Stewardship and the Concept of Yield in Landscape Water Conservation

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Growing up in what was rural Salt Lake County, my peers and I never knew a time when questions of water did not flow through our lives as surely as it flowed through the canals and irrigation ditches. We played in the flood of water pumped from the ditch onto our lawn, and we floated homemade rafts down the canal in the heat of the summer. We listened in amazement to descriptions of how the canals were built and wondered when we would be big enough to be asked to join the cooperative crew that skimmed the ditches in the summer to keep the water flowing. We saw the technology of weed control change from dragging a burning tire down the ditch to using a propane torch. We pondered the stories of water disputes, and we watched our mothers hover over open ditches and warn us of their danger. We also learned why the water was really there as we rose at two o'clock in the morning to take our water turn and irrigate our crops.

To us, irrigation water was obviously a shared resource with limited availability. But it was also part of our lifestyle and actually somewhat of an entitlement. Legally we owned the land and the water rights that accompanied it. Therefore, we believed, as long as we were on the land, we were entitled to the water to irrigate that land. As high-desert dwellers and descendants of pioneers, we felt that the satisfaction of watching little rivulets of water run down dry furrows was as much our right as having the Wasatch Range tower above us or enjoying the cool, dry breezes of a summer evening.

Times have changed along the Wasatch Front. Much of the farmland has been sold for development, and many ditches have been removed. Nevertheless, there is still a demand for water to sustain new and existing homes and businesses. These new households demand water, yet they may be located on old dry farms or steep foothills where water has historically been absent. Not only do they demand water, but they are using it at one of the highest per capita rates in the nation.[1] Concurrent with this demand, there is an ever-increasing realization that beneficial use of water should include environmental uses such as in-stream flows for fisheries.

A 1997 editorial responding to demands for increased water rates stated: "Once again, it appears City officials want to discourage residents from keeping beautiful lawns and gardens. They say home owners can get by with half as much water. Most serious gardeners know better. In a desert, beautification and water go together."[2] Are beautification and water inexorably linked? The ever-increasing demands for a finite yet renewable resource are forcing us to ask important questions of our stewardship of water.

Irrigation and the Latter-day Saint Culture

Since the first diversion of City Creek, Utah has become famous for the application of irrigation to agricultural production. Historically, irrigation has been a part of Mormon Utah culture. In the pioneer era, when the Church in Utah was dependent on agricultural production, irrigation was a common practice. Members of the Church understood that their livelihoods depended on adequate irrigation water, and it was so central to the success of the community that bishops were called to act as watermasters.[3] That irrigation remains part of this culture today is exemplified by a recent address to the general membership of the Church wherein a fatal dispute over water rights was related to illustrate a gospel principle.[4]

As an agrarian culture, the Mormon settlements throughout the western states were dependent on water for survival. In those communities where water was plentiful and dependable, such as Brigham City, Bountiful, or Provo, they prospered. In those where water was minimal or unreliable, such as Mosida, McCornick, Widtsoe, Upper Kanab, Adairville, and Johnson, they failed.[5] Water, and the use of that water to produce crops, became a critical aspect of such communities and part of their cultures. The concepts of water law became an integral part of the community and included such principles as "beneficial use," which required that this precious resource be used in a beneficial or productive manner or the rights to it would be forfeited.

The early irrigation projects consisted largely of diversion ditches of relatively short length. These ditches drew water from naturally flowing mountain streams and diverted it to agricultural fields, gardens, and homes. The success of these projects was due as much to the social structure of the communities as it was to the engineering and agricultural skills of the pioneers.[6] Near the turn of the century, the Bureau of Reclamation began an unprecedented effort of dam building with subsequent irrigation canals and systems. This era of large-scale water projects began with many members of the Church leading the way.[7]

The farmers physically running a small ditch project earned every drop of water that came into their fields. While they may have felt a sense of entitlement to the water that came out of the canyons, they knew and paid the cost of getting it to their fields. Surely the sheer amount of work it took to divert the water helped to ensure its conservation and best use. With the advent of federally subsidized water projects, what had been community efforts became public works. With this broadening and federalization, the real cost of water has become obscured while an attitude of entitlement has grown in our society. It seems our inalienable right to turn on the faucet and have clean, pure water flow out.

In all of these activities, and in all of the derived applications, the underlying premise is

the more water used, the greater the level of productivity and subsequent prosperity.

The Concept of Yield

When the Mormon pioneers first entered the Salt Lake Valley and diverted water from City Creek to irrigate ground for the planting of potatoes, they were doing it to sustain life.[8] Their goal was to have the greatest yield possible, because higher yields meant more food, more security, and greater economic power in an agrarian economy. Given the probable 1847 soil moisture conditions in the Salt Lake Valley, they had no hope of growing a crop naturally, let alone one with high yields. Only the diversion of water from City Creek permitted production of crops with an acceptable yield.

In an agricultural context, yield refers to the harvested yield of crops.[9] Yield is paramount because the greater it is, the greater the potential profitability. To this end, crops are bred and managed so that yields are maximized. Successful agriculturalists may be defined as those who obtain the maximum yield from the land over a sustained period of time—whether from wheat, olives, grapes, or alfalfa.

Crop yields are governed by the "law of the minimum." This law states that plant growth and productivity will increase until the lack of some required resource becomes limiting. For example, plants will cease growing when available soil nitrogen is used up, regardless of how much water or sunlight they receive. However, if supplemental nitrogen is added, plant growth will increase until something else becomes limiting. These limiting resources include mineral nutrients, light, heat, carbon dioxide, space, and, of course, water.[10]

In the arid Intermountain West, the resources that most often limit plant yield are temperature (heat) and water. If we want to grow crops regardless of temperature, we build a greenhouse to provide the necessary conditions for growth. In a greenhouse, it is so expensive to provide heat and light that the cost of water, fertilizer, or even carbon dioxide is insignificant in comparison. It makes no sense to build a greenhouse, heat it, and then have low yields because of inadequate water or nitrogen. The only factors limiting plant growth in a greenhouse should be light and temperature. Similarly, if we want to grow crops in arid environments during the summer, we build an irrigation system to provide the water necessary for growth. While it may vary with the local availability of water, in general during a Utah summer, water should be the only resource allowed to limit crop yield. Like heat in the winter, water in the summer is so precious and valuable that it would be unwise to irrigate a crop only to find that it failed because of a lack of weed control.

Studies on crop yields and irrigation have continued since the time of the pioneers. More than 154 years after City Creek was first diverted, research continues to verify the critical role of water in crop yields. Research in the Columbia River Basin to optimize irrigation techniques in specific soils once again reaffirmed that in this arid region, irrigation at less than replacement levels for evapotranspiration decreased potato tuber yield as compared to plants that received adequate irrigation to replenish soil moisture.[11] In cotton, while yields have been shown to increase by using better cultivars, controlling insects and diseases, and improving soil fertility—all without altering irrigation practices—generally gross yield increases with increasing water until a maximum point is reached, after which yields begin to decline.[12] This pattern can be repeated with most crops, depending on the natural precipitation levels and the inherent adaptability of the crop to arid environments. For instance, with corn grown in Davis, California, irrigation doubled the yield. But with sorghum, irrigation only slightly increased the production.[13]

The inescapable conclusion is that in a dry climate when all other requirements are not limiting, plant yield can be increased through irrigation. Conversely, when water supply does not meet plant demand, the plant will develop water

stress, and yield will be reduced.[14] Since water is often the most limiting factor in the arid West, the farmer who uses his valuable water to its greatest benefit by producing the greatest crop yield magnifies his situation and is a wise steward.

Deficit Irrigation in Horticultural Crops

Can we get by with using less water to grow plants? The answer is yes—with the right situation and the right stewardship. A common tool in the production of horticultural crops is the manipulation of cultural practices. Depending on the desired yield, it is possible to use reduced irrigation to enhance the product desired. For example, one of the problems in the production of greenhouse bedding plants is excessively tall growth and a lack of adaptation to the outside environment when transplanted to the landscape. Those plants that are shorter, more robust, and acclimated to allow optimum development during the transition period are a more valuable commodity, even though they may have less overall growth than potentially obtainable. Careful reduction in irrigation to induce mild water stress has been historically used in greenhouse production to obtain this result.[15]

In peach orchards,[16] reduced irrigation during periods of limited fruit growth reduced vegetative growth by up to 75 percent, without reducing the fruit yield. This would potentially allow an orchardist to use reductions in irrigation to reduce the amount of pruning required and still have acceptable fruit yields. In grapes, production of both vines and fruit increases with irrigation.[17] But, while high yield in grapes is only possible with high moisture conditions, irrigation can also cause excessive vegetative growth (vines and leaves) at the expense of reproductive growth (fruit). The effects of irrigation vary not only with the desired yield component but with the species or variety of plant. In strawberries, yield increases due to irrigation generally range from 25 to 75 percent,[18] but in some cases irrigation increased yield while decreasing berry sugar and dry matter content.[19] Studies of citrus have shown that water deficits can decrease vegetative growth while enhancing flower bud development.[20] Clearly, reduced irrigation can be of benefit in some cropping circumstances. The benefits are even more apparent in landscape situations where water deficits have a greater potential as a cultural management tool.

Water, Aesthetics, and Landscape Management

Contrary to agricultural production, the goal of landscaping is not to produce a commodity such as sugar, grain, or forage. The function of landscaping is primarily to provide aesthetically desirable surroundings. Secondarily, landscapes enhance our environment through protection of water quality, reduced soil erosion, improved air quality, reduced summer temperatures, and reduced use of resources for heating and cooling. Landscapes also increase property values,[21] enhance community appeal, reduce crime, increase tourism, and improve worker productivity and job satisfaction.[22] None of these benefits are contingent upon maximum yield. It is true that there are situations where rapid plant growth is desired (such as the establishment of new landscapes), but once in place the primary issue becomes one of keeping the plants alive and looking acceptable.

Oftentimes the reduction in yield of a crop plant is accompanied by a direct, visible deficiency. Plants are damaged by insects or diseases or may suffer from physiological disorders such as iron chlorosis. Such damage reduces both yield and—in a landscape situation—aesthetics. Growth of plants can also be reduced in ways that are much less apparent and may not be noticeable at all unless compared to a similar plant grown under optimum conditions.

For example, it is well documented that turfgrass competes with trees for resources and that trees grown in competition with turf are smaller than those grown in a mulched or other noncompetitive situations.[23] But, the tree in the turf, albeit smaller, does not show any visible symptoms of

damage or deficiency and appears so acceptable that we readily plant trees in our lawns, even though they would grow better if we put them in the garden. Yield, as defined by increased plant growth, is reduced. However, aesthetic values often are unaltered.

Sachs, Kretchun, and Mock[24] documented with several California landscape plants that irrigation could be reduced to a point where the plants did not reach their growth potential yet still survived with acceptable appearance. A similar report showed that several species of trees maintained acceptable quality but grew significantly less when irrigated at 35 percent of reference evapotranspiration versus 80 percent.[25] Similar to the trees in lawns, controlled water deficits can reduce overall plant size but not reduce the desired aesthetic effect of the plants in question. A further benefit of such growth reduction is the decrease in vegetative matter produced. In a landscape, excessive vegetative growth is often an expense rather than a benefit.[26] Excessive growth must be mowed or pruned, removed from the landscape, and often shipped off to a landfill. Reduction in irrigation to an acceptable deficit level has the potential to reduce the biomass that needs to be removed, reduce water use, and still leave aesthetic values unchanged.

Undoubtedly there are times when maximizing yield can translate into maximized aesthetic benefit. A flower bed with more blossoms is arguably more attractive and functional than one with relatively fewer blossoms, and water may very well be the key in many cases to maximizing blooms. However, there are other aspects of aesthetics that are independent of water. Nassauer[27] has shown that a primary component of landscape aesthetics is the perceived care that goes into the landscape. In other words, if the viewer can tell that a landscape has been well cared for through uniformity of size, color, or cleanliness, then such a landscape is perceived as more attractive than one that is unkempt. Such care is independent of water use, and in fact if the viewer recognizes the care made to conserve water, the landscape may be viewed even more favorably and accomplish its goal aesthetically by bringing additional pleasure to the viewer.

Landscapes are a unique subset of plant husbandry. Their quality is not directly linked to plant productivity, and they are not quantifiable in the traditional sense. In spite of this, it is interesting that most of the literature on irrigation of woody landscape plants describes reduced growth (rather than documenting maintenance of acceptable quality) under controlled water deficits. Plant water deficits can be eliminated by efficient application and timing of irrigation, selection of appropriate plant materials, proper maintenance to reduce water loss to weeds, the use of mulches, appropriate design, and other techniques.[28] But because of the unique nature of landscapes, the absolute amount of water required to maintain the landscape can also be reduced if water deficits are viewed as an acceptable horticultural management practice. When a reduced amount or rate of growth is acceptable (as long as the plant is healthy), then the absolute amount of water required can be reduced as well, regardless of what other water conservation techniques are used.

Water and Landscape Stewardship

Water was critical to the establishment of Latter-day Saint communities throughout the Intermountain West, and members of the Church had a great impact on the science of irrigation and the development of water in the West. However, access to water was not the entire reason for this success. Much of the success in Utah was due to the hierarchical structure of the communities, where bishops worked as watermasters and the goals of cooperation led to viable ditch companies.[29] Another factor in their success was the ability to respond to the ecology of the settled areas with crops that fit those environments. The Saints were successful not just because they built ditches but because they listened to their leaders and worked together and used a diverse,

adaptive approach to settling an area. In the Little Colorado River Basin of Arizona, the diversity of crops used and the geographic diversity of the communities provided a robust safety net so that when irrigation failed in one part of the basin, the overall community still survived. Survival was a function of not only water but their adaptability as stewards of the water, their crops, the land, and their communities.[30]

The most simplistic approach to water conservation is to claim landscapes are unnatural vestiges of lifestyles from wetter climates and eliminate them. This approach is much like burying one's talents, and it ignores the scriptural record. The account of the Creation explains that the Lord made "to grow every tree, naturally, that is pleasant to the sight of man; and man could behold it" (Moses 3:9) and further that "I, the Lord God, took the man, and put him into the Garden of Eden, to dress it, and to keep it" (Moses 3:15). Clearly the Garden was planted at least in part for beauty, and there was an expectation of stewardship in keeping it beautiful. In our day, people did not invent landscapes to use water; they were developed to serve a purpose. And, lest we forget their value, we would be wise to ponder the words of Wallace Stegner, who said: "I was nearly twelve . . . when I walked past my first lawn . . . I stooped down and touched its cool nap in awe and unbelief. I think I held my breath—I had not known that people anywhere lived with such grace. Also I had not known until then how much ugliness I myself had lived with. Our homestead yard was as bare as an alkali flat."[31] Clearly we cannot simply replace our landscapes with asphalt and colored stone. As good stewards, we should continue landscaping if for no other reason than to heed the call to plant gardens and fix up our yards.[32]

But can we expect the aesthetic equivalent of a Garden of Eden, or even a garden from Virginia? The Lord did not say that all the earth should be an English garden or a tropical paradise but that plants are pleasant additions to our lives and should be dressed and kept. In commenting about Utah, landscape architect and Utah State University professor Craig Johnson said, "Most people think landscapes should equal those found in the East and Midwest. We really don't have a concept of a native Western landscape."[33] As much as Stegner was moved by his first lawn, he went on to write about living in the arid West that "you have to get over the color green; you have to quit associating beauty with gardens and lawns."[34] The western United States is arguably one of the most beautiful spots in the world. As such, it would seem logical that our landscape aesthetic would reflect and harmonize with the environment and thus be different from that of other locations.

Perhaps it is a false dichotomy to look for a landscape solution that is entirely natural, or one that is entirely man-made. Maybe the missing Western aesthetic is an oasis that meets our needs (whatever they may be) while paying homage to the beauty of the natural environment through use of native and adapted plants, careful irrigation, and landscape scales appropriate to water conservation. Stegner also seemed to recognize the beauty of both the natural and man-made as he states: "There is no green so tender and welcoming as the irrigated green of a Nevada valley or a pocket among the red Utah cliffs. Nothing so stirs the spirit of someone who is really out submitting to the West's freedom as the trees of a town. A few cottonwoods, the guggle of water in a creek or ditch, can have as profound an effect on me as the grandest view. The grandest view somehow includes it, even if unseen. The equation is not complete without it."[35] As beautiful as these irrigated areas can be, appreciation of their beauty will increase even further if water conservation is incorporated in them, and as people come to understand the care and effort that underlies such a landscape.

The stewardship of many of the early pioneers was to produce the agricultural commodities that allowed the Saints to survive in the arid West. As such, the good stewards were those who coaxed the greatest yield from their fields.

In the suburban home of today, high-yielding agricultural production is not a direct economic necessity. Our stewardship needs to change from maximizing yield with scarce water to conserving water by using only what is needed to efficiently maintain the quality of life we desire. Elder John A. Widtsoe, an early pioneer in irrigation science, observed, "That dry-farming is a system of agricultural practice which requires the application of high skill and intelligence is admitted; that it is precarious is denied. The year of drouth is ordinarily the year in which the man failed to do properly his share of the work."[36] We should also learn and work to efficiently use water. The Lord has required us to learn about the things of the earth (see D&C 88:79). He has also said: "For it is expedient that I, the Lord, should make every man accountable, as a steward over earthly blessings, which I have made and prepared for my creatures. . . . For the earth is full, and there is enough and to spare; yea, I prepared all things, and have given unto the children of men to be agents unto themselves" (D&C 104:13, 17).

Historically, with each new move and assignment, the pioneers adjusted to their local environment. The fruit farms of Brigham City and Orem could not be sustained in Randolph, but cattle could be profitably raised there. Just as the pioneers showed flexibility in the crops they grew as they entered each new geographic area, we must be flexible in our view of landscape irrigation as we enter a new era of water conservation. We are not entitled to allocate and use water the same way our forebears did. Rather, we must show the same creativity and innovation as the pioneers and hope we are still pioneers enough to be recognized for our innovations in sustaining a high quality of life in the midst of relatively decreasing water supplies, just as our ancestors were recognized for their adaptations to this wonderful environment.

As stewards we are commanded, "Inasmuch as they receive more than is needful for their necessities and their wants, it shall be given into my storehouse" (D&C 70:7), which implies excess resources should be held in common. Utah landscapes are often irrigated excessively in an erroneous attempt to maximize benefits. If our philosophy of managing landscapes was changed to maintain aesthetics, rather than maximize yields, we would save water. This water could be returned to the community to help support the demands of increased growth. Today's stewardship challenge is to "be diligent in preserving what thou hast, that thou mayest be a wise steward" (D&C 136:27). "And the benefits shall be consecrated unto the inhabitants of Zion and unto their generations" (D&C 70:8). By learning to be better stewards of both our water and our landscapes, we can maintain our quality of life, use only the water we need, and consecrate the water saved to future generations.

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