TREES ARE SACRED, GRASS IS BAD, WHY?

History is dotted with examples of worthy causes which have been promoted by the use of questionable scientific data and assumptions. Unfortunately, the errors are often uncovered after it is too late to correct the environmental problems which occur. "The deterioration of environmental quality, in most respects, has proceeded almost imperceptibly."[1]

In many urban water conservation programs there is a perceived difference in the benefits and costs of trees versus grasses. Trees are promoted while all types of grass are targeted for removal or restricted. This perception is not fully based upon scientific fact but upon impressions and assumptions such as those we get when we see irrigation water running down the gutter in front of our homes each morning.

It is agreed that the Southwest has an impending water crisis which must be dealt with as the population grows and new urban water sources are developed at a much slower pace. Yet it is the purpose of this paper to outline a balanced approach to water conservation efforts. A balanced approach considers the water use of trees versus turf and recognizes that there are species of both trees and turf, which are water conserving. By maintaining areas of turf in our landscape, we preserve the many benefits turf provides to our cities and neighborhoods.

Water Use of Trees Versus Turf

If efficiently irrigated, research data indicates that many trees require as much water, if not more water than grasses. Research by Dr. Devitt et. el. in Las Vegas, NV indicated the tree to grass (bermudagrass/ryegrass low fertility) water use ratios were "1.5 and 1.7 for yearly averages for immature mesquite and oak trees."[3] Based on projections for mature trees the "tree to grass water use ratios increased to 2.0 for mesquite and 4.8 for oak."[2] Other research indicates that "Solid plantings of trees and shrubs use 10-20% more water than turf, whereas a solitary shrub or tree may use 2 to 3 times as much water as a comparable area of turf because it has greater exposure to sun and wind."[3]

The deep root systems of trees allow them to "mine" for water below the surface of the ground. However, it is also important to note that, in the absence of rainfall, water needed for healthy tree growth generally originates from irrigation of grass or other plant material. The inference is that the benefits provided by shade trees have little water cost since the plant material under the trees is considered to be the sole consumer of the irrigation water. This is incorrect since the removal of grass or other plant material will require separate irrigation cycles to maintain healthy shade trees.

An important scientific fact to understand is that a similar amount of water will be required to maintain the same amount of leaf area, whether grass or trees, that have similar leaf transpiration characteristics. "Leaf area index (LAI), an important structural variable descriptive of vegetation, is directly related to evapotranspiration."[4] Evapotranspiration (ET) reflects the level of plant water use since it is the combined process of plant transpiration and soil and plant evaporation.

As can be seen in Table 1 below, the leaf area index for turfgrasses mowed at 2.5 inches[5] is similar or less than that of the forest leaf index for several common tree varieties.[6]

Table 1 – Leaf Area Index of Popular Tree and Turf Varieties

Plant Variety	Leaf Area Index (meters^2/ meter$^{2)}$
Beech Tree	3.0 to 5.3
Oak Tree	1.9 to 5.1
Birch Tree	2.5
Spruce Tree	2.5 to 3.9
Perennial Ryegrass	1.91
Tall Fescue grass	2.06
Kentucky Bluegrass	1.72

Some allowance must be made for the lower density of trees growing in urban areas than those growing in a forest, but it is evident that Leaf Area Index and thus water use is comparable between trees and turfgrasses.

With this in mind, it is also important to understand that "[m]any environmental functions are related to leaf-surface area (e.g., reductions in air temperature, air pollution removal, volatile organic emissions, carbon dioxide sequestration)…"[7] The greater the leaf area of the trees and grasses, generally, the greater will be the environmental benefits. Since trees and grasses consume a similar amount of water for similar leaf area and similar leaf transpiration characteristics, one can infer that there may not be long-term water savings promoting trees and restricting grass. A better strategy would be to avoid broad generalizations regarding trees and turf and promote varieties of trees and turf that have low water use or provide specific benefits needed in a community.

Low Water Use Varieties

There are varieties of trees, which are low water use, such as those of the Mesquite family. Similarly, there are water conserving varieties of warm-season turfgrasses, such as Bermudagrass, Zoysia, and buffalograss, which are native to the Southwest. In research done by the University of California Riverside, differing amounts of water were applied to common Bermudagrass. Even with as little water as 50% of reference ET, the conclusion was that "common Bermudagrass quality was good throughout all treatments."[8] After considering irrigation distribution non-uniformity, this is within the target levels of water use promoted by conservation committees and public utilities. The low water use of warm-season grasses can be attributed to a deep root system (3 to 6 feet - depending on soil type and watering patterns) and the need for no irrigation (provided there is minimal precipitation) during winter dormancy.

Instead of restricting all types of turf, a balanced approach to water conservation includes recognizing the differences in both grass and tree varieties and their respective water needs.

Benefit-Cost Analysis

In examining all the benefits of trees, Tucson Water conducted a benefit-cost analysis and concluded that a "tree planting program would not adversely affect its conservation program."[9] Similarly, a benefit-cost analysis of Modesto's municipal forest . . . convinced city officials to increase the tree budget, and an electric utility to invest $20,000 in developing the Modesto Tree Foundation.[10] McPherson, et. al. determined that the total value of annual benefits from

Modesto's public trees was $4,963,816. Similarly, the projected value of annual benefits from an equivalent area of turfgrasses is $4,650,072, as seen below in Table 2.

Table 2. The Value of Annual Benefits From Modesto's Municipal Forest[10] and a Projected Value of Annual Benefits for An Equivalent Area of Turfgrass

Benefit Category	Total Dollars – Trees	Total Dollars - Turfgrass
Energy	$1,000,560	$ 601,200
CO_2	449,445	412,000
Air Quality	1,442,036	1,442,036
Trees-Stormwater Runoff	616,139	
Turf-Stormwater Runoff And Water Filtration		739,200
Aesthetic and other	1,455,636	1,455,636
Total Benefits	**$4,963,816**	**$4,650,072**

For a detailed examination of the economic benefits of trees and turf, please refer to Appendix A. A discussion of each of these benefit types is included below for both trees and turfgrass.

Energy Savings

Energy savings are a major reason why municipalities and utilities promote planting of trees. The Sacramento Municipal Utilities District has given away 375,000 shade trees prior to 2006 and plans to encourage planting of at least 4 million more trees. Similarly, Los Angeles is starting a campaign to plant a million trees. For every dollar it spends on trees, the city expects to realize a $2.80 return from energy savings, pollution reduction, storm-water management and increased property values." [11]

Trees provide shade in addition to cooling the atmosphere through evapotranspiration. Likewise, grass areas also provide cooling due to evapotranspiration. It has been found that, "[t]he front lawns of 8 average houses have the same cooling effect as 24 (3-4 ton capacity) home central air conditioning units."[12]

There is a direct relationship between surface temperature and the cooling effect provided by turfgrass. A study of average surface temperatures was conducted at Brigham Young University in the spring of 2002. From 7:00 AM to 7:00 PM, natural turf had the lowest average temperature of 78˚. Concrete and bare soil had average temperatures in the mid-90's. Asphalt had an average temperature of 98˚ and artificial turf came in at a scorching 117˚! [13] The conclusion in regards to energy savings is that replacing turf areas with anything other than similar plant material will result in higher temperatures and higher energy consumption.

A visual observation of most neighborhoods will indicate a problem with the energy savings attributed to trees - they are often placed too far from buildings to achieve maximum shade benefits. This may be an issue of landscape aesthetics or the fact that trees close to buildings require more frequent trimming or simply a lack of knowledge by those planting the trees. When trees do not shade buildings, the general cooling effect is similar to that of an equivalent area of turfgrass.

Air Quality Benefits

Turf and trees are great assets to our communities because of their ability to entrap pollutants and remove CO_2 from the atmosphere. Research has shown that turfgrasses remove "atmospheric pollutants such as carbon dioxide, ozone, hydrogen fluoride, and perosyzacetyle nitrate from the air."[14] "Grasses remove about 6 tons of CO_2 per acre per year from the atmosphere…"[15] Although the leaf area for trees and turfgrasses may be equivalent, the vertical height of trees indicates they would intercept more pollutants than grasses. However, "[s]ome researchers have noted that herbaceous species such as grasses and flowers absorb more gaseous pollutants than woody species such as trees and shrubs."[16] Additionally, turfgrasses also reduce airborne dust particulates and "offer one of the most cost-efficient methods to control…wind erosion of soil."[17]

Stormwater Runoff Reductions

With trees, most stormwater runoff reduction is due to the interception of rain by the tree's leaves, which delays water runoff for a short period of time. However, grasses will provide a significantly longer delay in runoff. The grass leaves slow down the flow of the water across the landscape's surface, allowing the water to penetrate the soil. Because grasses prevent and delay runoff of water, they also impact the number of sewer overflow events in a city, where the sewer water and storm water are combined.

An additional point to consider is that most rain in the Southwest occurs in the months of November to March. During this time, many deciduous trees are without leaves to intercept the rainfall. In contrast, even dormant turfgrass areas will provide significant reduction in water runoff in the rainy season.

In addition to providing for greater reduction in stormwater runoff than trees, "turf is good for filtering out oil and debris from the street. Grass is a tremendous medium to clean the environment." [18] Turf areas also have the added benefit of controlling soil .[19]

Aesthetic and Other Benefits

It is no secret that mature trees will increase the property values in a neighborhood. Trees provide "beautification, privacy, shade that increases human comfort, wildlife habitat, sense of place and well-being [that] are difficult to price."[10]

Similarly, surveys indicate that a well maintained lawn adds value to a home. Based on a Gallup survey on behalf of American Gardening Association, "A well-maintained lawn can enhance "curb appeal" adding as much as 15 percent to the value of a home."[20]

Although grass areas do not provide privacy and shade like trees, they provide the unique benefits of a safe surface for children and athletes to play on, fire protection around the home and a high visibility zone that discourages unwanted intruders and vandals.[17]

Negative Perceptions of Turf

After having considered the many benefits of both trees and turf, it is important to examine the misconception that maintenance of grass areas will have a greater negative impact on the environment than would occur with tree maintenance.

Lawns are criticized because of the grass clippings that are removed and disposed in landfills. However, if lawns are mowed on a regular basis there is no need to remove grass clippings from the lawn. "Despite popular belief, short clippings dropped on the lawn after mowing are not the cause of thatch buildup. Clippings are very high in water content and breakdown rapidly when returned to lawns after mowing, assuming lawns are mowed on a regular basis (not removing more than one-third of the leaf blade)."[21] Raking of tree leaves can also generate a significant volume of waste – directly proportional to the leaf area index as discussed above.

Lawns are perceived to leach fertilizers and pesticides into our water supply. Research indicates that when appropriate rates of fertilizers are applied to a dense stand of grass, there is very little runoff or leaching of the nutrients from the fertilized site. "Whenever N is applied to a site, there is the possibility that some of it may run off into surface waters. However, several recent studies indicate that N carried in runoff from turf areas is very low… That is because turf is comprised of many closely spaced plants forming a relatively closed canopy over the soil surface."[22]

Trees surrounded by grasses receive a benefit from fertilizers that are applied to the grass growing under their canopies. However, without grass growing under their canopies, trees may require fertilizations to maintain an acceptable tree quality. "Trees in their natural setting benefit from a layer of decayed leaves, twigs, and other organic matter that accumulates on the forest floor…But in urban and suburban landscapes where the environment has been drastically altered from its original state, mineral cycling does not occur and supplemental fertilization often becomes necessary."[23]

As with fertilizers, proper application of pesticides to turfgrass results in little impact on the environment. "Many university studies show that less than one percent of pesticides leach from the application site with the majority remaining in the turf or soil/thatch layer until it is degraded."[24] Pesticides may also be required by both trees and grasses. In the benefit-cost analysis of Modesto's municipal forest, the authors determined trees would require pesticide applications and allocated an annual budget of $67,747 to provide for pesticide applications to the trees.[10]

With proper education, "maintaining healthy turf areas can be accomplished by utilizing common sense and adhering to classic agronomic management principles. Know your soils and apply fertilizer and pesticides correctly. Adopt environmentally sound lawn service programs that will reduce leaching, runoff and erosion and maximize the environmental benefits of quality turfgrass."[25]

China's Lesson

During the Cultural Revolution of the 1960's, the People's Republic of China virtually eliminated all turfgrass areas and many types of trees. "[M]ore than three decades later, the human and environmental price of this action is just being thoroughly recognized and calculated." The lack of shade trees and turf causes cities to bear the burden of "heat islands"- which are 10 degrees to 30 degrees hotter than outlying rural areas. Further, when turfgrass is removed, the amount of smog and dust in the air increases because there are not sufficient numbers of plants to hold down the dust and trap particulate pollutants…Moreover, the lack of turf also increases erosion, which raises levels of pollution and damages water quality in ponds, streams, rivers and lakes. Throughout China today there is a tremendous effort underway to

repair the landscape and with it the environment and public health. Tree and turf areas are being expanded as quickly as possible before further damage can be done, but it will take several decades and many generations before the effort will be completed and start to yield results."[26]

"The People's Daily (2002) reported 'Beijing will take drastic moves to eliminate the sources of dust so as to reduce the amount of dust people breathe in everyday…worksites that refuse to plant trees shall be taken back...and shall be turned into lawns put under the management of gardening departments.'"[27]

Conclusion

As mentioned above, some government agencies advocate the removal and/or restriction on plantings of turfgrass to save water. They "are focused almost exclusively on projected water savings and have not fully contemplated the potential environmental impacts that may result from reducing the percentage of turf in the landscape."[28] Many also have not considered the option of allowing greater plantings of low water use grass varieties.

In China, the detrimental impact of the elimination of turfgrass and removal of trees was not recognized until three decades later.[26] Hopefully, we can learn from China and avoid making the same mistakes. Since both trees and grasses make significant positive contributions to our environment, both should be considered as part of a balanced approach in water conservation efforts.

Appendix A – Examination of Dollar Benefits for Trees and Turf as described in Table 2

A Benefit-Cost Analysis of Modesto's Municipal Urban Forest was conducted by McPherson, et. al.[10] They inventoried the street and park trees in Modesto. Using this data they estimated the 1998 annual benefits derived from this urban forest. The methods used to arrive at the annual benefits derived from trees are summarized in the paper and described in detail in a technical report.[29] The data on trees in Table 2 is a summary of the dollar value for the annual benefits Modesto's municipal forest provided. The data on grasses in Table 2 is a projection of the dollar value of the annual benefits that a like area of turfgrasses would provide. Below is a detailed description in the derivation of these dollar values for these annual benefits.

Energy Savings For Modesto public trees the "electricity saved annually from both shading and climate effects was 12,681 MWh, for a total retail savings of nearly $1,002,000…Air-temperature reductions (due to evapotranspiration) accounted for approximately 60% of cooling savings." [10] Turfgrasses do not provide shade but do provide cooling due to evapotranspiration, the same as with trees. "A significant portion of heat absorbed by turfgrass is likely dissipated through evapotranspiration of water."[30] It has been found that, "the front lawns of 8 average houses have the same cooling effect as 24 (3-4 ton capacity) home central air conditioning units."[10] Therefore, for an equivalent leaf area of turfgrasses, as the leaf area that was present on the Modesto public trees, the projected electricity saved annually, from the air temperature reductions (due to evapotranspiration), would be 7,608.6 MWh (60% of 12,681 MWh), for a total retail savings of approximately $601,200 (60% of $1,002,000).

Atmospheric CO_2 Reductions With the Modesto public trees "over 2,600 metric tones (t, or 1,000 kg) of CO_2 emissions were avoided annually as a result of energy saved from reduced space heating and air conditioning. This savings was valued at over $87,000." [10] The authors indicate trees did not provide a reduction in heating, therefore the avoided CO_2 emissions were very likely due to a reduction in air conditioning. "Street and park trees produced a small increase in heating costs because increased heating due to winter tree shade was slightly greater than savings from wind-speed reductions."[10] Therefore, with turfgrasses, the savings from CO_2 emissions avoided were determined based on a similar energy savings analysis, as mentioned above, or 60% of the trees benefit value, which provides for a turfgrass benefit value of $52,000 (60% of $87,000).

For Modesto trees the "sequestration less releases due to decomposition and maintenance (net sequestration) resulted in total savings of nearly 11,000 t (12,000 tons), with an implied value of over $360,000."[10] The canopy coverage of the 91,179 public trees was 1,866 acres.[10] Therefore, the sequestration was approximately 6.43 tons per acre. In a turfgrass study where the turfgrass was fertilized and the clippings were recycled, the authors projected 1,978 g C/m2 (8.8 tons/acre) were accumulated in the soil.[31] Therefore, the total CO_2 removed by the turfgrass leaf area was projected to be equal to that which was removed by the leaf area of the 91,179 public trees or approximately 11,000 t, with a value of over $360,000.

Air Quality Benefits For Modesto public trees the "[a]voided emission of NO_2, PM_{10} and VOCs due to energy saved from reduced space heating and air conditioning were small totaling 6.5 t (7.2 tons), valued at $68,000." [10] Additionally, the "pollutant deposition and particulate interception totaled 143 t (157 tons). The total value of this benefit was nearly $1.4 million." [10] Therefore, the total value for tree air quality benefits would be $1,468,000 ($68,000 plus $1,400,000).

Avoiding emission of NO_2, PM_{10} and VOCs, due to energy saved from reduced air conditioning, occurs with turfgrasses as well as with trees. As indicated above, turfgrasses provide a significant cooling effect on the environment, thereby reducing the air conditioning requirement. Furthermore, as occurred with trees, turfgrasses also entrap polluting gases. "Some researchers have noted that herbaceous species such as grasses and flowers absorb more gaseous pollutants than woody species such as trees and shrubs."[16~~13~~]

Turfgrasses also provide significantly greater reduction in airborne dust particles than do trees. "[P]erennial turfgrasses offer one of the most cost-efficient methods to control…wind erosion of soil."[17]

Since turfgrasses do not provide shade, they may provide slightly less emission avoidance of NO_2, PM_{10} and VOCs than trees. However, turfgrasses provide a significantly greater reduction in wind erosion of soil than trees. Therefore, the total aggregate benefit value for improvement in air quality by equivalent leaf areas of trees and turfgrasses, is projected to be similar for both or $1,468,000.

Stormwater Runoff Reductions "Modesto's street and park trees were projected to reduce annual runoff by around 292 million m^3 (102,943 Ccf) with an implied value of $616,000."[10] Most of the annual stormwater runoff reduction is due to the interception of rain by the tree's leaves. However, trees intercept only 35% or less of the total rainfall that occurs. "Average yearly interception rates are around 25% for hardwood species and around 35% for coniferous species."[32] Turfgrass leaves not only intercept rain but also directly reduce annual runoff by inhibiting the flow of water across the turfgrasses' surface. Research has indicated that even with a heavy 2 inch rain that only ".35 inches of runoff (occurred) in a park with turf grass."[15]

Turfgrasses, in addition to providing greater reduction in stormwater runoff than trees, also filter contaminants from water flowing across its' surface. "Grassed swales are shallow, vegetated ditches that reduce the speed and volume of runoff. Soils remove contaminants by infiltration and filtration…Swales have demonstrated solids removals exceeding 80 percent.[33]

Because turfgrasses provide for greater reduction in stormwater runoff than trees and also filter contaminants from water flowing across its' surface the value that turfgrasses provide, as far as stormwater runoff and filtering of contaminants, was projected to be 20% greater than for trees. Therefore, the value of turfgrasses, as far as stormwater runoff reduction and filtering of contaminants, was projected to be $739,200 (120% of $616,000).

Aesthetic and Other Benefits For trees the "[b]eautification, privacy, shade that increases human comfort, wildlife habitat, sense of place and well-being were difficult to price. However, the value of some of these benefits can be captured in the differences in sales prices of properties associated with trees…The projected total annual value of aesthetics and other benefits was nearly $1.5 million."[10] Turfgrasses do not provide all of the above listed aesthetics but do provide some of them, such as beautification and a sense of place and well-being. Additionally, turfgrasses provide benefits that trees do not provide, such as, a safe surface for children and athletes to play on, fire protection around the home and a high visibility zone that discourages unwanted intruders and vandals.[17]

As mentioned in the previous paragraph, the authors based there projected annual value for aesthetics and other benefits on the sale prices of properties.[10] Surveys have also indicated that a well maintained lawn adds value to a home. Based on a Gallup survey on behalf of American Gardening Association, "A well-maintained lawn can enhance "curb appeal" adding as much as 15 percent to the value of a home."[20] Therefore, it was determined that the same value, attributed to tree "aesthetics and other benefits" would also apply to turfgrasses or $1,500,000.

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