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Sustainability "How-To Guide" Series

Sustainable Landscaping

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TABLE OF CONTENTS

Acknowledgements . . . 1

About the Authors . . . 2

Foreword . . . 3

Part 1: Executive Summary . . . 5

Part 2: Introduction . . . 6

Part 3: Detailed Findings . . . 7
- 3.1 Sustainable Landscape Design . . . 7
- 3.1.1 Design Intent for Soil and Vegetation . . . 8
- 3.1.2 Design Intent for Material Selection . . . 8
- 3.1.3 Design Intent for Human Health . . . 8
- 3.2 Sustainable Landscape Construction . . . 8
- 3.3 Sustainable Landscape Maintenance . . . 10
- 3.3.1 Soil Type . . . 10
- 3.3.2 Fertilizers . . . 11
- 3.3.3 Irrigation . . . 11
- 3.3.4 Pest and Weed Control . . . 13
- 3.3.5 Pruning and Shearing . . . 14
- 3.3.6 Mulching . . . 14
- 3.4 Turf . . . 14
- 3.4.1 Is Turf Sustainable? . . . 15
- 3.4.2 Impact of Turf on the Environment . . . 16
- 3.4.3 Sustainable Turf Maintenance . . . 17
- 3.5 Ornamentals . . . 18
- 3.6 Herbaceous Plants . . . 18
- 3.7 Trees . . . 19
- 3.7.1 Tree Removal . . . 19
- 3.8 Green Roofs . . . 19
- 3.9 Summary . . . 20

Part 4: Making the Business Case . . . 21
- 4.1 Developing an Action Plan . . . 21
- 4.1.1 Sustainable Sites Initiative . . . 21
- 4.1.2 Professional Landcare Network (PLANET) . . . 23
- 4.2 Calculating Return on Investment . . . 23
- 4.3 Implementing the Plan . . . 24

Part 5: Case Studies . . . 25
- 5.1 Deer Valley School District, Glendale, Arizona . . . 25
- 5.1.1 Introduction . . . 25
- 5.1.2 Developing an Action Plan: Results of the Grounds Evaluation . . . 25
- 5.1.3 Results . . . 27
- 5.1.4 Lessons Learned from Deer Valley School District Case Study . . . 28
- 5.2 Hilton Hotel, Las Vegas, Nevada . . . 28
- 5.2.1 Introduction . . . 28
- 5.2.2 Results . . . 28
- 5.2.3 Lessons Learned from Hilton Hotel Case Study . . . 29
- 5.3 DC Ranch: A Sustainable Landscape in a Master Planned Community . . . 29
- 5.3.1 Introduction . . . 29
- 5.3.2 Action Plan . . . 30
- 5.3.3 Results . . . 32
- 5.3.4 Lessons Learned from DC Ranch Case Study . . . 32
- 5.4 Conclusion . . . 33

Part 6: Appendices . . . 34
- 6.1 Appendix A: References . . . 34
- 6.2 Appendix B: Additional Resources . . . 35
- 6.3 Appendix C: Glossary . . . 38

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Randy Zellers and Kent have known each other and worked together for over 15 years. Randy was a branch manager at The Groundskeeper prior to taking a grounds management position at a large school district with 35 schools and over 30,000 students. Randy is a perfect example of Dr. Deming's quote "if you can't measure it you can't manage it." Prior to Randy's arrival at the school district, there were no measurement or performance standards in place and the district struggled to get the turf cut each week. The DC Ranch case study within this guide was also completed under Randy's leadership.

—Steve Gustafson, Randy Zellers, Kent Miller

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FOREWORD

IFMA Sustainability Committee (ISC)

The IFMA Sustainability Committee (ISC) is charged with developing and implementing strategic and tactical sustainability initiatives. A current initiative involves working with the IFMA Foundation on the development of a series of "How-To Guides" that will help educate facility management professionals and others with similar interests in a wide variety of topics associated with sustainability and the built environment.

The general objectives of these "How-To Guides" are as follows:

1. To provide data associated with a wide range of subjects related to sustainability, energy savings and the built environment
2. To provide practical information associated with how to implement the steps being recommended
3. To present a business case and return-on-investment (ROI) analysis, wherever possible, justifying each green initiative being discussed
4. To provide information on how to sell management on the implementation of the sustainability technology under discussion
5. To provide case studies of successful examples of implementing each green initiative
6. To provide references and additional resources (e.g., Web sites, articles, glossary) where readers can go for additional information
7. To work with other associations for the purpose of sharing and promoting sustainability content

The guides are reviewed by an editorial board, an advisory board and, in most cases, by invited external reviewers. Once the guides are completed, they are distributed free of charge via the IFMA Foundation's Web site www.ifmafoundation.org.

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The mission of the IFMA Foundation is to promote and support scholarships, educational and research opportunities for the advancement of facility management worldwide.

Established in 1990 as a nonprofit, 501(c)(3) corporation, the IFMA Foundation is supported by the generosity of a community of individuals—IFMA members, chapters, councils, corporate sponsors and private contributors—and is proud to be an instrument of information and opportunities for the profession and its representatives.

A separate entity from IFMA, the IFMA Foundation receives no funding from annual membership dues to carry out its mission. Supported by the generosity of the FM community, the IFMA Foundation provides education, research and scholarships for the benefit of FM professionals and students. Foundation contributors share the belief that education and research improve the FM profession.

'Expand knowledge of the built environment, in a changing world, through scholarships, education and research'

The Vision Statement of the IFMA Foundation

1 EXECUTIVE SUMMARY

Landscaping provides many benefits to a facility. Some of the benefits include shading of surrounding buildings, areas for recreation and aesthetic appeal to help make a good first impression of the facility. Sustainable landscaping provides these benefits while balancing environmental, economic and social needs of the facility. The goal of this guide is to help facility managers, and those who work with facility managers, to better understand what sustainable landscaping is and how to apply sustainable landscaping practices.

The Introduction of this guide defines sustainability and offers an overview of the three phases of landscaping. Section 3, Detailed Findings, provides a summary of the three phases of a landscape project: design, construction and maintenance, including plant-specific recommendations, tips when forming a landscape team and options to decrease maintenance costs. Section 3 seeks to answer several questions:

- What is sustainable landscaping?
- What are the advantages of a sustainable landscape?
    - > During design
    - > During construction
    - > During maintenance
- What steps should a facility manager follow to obtain a sustainable landscape?

Section 4, Making the Business Case, provides insight for the facility manager to make the business case for sustainable landscaping to the building owner. The section includes a discussion of how to develop a plan and how to calculate return on investment (ROI).

In Section 5, Case Studies, three real world case studies are presented. The first case study, Deer Valley School District, discusses what can be achieved when there is little to no extra budget to work with. The second case study, Las Vegas Hilton, demonstrates how rebates can be used to implement a project when funding is available but limited. The third case study, DC Ranch, showcases the sustainable design, construction and maintenance of a landscape when sustainability is a priority and funding is available to support the effort.

As the topic of sustainable landscaping is continuously evolving and can vary broadly by climate, this guide is not intended to be an all-inclusive resource. Readers are encouraged to consult the extensive list of additional resources provided in Appendix B.

2 INTRODUCTION

Sustainability is defined as the ability to meet our needs without compromising the ability of future generations to meet theirs (Brundtland 1987). To apply the definition of sustainability, the triple bottom line is often considered. The triple bottom line takes into account the environment, economics and social impacts. Applying the triple bottom line to landscaping:

- **Social:** The landscape and building exterior make a significant impact and first impression on those who work and visit a building. The landscape can set the tone for how building occupants feel about being in the building and if they will choose to spend time outside the building during breaks or lunch periods.
- **Economic:** The cost of maintaining the building landscape must be balanced with many other costs, including capital improvements, utilities, custodial and scheduled maintenance costs.
- **Environmental:** A sustainable landscape requires proper selection of native and/or adapted plants to minimize the amount of irrigation and fertilizers required to maintain a healthy landscape.

There are three primary phases of landscaping: design, construction and maintenance. Each significantly impacts the long-term outcome of a sustainable landscape. This guide provides insights for facility managers, and those working with facility managers, on introducing sustainable landscaping practices at the site of a single building or campus of buildings, and on advancing sustainable landscaping practices at facilities that have already started to implement sustainable landscaping practices.

The purpose of this guide is to give an overview of sustainable landscape design, construction and maintenance, with an emphasis on sustainable landscape maintenance. This guide is organized into several sections, including detailed findings, making the business case and case studies. The detailed findings section includes an overview of:

- Sustainable landscape design
  - > Design intent for soils and vegetation, material selection and human health
- Sustainable landscape construction
- Sustainable landscape maintenance and special considerations dependent upon:
  - > Soil, fertilizers and plant types
  - > Irrigation methods
  - > Pest and weed control
  - > Plant sanitation
  - > Maintenance activities, including pruning, shearing, mulching, mowing and power raking

The making the business case section builds upon the detailed findings by applying the concepts discussed to help facility managers, and those working with facility managers, to develop a plan and calculate the return on investment for sustainable landscaping projects.

The case studies section gives three practical examples of how the business case was made to design, construct and maintain sustainable landscapes at three different facilities. The first case study, Deer Valley School District, captures the challenges when limited funding is available. The second case study, Las Vegas Hilton, demonstrates how available rebates can help achieve sustainability goals when funds may be limited. The third case study, DC Ranch, showcases an owner committed to having a sustainable landscape and who had funds available to support the sustainability commitments.

3 DETAILED FINDINGS

Sustainable landscaping is defined as the design, construction, operation and maintenance of a site that meet the needs of the present without compromising the ability of future generations to meet their own needs (SSI 2009b). This definition covers the three phases of sustainable landscapes:

- Design, also known as planning
- Construction
- Maintenance

3.1 Sustainable Landscape Design

All landscape projects, large or small, should begin with planning and design. New installations or complete landscape renovations are usually referred to as landscape construction. Smaller renovations are often called improvements. The first step of landscape planning and design is team selection. Team selection includes forming a team that includes architect(s), landscape architect(s) or designer(s), a full-service landscape management company, client (owners), end users and others with expertise in landscape construction and maintenance. Members of the team should have expertise in soils, hydrology, vegetation and landscape ecology.

The second step is site selection. When selecting a site, the following should be considered:

- Protection of soils that are designated as prime farmland, unique farmland or farmland of statewide importance
- Protection of floodplains, aquifers and groundwater
- Preservation of wetlands and habitat supporting endangered species
- How plants can be used to minimize storm water runoff

Desirable sustainable sites for new landscapes and building development include grayfields, brownfields, those in existing communities, and those that encourage nonmotorized transportation and use of public transit (SSI 2009b).

Once a site is selected, the third step is to conduct a pre-design site assessment and identify sustainable opportunities. The purpose of the pre-design site assessment is to collect detailed, accurate information about site conditions. Detailed site information helps to make sustainable decisions about the site design, construction and maintenance processes.

After the pre-design process is complete, the design process can begin. A well-developed landscape design will include practices to reduce water consumption, pruning and repetitive labor tasks as the landscape matures. Each amenity in the landscape – turf, trees, shrubs, groundcover and seasonal color – needs to be thought about long term. Microclimates will change as the landscape matures. Therefore, to avoid replanting costs it is important to take into account mature plant sizes when locating plants.

SSI (2009b) identifies four major emphases for sustainable landscape design:

- Water
- Soil and vegetation
- Materials selection
- Human health and well-being

The emphasis for water includes the protection and restoration of site hydrologic processes, including:

- Reducing use of potable water for irrigation by a minimum of 50 percent
- Protecting and restoring riparian, wetland and shoreline buffers
- Rehabilitating lost streams, wetlands and shorelines
- Managing storm water on site
- Protecting water quality and enhancing on-site water resources
- Designing rainwater/storm water features to provide landscape irrigation

REDUCING USE OF POTABLE WATER FOR IRRIGATION CAN BE ACHIEVED THROUGH A NUMBER OF WAYS

- **Use adapted or native landscape plants, as they require less irrigation**
- **Reduce or eliminate turf within the landscape**
- **Use drip irrigation, moisture sensors and/or weather data**
- **Use gray (reclaimed) or non-potable water, when available; some golf courses use retention ponds to collect rainwater for irrigation**

3.1.1 Design Intent for Soil and Vegetation
The design intent for soil and vegetation is to protect and restore associated processes and systems. This includes (SSI 2009b):

- Taking inventory of soils and plant quantities that are naturally occurring on the site
- Controlling and managing invasive species
- Using native and adapted, noninvasive plants
- Creating a soil management plan
- Minimizing soil disturbance during design and construction, including preservation of special status plants
- Preserving and restoring plant biomass
- Preserving and restoring native plant communities, and using vegetation to reduce building heating and/or cooling, thus reducing urban heat island effects
- Reducing the risk of catastrophic wildfires

3.1.2 Design Intent for Material Selection
Material selection and use are significant components of site sustainability. Sustainable site design practices related to material selection include eliminating the use of wood from threatened tree species; maintaining on-site structures; using hardscape and landscape amenities (water features, gazebos, sculptures, etc.); designing for demolition and disassembly; reusing salvaged materials, plants and on-site features; using recycled content materials; using certified wood; using regional materials; supporting sustainable plant production practices; and supporting sustainable practices in materials manufacturing. Structural, architectural or paving surfaces should be selected to have a minimum solar reflectance index of 29 (SSI 2009a)

3.1.3 Design Intent for Human Health
The landscape design should be appropriate for the intended end use. To determine appropriate end use conditions, human health and well-being should also be considered. The intent of sustainable site design for human health and well-being is to build strong communities and a sense of stewardship. This includes the promotion of equitable site development and use; sustainability awareness and education; protection and maintenance of unique cultural and historical places; designs that support optimum site accessibility and safety; opportunities for outdoor physical activity; views of vegetation and quiet outdoor spaces for mental restoration; outdoor spaces for social interaction; and reducing light pollution (SSI 2009a).

3.2 Sustainable Landscape Construction
After the design is complete, a contractor is hired to start construction. Techniques used during construction can have long-term impacts on the site and surrounding land. Therefore, when selecting and working with the contractor to determine appropriate construction techniques, be sure to keep sustainability in mind. If a low bid process is being used, the contractor may be looking for cost reduction measures that may negatively impact construction methods and/or material selection and thus negatively impact the sustainability goals for the project. Keeping the design team engaged during construction should help to build a relationship with the contractor and keep the goals at the forefront until the project is complete.

Before construction can begin, it is important to have a plan in place for:

- Controlling and retaining construction pollutants
- Restoring soils disturbed during construction
- Using appropriate equipment for the task

To control and retain construction pollutants means to prevent and minimize discharge of construction site pollutants from the site during

construction; to protect water and air quality; and to maintain a safe environment for the public around the construction site. To control and retain construction pollutants, a storm water pollution protection plan (SWPPP) should be developed and followed. The SWPPP should list and mandate best management practices (BMP) to prevent:

- Loss of soil from the construction site from storm water runoff or wind erosion
- Runoff or infiltration of pollutants such as fuels, lubricants, solvents, hydraulic fluids, concrete wash or other hazardous chemicals
- Sedimentation of receiving waters or other public infrastructure
- Pollution of the air with dust and particulate matter

To restore soil that was disturbed during construction requires rebuilding the soil's ability to support healthy plants, biological communities, water storage and infiltration. The soil restoration process includes five categories: organic matter, compaction, infiltration rates, biologic function and chemical characteristics. When restoring soil, it is also important to consider how the current construction efforts could help to restore soil surrounding the construction site disturbed by previous development; how construction and demolition waste can be diverted from the landfill; how reuse and recycling methods can be used for surplus vegetation, rocks and soil; and how greenhouse gas emissions can be minimized during the construction process (SSI 2009). See the Sustainable Site Initiative (2009a) for detailed information.

Often, surplus vegetation, rocks and soil can be reused and/or recycled on site during the construction process. The most economical practice is to reuse the materials on site because it does not require hauling or landfill costs. Soil and rocks can often be used for cut and fill, as well as building berms and/or rock features. Surplus vegetation can often be used in the landscape or be ground into mulch on or off site for reuse (SSI 2009a). If the materials cannot be used on the current site, it may be possible to use them at another site or within a manufacturing process.

To reduce greenhouse gas emissions during construction requires careful review of current construction practices. Practices that should be reviewed include (SSI 2009a):

- Equipment and vehicle idle time
- Equipment manufacturer maintenance requirements
- Low sulfur diesel fuels usage
- Alternative fuel (such as electric, natural gas or biodiesel) equipment usage
- Local vendor selection to decrease emissions associated with travel time
- Product choices emphasizing low volatile organic compound (VOC) content

Cranes and other equipment can be used to prevent soil compaction in landscaped areas and/or prevent disturbing natural areas (see Figure 1). Some landscape contractors are also starting to use biodiesel fueled vehicles (Hall 2009). In addition, low decibel equipment can be used to reduce noise pollution.

Figure 1: Crane installing 48" (1,220 mm) box palo verde tree

3.3 Sustainable Landscape Maintenance

Sustainable landscape maintenance begins with a maintenance plan. The maintenance plan should be developed by a team including the facility manager, the landscape architect or designer, and the account manager of the landscape maintenance firm. The plan should be a long-term, 10-year document outlining the desired outcome as a result of implementing the plan. More specifically, the plan should include:

- Scaled site plan
- Inventory of existing vegetation
- Skill level required to complete specified tasks and training requirements
- Schedule for each maintenance practice for each season
- Plant and soil stewardship
- Invasive species management
- Organic plant materials management
- Irrigation and water use
- Storm water management
- Snow and ice management
- Hardscape and structure management
- Recyclable material and waste management
- Equipment use and maintenance
- Fertilizer management practices
- Mulching and composting practices
- Maintenance requirements for paints and sealants

As the plan is developed and implemented, it is important to acknowledge that the plan should be modified as new sustainable practices become available and needs for the landscape change.

When developing the maintenance plan, be sure to differentiate between the needs for living versus nonliving components. Living components include plants, animals that inhabit the landscape and unseen soil fauna. Hardscapes include nonliving components, such as berms, terraces, masonry, pavement, water features, swimming pools, sculptures, boulders, rock mulches, trails and outdoor lighting. Most nonliving landscape components, except water features and swimming pools, require relatively low maintenance. All landscape components should be maintained for safety, function and longevity. To sustainably maintain hardscapes, clean them only as often as needed using water and environmentally friendly products when possible. If it is necessary to repaint or reseal hardscapes, be sure to use low VOC paints and sealants.

To maintain water features and swimming pools using sustainable practices requires careful selection of methods that will minimize environmental impacts. For example, to minimize algae blooms, microbes can be used to remove phosphates from water. The use of microbes can increase soil fauna when the water is used for irrigation.

Snow and ice removal can have harmful effects on site safety, longevity of pavement surfaces and plant health. Carefully select snow and ice removal products to determine which will have a lower environmental impact. If deicing chemicals are used, be sure to store them in a place and manner that avoids contaminating water sources (SSI 2009a). If deicing chemicals must be mixed for use, be sure to follow manufacturer suggestions to decrease negative environmental impacts.

Trash and debris removal is a major aesthetic and safety concern for landscape maintenance. All plant debris, whether due to human activity or natural events, should be removed as soon as possible. Plant debris should be composted either on or off site. When picking up trash from the site, sort waste and recyclable materials and dispose of appropriately (SSI 2009a).

3.3.1 Soil Type

Soil type is an important factor to be considered when developing the landscape maintenance plan. There are three major soil types: neutral, acidic and alkaline. It is important to select plants for the correct soil type. When alkaline soil is present, plants adapted to alkaline conditions should be selected. It is not advisable to neutralize the soil to allow the selection of non-alkaline plants. Some scientists (Chalker 2007) report that amending the backfill of planting holes will actually lead to poor root establishment and eventual high mortality of landscape plants. This suggests that using organic mulches and soil amendments is not always a panacea to healthy landscape plants and stresses the importance of choosing plants adapted to specific site conditions.

3.3.2 Fertilizers

Using high-quality organic top dressing can reduce or eliminate the need for traditional synthetic fertilizers. When fertilizers must be used, it is important to first determine the correct type to apply, given climate and application requirements. After the correct fertilizer is selected, when it is applied, it is important to remember to not apply more fertilizer than necessary. Over application can cause nitrates to pollute surface and groundwater, and is uneconomical. To reduce concerns regarding over application, consider using synthetic fertilizers. Slow-release synthetic fertilizers minimize nutrient leaching and runoff. Synthetic fertilizers should be applied with a top dressing after the first aeration of the season and again in the late fall. Humic acid can also be applied with a synthetic fertilizer to stimulate biotic activity and nutrient uptake.

Compost teas are an organic alternative to synthetic fertilizers. Compost teas contain substantial and diverse microbes and nutrients to increase plant growth and decrease some plant diseases and insect pests. The use of compost teas are likely to increase as the use and cost of synthetic fertilizers increases.

Organic gardeners will often use alfalfa pellets to boost the amount of nitrogen in the soil for ornamental plantings.

3.3.3 Irrigation

Water is a precious resource. Even some metropolitan areas like Seattle, Washington, and Portland, Oregon, known for their extended wet seasons, have placed restrictions on residential landscape irrigation over the last few years. The restrictions are due to infrastructure deficiencies, drought and increases in population.

In most regions, proper irrigation is also essential for healthy turf. Most turfgrass needs 1 inch (2.54 centimeters) of water per week during growing seasons. Without enough water, many turfgrasses will dry out and go dormant or die. In most circumstances, for healthy turf, a single deep irrigation once per week is preferential to several short applications. However, climate and soil type impact the frequency and amount of irrigation necessary. For example, clay or sandy soils can increase the frequency of irrigation. Irrigation is important, but be careful to not over irrigate. Over irrigation is wasteful and can increase plant mortality.

Deep irrigation encourages the roots of the turfgrass to grow deeper into the soil and have greater surface area from which to extract moisture and nutrients, resulting in healthier turf.

Automated irrigation systems are the most sustainable irrigation method. Automated irrigation systems can be tied to rain gauges or evapotranspiration data to minimize the amount of irrigation needed, maximizing the benefits of precipitation. Automated irrigation systems can utilize reclaimed water or harvested precipitation to reduce the volume of potable water used for irrigation. Manual irrigation is not recommended as a sustainable landscape maintenance practice. Manual irrigation generally results in too much or not enough irrigation. An exception to this recommendation is for turf located on steep slopes or for turf planted on soil with poor percolation. A more sustainable option is to plant turf alternatives on steep slopes and on soils with poor percolation.

When selecting an irrigation system, it is important to understand the long-term return on investment, including reduced water costs and tighter management of irrigation controllers. One irrigation system that should be considered is a computerized central control system. A central control system uses data to calculate irrigation runtimes for individual stations. The runtime is based on a factor of wind speed, temperature and moisture loss of plants. Water leaks and over usage are also reported daily to irrigation staff to quickly address these concerns. Central control systems can be a valuable tool to reduce water consumption.

Figure 2: Crew installing drip irrigation tubing in Tucson, Arizona

Sustainable irrigation practices minimize the use of potable water. To obtain credits under the sustainable sites category for LEED certification requires potable water used for irrigation be decreased by 50 percent (SSI 2009a). Additional LEED points can be earned when the use of non-potable water for irrigation is increased to 80 percent or more. The use of non-potable water, also called graywater, should be utilized both on a large scale and on the individual residential level. Within the United States, southwestern desert cities like Tucson and Phoenix, Arizona, and Las Vegas, Nevada, frequently use graywater to irrigate golf courses and parks.

To ensure that plants are not being over irrigated, meter, trend and track irrigation water consumption. Metering, trending and tracking irrigation water consumption will also help determine if there are leaks or other problems with the system.

Other sustainable irrigation practices to consider include:

- Rain gardens and retention ponds
- Graywater reclamation
- Xeriscaping

Rain gardens and retention ponds are two ways rainwater can be collected for irrigation and aesthetic use on a site. A rain garden is a small garden that is designed to capture storm water

Avoiding late evening irrigation can help prevent fungal attacks on foliage.

and can withstand extreme moisture and nutrient concentrations. Rain gardens are generally attractive and can be the home of birds and butterflies (Rain Garden 2007). Retention ponds are typically larger areas of land that are used to capture storm water. In some cases, retention ponds are designed to be aesthetically pleasing and provide a source of irrigation water and a method to decrease runoff rates from a site. In other cases, aesthetics may not play a part in retention pond design.

Graywater is water that is not treated to potable (drinking) quality, but can be used for non-potable applications, such as irrigation and toilet flushing. When considering using graywater for irrigation or uses within a building, it is very important to contact the local code and/or zoning officials having jurisdiction over the building and site. Requirements for water treatment, storage, coloration, signage and use vary widely by jurisdiction and how the graywater will be used. Figure 3 is an example of required signage at a public park within the San Francisco Bay Area stating that reclaimed (recycled) water is being used for irrigation.

Figure 3: Graywater irrigation signage at Madison Square Park, Oakland, California

Xeriscaping is an irrigation practice that minimizes the need for supplemental irrigation. Supplemental irrigation is reduced by:

- Planting native and drought-tolerant plants
- Zoning plants according to their water needs
- Using water efficient irrigation methods, such as drip irrigation, and using mulch to minimize moisture loss from soils

Diversify plantings to prevent a particular pest from invading an entire garden.

3.3.4 Pest and Weed Control

Control of plant pests, disease and insects is an important aspect of sustainable landscape maintenance. Integrated pest management (IPM) principles should be adhered to. The United States Green Building Council (USGBC) defines IPM as "the coordinated use of knowledge about pests, the environment, and pest prevention and control methods to minimize pest infestation and damage by the most economical means while minimizing hazards to people, property and the environment" (USGBC 2009). IPM includes regular scouting of the landscape to assess plant health and monitor levels of pests. If pest populations are above acceptable levels, it is necessary to reduce the pest population.

Sustainable methods of pest control that do not use synthetic pesticides include mechanical, beneficial organisms, and use of biological-based pesticides or compost teas. Mechanical pest control includes the use of traps, a fly swatter, a shoe sole or one's hands. Biological-based pesticides include neem oil and safe soaps. Safe soaps are low toxicity soaps and detergents used to control aphids, white flies, mealy bugs and other types of pests. Synthetic pesticides should only be used as a last resort to keep pest populations at an acceptable level.

Proper sanitation practices during landscape maintenance have a large impact on minimizing disease and pests. The first step for disease and insect control for shrubs and other woody ornamentals is to routinely hose off foliage. The use of a mild antiseptic (1 percent bleach solution) during pruning can minimize the spread of disease from infected to healthy plant material. The same mild antiseptic can also be used on mowing and pruning equipment between sites to prevent site contamination.

Mulching should be the first line of defense against weeds for sustainable landscapes. If mulching cannot be done or does not sufficiently control weeds, preemergent herbicides may be an option. Preemergent herbicides are nontoxic (high LD 50 ratings) and bind to the soil, preventing runoff. Preemergents kill the roots from newly germinated seeds before they grow above the surface of the soil. They are highly effective and reduce the need for other herbicides by 85 to 95 percent. Preemergent herbicides can also be coupled with organic mulches to provide a very effective weed barrier. Preemergents should not be used on newly planted herbaceous plants.

Healthy, vigorous growing plants form canopies whose shade helps limit the establishment of many weed species.

Weeds can be sprayed with a systemic herbicide, such as glyphosate, or other selective herbicides, such as triclopyr, dicamba and/or 2,4-D. When used according to label instructions by trained licensed applicators, herbicides pose little danger to humans or the environment. When herbicides enter the soil, they are digested. In some cases, herbicides will also dry to plant surfaces, where they are not very mobile.

Weed control for annuals is best accomplished by mulching after planting. Preemergent herbicides should not be used on newly planted annuals. Weeds around perennials can be controlled by mulching and limited use of preemergents, after the plants are established.

3.3.5 Pruning and Shearing

Pruning (Figure 4) is the select removal of branches to maintain appearance, sight lines, adequate air flow within and through the canopy, and clearance from structures, as well as to keep plants in allocated spaces and remove potential nest sites for undesirable species. When pruning, be sure to remove no more than one-third of the foliage at a time. Woody ornamentals should be pruned back to either the laterals or main stems.

Formal hedges should be sheared. Shearing is trimming all branches to a uniform length to give the plant a specific shape (Figure 5). Shearing can be done using manual or power shears and does not take into account where a cut is made on new growth. Repetitive shearing creates hardened wood within a plant, shortening its lifespan and usefulness in the landscape. Shearing demands more frequent trimming, requiring more manpower and often generates more plant debris. Therefore, it is recommended that the use of formal hedges be minimized.

Figure 4: Example of a pruned bush

Figure 5: Example of a sheared bush

3.3.6 Mulching

Mulching helps to retain soil moisture. To maintain healthy plants and minimize weed growth, mulches should be created from healthy trees. Be sure to avoid inadequately aged or cured compost mulches, as they may contain weed seed and produce weeds on the landscape where they are applied.

Mulches should be applied once per growing season. In general, about a 2 inch (50 millimeter) layer of mulch should be applied. If mulch was applied the previous growing season, it is not necessary to remove the old mulch before applying new mulch.

3.4 Turf

Turf, often called lawn or grass, is made up of many individual grass plants, up to 1,000 plants per square inch (645 square millimeters). A lawn may contain a single cultivar of turfgrass or be a blend of turfgrass types. Grass roots and leaves grow from a meristematic zone just above or below the soil line referred to as the crown. Crowns produce roots and shoots, leaves or stems depending on what stage of growth the grass is in. The ratio of roots and shoots growth is largely dependent upon the climate. Grass can also grow by specialized shoots that grow horizontally from the crown. Below are some turf terms.

- **Shoots:** Can grow either above or below the ground.
- **Stolons:** Shoots that grow above ground. Stolons can produce new plants at each node along the stolon.
- **Rhizomes:** Shoots that grow underground. Rhizomes can either terminate in a new shoot (determinant) or multiple new shoots (indeterminant). Kentucky bluegrass is a rhizomatous plant.
- **Stoloniferous:** Plants that produce roots and shoots, such as creeping bent grass.

A square foot (0.09 square meters) of lawn may contain up to 1,000 individual plants.

Geographical differences, such as climate, greatly influence turf. Turfgrasses are generally classified as cool season or warm season types. Some cool season turfgrasses include Kentucky bluegrass, perennial ryegrass, fine fescue and bent grass cultivars. Some warm season turf types include Bermuda grass, Saint Augustine grass and zoysia grass cultivars. The frequency of maintenance for each type of grass is dependent on the climate and grass growth cycle. In general cool season grasses grow best from early spring until summer where temperatures are above 85°F (29°C). Most cool season turfgrasses produce stolons and rhizomes during the cool season. Shoots grow faster in the fall than in the spring. Warm season grasses grow best when ground temperatures exceed 60°F (16°C) and air temperatures are above 80°F (27°C). Warm season grass growth peaks at the warmest temperatures given adequate moisture. Bermuda grass goes dormant when soil temperatures fall under 50°F (10°C). Optimal conditions produce the healthiest turf.

Optimal soils for turf are well draining and have good porosity, 25 to 33 percent organic matter and adequate levels of plant nutrients. In most cases, turf is often planted on less than optimal soil, initially requiring more care to produce healthy turf. Sustainable methods to improve soil fertility include:

- Inoculating soils with beneficial microbes, bacteria and fungi
- Regular aeration
- Application of various top dressings, depending on soil needs

Poor soil conditions can be improved by increasing the soil porosity. To increase porosity of clay soils, aerate the soil using deep-tine aeration. Then, dress the top of the soil with a course of sand. After repeating this process for several seasons, the porosity and drainage of the soil will greatly increase.

In most cases, aeration has the greatest benefit when completed early in the growing season. However, for turf that is breaking dormancy and/or tillers, such as Bermuda grass after winter, for optimal results it is better for the turf to be actively growing a few weeks before aeration.

Poor soil conditions can also be improved by adding organic matter as a top dressing, such as peat moss or lime. The addition of organic matter can alter the pH of the soil. Peat moss will decrease the pH while lime will increase the pH.

Turf benefits the most when all three techniques discussed above are applied. It is recommended that all three methods be part of a regularly scheduled turf maintenance program. At a minimum, each technique should be performed at least annually, although monthly aeration and top dressing during growing season is optimal.

3.4.1 Is Turf Sustainable?

Turf is the most controversial plant type within the discussion of sustainability. There are two general opinions:

- Opinion #1: Lawns are not sustainable because they are maintenance intensive
- Opinion #2: Lawns are sustainable and provide many sustainable benefits

The number of people who support each opinion, the strength of the opinions and rationale for support varies, often by geographical location. Within the southwestern United States, xeriscaping has been practiced for nearly 30 years and it is becoming the norm to minimize the use of turf and other hydrophilic plants. In Oregon, there is support for the use of turf substitutes, such as dwarf yarrow, clove and perennial rye blends, or weed-tolerant turf. Weed-tolerant turf includes turfgrass blends, including some nebulous tolerant level of weeds, such as white clover and dandelions.

When determining which opinion to align with, a facility manager must answer the following question: What are the owner's and clients' expectations for turf?

- Do they want turf?
- Would they accept a turf alternative?
- Would they accept weedy turf?

Throughout the authors' many years of experience in landscape management very few clients with turf were delighted with weeds. However, this does not preclude the possibility that times are changing. Change is acknowledged by an increasing number of local governments putting restrictions on pesticides and a growing number of organic lawn care firms. As restrictions are put on pesticides, lawn care firms will need to find alternative solutions to maintain healthy turf.

It is not the goal of this guide to conclusively determine if turf is sustainable but to outline the impacts of turf on the environment and to discuss turf maintenance practices. It is up to each facility manager to ask, is turf sustainable? If so, how should it be maintained? If not, what can be done within the current budget to provide a sustainable landscape without turf?

Some disadvantages of turf, compared to native plants, include:

- May require more irrigation in some locations
- Requires more maintenance to ensure it maintains proper appearance and health
- Can be more expensive to plant and maintain due to irrigation and pest management requirements

The front lawns of eight houses have the cooling effect of about 70 tons of air conditioning. That is amazing when the average home has an air conditioner with just a three- or four-ton capacity (TPI 2010).

3.4.2 Impact of Turf on the Environment

To understand if turf is sustainable, it is important to examine the impact of turf on the environment.

There are many benefits to turf. Turf (TPI 2010):

- Provides a natural, comfortable and safe setting for outdoor recreation
- Releases oxygen and cools the air
- Controls pollution and reduces soil erosion
- Purifies our water supply by reducing storm water runoff and controlling erosion from rain and wind
- Can enhance curb appeal, adding as much as 15 percent to the value of a home, when well maintained
- Traps and removes dust and dirt from the air
- Uses water very efficiently
- Acts as a natural filter, reducing pollution by purifying the water passing through its root zone

Additionally,

- On a hot summer day, lawns will be 30°F (-2°C) cooler than asphalt and 14°F (10°C) cooler than bare soil.
- The cooling effect of irrigated turf reduces the amount of fuel burned to provide the electricity to power air conditioners.
- A healthy lawn absorbs rainfall six times more effectively than a wheat field and four times better than a hay field.
- A sodded lawn will absorb greater amounts of rain than a seeded lawn, even after three years of growth.

Turf can have a positive impact on water, soil and air quality. Storm water runoff is a major contributor to water pollution. Runoff during a precipitation event can overflow combined sanitary and storm sewer systems. As a result, raw sewage may be directly diverted to waterways. As the ratio of impervious surfaces (roads, parking lots and roofs) to pervious surfaces increases, the potential for sewage overflow events increases.

Turf improves water quality by greatly reducing runoff. Recent research demonstrates that storm water runoff is rare from healthy, relatively dense lawns, even on modest slopes. A very intense rainfall event must occur for runoff to occur. However, a few exceptions are very steep slopes, frozen ground conditions, saturated soils and/or severely compacted soils. Turf allows rainfall to infiltrate into the soil, reducing the amount of sediment that leaves a site and recharging groundwater (SULIS 2006).

Rain infiltration onto turf increases soil moisture. Beneficial biotic activity is higher in moist, non-saturated soil than in dry soil. Healthy soils are composed of nonliving minerals and a vast array of biotic activity, including microbes, arthropods, worms and insects. The interaction and size of beneficial species and pathogenic species determines how healthy a soil is. The ability for soil to hold water and nutrients is mostly due to its organic content. Turf adds a significant amount of organic matter to soil through decaying roots and shoots.

Turf has at least three major affects on air quality. First, healthy turf can help cool air temperatures by evaporative cooling. As water from a plant is evaporated off of leaf surfaces, it cools the air. This process is called evapotranspiration. Second, as plants lose water through their leaves they remove carbon dioxide from the air in a process called photosynthesis. The carbon dioxide is converted into sugar providing energy for plants and oxygen for humans and animals to breathe. Third, plants filter particulate matter (dust and other pollutants) out of the air. Particulates stick to leaf surfaces, purifying the air. The impact of plants filtering particulate matter can be significant in areas where particulates are a major concern.

Landscapes can play an important role in moderating summer air temperatures in urban environments. Plants around homes can reduce air temperatures from 7 to 14° F (-14 to -10°C) through the effects of shading and evapotranspiration. This cooling effect can decrease summer air conditioning costs. One estimate suggests that strategic landscape plantings reduce total air conditioning energy requirements in the United States by 25 percent (SULIS 2006).

3.4.3 Sustainable Turf Maintenance

Sustainable turf maintenance focuses on minimizing resource use, including materials, water and labor, to keep the landscape healthy. A healthy turf landscape requires less material inputs than an unhealthy turf landscape. Additionally, healthy turf can tolerate higher populations of pathogens and insect pests than unhealthy turf. Healthy turf is more likely to recover from infestations of disease and/or pests.

Regular mowing is essential for healthy turf. A general horticultural rule is to never remove over a third of a plants leaf area. Thus, the mowing rule of thumb is to mow high and often because root depth decreases as leaf height decreases. For example, if the mow height is 2.5 inches (64 millimeters) up to 3/4 inch (19 millimeters) can be removed. If the turf height is only 1 inch (25.4 millimeters), only 1/3 inch (8 millimeters) of new growth should be removed. Therefore, during rapid growth periods shorter turf requires more mowing. Shorter turf is also more susceptible to drought and other stress because it has fewer resources to recover. In contrast, higher turf provides more shade to the soil, reducing water loss. Reduced water loss from the soil helps keep the turf strong and resistant to weed seedlings.

Mulching mowers recycle plant nutrients from the clippings into the soil, which reduces the need for additional fertilizer.

Turf should be mowed before it flowers. Flowering turf emits pollen into the air causing some people to have allergic reactions, which cause discomfort. If the flower seeds are caught by the wind, they can blow into adjacent ornamental plantings causing grass to grow in undesirable locations.

A power rake is a gas-powered rake that has many flail blades that rotate on a horizontal shaft and is used to rake turf. Power raking should be done when thatch buildup is greater than 1/2 inch (13 millimeters) thick to improve penetration of irrigation water and nutrients to the soil.

In summary, turf maintenance includes:

- Regularly scheduled irrigation and mowing
- Aeration, which should be done at least once in the early stages of the plant growth season, although monthly aeration is highly recommended
- Application of appropriate top dressing (which should follow aeration) that meets the needs of the soil
- Coupling the use of synthetic fertilizer, if used, with humic acid to stimulate the soil microbes and more efficiently utilize available nutrients
- Application of compost teas either biweekly or monthly to supply the soil with nutrients and aid in pest control
- Scouting weekly to make sure pest populations are at or below an acceptable level; IPM methodology should be followed to control pests

3.5 Ornamentals

There are over 250,000 species and cultivars of ornamental plants that can be used in landscapes. Ornamental plants can be divided into two basic categories: woody and herbaceous. Woody plants have secondary cell thickening of lignin. While herbaceous plants lack lignin (wood). The landscape function of ornamental plants includes screens, walls, ceilings, backdrops, hedges, accents and groundcovers. When selecting an ornamental plant, be sure to choose plants that are native or adapted to the environment and that the location and function are well aligned. Otherwise, plants will demand unsustainable levels of maintenance, such as pruning, irrigation and/or fertilization and not provide the desired functionality. For example, if a low hedge is desired, but a laurel is planted instead, the laurel would need to be pruned very frequently, resulting in an unattractive and probably unhealthy plant.

Ornamentals have different environmental tolerances, including temperature, soil moisture, nutrient levels, drainage requirements, pH, aeration and other conditions. Thus it is important to select plants that are well adapted to the conditions to which they will be exposed. The most sustainable practice is to select native plants or those tolerant to the environmental conditions.

When selecting plants, native plants will require the least amount of maintenance over time, and thus are generally the most sustainable choice.

3.6 Herbaceous Plants

Herbaceous plants include perennials and annuals. Perennials are plants that live more than one year. The irrigation requirements for perennials vary by location. Some examples of perennials include herbs, grass, succulents and cacti. Perennial ornamental grasses can provide off season texture. Perennial ornamental grasses require limited pruning. It is best to prune them just before the start of a new growth season. Perennials are more tolerant in poor soils and drought conditions than many types of annuals. Many perennials produce ornamental fruits and can require less individual care than some annuals. Thus, in some cases perennials are more sustainable.

Figure 6: Perennials, such as basket of gold, white rockcress and candytuft, can beautify rock walls

Annuals are plants that live for one year. The seasonal requirements for annuals include a no-frost and sun-tolerant environment. Annuals require well-prepared soil and irrigation. To keep annuals aesthetically pleasing, many annuals need to be dead headed to continue to bloom throughout the season. Dead heading is the removal of withered flowers or buds that have dried up before opening. When fertilizing annuals, use slow-release granular fertilizer.

Perennials and annuals are an important part of a landscape because they provide color and diversity and can be used as accents. When fertilizing both perennials and annuals, fertilizer should be selected based on soil testing.

Figure 7: Duncan Garden, Manito Park, Spokane, Washington, displays a variety of annuals. Foreground blue ageratum borders yellow marigolds, white alyssum and lavender petunias.

3.7 Trees

Most trees grow best when irrigated with deep irrigation methods, as opposed to methods typically used to irrigate turf. Therefore, trees should be on a separate irrigation zone that provides less frequent, but longer (deeper) periods of irrigation. Drip emitters or bubbler types both work well for tree irrigation. Alternately, special deep irrigation injectors can be utilized. When deep irrigating, fertilizers can also be applied through the irrigation system. This process is called fertigation. Fertigation can use either organic-based soluble fertilizer or compost teas.

Physical injury to tree trunks due to collisions by mowers and/or girdling by string trimmers are major contributors to early tree mortality. Installation of mulch rings around trees in turf can minimize these injuries. However, mulch should not be allowed to accumulate directly against tree trunks.

Tree maintenance presents special challenges because poorly maintained trees can result in displeasing aesthetics or serious liability issues. Therefore, tree maintenance should be done under the supervision of highly trained professionals, such as Certified Arborists.

The use of integrated pest management (IPM) is also an important part of tree maintenance. To control pests, the use of spray insecticides and/or fungicides should be avoided. Some municipalities and owners have restrictions on the use of sprays to control pests and diseases. Instead of using spray insecticides, regularly monitor trees to detect early signs of disease.

3.7.1 Tree Removal

If a tree needs to be removed, efforts should be made to seek input from the client before removal or major tree pruning is undertaken. In some cases, input from the surrounding community may also need to be considered before action can be taken. Additionally, many towns and cities have ordinances that impact how trees are maintained in the right of way and/or on private property.

When removing or performing a large amount of pruning, determine if the debris can be mulched on site. This can provide several benefits:

- If mulch is used on the site, the fresh mulch can be directly applied to the site.
- When debris does not need to be removed from the site, it is possible to reduce fuel costs by 25 to 40 percent (McCoy 2009; Santos 2009). Reducing fuel use also reduces environmental emissions.

3.8 Green Roofs

Green roofs are roofs of buildings that are partially or completely covered with plants, planted over a waterproofing membrane. Green roofs can be categorized as intensive, semi-intensive or extensive, depending upon the depth of the planting medium and the amount of maintenance required. Traditional green roofs (roof gardens) are intensive green roofs and may look parklike with roof access for building occupants. Plant types may include herbs and small trees. Intensive green roofs require a soil depth of about 6 to 24 inches (150 to 600 millimeters), weigh about 80 to 150 pounds per square foot (390 to 730 kilograms per square meter) (GLWI 2010) and are labor intensive because they require irrigation, fertilization and other maintenance. Extensive green roofs require a soil depth of about 1 to 6 inches (25 to 150 millimeters), weigh about 15 to 50 pounds per square foot (73 to 245 kilograms per square meter) (GLWI 2010), are designed to be nearly self-sustaining and require minimal maintenance, such as annual weeding and/or application of slow-release fertilizer. Extensive green roofs are generally only accessed for maintenance. A semi-intensive green roof includes features of both intensive and extensive green roofs.

Some benefits of green roofs include:

- Absorbing rainwater to reduce storm water runoff from the site
- Providing insulation to reduce heat loss from the building, reducing energy bills
- Creating habitat for wildlife
- Reducing urban heat island effects

A full discussion of green roofs is beyond the scope of this paper. A few resources about green roofs are found in Appendix B: Additional Resources.

3.9 Summary

Healthy plants are essential for a sustainable landscape. Using sustainable landscape maintenance practices reduces resource consumption, including irrigation water, energy and chemicals. As shown in Section 5, sustainable landscapes can be maintained, even with a limited budget.

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4 MAKING THE BUSINESS CASE

Many consumers desire a sustainable landscape (McCoy 2009). Major corporations, governments and foundations are investing in sustainability, including Cisco Systems (Santos 2009), City of Virginia Beach, Virginia, (Fentress 2009) and The Meadows Foundation, Dallas, Texas (SSI 2009b). Some corporations, governments and foundations are investing in sustainable landscape renovations as a way to control or lower increasing maintenance costs (Santos 2009; Agudelo-Silva et al 2002) and because they believe it is the responsible thing to do.

4.1 Developing an Action Plan

Facility managers who want to have sustainable landscapes should form a team to evaluate the property, analyze potential savings and return on investment (ROI) opportunities, and determine sources of project funding. If the facility manager's team does not include an experienced landscape architect, horticulturalist or agronomist, it is important to hire a landscape consultant.

When evaluating the property and sustainability alternatives, consider what is most important, such as:

- Irrigation methods
- Types of plantings
- Use of fertilizers
- Reducing costs and available budget
- Plant health
- Reuse and/or use of native plants on site
- End landscape use
- Cultural factors of the site
- Reducing time or cost to maintain

After an agreement is reached about what is most important, set several attainable goals within each area of importance. Be sure the goals include a realistic timeline and budget. When developing goals, it can be helpful to talk with other professionals, companies and consultants who have successfully completed similar projects. The Sustainable Sites Initiative (SSI) and the Professional Landcare Network (PLANET) can also be helpful resources to consult to determine what is most important and how to set goals.

4.1.1 Sustainable Sites Initiative (SSI)

The Sustainable Sites Initiative (SSI) is a consortium whose goal is to produce guidelines and performance benchmarks to be used in conjunction with LEED to certify sustainable landscapes during design, construction and maintenance. The SSI consortium includes the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center at The University of Texas at Austin and the United States Botanic Garden. In 2009, SSI published the SSI Guidelines and Performance Benchmarks (SSI 2009a), a step-by-step guide of over 200 pages about how to:

- Design, construct and maintain sustainable landscapes
- Document and prepare submittals for achieving LEED certification

Table 1 presents the guiding principles of a sustainable site. As shown in the table, the guiding principles include actionable items that can be used to define what is important for a sustainable landscape at a specific site. For example, if the goal of the team is to design the landscape with an emphasis on nature and culture, the team would need to identify what is important to the natural landscape surrounding the site and also what is culturally important. In an arid environment, this may include selecting drought resistant plants that have cultural significance to indigenous groups within the region.

Table 1: Guiding principles of a sustainable site (SSI 2009a)

Do no harm	Make no changes to the site that will degrade the surrounding environment. Promote projects on sites where previous disturbance or development presents an opportunity to regenerate ecosystem services through sustainable design.
Precautionary principle	Be cautious in making decisions that could create risk to human and environmental health. Some actions can cause irreversible damage. Examine a full range of alternatives — including no action — and be open to contributions from all affected parties.
Design with nature and culture	Create and implement designs that are responsive to economic, environmental and cultural conditions with respect to the local, regional and global context.
Use decision-making hierarchy of preservation, conservation and regeneration	Maximize and mimic the benefits of ecosystem services by preserving existing environmental features, conserving resources in a sustainable manner and regenerating lost or damaged ecosystem services.
Provide regenerative systems as intergenerational equity	Provide future generations with a sustainable environment supported by regenerative systems and endowed with regenerative resources.
Support a living process	Continuously re-evaluate assumptions and values and adapt to demographic and environmental change.
Use a system-thinking approach	Understand and value the relationships in an ecosystem and use an approach that reflects and sustains ecosystem services; re-establish the integral and essential relationship between natural processes and human activity.
Use a collaborative and ethical approach	Encourage direct and open communication among colleagues, clients, manufacturers and users to link long-term sustainability with ethical responsibility.
Maintain integrity in leadership and research	Implement transparent and participatory leadership, develop research with technical rigor, and communicate new findings in a clear, consistent and timely manner.
Foster environmental stewardship	In all aspects of land development and management, foster an ethic of environmental stewardship — an understanding that improves the quality of life for present and future generations.

Ecosystem services are goods and services produced by ecosystem processes that provide direct or indirect benefits to humans. Ecosystem processes include the interaction of living elements with nonliving elements. Living elements include, but are not limited to, vegetation and soil organisms. Nonliving elements include, but are not limited to, bedrock, water and air. SSI sustainable philosophies of ecosystem services relevant to sustainable sites are further clarified in Table 2. This table can also be helpful in determining what is most important for goal setting because it provides a list of how the environment and people are impacted by landscapes. For example, during the landscape design process, a team within a new development or construction zone may decide that erosion and sedimentation control is very important, while pollination is less important.

SSI and PLANET are valuable resources for facility managers seeking detailed information about sustainable landscapes, especially when striving to earn sustainable sites credits within the United States Green Building Council Leadership in Energy and Environmental Design (LEED) rating systems.

Table 2: SSI Sustainable philosophies of ecosystem services (SSI 2009a)

Global climate regulation	Maintaining balance of atmospheric gases at historic levels, creating breathable air and sequestering greenhouse gases
Local climate regulation	Regulating local temperature, precipitation and humidity through shading, evapotranspiration and windbreaks
Air and water cleansing	Removing and reducing pollutants in air and water
Water supply and regulation	Storing and providing water within watersheds and aquifers
Erosion and sediment control	Retaining soil within an ecosystem; preventing damage from erosion and siltation
Habitat functions	Providing refuge and reproduction habitat to plants and animals, thereby contributing to conservation of biological and genetic diversity and evolutionary processes
Waste decomposition and treatment	Breaking down waste and cycling nutrients
Hazard mitigation	Reducing vulnerability to damage from flooding, storm surge, wildfire and drought
Pollination	Providing pollinator species for reproduction of crops and other plants
Human health and well-being benefits	Enhancing physical, mental and social well-being as a result of interaction with nature
Food and renewable non-food products	Producing food, fuel, energy, medicine or other products for human use
Cultural benefits	Enhancing cultural, educational, aesthetic and spiritual experiences as a result of interaction with nature

4.1.2 Professional Landcare Network (PLANET)

PLANET, the Professional Landcare Network, is an international association that serves lawn care professionals, landscape management contractors, design/build/installation professionals and interior plantscapers. PLANET was formed in 2005 as a joint effort between the Associated Landscape Contractors of America (ALCA) and the Professional Lawn Care Association of America (PLCAA) to increase the network of green industry professionals. PLANET has published many educational materials, including *Crystal Ball Report #29 – Green Industry ECOnomics: Innovating Toward a Sustainable and Profitable Future* (2009). This report provides insight into how landcare is sustainable (PLANET 2010).

4.2 Calculating Return on Investment

The ROI of a sustainable landscape can vary greatly depending on geographic location. In arid climates where irrigation water is expensive, adopting xeriscape principles and minimizing turf can yield a ROI of 1.5 to 3 years (Agudelo-Silva et al 2002). In other cases, the ROI for a sustainable landscape may be longer or come in the form of less tangible effects on the bottom line, such as company and employee pride, acceptance as good community partners, cleaner air and water, and/or healthier citizens and employees.

In the desert southwest of the United States and in California the annual cost per area of turf maintenance is reported to be $0.40 per square foot ($4.31 per square meter) (US dollars) or higher depending on water and fluctuating fuel costs (Santos 2009). In comparison, the annual cost per area of sustainably maintained native or adapted ornamental shrub beds is $0.20 per square foot ($2.15 per square meter) (US dollars). For new landscapes, there is clearly an economic savings. To replace a turf landscape with native or adapted ornamental shrub beds, assuming a cost of $2.00 to $3.00 per square foot ($21.50 to $32.30 per square meter) (US dollars), the ROI is estimated to be 10 to 15 years. However, where rebates are available, such as Las Vegas, Nevada, the ROI can be as low as four to six years.

When irrigation requirements are low, turf is often economical to maintain. For example, the cost to maintain turf in Virginia Beach, Virginia, is about $0.057 per square foot ($0.60 per square meter) (US dollars), where the cost to maintain ornamental beds is about $0.40 per square foot ($4.31 per square meter) (US dollars).

It is important to use regional cost data to analyze landscape maintenance costs and ROI.

4.3 Implementing the Plan

After the goals are set, the ROI has been calculated and the action plan steps have been determined, it is time to start implementing the plan. To implement the plan, be sure that all team members are aware of the sustainability goals. It is important that landscape designers, constructors and maintainers, as well as those who are assisting with procurement and project planning, are all aware of the sustainability goals. If the goals are not shared across the entire team, it will be difficult to ensure the goals are understood. If the goals are not understood, it will be difficult to obtain buy-in and achieve the goals.

5 CASE STUDIES

The first two case studies demonstrate what can be done with a small budget and a substantial budget, respectively. The third case study describes the design, installation and maintenance of a large development using sustainable landscape methods.

5.1 Deer Valley School District, Glendale, Arizona

5.1.1 Introduction

The Deer Valley School District consists of 35 schools: five high schools, three middle schools, nine kindergarten to eighth grade schools, 16 kindergarten to sixth grade schools and two trade schools. Total enrollment across the district is about 30,000 students. Within the district, the landscape operations manager reports to the school district superintendent. The superintendent was dissatisfied with the landscape and thought the grounds and athletic fields needed improvement. A landscape consultant was hired to help address the concerns. The first question the consultant asked was how many acres of turf does the district own? Since the answer was unknown, the first objective was to measure and quantify the district's grounds and to evaluate the grounds operation processes. The completion of both of these tasks was necessary to set a standard of service and gain staff accountability.

The evaluation began with quantifying the landscape at each school, including turf, trees, shrubs, accents, irrigation valves, heads and controllers, and other landscape features. Labor, equipment, material requirements and inventories were also quantified. Next, the operations management team was interviewed to determine production expectations and priorities, maintenance schedules, irrigation controller access, irrigation and irrigation maintenance schedules, client use schedules, equipment service schedules and chemical application schedules.

5.1.2 Developing an Action Plan: Results of the Grounds Evaluation

As a result of the grounds evaluation, it was found that mowing was about the only task being accomplished. Each crew focused on mowing prior to students arriving on campus for safety and liability reasons. The campuses looked undesirable and unkempt. Weeds were not controlled and dead plants were not removed and replaced with new plants. Irrigation methods also needed improvement. When irrigation valves were functional, turf was over irrigated. In other areas, turf was completely dead due to nonexistent irrigation. The crew structure was found to be inefficient. Each crew serviced one school per day. Other challenges discovered included:

- A landscape specification for plant, irrigation methods and other landscaping materials did not exist.
- Each school wanted landscape work to be completed at the same time. However, they also wanted the school to be aesthetically pleasing to help set high expectations for scholastic achievement versus a defeatist attitude at first sight. (Aesthetically pleasing was described to include the absence of graffiti, weeds and dead plants, and removing tree stakes after they were no longer needed.)

As a result of the grounds evaluation, several suggestions for improvement were made. Recommendations and actions taken are listed in Table 3.

Table 3: Recommendations and actions resulting from grounds evaluation

Recommendation	Action
Mowing cannot be completed just before students arrive on campus; it must also be done while school is in session.	Negotiate with administrative personnel to allow mowing while school is in session. A mandate was also put in place so that physical education classes moved out of the way of mowing crews.
Create detail crews. Detail crews will be responsible for weed control, dead plant removal, trash removal and raking.	Detail crews were created.
Create irrigation crews.	Irrigators were assigned to two schools per day to completely analyze the functionality of the irrigation system and prioritize tasks to repair as much of the irrigation system as possible. When it was not possible to repair or the repair was too costly, turf was removed if it was nonessential to the campus.
Crews should service more than one school per day.	Crew scheduling was changed so that each crew serviced several schools per day.
Crews need to be held accountable to complete assigned work.	Work was divided by crew and into zones to determine who was/was not completing assigned work.
Create landscape specifications.	A landscape specification that included performance levels was created, including clearly defined goals so that each crew member know what was expected of him or her.
Develop a maintenance plan.	A maintenance plan, including mowing, detail and irrigation requirements, was developed.
Implement methods to increase labor efficiency.	The landscape was divided into areas: high profile, high traffic and the back 40. High profile and high traffic areas are to be maintained at higher frequencies than the back 40.

When crew members know what is expected of them they are motivated to do their best and take pride in their work. Encourage crew workers by providing daily recognition for a job well done.

Labor is generally the largest item in the landscape budget. Labor typically represents 35% to 60% of a landscape budget.

Based upon the landscape area and amount of work needed to improve the landscape, it was recommended to add four people to the landscape staff and to increase the landscape budget from $125,000 (US dollars) to $400,000 (US dollars). However, the district budget limited the landscape staff budget to 15 people and could not be increased to the recommended amount. After further review, the consultant determined that a large bat wing mower could increase mowing efficiency by as much as 40 percent. Purchasing this mower would allow crews to be restructured. Therefore, the five crews that performed all three functions – mow, irrigate and detail – were restructured to have two crews mow, three crews irrigate and four crews perform detail work (see Table 4).

Table 4: Landscaping personnel before and after landscape improvements

Before improvements			After improvements		
Number of crews	People per crew	Crew function	Number of crews	People per crew	Crew function
5	3	Mow, irrigate and detail	2	2	Mow
			4	2	Detail
			3	1	Irrigate
	Total people: 15			Total people: 15	

In addition to restructuring the crews, daily task lists were generated as part of the performance specifications so that each crew knew what it needed to accomplish within a given time period. The performance specifications included work schedules and chemical application schedules. The schedules were also posted for staff.

Route books were created to map and identify high traffic areas and information about each site. More specifically, the route books included:

- Landscape specifications
- Daily, weekly, monthly schedules
- Location of water meters and valves
- Site-specific considerations and instructions
- Site contact information

High traffic areas were to be policed twice per day and fertilized more frequently to endure higher levels of foot traffic and meet quality expectations. Any graffiti found in a high traffic area was to be removed within 48 hours.

Methods to reduce the amount of labor to maintain the landscape were explored. Such methods included the use of chemical edging instead of mechanical edging, the creation of tree wells in turf areas to eliminate mechanical edging and increasing mowing speed.

Rain days became education days. Education days are mandatory horticultural training programs. The education days helped staff to become knowledgeable and more efficient, take pride in their work and receive accolades from the principals, athletic directors and district administrators for landscape improvements.

5.1.3 Results

By implementing the recommendations, the efficiency of the crews increased, while they gained knowledge about horticulture. Additionally:

- High traffic areas were kept clean.
- Mow crews completed special projects during the winter, including the conversion of 25,000 square feet (2,322 square meters) of turf to decomposed granite beds. Irrigation methods were adjusted from turf sprinklers to drip irrigation for plants, and adapted and native desert trees added to the beds. The conversion decreased irrigation and mowing costs.
- Attitude of staff and school officials improved.
- Landscape crews continued to receive recognition for high-quality work.

The efforts also included multiple sustainable improvements:

- Decreasing annual irrigation needs by converting over half an acre of turf to desert landscape
- Decreasing irrigation to entry plants (plants at the focal point of building entrances) to restrict growth
- Irrigating based on proper scheduling and properly maintaining irrigation systems
- Adopting naturalistic pruning methods – thinning versus shearing
- Planting native and low water use plants in replacement, new and perennial plantings

Figure 8: Deer Valley School District: desert landscape with native plants

5.1.4 Lessons Learned from Deer Valley School District Case Study

The main lessons learned from the case study were:

- Start by quantifying the landscape and feature types including area of turf and quantity of trees, shrubs and irrigation valves. As stated by Deming, "You can't manage what you can't measure."
- Having exact data about landscape features provided a structure to hold crews accountable through time and motion studies for each landscaping task. Increased accountability improved quality control and routing efficiency of the landscape crews.

5.2 Hilton Hotel, Las Vegas, Nevada

5.2.1 Introduction

The purpose of the Hilton Hotel Las Vegas project was to convert turf to desert landscaping. The project was designed in five phases to limit inconvenience to the hotel's clients. The scope of the project included:

- Removal of 323,000 square feet (30,000 square meters) of turf
- Installation of over 10,000 ornamental plants of various sizes including 1 gallon (3.75 liters), 5 gallon (18.9 liters) and 15 gallon (56.8 liters)
- Placement of over 4,500 tons (4,082 tonnes) of 3/4 inch (19 millimeters) ornamental rock and 2 to 4 inch (102 millimeters) cobble rocks as rock mulch

Best practices used for the desert landscape included:

- Planting native or adapted species to provide a drought resistant, colorful landscape
- Spacing plants to allow them to grow to their genetic potential and avoid the necessity of frequent pruning
- Planting in holes twice the diameter of the plant pot size and backfilling with 25 percent organic soil
- Using rock mulch. Rock mulch inhibits moisture loss while minimizing blowing dust
- Installing weed barrier cloth prior to the rock mulch to minimize the need for pre- and post-emergent herbicides by controlling weed growth
- Converting the pop-up heads irrigation system to a drip irrigation system

5.2.2 Results

The results of this case study were quantitatively measured using return on investment to demonstrate economic benefits, while environmental benefits were quantitatively demonstrated by decreased resource consumption.

The return on the investment for the turf conversion was substantial. The total project cost was $726,750 (US dollars). To reduce the cost of the project, a rebate of $484,500 (US dollars) was received from the Southern Nevada Water Association (SNWA). The annual saving on irrigation water was $61,500 (US dollars). The return on investment for the project was four years when maintenance costs were not included and two years when maintenance costs were included.

The SNWA rebate offered was $1.50 (US dollars) per square foot ($16.15 per square meter) of converted turf.

The sustainable benefits from this project included:

- Decreased irrigation
- Decreased herbicide used
- Decrease in plant debris generated
- Reduced maintenance costs by 50 percent

Figure 9: Hilton Hotel before turf conversion to desert landscaping

Figure 10: Hilton Hotel after turf conversion to desert landscaping

5.2.3 Lessons Learned from Hilton Hotel Case Study

The main lessons learned from the Hilton Hotel case study were:

- The value of finding a rebate from the water utility: Although removing the 323,000 square feet (30,000 square meters) of turf was the right thing to do from an environmental perspective, without the rebate program it was not economical for the hotel owners.
- To reduce weed growth during the transition from turf to a native landscape, a one-year weed control program should have been put in place.

5.3 DC Ranch: A Sustainable Landscape in a Master Planned Community

5.3.1 Introduction

The purpose of this project was to develop the design concepts and maintenance practices to ensure a lasting and sustainable landscape for a master planned community, the DC Ranch. The DC Ranch is a golf and residential community in the high Sonoran Desert in Scottsdale, Arizona. The community consists of four villages. Each village has a landscape theme to create a specific look as one drives through the village.

Figure 11: DC Ranch

5.3.2 Action Plan

The action plan for the DC Ranch included design, construction and maintenance of a sustainable landscape. One of the first considerations of the design team was to observe the land surrounding the proposed development. The developer of DC Ranch wanted to respect the Sonoran Desert and had a high level of sensitivity for the community located at the base of the McDowell Mountains in north Scottsdale, Arizona. The developer's vision was to honor and celebrate the native desert within their landscape design and to provide a seamless transition from native desert to developed landscape. To do so, species that were already thriving on the property were selected. This decision had many benefits:

- Enhanced the survival rate and reduced the maintenance costs of the plantings
- Eliminated nearly all pruning costs for shrubs

A goal of any landscape design should be the gradual reduction of maintenance costs as the landscape matures.

Understanding maintenance costs during design is important to a sustainable landscape. Many designs start with extensive amenities in an effort to sell property. However, this does not take proper horticultural practices into consideration. One of the best checks and balances the developer went through during the design of the DC Ranch was to quantify each landscape amenity and affix a cost for long-term maintenance. This analysis drove many decisions about turf quantities, species of trees and plants, and the overall layout and orientation of the community.

DC Ranch averages one staff person for every 10 acres of landscaped area.

Figure 12: DC Ranch firecracker penstemon, Parry's penstemon, Mojave lupine

In the desert, turf is costly to maintain because it must be irrigated. At DC Ranch, 6 percent – 18 acres (7.3 hectares) – of the total maintained landscape is turf. The turf was strategically designed to be a gathering point for residents living in the neighborhoods, minimizing the amount of turf around each home. Turf was not used for ornamental purposes. Therefore, when turf was used it needed to be placed in a functional location of adequate size. The turf also had to blend naturally with the surrounding landscape. Turf parks were created to meander between home sites and walkways within each community to add value, aesthetics and meeting places for each neighborhood. The average size of the turf areas within DC Ranch is 13,300 square feet (1,240 square meters), large enough to play ball, exercise the dog or have a quiet picnic with friends and family. To encourage activities within the park areas, grills and shaded seating areas were installed.

During the build out and marketing phase of the development, turf was mowed twice per week as instructed by the developer. However, after the build out and marketing phase was complete, mowing was decreased to once per week. During the build out and marketing phase, the developer subsidized the DC Ranch Association's landscape maintenance budget to cover the additional cost of mowing, irrigation and fertilizer.

Tree layout within a landscape is important to the success of a project. Well-maintained, healthy trees add more value to the landscape than any other amenity when replacement costs are included. At the DC Ranch, trees include a diverse inventory of desert-adapted trees and saguaros. Saguaros are placed at strategic locations where the most dramatic visual impacts and benefits of shade to the community could be achieved.

As the developer understood the value of trees to a community, decisions about what trees to place where were made very carefully. Highly visible entry points into the community and vantage points from arterial roadways were given great amounts of attention. The goal was to create a landscape palette with dramatic tree placement. Table 5 summarizes the quantities, total value and average unit value for the trees and saguaros.

Table 5: Quantities and costs of trees at DC Ranch

	Quantity	Cost
Trees	16,277	$52,704,981
Saguaros	3,024	$4,976,200
Total	19,301	$57,681,181

In order to successfully maintain an inventory of trees, it is important that staff maintaining the trees understand the role trees play in the overall design, including the design intent and the value of the trees. Maintaining trees requires adherence to species-specific irrigation and pruning schedules. It is very important that proper tree maintenance starts right after the trees are planted to support optimum tree health. The development of strong caliper and branch structure is vital to the longevity of trees. Strong trees are also less likely to be damaged by the wind.

The DC Ranch prioritizes tree pruning training. Each crew has a knowledgeable tree worker. The tree worker trains each crew member on how to properly prune the trees. A crew member is not given pruning assignments until they have been properly trained. During training, before each pruning cut is made, there is a discussion on the ramifications of the cut and how the tree will look "post prune." It is also emphasized that you cannot reattach a branch after it has been pruned, so make sure it is in the best interest of the tree before the cut is made.

Shrubs provide accenting, adding dramatic color, texture and scale to the landscape palette. When planting shrubs, it is important to provide proper spacing. As with trees, this eliminates the need for repetitive pruning and shearing.

At DC Ranch, base shrubs are only pruned for pedestrian or vehicular visibility purposes. This allows the shrubs to grow to their normal maturity, providing natural shapes and color. As all shrubs flower at the ends of their branches, not shearing shrubs allows them to produce incredible blooms of color and allows them to absorb abundant sunlight for healthy growth.

At DC Ranch, shrubs are the dominant plant used to create a cohesive theme within each village. Country Club Village and Desert Camp Village were designed to mimic the natural desert surroundings in their plant palette. The Silverleaf Village was designed to have a formal park setting and a more exotic variety of plants. Desert Parks Village has a traditional landscape design with a diverse array of plants.

The base shrub in each village was selected considering adaptability and minimal pruning needs. These decision criteria allowed the developer to have a large quantity of shrub bases without increasing the long-range maintenance costs while creating neighborhood themes. The shrub base for each village is summarized in Table 6.

Table 6: Shrub bases for each village at DC Ranch

Village name	Shrub base (common name)	Shrub base (scientific name)
Country Club Village	Bursage	Ambrosia deltoidea
Desert Camp Village	Bursage	Ambrosia deltoidea
Silverleaf Village	Damianita	Chrysactinia mexicana
Desert Parks Village	Turpentine bush	Ericameria laricfolia

Figure 13: DC Ranch little leaf palo verde (tree), turpentine bush (shrub), bursage (small shrub), firecracker penstemon (red), desert marigold (yellow)

The staff at DC Ranch has four irrigation technicians that manage 306 acres (124 hectares) of landscape. The landscape manager creates irrigation schedules based upon observations by staff and daily inspection reports. Data is collected and analyzed on a computer. Table 7 provides a summary of seven years of irrigation costs at the DC Ranch.

5.3.3 Results

Since 2007, DC Ranch has been operated by a resident board of directors. The board oversees and approves the landscape maintenance and operations budget. The goal of the board is to deliver quality and efficiency through proper horticultural practices while maintaining the value of the common areas of the property. High-quality landscape maintenance is also important to the residents of the community. In resident surveys, both written and telephone, the landscape maintenance ranked very high in importance and satisfaction for many years.

5.3.4 Lessons Learned from DC Ranch Case Study

The main lesson learned from the DC Ranch case study was the importance of developing a sustainable landscape maintenance plan at the very beginning of the project. At the start of the project, an adapted plant palette that consisted of native desert plants was selected to emulate the native desert that surrounded the property. The minimalistic approach to landscape maintenance was also communicated upfront to all purchasers of property within the community.

The keys to achieving the goals were:

- The vision was clearly understood and encouraged by residents at the outset of the development.
- The developer, home buyers, realty agents and staff all were on the same page with how the landscape will mature and look years into the future. If a vision is created and explained, anything is possible.

Table 7: 2003 to 2009 irrigation costs and water used at DC Ranch

Year	Budget	$/1000 gallons	$/1000 liters	Expenses ($)	Over/ under ($)	Water budget		Actual water consumption		Over/under (volume)		Rainfall		ETo factor
						Gallons	Liters	Gallons	Liters	Gallons	Liters	Inches	Cm	
2009	$653,265	$3.99/1000	$15.10	$522,384	-$131,187	163,725,564	619,701,260	130,923,308	495,544,721	-32,802,256	-124,156,539	5.31	135	81.1
2008	$673,800	$3.57/1000	$13.51	$614,624	-$59,176	188,739,496	714,378,992	172,163,585	651,639,169	-16,575,911	-62,739,823	9.74	247	80.6
2007	$534,320	$3.40/1000	$12.87	$743,466	$209,146	157,152,941	594,823,882	218,666,471	827,652,593	61,513,530	232,828,711	8.67	220	81.5
2006	$542,756	$3.18/1000	$12.04	$684,233	$141,477	170,677,987	646,016,181	215,167,610	814,409,404	44,489,623	168,393,223	7.34	186	74.7
2005	$328,832	$2.97/1000	$11.24	$421,247	$92,415	110,717,845	419,067,043	141,834,007	536,841,716	31,116,162	117,774,673	12.16	309	75.9
2004	$233,852	$2.78/1000	$10.52	$319,084	$85,232	84,119,424	318,392,020	114,778,417	434,436,308	30,658,993	116,044,289	9.94	252	79.5
2003	$195,936	$2.60/1000	$9.84	$163,896	-$32,040	75,360,000	285,237,600	63,036,923	238,594,754	-12,323,077	-46,642,846	12.1	307	76.6

1. ETo factor is the amount of moisture in inches lost through evapotranspiration. A higher ETo number indicates that more irrigation water is needed for healthy plant growth.
2. All dollar values are in US dollars.

5.4 Conclusion

Sustainable landscaping encompasses the skills and best practices of landscape architecture, horticulture and environmental science to create and maintain landscapes that minimize environmental impacts while producing lasting, aesthetic, functional sites that contribute both to human well-being and natural ecosystems. The process starts with team selection and design. The development of a sustainable landscape is best achieved when the team, including the owner and facility manager, continually focus on the sustainability goals through the entire project: design, construction and maintenance.

Figure 14: DC Ranch firecracker penstemon (red), Mojave lupine (purple), desert marigold (yellow)

6 APPENDICIES

6.1 Appendix A: References

Agudelo-Silva, F. and Novy, L. (2002). Sustainable landscaping's success. www.lindanovy.com/docs/Sustainable_Landscaping.pdf

Brundtland (1987). "Our Common Future." World Commission on Environment and Development. Oxford Press, Oxford.

Chalker-Scott, L.(2007). "Impact of mulches on landscape plants and the environment - A review." *Journal of Environnemental Horticulture* 25(4): 239-249.

Fentress, F. (2009). Sustainable Landscape Management. www.vbgov.com/file_source/dept/planning/SustainableLandscapeManagement.pdf

GLWI (2010). Great Lakes WATER Institute Green Roof Project, Green Roof Installation. www.glwi.uwm.edu/research/genomics/ecoli/greenroof/roofinstall.php. Accessed April 27, 2010.

Hall, R. (2009). *Crystal Ball Report #29 – Green Industry ECOnomics: Innovating Toward a Sustainable and Profitable Future.* PLANET (Professional Landcare Network).

McCoy, M. (2009). "Consumers Look for Sustainable Landscape Practices." *Oregon Landscape*, Oregon Landscape Contractors Association, December 2008 – January 2009. p15.

PLANET (2010). PLANET, Professional Landcare Network. www.landcarenetwork.org/cms/home.html. Accessed March 24, 2010.

Rain Garden (2007). What is a Rain Garden? Rain Garden Design Templates. The Low Impact Development Center. www.lowimpactdevelopment.org/raingarden_design/whatisaraingarden.htm. Accessed April 19, 2010.

Santos, E. (2009). "Maximizing Water Conservation in Challenging Times." BOMA. March/April 2009. p26.

SULIS (2006). Sustainable Urban Landscape Information Series. 2006 Regents of the University of Minnesota.

SSI (2009a).*The Sustainable Sites Initiative: Guidelines and Performance Benchmarks 2009*. Sustainable Sites Initiative: www.sustainablesites.org/report

SSI (2009b). *The Case for Sustainable Landscapes.* Sustainable Sites Initiative: www.sustainablesites.org/report

TPI (2010). Turfgrass Producers International: www.turfgrasssod.org

USGBC (2009). United States Green Building Council Leadership in Energy and Environmental Design (LEED) Guide for Green Building Operations and Maintenance, 2009 edition.

6.2 Appendix B: Additional Resources

WEB SITES

American Nursery & Landscape Association: www.anla.org

American Society of Irrigation Consultants: www.asic.org

American Society of Landscape Architects: www.asla.org

Golf Course Superintendents Association of America: www.gcsaa.org

Irrigation Association: www.irrigation.org

Professional Landcare Network (PLANET): www.landcarenetwork.org

SportsTurf Managers Association: www.stma.org

Sustainable Landscape Council: www.sustainablelandscapecouncil.com

The Sustainable Sites Initiative: www.sustainablesites.org

Synthetic Turf Council: www.syntheticturfcouncil.org

Turfgrass Producers International: www.turfgrasssod.org

U.S. Green Building Council Leadership in Energy and Environmental Design (LEED): www.usgbc.org/leed

US Composting Council: www.compostingcouncil.org

United States Environmental Protection Agency (EPA) GreenScapes:
www.epa.gov/epawaste/conserve/rrr/greenscapes/index.htm

US EPA WaterSense: www.epa.gov/watersense

TOPICAL RESOURCES

Edible Landscapes

Creasy, R. (1982). T*he Complete Book of Edible Landscaping: Home Landscaping With Food-Bearing Plants and Resource-Saving Techniques.* San Francisco: Sierra Club Books.

Creasy, R. (1999). *The Edible Flower Garden*. North Clarendon, Vt.: Periplus Editions.

Darcy, M. (2009). “A Harvest at Home” The Green Issue. Digger. Oregon Association of Nurseries. 53(6):19.

Hagy, F. (2001). *Landscaping With Fruits and Vegetables.* New York: Overlook.

Kourik, R. (2009). *Designing and Maintaining Your Edible Landscape Naturally.* Hampshire, England: Permanent Publications.

Green Roofs

Dunnett, N., and N. Kingsbury (2008). *Planting Green Roofs and Living Walls.* Portland, Ore.: Timber Press.

Earth Pledge (2004). *Green Roofs: Ecological Design & Construction.* Atglen, Pa.: Schiffer Publishing.

Osmundson, T. H. (1997). *Roof Gardens: History, Design, and Construction.* New York: W.W. Norton and Company.

Peck, S. (2008). *Award Winning Green Roof Designs.* Atglen, Pa.: Schiffer Publishing.

Preusch, M. (2009). "Go Up on the Ecoroof." *The Oregonian.* May 29, 2009. Sunrise Ed. D1.

Snodgrass, E.C., and L. L. Snodgrass (2006). *Green Roof Plants: A Resource and Planting Guide.* Portland, Ore.: Timber Press.

Werthmann, C. (2007). *Green Roof: A Case Study: Michael Van Valkenburgh Associates' Design for the Headquarters of the American Society of Landscape Architects.* New York: Princeton Architectural Press.

Healthy Soils

Craul, P.J. (1992). *Urban Soil in Landscape Design.* Hoboken, N.J.: Wiley.

Keefer, R.F. (2000). *Handbook of Soils for Landscape Architects.* New York: Oxford University Press, USA.

Miller, R. W. and D.T. Gardiner (2007). *Soils in Our Environment (11th Edition)*. Upper Saddle River, N.J.: Prentice Hall.

Plaster, E. (2008). *Soil Science and Management (5th Edition).* Delmar Cengage Learning.

Sustainability

Estes, J. (2009). *Smart Green: How to Implement Sustainable Business Practices in Any Industry – and Make Money.* Hoboken, N.J.: Wiley.

Esty, D.C., and A. S. Winston (2006). *Green to Gold: How Smart Companies Use Environmental Strategy to Innovate, Create Value, and Build Competitive Advantage.* New Haven: Yale University Press.

Friedman, T. L. (2008). *Hot, Flat, and Crowded: Why We Need a Green Revolution – and How It Can Renew America.* New York: Farrar, Straus and Giroux.

McDonough, W. and M. Braungart (2002). *Cradle to Cradle: Remaking the Way We Make Things*. North Point Press.

Sustainable Landscaping

Dell, O. E. (2009). *Sustainable Landscaping for Dummies.* Hoboken, N.J.: For Dummies.

Dirr, M. A. (1998). *Manual of Woody Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propagation and Uses.* Champaign, Ill.: Stipes Publishing.

Ellis, B. W. and F. Marshall Bradley (1996). *The Organic Gardener's Handbook of Natural Insect and Disease Control: A Complete Problem Solving Guide to Keeping Your Garden and Yard Healthy without Chemicals.* Emmaus, Pa.: Rodale Books.

Haight, A. (2009). "For landscaping plants, try going native." *The Oregonian*. May 29, 2009, Sunrise Ed. D1.

Landscape Plant Selection, Soil Preparation & Planting. A.C. Burke & Company. (DVD)

Margolis, L. and A. Robinson (2007). *Living Systems: Innovative Materials and Technologies for Landscape Architecture.* Basel, Switzerland: Birkhauser Architecture.

McCoy, M. (2009). "Lush exteriors." The Green Issue. Digger. Oregon Association of Nurseries. 53(6):22.

McCoy, M. (2009). “Nature is the Expert, Sustainability in Landscapes,” *Oregon Landscape.* Oregon Landscape Contractors Association, April-May 2009. p6.

Selman, P. (2008). What do we mean by sustainable landscape? Sustainability: Science, Practice, & Policy. Fall/Winter 2008. 4(2): ejournal.nbii.org/archives/vol4iss2/communityessay.selman.html

Thompson, J.W., and K. Sorvig (2007). *Sustainable Landscape Construction: A Guide to Green Building Outdoors, Second Edition.* Washington, D.C.: Island Press.

Turgeon, A.J. (2007). *Turfgrass Management (8th Edition).* Upper Saddle River, N.J.: Prentice Hall.

Water Conservation and Landscaping

Dreiseitl, H., and D. Grau (2005). *New Waterscapes: Planning, Building and Designing with Water.* Basel, Switzerland: Birkhauser Basel.

Dunnett, N., and A. Clayden (2007). *Rain Gardens: Managing Water Sustainability in the Garden and Designed Landscape.* Portland, Ore.: Timber Press.

Kinkade-Levario, H. (2007). *Design for Water: Rainwater Harvesting, Stormwater Catchment, and Alternate Water Reuse.* British Columbia, Canada: New Society Publishers.

Lancaster, B. (2006). *Rainwater Harvesting for Drylands.* Tucson, Ariz.: Rainsource Press.

Ludwig, A. (2006). *Builder’s Greywater Guide.* California: Oasis Design.

Ludwig, A. (2006). *The New Create an Oasis with Greywater: Choosing, Building and Using Greywater Systerns - Includes Branched Drains.* California: Oasis Design.

Sandrock, D. (2009). “Rain gardens for Stormwater Management, An Effective Landscape Solution.” *Oregon Landscape.* Oregon Landscape Contractors Association. April-May 2009. p11.

Xeriscape-Appropriate Landscaping to Conserve Water. San Luis Video. (DVD)

Water Issues

Barlow, M. (2008). *Blue Covenant: The Global Water Crisis and the Coming Battle for the Right to Water.* New York: New Press.

Glennon, R. (2009). *Unquenchable: America’s Water Crisis and What to do About It.* Washington, D.C.: Island Press.

Glennon, R. (2004). *Water Follies: Groundwater Pumping and the Fate of America’s Fresh Waters.* Washington, D.C.: Island Press.

Pearce, F. (2007). *When the Rivers Run Dry: Water – The Defining Crisis of the Twenty-first Century.* Boston: Beacon Press.

Reisner, M. (1993). *Cadillac Desert: The American West and Its Disappearing Water, Revised Edition.* New York: Penguin.

Villiers, M. (2001). *Water: The Fate of Our Most Precious Resource.* Boston: Mariner Books.

6.3 Appendix C: Glossary

100-year floodplain: All areas below the 100-year flood elevation of waterways, including depression areas, wetlands, areas behind levees, ephemeral and intermittent streams, rivers, lakes and shoreline and coastal areas. The areas are generally depicted as zones on the current Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map.

Baseline landscape water requirement (BLWR): The amount of water required by a landscape covered with cool-season grass at a uniform height of 4.7 inches (12 centimeters) to actively grow, completely shading the ground and not short of water. Alternately, the water requirement for a similarly sized vegetated landscape at the local reference evapotranspiration level.

Brownfield: An abandoned, idled or underused industrial and/or commercial facility or site that has been contaminated, making development more difficult. A site is defined as a brownfield by a local, state or federal government agency. ASTM E1903-97 Phase II Environmental Site Assessment can be used to complete the documentation process.

Created water features: Aesthetic water features. Created water features can include ponds, streams, pools, fountains, water gardens, created wetlands for ornamental or for water cleansing purposes, or any other water elements in the landscape with permanent or seasonal, occasional or otherwise intermittent use.

Design for deconstruction: The design of buildings or products in a manner that supports future changes or dismantling of the building or product at the end of its life. During deconstruction, systems, components and/or materials can be reused or recycled. Also called design for disassembly.

Diameter at breast height (DBH): A standard method for determining the trunk diameter of a standing tree. In the United States, DBH is typically measured in inches at 4.5 feet (137 centimeters) off the ground on the uphill side. Wounds, branches, multiple stems and defects may change how diameter is measured. For guidance, see the International Society of Arboriculture Web site, www.isa-arbor.com/publications/tree-ord/measuringdbh.aspx.

Evapotranspiration: The process by which water exits the leaves of plants through pores (stomata).

Farmland of statewide importance: Farmland that does not meet all prime farmland criteria, but is able to economically produce high yields of crops when treated and managed using acceptable farming methods. Soils are designated as farmland of statewide importance by the Natural Resources Conservation Service of each state within the United States.

Grayfield: A site that has been previously developed or graded.

Graywater: Domestic wastewater from kitchen, bathroom and laundry sinks, tubs, and washing machines.

Healthy soils: Soils that support plant growth. Healthy soils have good soil structure (porosity), nutrient content and an active aerobic biotic component. Healthy soils are absent of toxic compounds.

Heat island: An area, typically found within an urban environment, where the temperature is significantly warmer than the surrounding area. The temperature increase can be the result of large amounts of reflective surface areas, such as concrete, asphalt and buildings, as opposed to light- and heat-absorbing surfaces, such as trees and vegetation.

Integrated design team: The owner and/or client and professionals knowledgeable in landscape design, construction and maintenance. Team members should be selected to meet the unique constraints and opportunities of the site.

Invasive species: Species that are not native to the ecosystem and cause, or may cause, economic or environmental harm, or harm to human, animal or plant health.

Isolated wetlands: Wetlands without connections to surface water or other aquatic resources.

Minimal impact site development: Development that does not significantly alter existing vegetation or hydrology of the vegetation or soil within a protection zone. Soil may include trails, picnic areas or boardwalks.

Native plants: Naturally occurring hybrids, varieties and cultivars of species native to an ecoregion. Within the United States, native plants are classified within the US Environmental Protection Agency (EPA) Level III ecoregion. These plants must be native to the site or known to grow naturally within 200 miles (322 kilometers) of the site.

Organic matter: Carbon-containing material within soil composed of both living organisms and decomposing plant and animal matter. Soil organic matter content can be supplemented with compost or other partially decomposed plant and animal material. Soil organic matter content is commonly measured using “loss on ignition” tests that measure the amount of the carbon, a key constituent of all organic matter.

Photosynthesis: The process through which plants use energy from sunlight to take up carbon dioxide from the air to make sugar within their leaves.

Peak watering month: The month with the highest rate of evapotranspiration. During this month, plants require the most water. For most regions in the United States, the peak watering month is July.

Potable water: Municipally treated water or well water that is suitable for drinking

Previously developed site: A site where at least 75 percent of the site area is/was pre-existing pavement, construction or altered landscape. Note, this definition does not apply to streets, roadways or landscapes altered for agricultural use.

Prime farmland: Land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber and oilseed crops. Prime farmland can also be used for cropland, pastureland, rangeland, forestland or other land, but cannot be used for urban development. In general, prime farmlands have an adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, acceptable salt and sodium content, and few or no rocks.

Receiving waters: Waters that receive treated or untreated wastewater and storm water, including groundwater, creeks, streams, rivers, lakes, combined sewer systems and storm drains.

Reference soils: Undisturbed native soils within the site’s region that have native vegetation, topography and soil textures similar to the site. When undisturbed soil does not exist, reference soils are those that support native plants.

Soils disturbed by previous development: All areas of soils disturbed by previous human development. Indicators of disturbed soils may include one or more of the following: soil horizons that differ significantly in depth, texture, physical or chemical properties from the reference soil; bulk densities that exceed the Maximum Allowable Bulk Densities; organic matter content lower than that of the reference soil; soil chemical characteristics different from that of the reference soil; presence of compounds toxic to the intended plants; or presence of weedy, opportunistic or invasive plant species.

Special status plants: Refers to vegetation designated as important by local, state or federal entities. Designations may be for size, species, age, rare or special collections, ecological and environmental value, unique genetic resources, aesthetics, location or other unique characteristics. Groves/clusters may also be designated special status.

Unique farmland: Refers to soils designated by the Natural Resources Conservation Service as "unique farmland." Unique farmland is land other than prime farmland that is used for the production of specific high-value food and fiber crops. It has the special combination of soil quality, location, growing season and moisture supply needed to economically produce sustained high quality and/or high yields of a specific crop when treated and managed according to acceptable farming methods.

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