leadership in Energy and Environmental Design (LEED) rating system, including accredited professional and green associate.

LEED became one of the most popular green building certification programs used worldwide that aims to help building owners and operators achieve environmental responsibility and use resources efficiently (USGBC, 2016). Conceptually, this certification emerged in 1993 and it has evolved to incorporate recent environmental issues and building strategies with the newest version being LEED v 4, encompassing a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes, and neighborhoods.

The impact of building on the natural environment and human health are examined in this paper, using the LEED framework as guidelines and looking at five major areas such as land, water, energy, materials, and indoor environment. Moreover, it is noteworthy to mention that the LEED rating system is designed to evaluate buildings, spaces, or neighborhoods, and all environmental impacts associated with those projects.

The water efficiency section of the LEED certification addresses water holistically, looking at indoor use, outdoor use, specialized uses, and metering. The section is based on an “efficiency first” approach to water conservation. Thus, each prerequisite looks at water efficiency and reductions in potable water use alone. Then, the WE credits additionally recognize the use of non-potable and alternative sources of water (LEED, 2016).

Required activities to conserve water included in this LEED section are outdoor water use reduction, indoor water use reduction, and building-level water metering. LEED credit-earning activities are the following: outdoor water use reduction, indoor water use reduction, cooling tower water use, and water metering.

A take on xeriscaping

Xeriscaping is normally defined as a landscaping method developed especially for arid and semiarid climates that utilizes water-conserving techniques, such as the use of drought-tolerant plants, mulch, and efficient irrigation. Nolon (2016) mentioned that this technique typically involves changing landscapes to utilize surfaces and materials that use less water. However, there can be tradeoffs that result from this type of water conservation, particularly the amplification of the Urban Heat Island effect.

Compared with turf, xeriscaped surfaces absorb more sunlight that have a lower albedo and use more of the absorbed energy for sensible heat and raising the temperature than for latent heat that is evaporating water without raising the temperature. The albedo effect was earlier discussed by Bodah and Bodah (2016). In model simulations, Chow and Brazel (2012) acknowledge that large scale residential xeriscaping likely results in greater overall thermal discomfort to the local populations, but highlight the microclimate cooling potential and water savings from extreme daytime temperatures of xeric (low-water demand) shade trees when utilized as an integral part of xeriscaping in the U.S. desert southwest. Shade trees provide a refuge from the sun during the hottest portion of the day for wildlife, nearby plants, and people.

Choosing drought tolerant plants that are native to the area of landscaping is the best option to also reduce costs involved with maintaining the landscape. In the U.S., the landscaping network (landscapingnetwork.com) has a list of several species in different categories used for xeriscaping. For instance, the top recommended evergreen trees are: *Acacia* spp., *Agonis flexuosa*, *Callistemon viminalis*, *Calocedrus decurrens*, *Cupressus* spp., *Eucalyptus* spp., *Juniperus* spp., *Olea europea*, *Pinus* spp., and *Schinus molle*.

Among the top recommended deciduous species there are the following trees: *Brachychiton populenus*, *Cercidium* spp., *Cercis occidentalis*, *Chilopsis linearis* cvs., *Lagerstroemia indica*, *Prosopis chilensis*, *Puncia granatum* cvs, *Quercus* spp., *Robinia ambigua* 'Idahoensis', and *Vitex agnus-castus*.

The choices for Western (U.S.) native shrubs include *Arctostaphylos* spp., *Artemisia arborescens*, *Ceanothus* spp., *Encelia californica*, *Fremontadendron californicum*, *Heteromeles arbutifolia*, *Lavatera assurgentiflora*, *Leucophyllum frutescens*, *Mahonia aquifolium*, and *Tecoma stans*. There are also flowering shrubs such as *Alygone huegelii*, *Cistus* spp., *Grevillea* spp., *Hibiscus syriacus*, *Lavandula* spp., *Plumbago auriculata*, *Raphiolepis indica*, *Ribes sanguineum*, *Tecomaria capensis*, and *Xylosma congestum*.

A five-year study conducted by Sovocool et al. (2006) demonstrated a 76% reduction in water needs for xeriscaped landscapes in Southern Nevada State, U.S. when compared to turf lawns. 73 gal/ft^2 (2974.45 l/m^2) were consumed annually on average by turf, whereas only 17.2 gal/ft^2 (700.83 l/m^2) were required for xeriscaped landscapes.

Flowering, photoperiodism, and stress

Flowering is controlled by several intrinsic and extrinsic signals, including a developmental clock and day length. Critical day length requirements are complex and vary in each species or even cultivar.

Levy and Dean (1998) state that much of plant development occurs postembryonically, through the reiterative production of organ primordia at the shoot apical meristem (SAM); which in most species initially gives rise to vegetative organs such as leaves. At some point, the SAM makes transition to reproductive development and the production of flowers through many diverse processes and light signals. Photoperiod or the physiological response of to the relative duration of light (day length) and dark periods is one of the factors that can affect flowering as well as seed development.

Taiz and Zeigar (2006) point out that the transition from vegetative to reproductive development is marked by an increase in the frequency of cell divisions within the central zone of the SAM that can be triggered by light using a photoreceptor protein, such as phytochrome to sense seasonal changes. It generally occurs in photoperiodic plants that can be defined as obligate photoperiodic (require a long or short enough night before flowering) and facultative (more likely to flower under the appropriate light conditions, but will eventually flower regardless of night length).

More in depth, photoperiodic flowering plants can be also classified as long-day, short-day and day neutral plants with specific critical day length:

(1) Long-day plants generally require less than 12 hours of darkness in each 24-hour period to induce flowering, some examples are carnation, oat, ryegrass and clover; pea, barley, lettuce, wheat and turnip are examples of facultative long-day plants.

(2) Short-day plants flower when the night is longer than the day, requiring a consolidated period of darkness before floral development can begin, some examples are coffee, poinsettia, strawberry, some varieties of tobacco and corn; facultative short-day plants are hemp, cotton, rice and sugar cane.

(3) Day-neutral plants, such as cucumbers, roses and tomatoes, do not initiate flowering based on photoperiodism, they flower after attaining a certain overall developmental stage or age, or in response to alternative environmental stimuli, such as vernalization.

When the environmental stimuli are given within the photoperiodic requirement the leaf becomes the site of signal perception (through LFY gene), signal transduction is triggered and gene transcriptional activation starts. The signal is transported into the phloem in all directions until reaches the responding tissue (competent vegetative apices in shoots) and flower induction or evocation begins, followed by development of flower initials or morphogenesis and development of flower.

Flowering time becomes critical to manage interventions such as thinning, pruning and harvest in plants. To understand how to induce and to control flowering is also essential in choosing proper cultivars or varieties that fit to the environmental conditions and day length of an area, or in the food industry by selecting dwarf and precocious rootstocks to produce earlier high quality fruit. Many studies have been developed to find the critical day length and photoperiodic affects ornamental crops.

For instance, Nyshyiama et al (2006) researched the critical photoperiod for inflorescence production and flower bud initiation in ever bearing strawberry, founding also many variables. Another important researched crop is soybean, which is a short-day plant and, therefore, cannot be produced in Alaska because of the long days (Poovaiah, 2010).

Overall, flowering is a complex process that involves internal mechanisms and environmental conditions. Thus, understanding photoperiod is important to have an efficient crop management or to manipulate blooming. Excess light might also create a problem to the plants under stress, especially if combined with drought.

Exposure of plants to irradiances far above the light saturation point of photosynthesis, known as high-light stress, induces various responses including light adaptation of the photosynthetic apparatus and chloroplast ultra-structure (Lichtenthale and Burkart,1999). Consequently, photodamage, photoinhibition, and other related problems can decrease photosynthetic capacity of many plants and plant parts, affecting, for example, fruit development.

Furthermore, visible damage can occur and be intensified when high-light stress is associated with high temperatures, affecting fruit quality and causing significant losses of production. In other words, prolonged exposure of plants to high fluxes of solar radiation as well as to other environmental stressors disturbs the balance between absorbed light energy and capacity of its photochemical utilization resulting in photoinhibition of and eventually in damage to plants (Solovchenko and Merzlyak, 2008).

Overall, different species, and even different cultivars, have distinct mechanisms to cope with stress. Thus, a well-planned design that accounts for natural variation that occurs in the ornamental plants becomes necessary towards sustainability.

Conclusion

Drought and stress conditions are only expected to increase as global climate change progresses. Thus, having a well suitable design to conserve water and using natural genetic variance for drought tolerance in plants is a promising area. Water conservation through xeriscaping seems to be a great alternative to traditional landscaping. The choice of drought tolerant plant varieties, the time of flowering and good management practices are important pieces of a successful landscaping that will contribute to water conservation.

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