Water-Conserving Gardens:
A User's Manual

By

The Center for the Study of the Built Environment (CSBE)

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Water-Conserving Gardens: A User's Manual
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Introduction

People often assume that a low-water using landscape has to be barren and dry, and that it is characterized by a predominance of rocks and cacti. This could not be further from the truth. Through a series of practices related to water conserving landscapes you can create attractive and sustainable gardens that are lush and colorful, and that also save water and money. Such practices include using drought tolerant plants, incorporating hardscaped surfaces, taking advantage of rainwater harvesting, as well as following specific maintenance techniques when caring for your plants.

This manual introduces the various possibilities of water-conserving gardening, and will prove useful whether your garden is small or large, and whether you are creating a new garden or upgrading an existing one. The manual is divided into seven chapters, each illustrating one of the principles associated with water-conserving landscapes. In each chapter, you will find clear ideas and easy to follow guidelines that will help you create a beautiful, water-conserving garden. This manual also includes references to both printed and web-based resources for those who would like to get more in-depth knowledge about the subjects covered in its various chapters.

Chapter 1: Planning and designing your water-conserving garden

Topics to be covered in this chapter

I. Designing a water-conserving landscape
II. Identifying the main water-use zones in a garden
III. Creating microclimates
IV. Renovating an existing landscape
V. General considerations

Introduction

Developing a landscape plan is the first and most important step in creating a water-conserving landscape. Start with an accurate plan of the site, identify site problems and potentials, and develop a list of needs and wants to be incorporated in the plan. As your plan begins to take form, divide the landscape into water-use zones, and, whenever possible, incorporate shade.

Definitions

Hardscaping: the inorganic components of the landscape design (paved areas).
Microclimates: climates of localized spaces that differ from the overall climate of the area, such as under a tree, at the top of a hill or in between buildings.
Water-use zone: the zoning or grouping of plant materials according to their water needs.

I. Designing a water-conserving landscape

1. Start out with a plan of your property showing the location of the structure(s) and the existing features of your site.

2. Identify the characteristics of your site, such as desirable views, drainage patterns, natural elements, and orientation of the structure(s).

Site elements and characteristics to be identified

- Buildings and hardscaping elements (doors, driveways, terraces, and sidewalks)
- Property boundaries (streets, sidewalks, common areas, and adjacent lots)
- Infrastructure services (utility and sewage lines)
- Direction of water flow (waterways, downspouts, flow across property, and paved surfaces)
- Weather and microclimates (prevailing winds, slope orientation, sunny and shady areas, as well as wet and dry spots)
- Existing features (topography, natural features, existing plants, and adjacent structures)

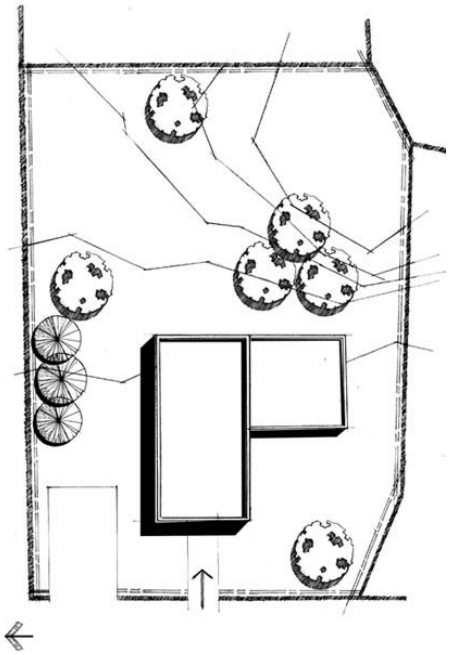


Fig. 1.1: A site plan showing the location of structures and existing features.

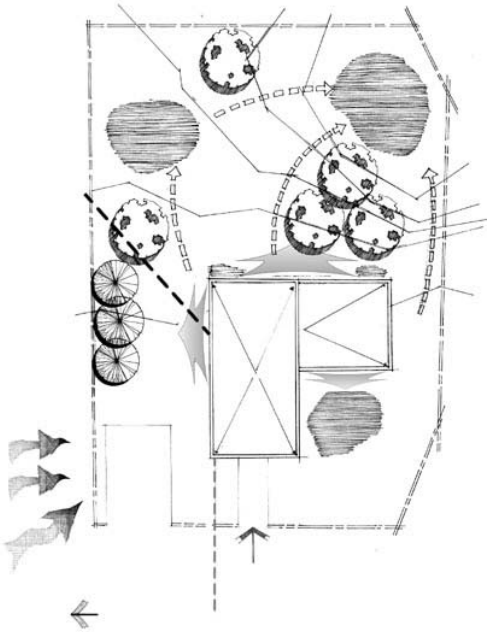


Fig. 1.2: A site plan showing site characteristics (views, drainage, … etc).

3. Consider the indoor/outdoor relationship between the different rooms in your structure and your garden.

Ask the following questions

- How do I want the site to look like from the indoors?
- How will the garden appear in the different seasons?
- What are the sun and shade patterns for each season?
- Which rooms have access to the garden?

4. Define the functions that your garden will accommodate. Indicate the *public*, *private*, and *service* areas of your landscape.

- Public areas, such as the entry area to the structure, are the most highly visible areas in the garden.
- Private areas are where most of the outdoor activities take place. The landscape in this area needs to be functional, attractive, and durable.
- Service areas require the least care and water of the three areas, as they usually are screened from view. They include work or utility areas that may consist of garden sheds and equipment.

5. Establish water-use zones in your garden by positioning plants that use similar amounts of water together. (See following section)

6. Develop a master plan of your garden, taking into consideration issues such as function, color, and the desired overall effect.

7. Fit plants to the design, once you have achieved the overall effect you desire. For principles of plant selection refer to chapter 4.

II. Identifying the main water-use zones in a garden

1. **High water-use zones** are small, highly visible and highly maintained areas in your landscape such as the public area and area around the patio. Plants in these zones should create the lushest part of your landscape, and therefore require regular watering in the absence of rainfall. When designing your garden, place this high water-use 'oasis' close to the structure or to a terrace, where it would be most regularly and easily used.

2. **Moderate water-use zones** blend lush areas with the drier parts of your landscape that require only occasional watering once plants are established. For this zone, use plants that can take advantage of rain and possible runoff water from the structure, but that also do not require constant watering. These can include low water-use ground covers and shrubs.

3. **Low water-use zones** are areas that are farthest away from the most active areas of your garden and that do not need irrigation once plants are established, since its plants are watered by natural rainfall. For this zone, use drought-tolerant native vegetation or imported plants from other regions with similar climates.

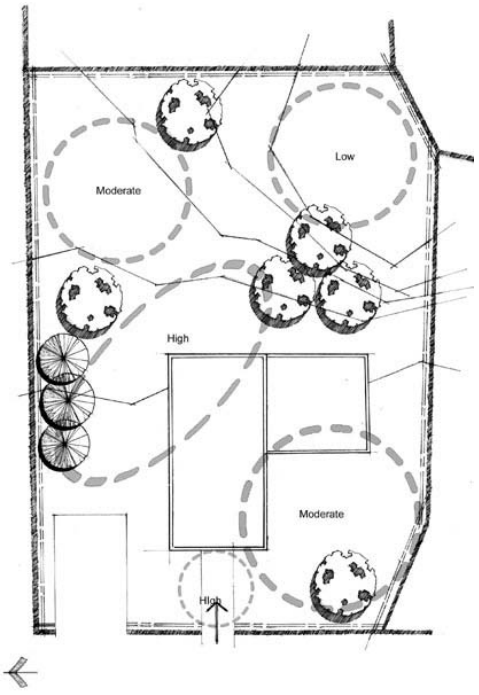


Fig. 1.3: A site plan showing water-use zones.

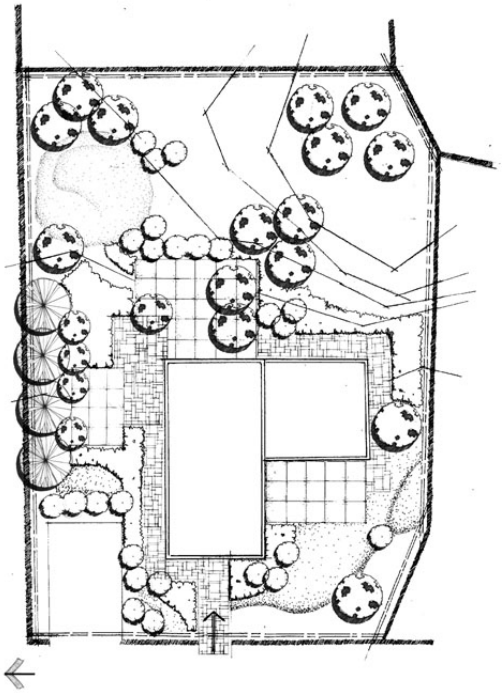


Fig. 1.4: A master plan of the garden design.

III. Creating microclimates

Microclimates result from differences in sun exposure, shade patterns, wind patterns, topography, soil, plants, and the location of adjacent structures.

- Even the smallest microclimates, such as those resulting from the existence or placement of a large rock or a hedge, should be taken into consideration for appropriate plant placement.
- Shade from trees or structures in the landscape keeps the landscape cooler and reduces water loss, while creating a comfortable, pleasant living environment.
- The basic microclimates on your site should take the four main exposures (south, north, east, and west) into consideration.

Southern exposure:

- Is exposed to more sunlight on a regular basis than other exposures.
- Provides a longer growing season in the fall and an earlier warm-up date in the spring.
- Can be shaded easily in the summer by an overhang planted with vines or by a large deciduous canopy tree.
- Is suitable for species that naturally grow in full sun.
- Provides an ideal orientation for an outdoor winter area.

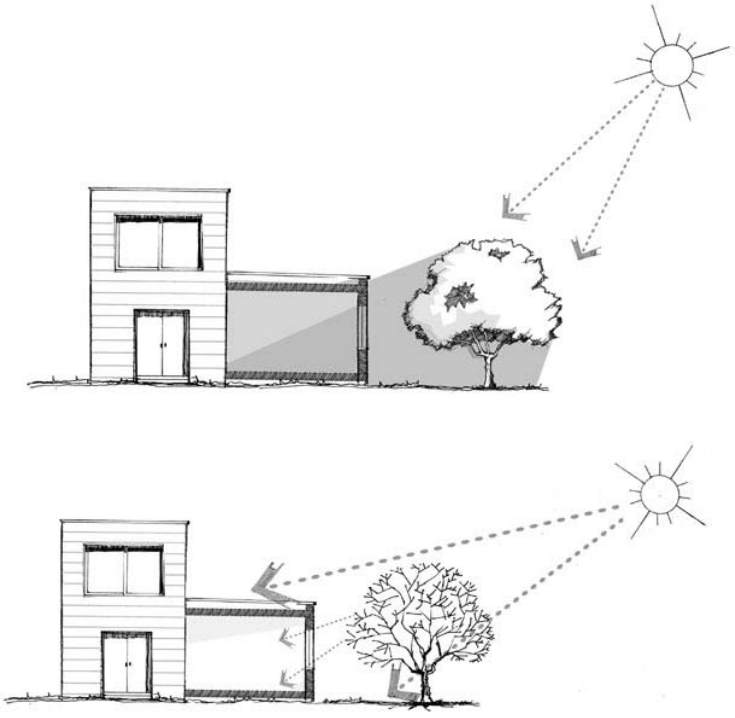


Fig. 1.5: Large deciduous trees shade the southern exposure during the summer, but allow for the winter sun to enter.

Northern exposure:

- May experience shade year-round.
- Is the last to warm up in the spring and the first to cool down in the fall.

- Has less extreme temperature swings than other exposures.
- Is suitable for plants that prefer cool, moist, shaded areas.
- Can provide a cool outdoor living area in the summer.

Eastern exposure:

- Is relatively well protected from the winter winds, and provides temperatures that are more moderate in comparison to southern and western orientations.
- Receives morning sunshine throughout the year.
- Provides relief from the afternoon sun.
- Needs large ornamental shrubs or small trees with low branches to filter the morning summer sun from indoor or outdoor living areas.
- Is suitable for plants that are native to sunny areas, and some plants that prefer part shade exposures.

Western exposure:

- Is characterized by significant temperature swings and rapid drying.
- Provides morning shade but receives afternoon sun.
- Can result in intensely hot areas in the summer.
- Is comfortable in the mornings during the summer, but because of the intense afternoon summer sun, needs to be shaded with tall deciduous trees planted at a reasonable distance from the structure.
- Is suitable for plants that prefer dry soil and warm temperatures.

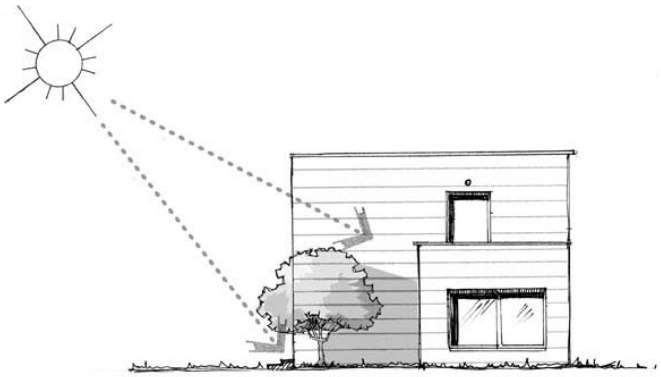


Fig. 1.6: Large trees protect the western exposure from the hot afternoon summer sun.

IV. Renovating an existing landscape

- Identify which plants to keep and which to remove from your existing landscape. (See list of recommended plants)
- Develop a list of plants you want to add to your garden.
- Identify changes you will need to make to your existing irrigation system. This may include installing a drip system, or providing the existing one with additional valves.
- Take advantage of the topographic characteristics of your site to direct rainwater to your plants.
- Considerable savings can be obtained by converting irrigated areas –especially lawn areas- into hardscaped ones.

- When planning your hardscaping, make sure to provide an adequate slope to allow for proper drainage.

V. General considerations

- Modifying an existing landscape to conserve water may be as simple as relocating a few shrubs and flower trees to more suitable locations.
- Altering plant maintenance practices and watering habits, even without making physical changes to the landscape, can save large amounts of water.
- Control erosion and runoff on slopes with low-water use vegetation, and consider introducing terraces or minor changes in the topography.
- Keep high-water-consuming areas to a minimum.
- Group plants with similar sun-exposure and water needs together, matching plants with the appropriate microclimate.
- Situate plants where they can benefit from the runoff water from adjacent areas.
- Eliminate plants that need irrigation from areas that are neither seen nor used.
- Where appropriate, modify conditions to reduce water loss by providing afternoon shade and windbreaks. These protect your plants from intense sun and drying winds.
- Plant wisely to avoid competition for water between trees and surrounding vegetation.
- Use mulch to reduce evaporation and to protect soil from erosion.
- Minimize changes to the original landscape to maintain its natural character.
- Tight curves or unnecessary bends in the design of planting beds and hardscaping are more expensive to implement and can result in maintenance problems. Straight lines or smooth flowing curves are the most suitable.
- Be realistic about the maintenance you are willing to provide or to perform in the future and plan accordingly.

Chapter 2: Creating paved areas in your garden

Topics to be covered in this chapter

I. Why create paved areas?
II. Paving materials that are readily available in Jordan
III. Joints between tiles
IV. General considerations

Definitions

Hardscaping: the inorganic components of the landscape design (paved areas).
Softscaping: the planted areas of the landscape.
Water harvesting: capturing rainfall to store it for irrigation and for different domestic uses.

Introduction

Whenever possible, consider using paved areas instead of the high water-consuming lawns. Paved areas provide almost maintenance-free surfaces that can serve various utilitarian and recreational purposes. A wide variety of paving materials that come in a wide range of prices and that provide a diversity of effects, is available in the market. By carefully selecting and applying these materials, you will obtain attractive and functional solutions for your landscaped area.

I. Why create paved areas?

- Paved areas provide relatively maintenance-free surfaces that consume almost no water.
- The combination of different colors and textures of softscaped and hardscaped surfaces can provide for a very powerful visual effect.
- Hard, dry, non-slip surfaces serve various utilitarian and recreational purposes such as sitting, playing, or parking of vehicles.
- Hardscaped surfaces function as an integral part of a water harvesting system by collecting and channeling rainwater.
- Certain landscape design ideas can be emphasized through hardscaping such as suggesting direction, indicating focal points, or drawing attention to changes in level.

Fig. 2.1: Combining hardscaped areas with softscaped edges gives the garden a lush look without having to use too many plants.

Fig. 2.2: Hardscaped surfaces serve to collect and channel rainwater as part of a water harvesting system.

Ask the following questions

What is the budget I have for creating the paved area?
What are the available materials in the market that fit my budget?
Do the materials I chose help achieve the overall effect I want in my landscaped area?

Gardener's checklist
Paving material characteristics

- Color
- Texture
- Safety
- Light reflectivity
- Accumulation of dust
- Water drainage
- Composition of the bedding that supports the paving surface

II. Paving materials that are readily available in Jordan

1. Concrete:

Availability: Easily available since it is manufactured locally.
Cost: Moderately priced.

Use:

- Available in a wide range of possibilities in terms of thickness, shape, and color.
- Provides a highly durable surface.
- Can be made to resemble other materials such as stone or brick.

Types of concrete paving systems differ according to the methods of casting:

a. Pre-cast concrete tiles:

- Available in different shapes, textures, and colors.
- Provide a variety of tile textures that result from adding aggregates of different sizes to the concrete mix.

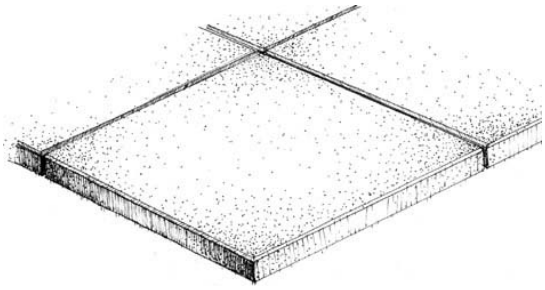


Fig. 2.3: Pre-cast concrete tiles.

b. Interlocking concrete tiles:

- Available in different shapes and colors.
- The interlocking nature of these tiles strongly binds the paving units, thus preventing any lateral movement amongst them.
- Because mortar is not required to bond paving units together, some of the excess water seeps through the open joints to the soil below, thus reducing water-ponding problems.
- Because of the strong bonding created between the individual paving units, and the thickness of the units, interlocking paving systems do not require a concrete bedding and can be placed directly on a compacted layer of sand.
- Tiles easily can be removed and reused again in the same location (if maintenance work is to be carried out), or can be placed in a different area.

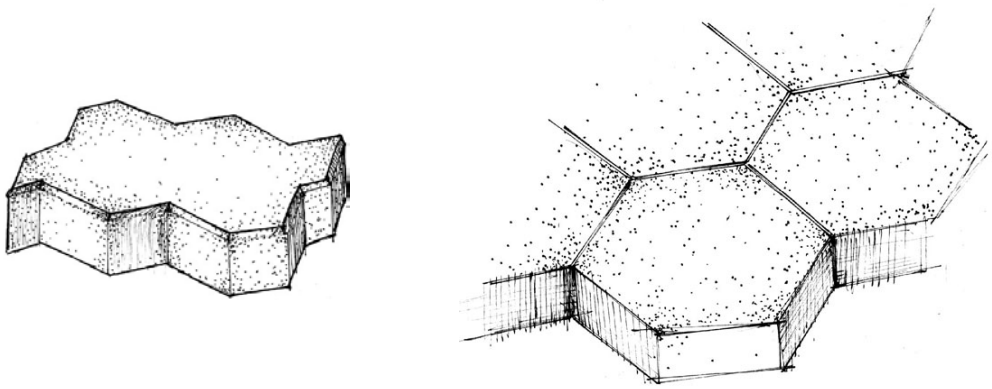


Fig. 2.4: Interlocking concrete tiles.

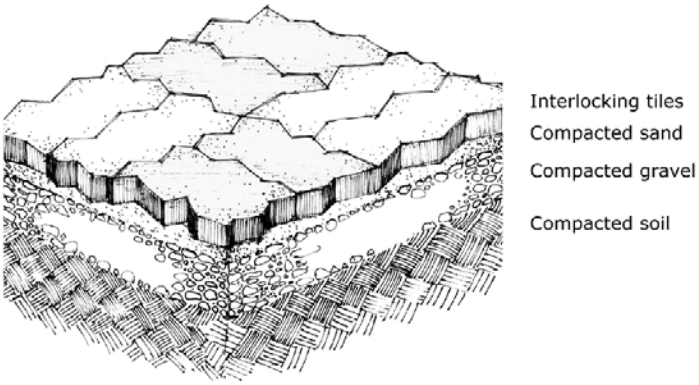


Fig. 2.5: Section showing composition of the bedding that supports the interlocking tile paving surface.

c. Cast-in-place concrete pavements:

- Available in various patterns, colors, and textures, and can be used to pave areas of just about any shape.
- Require the placement of contraction joints at six-meter intervals to avoid the cracking of the pavement.

Fig. 2.6: Cast-in-place concrete pavements.

2. Stone:

Availability: Jordan has a wide variety of quarries that produce very high-quality stones.

Cost: Comes in a wide range of prices. Initial costs for materials and installation are relatively high, but maintenance costs are very low.

Use:

- Allows for a wide diversity in terms of thickness, texture, shape, and color. Stone pieces may consist of geometrically cut pieces - usually square or rectangle - or of irregular pieces.
- Has a long life span and requires minimal maintenance.
- Irregular stone paving tiles usually consist of leftover pieces resulting from the stone cutting process, and can be obtained at relatively low prices.

Fig. 2.7: Stone paving.

Stone weathering

Natural weathering works unevenly on stone surfaces and tends to produce attractive effects. Stone also can be weathered artificially, usually through applying acid to the stone surface. Other artificial weathering techniques include breaking the edges of the stone paving units, or sand blasting the stone surface. These techniques can be used in addition to, or, in place of, applying acid.

3. Ceramic Tiles:

Availability: Both locally produced and imported ceramic tiles are available in the market. Most of the imported tiles available in Jordan are manufactured in the United Arab Emirates, Italy, or Spain.

Cost: Available in a wide range of prices.

Use:

- Provide for a wide diversity in terms of texture, color, and size of units.
- If using ceramic tiles, it is advised to buy extra quantities and to store them, in case there is a need to replace any of the original tiles. The continuous availability of a given type of ceramic tiles is not guaranteed.

Fig. 2.8: Ceramic tiles.

4. <u>Brick:</u>
Availability: Local and imported bricks are available in the market. Most of the imported bricks available in Jordan are manufactured in the United Kingdom.

Cost: Both locally produced and imported bricks are relatively expensive.

Use:

- Offers considerable flexibility in layout because of the small size of the individual brick units.
- If using bricks, it is advised to buy extra quantities and to store them, in case there is a need to replace any of the original bricks. The continuous availability of a given type of brick is not guaranteed.

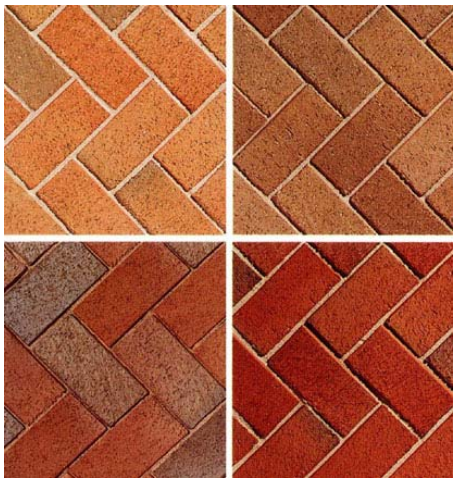


Fig. 2.9: Brick paving.

5. <u>Mosaics:</u>
Availability: Custom-made locally according to the required design.

Cost: Relatively expensive, and therefore it is advised to limit the use of mosaic surfaces to very small areas.

Use:

- Allows for a wide diversity in terms of color, shape, and size.

Jordan overview

Jordan contains some extremely impressive historical mosaic panels. These are found in historical sites throughout the country, including Madaba, Jerash, and Pella.

Fig. 2.10: The sixth-century AD Sweifieh floor mosaic in Amman.

6. <u>Inorganic loose materials:</u>

Availability: Available in a wide range of materials and sizes. Inorganic loose materials include decomposed gravel, river run rocks, crushed terra cotta, or pumice stone (locally known as *touf*).

Cost: Relatively inexpensive in terms of material and installation costs.

Use:

- Life span differs from one material to another and depends on the frequency and type of use for the covered areas. Most surfaces need replenishment every few years.
- Loose materials may be laid directly on the soil, or on a compacted layer of sand. A netting material may be laid underneath to keep particles from becoming embedded in the soil.
- Need to be contained within clearly defined physical edges to restrain the horizontal movement of individual pieces.

Fig. 2.11: Crushed stone ground cover combined with a Lavender (*Lavandula angustifolia*) border. Inorganic loose materials can be easily worked into curving shapes that naturally complement adjacent planting materials.

Jordan overview

In Jordan, while ten square meters of lawn may need 80 cubic meters of water annually, the same area of paving material may collect up to 4.75 cubic meters of water during the same period, depending on the location of the site within the country. This means that at least 50 JD worth of water could be saved annually for every ten square meters of paving used instead of lawn.

III. Joints between tiles

The manner in which the joints between individual paving units are treated greatly influences the character of paved areas. For best results, consider the following tips:

- The joints between individual tiles can be used to provide effective touches that articulate outdoor paved surfaces. Mortar of a different color than the individual paving units, and also wide mortar joints, may be used to emphasize the individual units. Also, soil may be placed between the tiles instead of mortar, and can be planted with grass to create the pleasant effect of paved areas articulated with planted strips.

- Joints can be almost completely done away with by using unfilled, tight joints that provide the effect of a single continuous surface. However, such a treatment is only possible with units of regular size and shape.

- Mortar should be brushed dry into the joints and then watered. This method reduces the risk of having the mortar stain the paving tiles.

IV. General considerations

- The composition of the bedding that supports the paving surface is as important as the paving material itself. The choice of bedding depends on many factors such as the type of soil originally located on the site, and the nature of the use intended for the paved area. Most paving materials require a sub-layer of concrete bedding that is placed over a compacted layer of sand.

- Make sure that the paved area slopes gently away from adjacent structures, and towards planted areas or a water cistern. This will prevent drainage problems and will save water for the dry season. A slope of 1.5 - 2% is suggested, and steeper slopes can be used, if the surface is not to be used for utilitarian purposes, especially for seating. When using highly textured paving materials such as pre-cast aggregate concrete tiles, a minimum slope of 3% is recommended.

- When mixing different paving materials, consider using ones with similar thickness, so as to unify the bedding thickness and to simplify the installation process.

- Keep in mind that surfaces paved with highly textured paving materials, although aesthetically attractive, cannot comfortably accommodate many uses such as walking, running, or bicycle riding.

- The choice of color for paved surfaces is a very important design decision. Colors add interest to overcast areas that get limited sunshine during the winter months. On the other hand, light colored materials cause glare in summer.

- Keep the outline of paved areas simple, to minimize costs. Complexly shaped paved areas require too much cutting of individual units, thus considerably raising costs.

- Although paved areas require limited maintenance, it is advised to carry out certain maintenance activities on a regular basis. These include cleaning and sealing joints, repairing broken segments or settled areas, and sweeping surfaces to remove accumulated particles and dust.

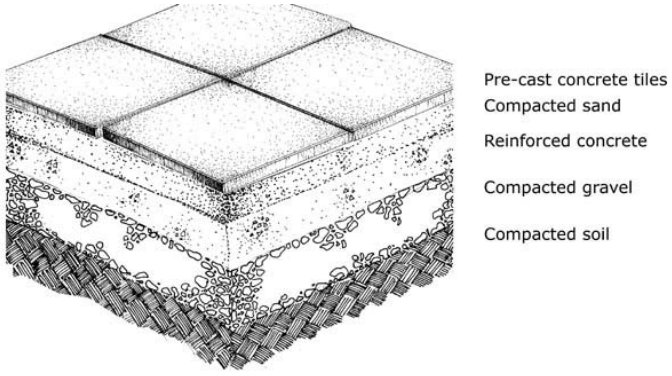


Fig. 2.12: Section showing composition of the bedding that supports the paving surface.

Hardscaping suppliers:

For a list of suppliers of paving materials in Jordan, see the Suppliers list in the Water Conserving Landscapes section of the CSBE web site (**http://www.csbe.org**).

Chapter 3: Harvesting rainwater for landscape use

Topics to be covered in this chapter

I. Why harvest rainwater?
II. Creating a rainwater harvesting system
III. Types of rainwater harvesting systems
IV. Components of a rainwater harvesting system
V. General considerations

Definitions

Catchment area: is any area from which water can be harvested, such as rooftops, paved areas, and driveways.
Drip line: an imaginary line that defines the area beyond the outer edge of the plant's foliage.
Water harvesting: capturing rainfall for use in irrigation and for different domestic uses.

Introduction

Harvested rainwater is a renewable source of clean water that is ideal for landscape use. Water harvesting systems provide flexible solutions that can effectively meet the needs of new and existing, as well as of small and large sites. Using a water harvesting system is an ongoing process that can be developed over time.

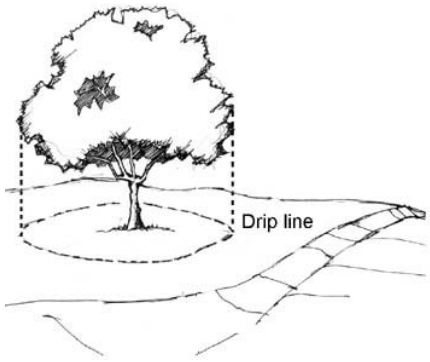
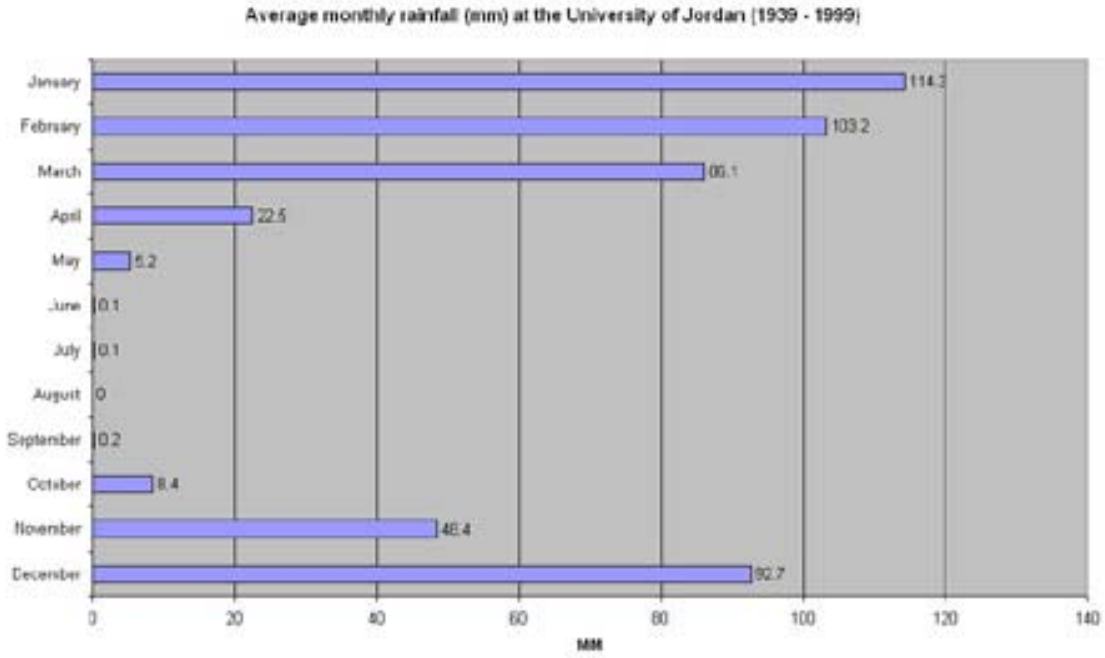


Fig. 3.1: Most of the plant's feeder roots are concentrated near the drip line, beneath the outer edge of the plant's foliage.

I. Why harvest rainwater?

- To save water for the long dry season: The average rainfall in Amman during January may exceed 115mm, but goes down to zero during the three months of June, July, and August. Harvesting rainwater makes it possible to save the excess winter rainwater for use during the dry summer months.
- To save money: Harvesting rainwater can reduce your dependence on municipal water supplies and consequently result in considerable savings in your water bills.
- To reduce off-site flooding and erosion by holding rainwater on the site.
- To provide a source of water that is ideal for plants, since it is clean, salt-free, and has a hardness of zero.

- To reduce salt accumulation in the soil (when using passive rainwater harvesting; see following section). Rainwater percolates into the soil and forces salts down and away from the root zone area (a process called leaching). This allows for greater root growth and water uptake, and eventually increases the drought tolerance of plants.



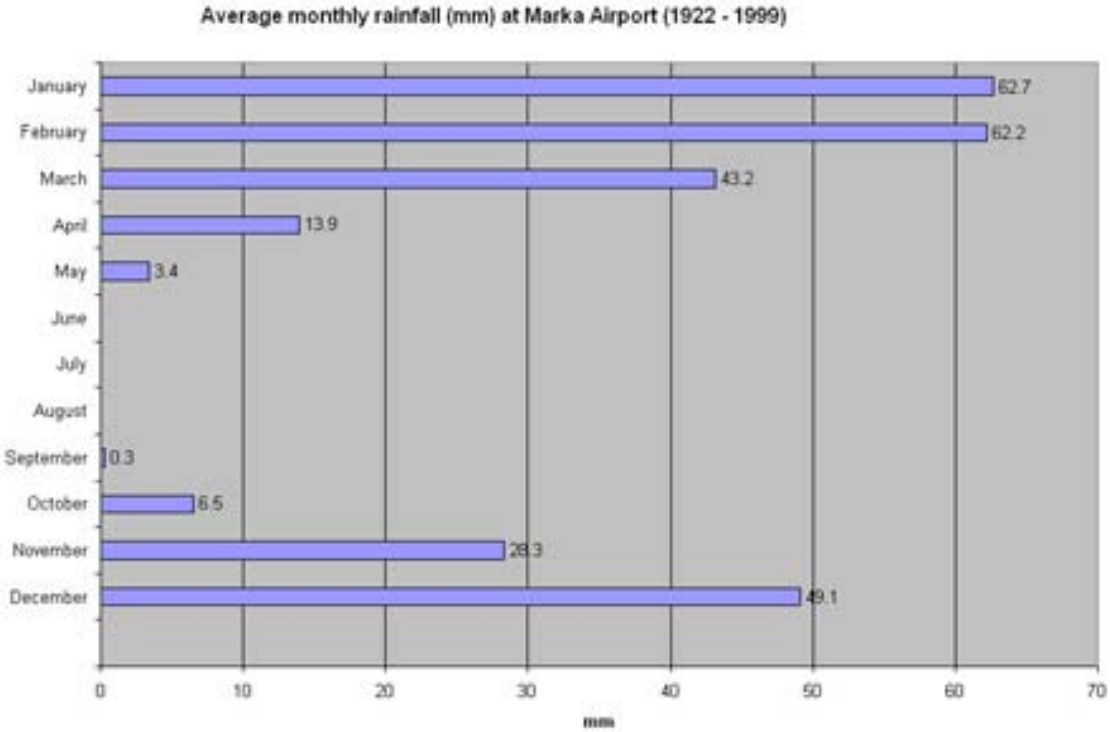


Fig. 3.2: Monthly mean precipitation charts for the University of Jordan and Marka, Amman. (Source: Jordan Meteorological Department, Amman.)

Jordan overview

Historically, rainwater harvesting was used in Jordan to provide water that is suitable for various domestic and irrigation uses. A number of distinctive historical examples that incorporate effective water harvesting systems survive in the country. These include the cut-stone reservoirs of the Nabatean city of Petra, as well as the underground cisterns found in the country's Umayyad desert palaces, Crusader period castles, and traditional village houses.

Fig. 3.3: A historical example of water harvesting at the Amman Citadel. Water collected from the roof is directed through channels towards water storage areas.

II. Creating a rainwater harvesting system

- Carefully observe and analyze the site during a rainfall period to be able to harvest water from it in the most efficient possible manner.

Gardener's checklist
Analyzing a rainwater harvesting site

- Identify high and low rainwater areas.
- Identify drainage patterns and gravity flow.
- Identify catchment areas.
- Study the site's natural topography.
- Study the type of soil on the site.
- Study existing plants on the site and their water requirements.

- A water harvesting system can provide an attractive landscaping and architectural design element that is functionally and aesthetically integrated within the site.
- Developing a water harvesting system is an on-going process that can be improved upon and expanded over time.

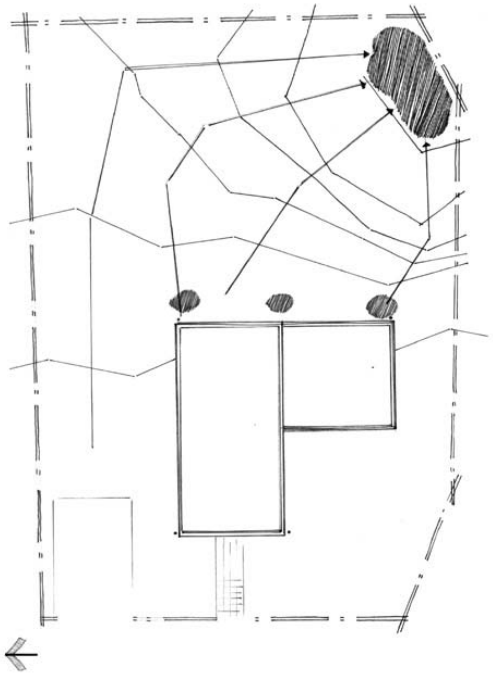


Fig 3.4: A site plan showing an analysis of rainfall drainage.

III. Types of rainwater harvesting systems

1. <u>Passive rainwater harvesting systems:</u>

No storage containers are used, and rainwater can be diverted from roof areas or paved surfaces in the garden immediately to the soil (or to the "landscape holding" areas) in the site, for direct use by the plants.

- Make sure that the soil in the landscape-holding areas is not compacted, because this inhibits water from moving through the soil. After planting, apply a layer of mulch to reduce evaporation and to control erosion. If the soil is compacted, loosen it by tilling. If the soil is too sandy, add organic matter to increase the soil's moisture-holding potential.
- Be careful in the selection of plants for the low-lying landscape-holding areas. These areas can get saturated with water for extended periods of time, and some plants may not be able to survive such conditions.
- For new plantings, locate the plants at the upper edge of concave holding areas, to encourage extensive rooting and to prevent soil erosion.
- To take advantage of water falling freely from roofs, plant large sturdy plants where the water falls. Also, use rocks or other hard material, or hang a large

chain from the downspout to the ground, to disperse and slow down the water, and also to prevent erosion.

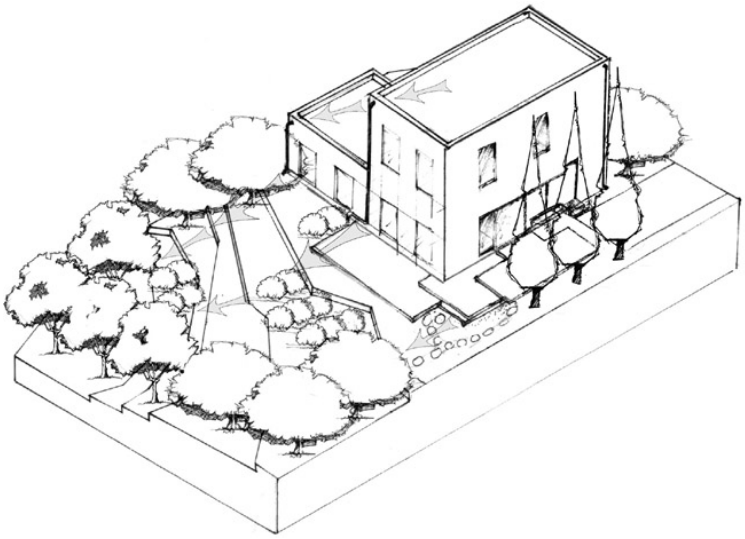


Fig. 3.5: A site plan showing an analysis of rainfall drainage.

Creating landscape holding areas

- Locate and identify existing landscape holding areas on the site. If you do not find such areas, create them. They may consist of concave depressions that are dug out with the extra soil berming them, or flat areas supported with berms, moats, or soil terracing.
- Extend these areas beyond the drip line of the plants to accommodate and encourage the growth of extensive root systems. Do not dig such areas around existing plants, but construct berms or moats on the existing surface, to avoid damaging plant roots.
- If the site is sloped, create large connected and descending holding areas, to avoid flooding.

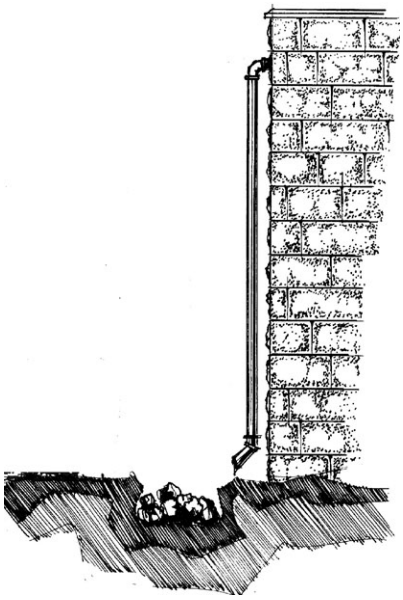


Fig. 3.6: Rocks may be used to disperse water coming out of a downspout.

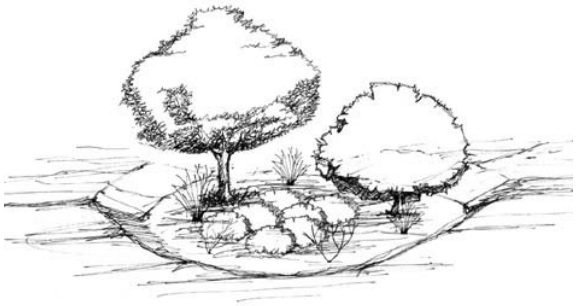


Fig. 3.7: Landscape holding areas may be concave depressions that hold rainwater passing through the site, thus allowing plants to better benefit from that rainwater.

2. <u>Active rainwater harvesting systems:</u>

All or some of the rainwater falling on the catchment areas is not used immediately, but is stored in containers for the dry season. (The sections below provide details regarding the creation of an active water harvesting system).

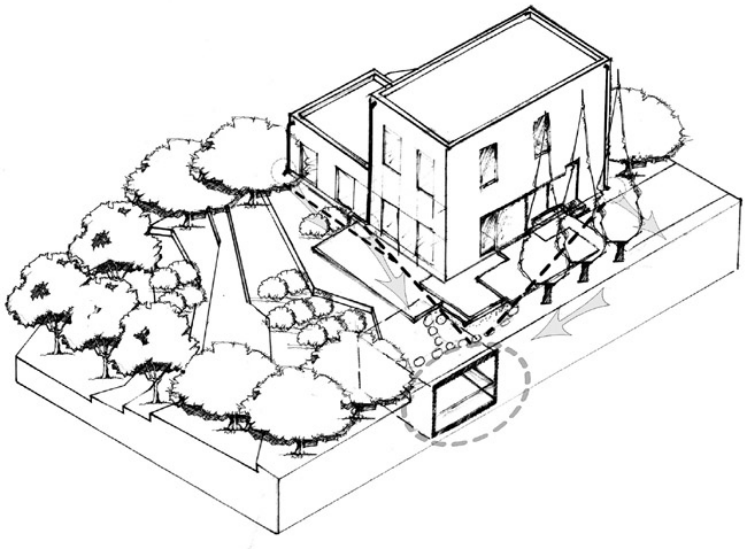


Fig. 3.8: An active rainwater harvesting system.

IV. Components of a rainwater harvesting system

A rainwater harvesting system depends on four elements:

1. Catchment area.
2. Water storage container.
3. Conduits connecting the catchment area to the water storage container.
4. Conduits distributing the water from the storage area to the landscape.

A passive water system will only include the catchment area, and might also include simple conduits; but an active system incorporates all of the above-mentioned elements.

1. Catchment area:

- Hard, smooth surfaces are the most suitable for catchment areas. While ten square meters of smooth concrete may harvest up to 4.75 cubic meters of water in the wetter parts of Jordan (depending on the microclimate), an equivalent area of flat sandy surface may harvest only 0.25 cubic meters.
- If the surface is impervious, runoff occurs immediately; but if the surface is pervious, runoff will not occur until the surface is saturated.
- Do not paint catchment areas with potentially toxic materials, especially if the water is to be used to irrigate vegetables and herbs.

How much rainwater will you be able to harvest?

QUANTITY OF HARVESTED RAINWATER (CUBIC METERS) = RAINFALL (METERS) X CATCHMENT AREA (SQUARE METERS) X RUNOFF COEFFICIENT *

* The runoff coefficient is the percentage of the rainfall that can be harvested from a specific material. It varies from 0.95 - 0.90 for asphalt and smooth concrete to 0.10 - 0.05 for flat, sandy soil.

2. <u>Water storage containers:</u>

Water can be stored in many different types of containers; the choice of these containers depends on your needs, preferred materials, placement, capacity, and cost.

- Locate water storage containers as close as possible to the points of collection and use, and far away from contamination sources, such as septic tanks and sewage networks.
- When collecting water from a high-level catchment area such as a roof, place containers at an elevated level to take advantage of gravity flow. This will put less stress on pumps and will conserve electricity.
- Place the containers at the high end of the property, to facilitate gravity flow.
- Connect the water storage containers to the municipal water supply and make them accessible to water trucks, so as to be able to replenish them if the amounts of harvested rainwater become scarce during the dry season.
- Seal the water container to keep out organic materials and sunlight. This will prevent evaporation and bacterial growth.
- Provide the inlet for the water storage tank with a filtering device (which could simply consist of a window screen), to stop leaves and debris from making their way into the tank. The level of filtration depends on the irrigation system used. For example, drip irrigation requires finer filtering, in comparison to irrigation with a hose.
- Divert the first part of the rainfall away from the storage area, so as to wash away the dust and debris that collect on the catchment area during the dry

period, and to prevent the dust and debris from accumulating in the storage containers.

- In some cases, it is more useful to locate several smaller water containers where water is required. These might be easier to handle and to hide, but they will increase installation costs.

Underground vs. aboveground water storage containers

- Underground water storage areas, or cisterns, are expensive to build. However, they are visually unobtrusive and occupy almost no space in the garden.
- Swimming pools, unused septic tanks, and culverts can be used as underground cisterns.
- New underground cisterns can be built of concrete block, cast-in-place concrete, building rock, or steel.
- Aboveground water storage containers are less expensive to install than cisterns, but occupy space in the garden.
- Aboveground large water storage containers can be made of reinforced concrete blocks, stone, steel, or polyethylene. One can also use prefabricated smaller containers made of steel, polyethylene, or clay.
- When using aboveground water containers, consider placing them vertically, rather than horizontally. This way, they will occupy less space and will provide for additional gravity flow.

3. Water conduits connecting catchment areas to water storage containers:

A great variety of alternatives exists for water conduits. These include gutters, downspouts, channels, and ditches. Proper sizing of these elements is important to efficiently direct the harvested rainwater.

- Gutters and downspouts can be either concealed inside the wall, or attached to the exterior of the building. Exterior gutters and downspouts have the potential of forming distinguishing architectural elements. They can also be added at any time to the outside of the building.
- To maximize the efficiency of water collection, space downspouts a minimum of 6 meters, and a maximum of 15 meters, apart.
- Provide 7 square centimeters of downspout area for every 10 square meter of roof area.
- To insure the proper flow of water, provide the gutters with a minimum slope of 2%.
- When using outside gutters, provide them with supporting hooks at one-meter intervals.
- Do not paint water conduits with potentially toxic materials, especially if the harvested rainwater is to be used to irrigate vegetables and herbs.

4. Water distribution:

Water can be distributed from storage containers to the planted areas through a variety of conduits, including hoses or solid or perforated pipes.

Drip irrigation systems are the most effective, in terms of achieving significant water savings. Constructed channels can provide a unique aesthetic value to the landscape, and also are durable and almost maintenance-free.

If gravity flow is not possible, an electric pump would be needed to distribute water.

V. General considerations

- When adding a water harvesting system to an existing garden, compare your water bills before and after installing the system - to accurately assess its effectiveness.
- Observe and test your system during the rainy season and implement the necessary adjustments to increase its efficiency.
- Inspect your system before and after each rainy season.
- Make sure that no water escapes your property. This way you not only save water, but also contribute to preventing urban flooding and the overflow of the municipal storm water system.

Maintenance tips

- Keep holding areas, gutters, and downspouts free of debris.
- Clean and maintain the storage containers as well as the different conduits of your water harvesting system such as gutters, downspouts, channels, and filters.
- Control and prevent erosion. Block erosion trails.

Chapter 4: Selecting plants for your water-conserving garden

Topics to be covered in this chapter

I. Major functions of plant materials
II. Appropriate plant selection
III. Native plants
IV. Safety considerations
V. Selecting plants at the nursery
VI. Planting in containers
VII. Design tips for plant placement

Definitions

Accent plant: a plant with special characteristics that attracts attention due to its flowering color, leaf texture, height, or form; this plant is usually used to provide a focal point to a particular grouping of plants.

Fig. 4.1: The strong architectural form of the Golden-tooth Aloe (*Aloe nobilis*) provides a focal point in this plant grouping where it is used as an accent plant.

Annuals: herbaceous plants that complete their growing cycle in a single season and must be planted anew each year.
Border: annuals or perennials developed to form rows or masses placed along a path, or at the edge of a planter.
Herbaceous plants: non-woody plants that have flexible, green stems.
Oasis area: small, highly visible and highly maintained, and the lushest area of the landscape - such as the public zone, or area around the patio - that contains high water-use plants. The plants in these zones need to be watered regularly in the absence of rainfall.

Fig. 4.2: The oasis area should be placed closest to the house to provide maximum use and enjoyment.

Perennials: herbaceous or woody plants that continue to live from year to year.
Specimen tree: a tree with particularly impressive characteristics embodied in its flowers, leaf texture, or form. Specimen trees can be planted alone or in groups, usually in the most important areas of the garden, and generally are installed as mature plants, when their true form and unique, individual character has begun to emerge. Specimen plants tend to be more expensive than are plant materials used en masse.

Fig. 4.3: The lacy and graceful Silk Tree (*Albizia julibrissin)* with its flat spreading crown functions as a specimen tree in a prominent location near the entrance to a residence.

Succulent: a plant that stores water in its leaves and stems, and occasionally in its roots. The water-storing part of a succulent plant is swollen, often greatly so. This attribute creates conspicuous and often striking growth forms, and therefore, most succulents can be used as accents, if they are large enough to be readily noticed.

Fig. 4.4: Sempervivum sp. is a succulent that stores water in its fleshy leaves.

Introduction

Whether establishing a new garden or renovating an existing one, proper plant selection is very important towards creating a successful garden. When selecting plants, focus on detail, and plan for combinations of plants based on their design characteristics such as size, texture, color, and form. Before purchasing the plants, evaluate your choices according to the intended aesthetic, spatial, and climatic functions of the plants. As you begin to select and introduce the plants into your landscape, situate them where they can most effectively perform their intended functions, while taking care to group together plants of similar water requirements.

I. Major functions of plant materials

Aesthetics:

The visual principles of color, texture, scale, and rhythm can be used to create an aesthetically pleasing planting environment. Special plants of high visual interest, such as specimen trees or perennial borders, can be used to dramatize certain views. Plants can also unify other design elements, serve as neutral backgrounds to focal points, can relate a structure to its surrounding site, and reduce the 'hardness' of the adjacent or surrounding architecture.

Creating pleasant microclimates:

One can influence the microclimate of an outdoor space through the careful placement of trees and shrubs, so as to block excessive sun or wind.

Tips

- Trees with dense canopies produce dense shade that may restrict what you can grow underneath them. On the other hand, trees that produce filtered shade provide protection from the sun and allow undergrowth.
- Plants intended as a windbreak should be planted perpendicular to the prevailing winds, and should consist of several rows of different plants types (e.g. one row of trees, one row of shrubs, one row of smaller shrubs), to minimize wind infiltration.

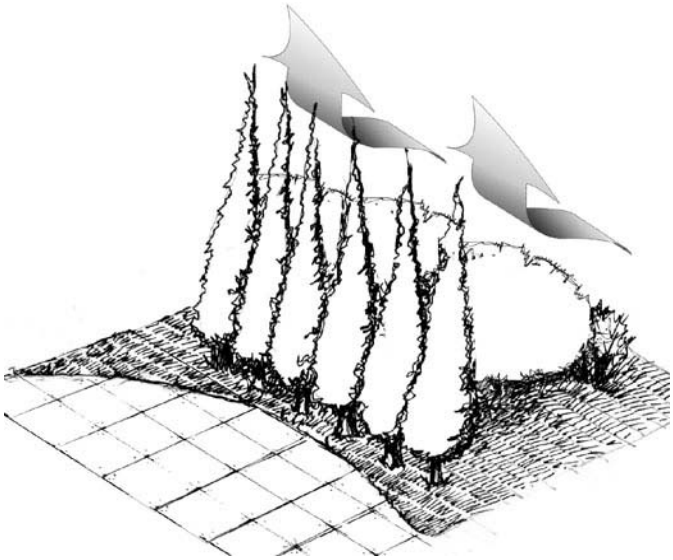


Fig. 4.5: The use of sturdy, evergreen plants with dense foliage provides an effective windbreak.

Screening:
Plants that act as visual screens can range from semi-transparent to uninviting thorny hedges. Such screens can be used to provide privacy, mark boundaries, discourage intruders, or block unpleasant views. Screen plants should be dense and tall enough to provide a visual barrier.

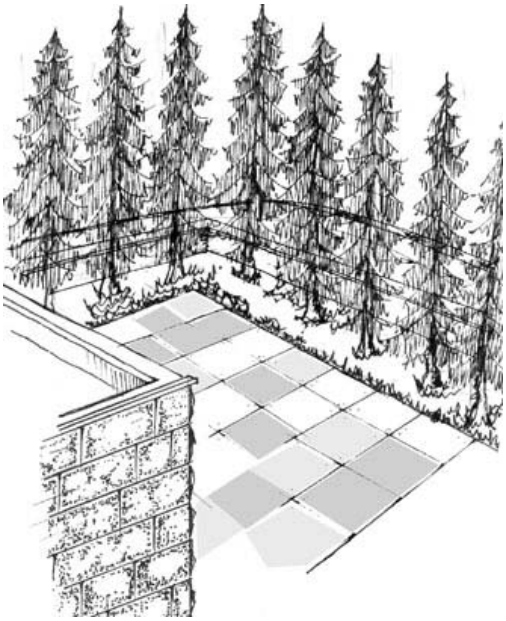


Fig. 4.6: Plants as visual screens.

Space defining elements in the landscape:
Plants can serve the same functions that many "hard" building materials serve: to form outdoor walls, fences, and canopies that define spaces or circulation routes.

Although they require more space than hard building materials, plants typically are less expensive to buy and install, and require little maintenance, if properly chosen.

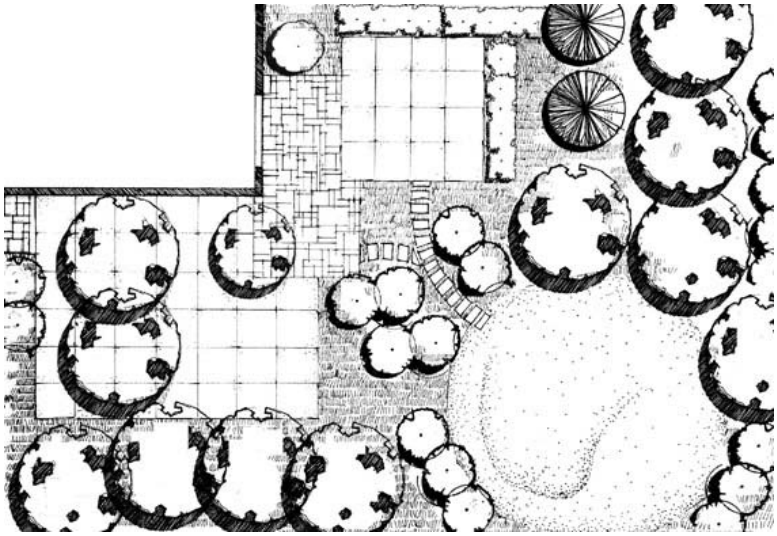


Fig. 4.7: Plants as space-defining elements.

Tips

- Use dense and low growing plants as ground covers.
- To create a canopy, use plants that have adequately dense leaves to define an overhead space, and that are tall enough to walk under, without the need for constant pruning.
- Use deciduous vines for overhead trellises, to allow the winter sun to enter.

Wildlife attraction:
Planting can attract birds, butterflies, or other forms of wildlife for human enjoyment. Conspicuous fruits, both fleshy and dry, attract birds, and showy, nectar-bearing flowers may attract hummingbirds and butterflies.

Environmental stabilization:
Plants can be used to stabilize eroded slopes and to revitalize damaged soils. When using plants to prevent water erosion, such as on a slope, use plants with fibrous roots, and low-growing plants with dense foliage that is close to the ground.

II. Appropriate plant selection

A number of issues need to be taken into consideration when selecting plants for your water-conserving garden. In addition to selecting drought-tolerant plants, select plants that are compatible with the design of your landscape and that are well suited to your site and local environment. Choose plants that can tolerate the site's soil type and light levels. For example, although junipers are extremely drought tolerant, they cannot tolerate wet soils or heavy shade.

Fig. 4.8: An example of a water-conserving garden that incorporates a variety of drought tolerant plants including a perennial border of Coreopsis (*Coreopsis auriculata*), Rosemary (*Rosmarinus officinalis*), and Japanese Barberry (*Berberis thunbergii*).

Other important criteria to consider when selecting plants for your garden include the following:
- Hardiness (resistance to frost).
- Growth-rate: slow-growing plants might require less maintenance (such as pruning and sheathing), than do fast-growing ones; but these plants take considerable time to reach their desired size.
- Mature size and form: consider if the plant will remain in scale with the rest of the landscape as it matures, and if it will compete with other plants for space, nutrients, and water.
- Striking form and/or showy flowers: accent plants have bold forms and/or showy flowers that can add interest and color to the landscape.
- Texture: consider if the leaf texture is fine, medium, or coarse, and if it combines well with the adjacent plants.

Plant texture

- Coarse textured plants such as *Echeveria imbricata* (Hen and Chickens) are highly visible and bold plants with large leaves. They have an informal feel to them, and also serve to provide clear focal points in the landscape.
- Moderate textured plants such as *Berberis thunbergii* (Japanese Barberry) are less transparent and are stronger in silhouette than are coarse-textured plants. They serve to unify a composition and to provide a link between coarse and fine-textured plants.
- Fine textured plants such as *Artemisia arborescens* (Faith Raven) have small leaves, thin branches and twigs, and/or a tight dense habit of growth. They provide a soft and delicate look to the landscape, and a neutral background for other plants.

Fig. 4.9: Hen and Chicken (*Echeveria imbricate)* is an example of a coarse textured plant with large bold leaves.

Fig. 4.10: Japanese Barberry (*Berberis thunbergii)* is an example of a medium textured plant.

Fig. 4.11: Faith Raven (*Artemisia arborescens)* is an example of a fine textured plant with small leaves and twigs.

- Color: color is an easily discernable visual quality in plants that is clearly present in the foliage, flower, fruit, twigs and branches, and trunk bark. Dark colors convey a quiet, peaceful feeling, and give a sense of solidity and weight. Bright colors convey a light cheerful atmosphere. Flower color can be used as an accent that provides contrast to the green summer foliage. Use plants with different flowering seasons, so that your garden is in bloom throughout the year.

- Functional use: study if the plant is suitable for its intended location and purpose. For example, a large plant or tree in front of a window facing a pleasant view might block that view. On the other hand, a large plant or tree in front of a west-facing window will provide protection from the harsh afternoon summer sun.

III. Native plants

Jordan is blessed with a variety of beautiful native plants that are intrinsically tolerant to drought conditions. Because of their adaptability to arid regions, they are ideal for use in water conserving gardens and in the larger landscape context. They also provide other benefits such as affording habitat for native fauna. Moreover, native plants provide color throughout the year, since their various species have different blooming seasons.

Unfortunately, most of these plants are not yet commercially available at nurseries; among the aims of the CSBE project on water conserving landscapes is to encourage their commercial propagation. In this context, it is imperative that these plants are not harvested from the wild and that purchased native plants are obtained from professional nurseries that have propagated them.

Fig. 4.12: Cyclamen (*Cyclamen persicum)* is an example of Jordan's rich and diverse native flora.

IV. Safety considerations

Designing a safe environment depends on matching the proper plant with the proper place. A number of safety issues should be considered when determining the location of a given plant in the landscape.

Ask the following questions

- Is the plant poisonous?
- How much litter does it produce?
- What is the natural strength of its limbs?
- Will drooping branches obstruct pathways?
- Will its roots break pavements?
- Does it have thorns?
- Does it attract stinging insects or other pests?

Plants that can cause hazards or nuisances

Hazard/Nuisance	Species	Comments
Poisonous plants	Privet, Oleander	Children might be tempted to sample bright-colored berries or leaves.
Debris: fruits and nuts	Olive, Chinaberry	Berries and nuts can be slippery or difficult to walk on. They may result in floor litter, and can stain paved surfaces.
Cones and seed pods	Pines, Carob	Cones, while having many decorative uses, can cause problems for pedestrians and small-wheeled vehicles.

Drooping branches	Willow, Bottlebrush	Branches can drop below minimum clearances on walkways, and may cause facial and eye injury.
Shallow roots	Willow, Pepper Tree	Surface root systems can break apart paved surfaces.
Odor	Mimosa, Carob (male)	Emit unpleasant odors during flowering season.
Thorns and spikes	Barberry, Firethorn	Plants with thorns or spikes can be painful and dangerous to brush against or fall into.
Insects and pests	Fruit trees	Not recommended near seating areas.

V. Selecting plants at the nursery

When you are ready to select an individual plant, keep the following factors in mind:

- Proportion of the size of the plant to the size of its container: select a plant that is of average size relative to its container. Do not pick the largest plant, which may have had its roots overgrow in relation to the container size, nor the smallest plant, which may not have been in the container too long.

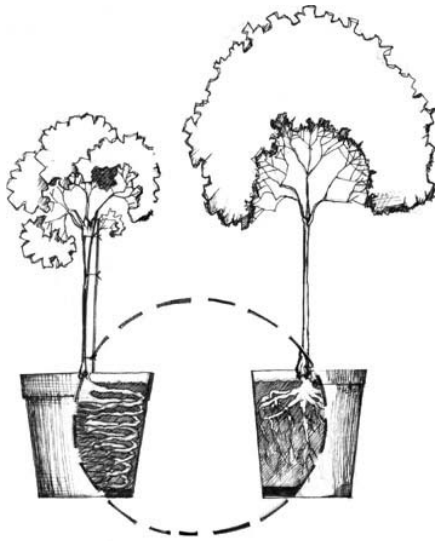


Fig. 4.13: When selecting a plant at a nursery, check its size relative to its container, and make sure it is vigorous and healthy.

- Vigor and health of the plant: look for a plant that has a strong trunk and that can stand alone without a stake. Also, look for trees that clearly taper from the bottom to the top. Limbs should be strong and healthy, and branches should be evenly spaced vertically and radially around the trunk(s) with wide branch angles.

Beware

- Make sure that there is no evidence of insects or disease. Beware of signs such as holes in leaves, discolored foliage, markings left by insects, etc.
- The leaves should be uniform in size and color.
- There should be no fungus or weed problems in the container.
- The trunk and branches should not be bruised, broken, or damaged.
- Bruised, tattered, or torn foliage, and dried or shriveled twigs and buds might indicate wind drying, in addition to insect damage and disease.

VI. Planting in containers

Planting in containers of varying shapes and heights can serve to display foliage textures and forms, and to provide lively color and form to your terrace or hardscaped areas. However, a few issues need to be taken into consideration when planting in containers:

- Plants in containers need more watering than those planted directly in the ground. However, you can reduce the amount of water they require by choosing the most suitable plants, containers, and soil mix.
- Your container garden might be your oasis area, where you can place desirable plants that have higher water needs.
- Many drought-resistant plants are well suited for containers, since they can tolerate water deprivation for considerable periods of time.
- Water-retaining crystals, non-porous containers, and mulches can be used to reduce the amount of water that the plants need. When exposed to water, water-retaining crystals swell with water and act as micro-reservoirs, slowly releasing moisture into the soil mix. Add these crystals before planting, and only use the recommended amounts.
- Make sure that your containers have proper drainage, so as to prevent root rotting. Otherwise, water tends to collect in the container, saturate the soil, and prevent it from breathing, thus causing the roots to rot.
- Although terracotta containers provide aesthetically pleasing results, their porosity will cause the soil to quickly dry out. Painting or sealing such containers with varnish from the inside will reduce moisture loss.
- Plastic and fiberglass containers retain moisture well, but can gain considerable heat when exposed to the sun. Placing them inside another container, such as a wooden planter, will help reduce moisture loss.
- Whenever possible, choose large containers, since the larger the volume of the soil mix, the slower it dries out. Also, grouping containers allows them to protect one another from the heat and drying winds.
- Soil tends to get compacted in containers, and this prevents the soil from "breathing." Consequently, it is necessary to change the soil on a regular basis. The water-retaining crystals mentioned above create spaces between the soil particles and therefore help reduce soil compaction in containers.

Fig. 4.14: Planting in containers serves to emphasize a plant's dramatic foliage and forms.

VII. Design tips for plant placement

- Use odd numbered groupings (1, 3, 5, …), to give a more natural look to the landscape.
- Use bands of low-growing plants or ground covers to tie together and unify groups of taller shrubs.
- Space your plants properly to ensure easy maintenance and efficient use of water (taking into account the mature height and spread of the plants). Over-planting not only increases buying and installation costs, but also results in long term maintenance problems, since the plants will get entangled with each other and will compete for water and nutrients.
- Select plants with sizes and forms that allow them to fit in their intended location without the need for extensive and constant shearing and pruning. Some plants are naturally tall and thin, others short and spreading. Also, some are irregular in form and have widely spaced branches, and others are compact in form and have dense foliage.
- Avoid using of too many types of plants. Otherwise, your landscape will lack unity.
- Create water zones by grouping together plants of similar water requirements. This will help you create a water-efficient garden.

Fig. 4.15: In order to increase a garden's efficiency in water consumption, plants with differing water needs should not be grouped together. For example, it is not recommended to group English Ivy (*Hedera helix*), which requires regular irrigation, next to Agaves (*Agave sp.*), which do not require irrigation after establishment.

Plant selection tables:
For lists of drought tolerant as well as water consuming plants, please refer to the manual's appendices.

Chapter 5: Irrigating your water-conserving garden

Topics to be covered in this chapter

I. How much water does a plant need?
II. Types of irrigation systems
III. General considerations for the creation of an effective irrigation system

Definitions

Drip irrigation: a method of watering landscapes in which water is released evenly and slowly through emitters at a constant and specific rate.
Drip line: the line beyond the outer edge of the plant's foliage.
Emitter: a device used in a drip irrigation system to deliver water to a plant's root zone at a constant and specific rate, and at a low volume and pressure.
Establishment period: the length of time needed for plants to clearly show root and foliage growth.
Leaching: the movement of soluble salts or contaminants in the soil below the root zone.
Spray irrigation: a method of watering landscapes using a mechanical device that releases water into the air in a series of droplets approximating rainfall.
Transpiration: loss of moisture from plants through leaves and other parts of the plant.

Introduction

Efficient irrigation practices will provide plants with their water needs without waste. There are many types of irrigation systems that differ greatly in their performance, efficiency, and cost. Properly designed and well-maintained systems save water and promote healthy plant growth. Using a combination of irrigation systems often provides better results than depending on one system.

I. How much water does a plant need?

An irrigation system should provide plants with their water needs, but not more. Yet, it is difficult to accurately calculate the water needs of a given plant, as they are determined by a number of factors that include the following:

1. Climatic factors: part of the water given to a plant is lost to evaporation, and therefore does not reach the plant. The rate of this evaporation is affected by a host of factors, including sun exposure, temperature, humidity, and wind speed.

2. Microclimatic factors: a plant's water needs are also determined by its location. For instance, plants located along southern and western exposures need more water than ones located along eastern exposures; and plants located along northern exposures generally need the least amounts of water. Also, plants located in shady and protected areas usually need less water than those located in the sun or those plants that are exposed to winds.

3. The stage of growth: a young plant will require more frequent irrigation. As the plant matures, it will require more widely spaced but deeper irrigation.

4. The depth of the root system: drought tolerant plants usually have deeper root systems than have water-consuming plants. Also, trees have deeper root systems than shrubs, and shrubs have deeper root systems than have groundcovers.

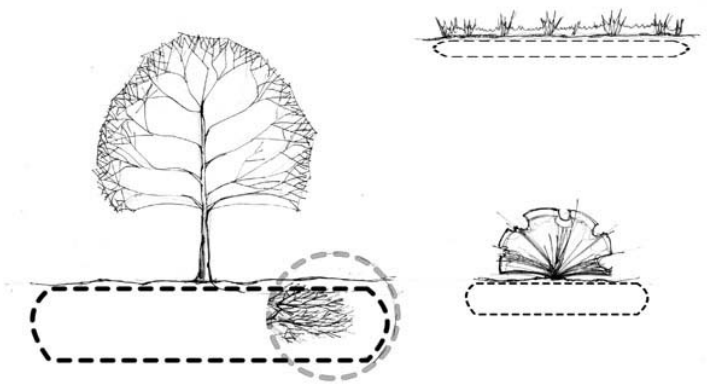


Fig. 5.1: The depth of the root system for trees, shrubs, and ground covers defines the area in the soil from which the plant can draw moisture.

5. Soil composition: soils differ greatly in their ability to store water. Soils that include a mixture of topsoil and organic fertilizers retain moisture well and also provide plants with their nutritional needs. Note that most agricultural soils in Jordan are clay loam and have a higher water holding capacity than have sandy soils. Adding organic materials to your soil mix will further increase its water holding capacity.

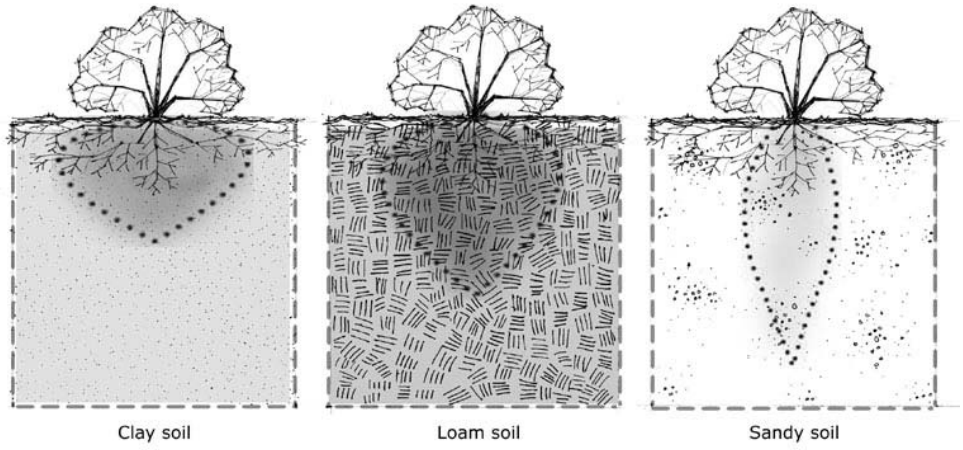


Fig. 5.2: Soil composition determines the soil's ability to store water.

Tips

A good way to identify the rooting depth for a given plant and the moisture of its soil is through using a soil probe or screwdriver. Insert it into the soil after irrigation, and push it until it hits dry soil and stops. This will give you an indication as to how deeply your plants are being watered.

6. Maintenance procedures such as fertilizing and pruning: providing proper maintenance for plants and the soil will result in savings in the amount of water that the plants consume. For more details about maintenance practices refer to chapter 7.

How much water do drought tolerant plants usually need?

Trees need supplemental irrigation to get established, especially if planted after the rainy season: During the first year, a tree needs to be irrigated in the amount of 20 - 25 liters of water two times a week. During its second year, it needs to be irrigated in the amount of 40 liters once a week. Beginning with the third year, when trees usually get established, some trees need to be irrigated in the amount of 50 - 60 liters once a month (e.g. Pomegranates), and some do not require any supplemental irrigation (e.g. Cypresses). Usually, native trees (e.g. Carob) do not need supplemental irrigation. On the other hand, trees with flowers or crops need supplemental irrigation after their establishment to achieve optimal results.

Ornamentals should be irrigated during their establishment period, which may extend to two or three years. After establishment, some require no irrigation (e.g. Agave), and others require irrigation once every week, two weeks, or every month.

II. Types of irrigation systems

1. Hand watering:

- Requires time and effort, but is very simple to use. Needs no maintenance and its initial cost simply consists of the price of the water container.
- Is specially suited for newly planted ornamentals and for selected plants that show signs of stress during the dry season.

Water saving tips for hand watering:

- Build a shallow basin just outside the drip line and apply water slowly in the basin.
- If runoff occurs before the full required amount of water is applied, move on to another spot and come back after the water has soaked in.

Fig. 5.3: Build a basin just outside the plant's drip line, where most of the feeder roots are concentrated.

2. Flood irrigation:

- Provides a continuous layer of water over a fairly level surface of soil. Water is usually applied by using a hose.
- Is easy to implement, and is considered to be the oldest irrigation method, since it is similar in principle to the way in which rain irrigates plants.
- Requires time and effort, but not regular maintenance or high initial cost, because it is manually operated.
- Does not promote healthy plant growth. The excessive amounts of water provided to plants lead to weed growth and to pest problems. Also, flood irrigation might give plants more water than they need and at a faster rate than their ability to absorb it. This results in reducing the drought tolerance of plants.
- Much of the water provided might be lost through evaporation, runoff, or wind distortion.

Fig. 5.4: Irrigation with a hose is the least efficient watering method.

Water saving tips for flood irrigation:
- Flatten the irrigated area and create a ditch around each plant to minimize water runoff.
- To avoid runoff when using a hand-held hose, use a nozzle that divides the spray into rain-size drops. Some nozzles have a built-in spray pattern adjustment.

3. Spray Irrigation:

- Spray irrigation systems range from a single sprinkler attached to a garden hose to a complex system of underground pipes and pop-up spray heads. The latter is more expensive, but more convenient and efficient.
- Does not require much time and effort, but more complex spray systems require constant maintenance and have a relatively high initial cost.
- Applies water uniformly over the desired area with a minimum of over-spray into adjacent areas. It is suitable for irrigating areas of various shapes, whether rectangular or circular.
- Does not encourage the growth of deep root systems, because it wets the soil for continuous periods of time. Consequently, limit its use to plants that have shallow root systems, such as grass.
- Up to a third of the water provided might be lost before it reaches the plant due to wind distortion or evaporation.
- Many types of sprinklers are available. Some are designed for lawns, others for beds of taller plants. Some sprinkler heads are designed for watering irregularly shaped areas.

Water saving tips for spray irrigation:
- Space sprinklers at intervals of about 50% to 60% of their wetting diameter.
- Place the nozzles as close as possible to ground level.
- Place part-circle sprinklers along the boundaries of the irrigated area to avoid over-spray onto buildings and paved areas.
- Make sure that each sprinkler head has the ability to spray free of obstructions, such as trees or tall plants.
- Use an irrigation time clock to control the irrigation program.
- Check lines and faucets for leaks.
- Regularly check sprinkler heads and unclog ones that have distorted patterns.

Measuring water output

You can determine how much water your sprinkler system puts out, by placing identical containers out on your lawn in random positions. Run the system for 15 minutes. Measure the amount of water in each container with a ruler and average the amounts. The containers that only collect 20% or less of the average indicate performance problems, and the sprinkler heads watering these areas need to be relocated.

4. Drip Irrigation:

- Consists of a system of main PVC (polyvinyl chloride) or polyethylene lines carrying water from the water source to specific plants through emitters.
- Is appropriate for irrigating all landscape areas, except for lawns.
- Does not require much time and effort, but requires constant maintenance and a relatively high initial cost.
- Promotes healthy plant growth, controls weed growth, and reduces pest problems, because of the precise water placement that it provides. The slow rate of water output gives the plants adequate time to absorb the water. Drip irrigation also wets a deeper, larger soil area in comparison to other irrigation systems, and thus encourages larger, more drought tolerant root systems.
- Uses 30% to 50% less water than spray systems. This is because very little water is lost to runoff, evaporation, or wind distortion. Consequently, it is most suitable for irrigation in arid areas, as well as in areas characterized by high winds or strong slopes.
- Is flexible. The number and location of emitters on the irrigation pipes, as well as the rate of water output, can be adjusted whenever the need arises.
- It is very easy to retrofit an existing landscape with a drip irrigation system.
- Drip irrigation lines may be placed above the ground, or they can be buried under the soil or mulch, near the plants' root systems to improve appearance and to protect them against sunlight. Placing pipes at a depth of 5 cm below ground will hide the pipes and still show a wet spot on the surface for inspection.
- Emitters can be placed along the irrigation line, wherever water outlets are desired.

Water saving tips for drip irrigation:
- Use a filter to prevent dirt and debris from clogging the emitters. This filter should be placed in the main line before water reaches any of the emitters.
- Place emitters immediately beyond the drip line of the trees to encourage them to expand their roots.
- Consider using a timer to better control the irrigation program.
- Make sure to keep dirt out of the tubing during assembly.

Fig. 5.5: Drip irrigation is the most efficient watering method.

III. General considerations for creating an effective irrigation system

- Place plants with similar water requirements close to each other, so as to irrigate them using the same irrigation line.

- Develop a schedule that trains your plants to consume less water and thus increase their overall drought tolerance. This can be achieved by watering at widely spaced intervals, but with deep applications, so as to encourage root systems to extend deeper into the soil in search of water.

Why should deep root growth be encouraged?

- Deep roots have access to additional sources of water in the soil.
- They are better insulated against extreme temperature swings.
- They provide better anchoring against the wind.

- While trees require generous amounts of water at widely spaced time intervals, plants with shallow root systems such as groundcovers, should be irrigated with smaller amounts of water, at more tightly spaced time intervals. When irrigating, water should reach a soil depth of 50 - 60 cm for trees, 35 - 40 cm for shrubs, and 15 cm for ground covers.

- Irrigate in the early morning when temperatures are lowest and evaporation is minimized.

- Modify your irrigation schedule as the seasons change and your plants grow. During the rainy season for instance, irrigation can be decreased considerably, if not stopped altogether. Also, keep in mind that drought tolerant plants need less water as they mature.

- Leach the soil during the dry season on a monthly basis by doubling up on the irrigation time, in order to carry the salts away from the root zone.

- Apply water more slowly at slopes to allow for better penetration. In general, do not apply water faster than the soil's ability to absorb it.

- Consider the use of moisture-retaining materials to minimize the need for irrigation. These can be placed either on top of the soil or mixed in it. One such material is pumice stone.

Jordan overview

Pumice stone is extracted in Jordan, where it is known as "touf" stone, and can be obtained in various sizes and colors. It contains cavities that hold moisture and also provide breathing space for the soil. Using pumice stone on top of the soil not only saves water, but also can provide an aesthetically pleasing groundcover.

Fig. 5.6: Pumice stone mulch serves to reduce evaporation.

- Carry out a soil test to determine the soil's chemical make-up and moisture-holding ability.

- Select the appropriate irrigation system for the different plants and for the different water-use zones in your landscape. Trees and shrubs in the low water-use area might need supplemental irrigation only during the establishment period. Plants in the moderate water-use zone might require water during periods of limited or no rainfall. Therefore, hand watering might be sufficient for these areas. On the other hand, high water use-zones that require frequent watering may warrant a drip irrigation system.

- Select quality equipment. Spending a little money up-front will save time and money later.

Chapter 6: Mulches

Topics to be covered in this chapter

I. Why is mulching important?
II. Types of mulch
III. Selecting a mulch
IV. Application of mulch

Introduction

Mulching is a highly beneficial landscape practice. Mulches serve various functional uses, while enhancing the aesthetic appeal of your landscape.

I. Why is mulching important?

Mulches are organic or inorganic material applied to a planting bed as a top-dressing to serve a number of purposes. In addition to serving as an aesthetic element in the landscape, mulches play several important roles in a water-conserving garden. These include the following:

- Maintaining moisture levels in the soil.
- Moderating soil temperatures.
- Inhibiting weed growth, thus reducing competition for water amongst plants.
- Reducing soil erosion, compaction, and water run-off.
- Providing a barrier between the plant and the soil, thus successfully controlling soil-borne diseases that might cause plant stress.

Also keep in mind that aside from occasional weed control and top-dressing with additional mulch, unplanted mulched areas require no water and little routine maintenance.

II. Types of mulch

In general terms, mulches can be anything that covers the soil, including ground cover plants. However, mulch usually is divided into two main categories: organic and inorganic.

Fig. 6.1: A combination of both organic and inorganic mulches.

Organic mulches are derived from plants and their byproducts. Examples of organic mulches include the following:

- Pine straw: excellent mulch for water conservation, but flammable when extremely dry. It fades to a dull gray-brown color with age and decomposes quickly, and thus requires replenishment on an annual basis.
- Bark chips: provide a more durable type of mulch, but also require regular replenishment.
- Leaves: an overlooked and readily available mulch, but not as neat or uniform in appearance as pine straw and bark chips.
- Pine cones: an unusual natural looking mulch that provides a decorative look to the landscape. Can be used for potted plants.

Organic mulches

- Organic mulches weather and decompose with time, and therefore are recycled back into the landscape, thus providing the soil with a natural source of nutrients.
- Non-woody organic mulches break down quickly and thus are best used with seasonal plantings, or as temporary cover.
- Some organic mulches easily can be blown away by strong winds.
- The larger the bark chip pieces, the longer they take to decompose.

Inorganic mulches consist of stone, rock, and synthetic products. Examples of inorganic mulches include the following:

- Gravel
- Marble chips
- Crushed stone
- Decomposed granite
- River run rock
- Pumice stone: known locally as 'touf' stone. It retains moisture well because of its highly porous structure.

Inorganic mulches

- Inorganic mulches generally are long lasting, and are available in a wide range of colors and sizes.
- Unlike organic mulches, inorganic mulches do not decompose and therefore cannot be incorporated into the soil, nor do they provide it with any measurable nutrients.
- Some inorganic mulches may absorb and reradiate considerable amounts of heat, thus over-heating the landscape.
- A mulch of shells, pebbles, and sparkling glass nuggets can add a lively touch to potted plants.

Fig. 6.2: Inorganic mulch consisting of river-run rock.

Fig. 6.3: Pumice stone mulch is available in different sizes.

III. Selecting a mulch

- Keep in mind that dark colored mulches retain heat in the landscape, which may result in increased water evaporation. Light colored mulches are highly reflective. This can heat up adjacent structures and result in glare. Often, neutral/beige tones are the most suitable since they reduce glare, heat retention and heat reflection problems.
- Ideally, a mulch should be easy to apply, inexpensive, locally available, aesthetically pleasing, and should last a long time.

- For small areas such as planting beds, organic mulches are best; they include bark chips, compost, and the plant's own leaf litter. Organic mulches are well suited to plants that are naturally found in moist soils, since they preserve moisture in the soil.
- For large areas, inorganic mulches such as river run rock and decomposed granite are very suitable, since they are more permanent. They also serve to reduce the dust coming out of the soil.

IV. Application of mulch

- Spring is usually the best time to apply mulches, as the soil is still damp and has not yet been dried by the summer sun. Apply about 7 - 10 cm of mulch under ornamental plants in the landscape. Avoid applying greater amounts of mulch, because it retains moisture in the upper levels of the soil and therefore encourages shallow roots.
- Once the mulch is in place, pull it away 12 to 20 cm from the trunk of trees and shrubs, to prevent wood rotting diseases.
- Organic mulch should be watered immediately after it is installed, to better bind together its pieces.
- If the mulch is near a path, provide a raised edge or curb to prevent the mulch from spilling onto the path.

Mulch suppliers:

For a list of mulch suppliers in Jordan, see the Suppliers list in the Water Conserving Landscapes section of the CSBE web site (**http://www.csbe.org**).

Chapter 7: Maintaining your water-conserving garden

Topics to be covered in this chapter

I. Maintenance in a water-conserving landscape
II. Using fertilizers
III. Pruning
IV. Weeding and weed control
V. Insect and disease control
VI. Water-saving maintenance practices

Definitions

Bud break: projection on stem of undeveloped shoot, leaf, and/or flower.
Growing season: the period from early spring to late summer when plant growth occurs.
Herbicides: chemical agents used to destroy or inhibit plant growth.
Leaching (of fertilizers)**:** the movement of fertilizers in the soil below the root zone. Leached fertilizers are wasted and might find their way into the groundwater, where they might have adverse environmental effects.
Maintenance: keeping the landscape and plants well cared for and in a healthy condition.
Pesticides: legal poisons that kill plant-infecting organisms by contact or ingestion.
Pruning: cutting off parts or branches of a shrub or tree to improve its shape or growth.
Shearing: the uniform cutting or clipping of plant materials with large scissors or shears.
Slow-release fertilizer: fertilizing materials (natural or synthetic) that require microbial, chemical, and/or physical breakdown to become available to plants.
Water stress: a condition that occurs when a plant's demand for water exceeds the supply.
Weed: aggressive, prolific, exotic species that are opportunistic and grow obstinately in exposed soil.

Introduction

Proper maintenance of your water-conserving landscape is very important to ensure the optimum performance from your garden, but it does not have to be labor-intensive. Gardeners often tend to over-fertilize, over-water, and over-prune in a traditional garden. In your water conserving landscape, keep your plants healthy, but do not encourage new growth at all times. Fertilizing less often and with less fertilizer, pruning lightly when necessary, and irrigating wisely, will help you obtain a beautiful and low-maintenance garden.

I. Maintenance in a water-conserving landscape

By following the instructions and guidelines provided in the previous chapters concerning water conservation in the landscape, you will have a beautiful landscape that not only saves water and money, but also a landscape that requires minimal maintenance. This chapter explains maintenance practices that will help keep your garden in optimum shape.

II. Using fertilizers

Maintaining your water-conserving landscape will result in fertilizing less often, and with less fertilizer -- which will keep your plants healthy but will not encourage new growth at all times. Use fertilizers when you want to encourage growth, but note that this will increase your plants' water-use and pruning requirements.

Fertilizer types

There are two kinds of fertilizers: organic and inorganic.

Organic fertilizers can be natural (i.e. derived from animal and plant sources) or synthetic (i.e. composed of carbon-based structures). Organic fertilizers generally are not soluble in water. Instead, they depend on microorganisms for release, and thus release nutrients more slowly.

Inorganic fertilizers are derived from natural mineral sources. They are highly soluble and release nutrients very quickly, but have a higher fertilizer burn and leaching potential.

- Use inorganic fertilizers on plants showing a nutrient deficiency, because these fertilizers release nutrients rapidly and uniformly. Organic fertilizers release nutrients less uniformly and more slowly, and thus need to be applied less frequently.

- Inorganic fertilizers come in liquid or granular form. Granular fertilizers are also available as slow-release types.

- If available, use fertilizers that provide nitrogen in a slow-release form, such as sulfur-coated urea, urea formaldehyde, IBDU (isobutylene-diurea) or methylene urea. Slow-release type fertilizers generally cost more than soluble all-purpose garden fertilizers, such as an 8-8-8 or 10-10-10 (the percentages in the ratio represent nitrogen, phosphorus, and potassium, respectively); these last longer, since they release nutrients gradually.

Slow-release fertilizers

Slow-release fertilizers derive from natural or synthetic organic, or coated materials. Slow-release sources may require microbial, chemical, and/or physical breakdown. The advantages of slow-release fertilizers are that nutrients are not made available to the plant all at once, thus reducing the risk of fertilizer burn; also fewer applications are needed, therefore reducing the risk of leaching or pollution.

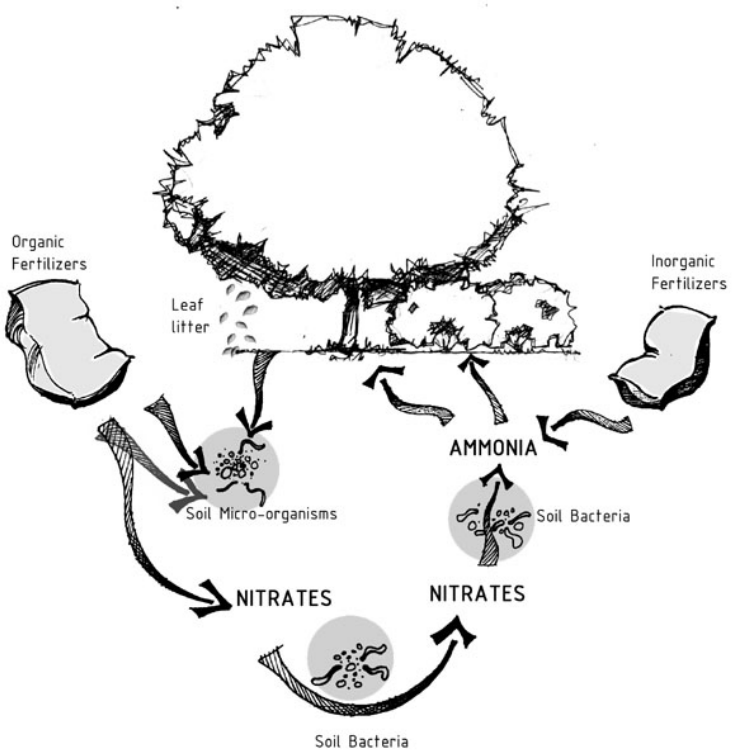


Fig. 7.1: Nitrogen sources for plants.

- Most nurserymen grow specific plants and consequently use a high nitrogen fertilizer. In a water-conserving landscape, however, use a low-nitrogen fertilizer. Nitrogen promotes *rapid* growth – which would be undesirable, because more growth would require more watering. Also, over-fertilization reduces root growth in favor of shoot and leaf growth, thus reducing overall drought resistance. A low nitrogen fertilizer with a 5-10-10 or a 2-10-10 ratio is recommended.

When to fertilize

- Drought tolerant plants usually do not require fertilizers, unless nutrient deficiencies occur.

- In general, most soil is fertile as is the case for trees and shrubs, because mycorrhizae (special fungi that live in and on plant roots) help plants exploit larger volumes of soil. Avoid over-watering, soil compaction, excessive fertilizing, as well as exposure to harmful chemicals and pollution, since all of these may harm the mycorrhizae fungi and other useful microorganisms.

- Every plant part - leaf, flower, fruit, stem, or root - removed from the soil takes some nutrients with it. It therefore is advisable to allow plant residue to remain in the soil and to decompose in place.

- Unless otherwise advised by a professional, fertilizers should not be applied to more mature trees or shrubs.

- Fertilizers replenish soluble salts. If at any time the soil becomes deficient in any one of the numerous minerals (such as nitrates as a source of nitrogen, phosphate as a source of phosphorus, and compounds containing potassium, calcium, iron, magnesium and aluminum), fertilizers can replace them.

- Base the need for fertilizers on plant performance, on visual clues such as lack of vigor, sparse foliage, light green or yellow leaves, twig die-back, gradual slowing of growth, and on a comparison with adjacent plants. Before assuming nutrient deficiency, consider other external environmental effects (such as disease or pollution) that might adversely influence plants.

Nutrient deficiencies

- Both nitrogen and iron deficiencies can produce chlorosis – yellowing of plant tissues.
- Nitrogen deficiency causes the older leaves of the plant to become chlorotic first; new leaves may follow.
- In case of iron deficiency, plant leaf veins remain green, but the rest of the leaf turns yellow. New leaves become chlorotic first, older leaves may follow.

- In the spring, when growth is lush, there is no advantage to forcing growth with fertilizers. If fertilizers are necessary, they should be applied just before new growth begins (late winter and early spring).

<u>General guidelines for fertilizer application</u>

- Fertilize before a scheduled irrigation, not after the soil is already wet; and always irrigate sufficiently when applying fertilizers, as nutrients must be dissolved in water to enter the roots of the plant.

- Watering too deeply can cause nutrients to move below the root zone and result in leaching. Reduce leaching by watering carefully.

- Use discretion when applying any fertilizer. Too much potassium inhibits the uptake of nitrogen and calcium. Too much nitrogen stimulates lush leaf and stem growth, reduces root development, lowers carbohydrate reserves, and increases susceptibility to environmental stresses such as disease. In general, do not use more fertilizer than is recommended.

Watch out!

Fertilizers dissolve in soil water. If too much fertilizer is applied, high salt concentrations outside the plant's roots can cause the plant cell membrane to reverse the flow of water, and this will result in what is known as "physiological drought." "Fertilizer burn" or scorched foliage is the visible symptom of this form of dehydration within the plant.

- Herbicides combined with fertilizers are not recommended, since they can produce a mixture that is harmful to the plants.

- Read and follow the label directions for application rates and guidelines, and do not use more fertilizer than is recommended. However, note that accepting a lower growth rate for your plants can minimize or even supplant the use of fertilizers. Also, once plants are established, reduce the amount of nitrogen applied, as well as the application rate and frequency of application. The application rate that is stated on the fertilizer label is intended for optimum growth, and thus can be reduced after establishment.

III. Pruning

In a water-conserving garden, you don't have to prune as much as you would in a traditional garden. If plants are located in areas with adequate space, the need for regular pruning will be greatly reduced. However, some minor pruning may be necessary at times and can be beneficial to plants if done properly.

When to prune

- Plants should not be pruned immediately after planting, except to remove dead, diseased, or protruding branches.

- Light pruning may be carried out anytime, if proper pruning techniques are followed. For deciduous plants, heavier pruning should be carried out when plants are dormant (after leaf drop in the fall or before bud break in early spring); for evergreen plants, late fall or early spring is best.

- In general, avoid pruning when plants appear stressed or during periods of prolonged heat.

- Pruning stimulates growth, which requires additional water. Therefore, reduce pruning during dry periods.

- Once the landscape is established, you will have to carry out maintenance pruning. Of course, if you select the proper plant for its location and provide it with adequate space, this will greatly reduce the need for pruning, or will even eliminate it.

General guidelines for pruning

- Use plants with a 'free' form. Such shrubs and plants grow as they will – as they would in nature - thus avoiding the need for constant trimming into more formal

shapes. With these looser, more natural shapes, pruning becomes an occasional matter.

- Prune dead twigs or branches; these do nothing for the plant.

- Branches along the lower trunk of trees should be allowed to grow for at least two years before removal, because they encourage strong trunk growth, and protect the tree from sunburn and reduced wind resistance.

- Branches that are rubbing against each other should be trimmed.

Fig. 7.2: Branches rubbing against each other should be removed.

- When pruning trees, retain the strongest branches and remove damaged, weak, crossed, or narrow angled branches. Also, remove shoots growing from the ground or base of the plant (known as suckers).

- Remember that trees should never be stubbed (to cut off or remove the top of the tree), since that will greatly impede their vertical growth.

- Pruning helps rejuvenate an older shrub that no longer flowers.

- Where pruning is needed to encourage dense growth, trim off a terminal bud ("a process known as pinching"). This will encourage lateral branches to sprout, thus promoting the development of a bushier, more compact shrub.

- Many plants eventually will send up long shoots (nurserymen call this getting "leggy"). Such leggy growth should be removed to ensure uniform plant growth.

- If the plant starts to look too thin and woody, trim it back to about a third to a half of its original height. If you ever are in doubt about what to remove, don't remove it.

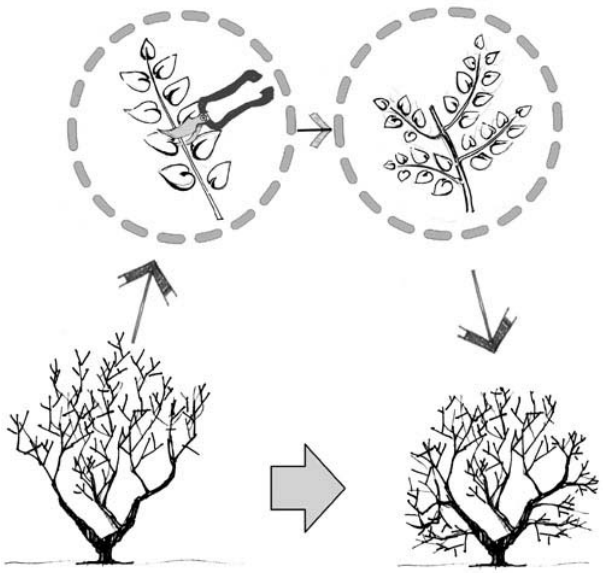


Fig. 7.3: Pinching a terminal bud encourages dense growth in a shrub.

- If shearing or hedging is carried out for shrubs, keep the bottom of the shrub wider in diameter than the top, and thin out some of the branches. This allows greater sunlight to penetrate and encourages internal leaf growth.

- Use the proper pruning tools and makes sure that they are clean, by dipping them in a 10% bleach/water solution between cuts to avoid spreading disease.

Fig. 7.4: A selection of pruning tools.

- Keep your tools sharp, so that they can make a nice cut – normally a slanted cut, at about a 45-degree angle, and above the bud.

- Always make smooth cuts and avoid crushing plant tissues.

- Use a pruning saw for branches that are more than 2.5 cm thick.

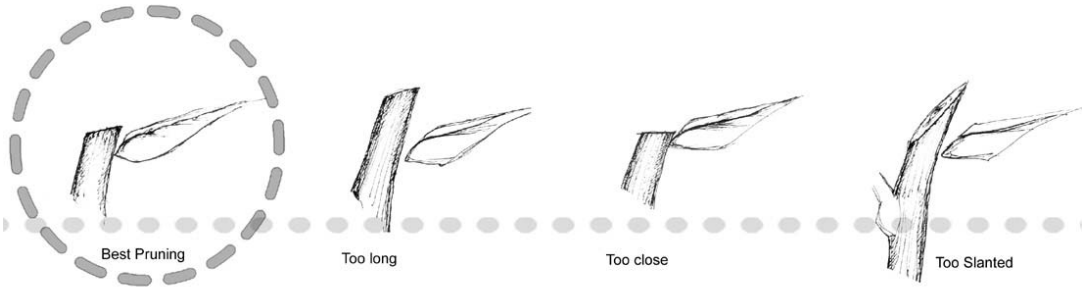


Fig. 7.5: Pruning cuts should be made at a 45-degree angle above the bud.

IV. Weeding and weed control

- When trying to conserve water, keep in mind that any plant out of place can be called a weed, because it is using water and nutrients intended for other plants.

- Eliminate weeds before they set seed, to reduce future weed problems.

- Mulches can reduce weed seed germination by preventing their exposure to sunlight.

- Common ways of removing weeds include hand picking, which is simply to dig up the weeds, either with bare hands or with a hoe. Manual weed removal can be effective when weed populations are low.

- In extreme cases, chemical control through herbicides may be necessary. Herbicides are chemicals that kill plants and can be effective with weeds. However, if you use herbicides you must follow the accompanying label directions carefully.

Beware

Any herbicide that kills weeds can just as easily also damage and kill your desired plants.

V. Insect and disease control

- A pest is any organism that is out of control (weeds, insects, fungi, bacteria, and viruses), and that destroys the health, minimizes the vigor, or ruins the aesthetics of the plants in your landscape.

- Healthy plants have a natural ability to ward off insects and diseases, but urban environments can increase the potential for insect problems in trees and shrubs, due to urban stress conditions. These include extreme temperature and moisture fluctuations, air pollution, and acid rain.

- Shrubs and trees in poor condition are likely to attract insect pests and are susceptible to damage when attacked.

- Incorrect maintenance practices also create plant stress, thus making plants susceptible to insects and disease. To prevent these problems, follow proper planting, pruning, irrigation, and weed control practices.

- Careful diagnosis is a necessary first step for dealing with any problem.

Ask the following questions to help in making a proper diagnosis:

- Is the plant getting enough or too much water?
- Has the plant been over-fertilized or sprayed with pesticides or herbicides?
- Are insects visible on the plant?
- What is the maintenance history of the plant?

- Note the list of symptoms and consult a qualified person to help address the problem.

- Scout for insect and disease pests before you spray. Control pests when they begin affecting the appearance and overall health of a plant.

- Target your control measures to the affected plants and avoid spraying the entire landscape, if the pest problem is confined to a small area.

- Alternative methods of dealing with pests and disease include what is known as the Integrated Pest Management (IPM) program. The basic principle behind IPM is to monitor the plants to see if there is a problem and to determine if and when the infestation has reached an intolerable level. Improving plant health in general often enables the plant to deal with the problem on its own.

Ask the following questions when deciding whether or not to control a pest:

- What part of the plant is being affected? Is it a part that is to be harvested? If so, you should not use a pesticide.
- Can the pest be ignored?
- Is the plant healthy enough to tolerate the damage? Vigorously growing plants can tolerate some leaf loss without permanent damage.
- If the pests are plants, will they seed and become more invasive?
- If the pests are insects, are they young enough or is it early enough in the season for these to potentially cause more injury later on? If this is the case, a more aggressive

response may be necessary. Many times a pest is detected when it is in its terminal stage and about to stop feeding. By then it is too late to do anything that would be of any use.

VI. Water-saving maintenance practices

- Do not let weeds compete with plants for water: scout the landscape regularly and make sure that weeds do not take over. Hand weeding, chemical herbicides, and mulches will help keep weeds in check.

- Make every drop count: where irrigation systems are used, check nozzles and emitters regularly to see if they are operating efficiently and are delivering the right amount of water in the right locations.

- Let your plants tell you when they need water: learn to identify the symptoms shown by plants under water stress.

Water stress symptoms

- Shrubs will turn a gray-green color and wilt.
- Trees will show premature fall color and shed leaves.
- Lawn grass will turn a dull gray-green color, and the blades will wilt and roll inward.

Appendices

Appendix A: High water-use plant table
Appendix B: Tree selection table
Appendix C: Ornamental selection table
Appendix D: Native selection table

Appendix A: High water-use plant table

Botanical name	**Common name**	**Type**
Abies sp.	Fir	Trees
Abutilon sp.	Flowering Maple	Shrubs
Acer sp.	Maple	Trees
Alnus sp.	Alder	Trees
Araucaria sp.	-	Trees
Bauhinia variegate	Orchid Tree	Tree
Begonia sp.	Begonia	Perennials
Betula sp.	Birch	Trees
Buxus sp.	Boxwood	Shrubs
Camellia sp.	Camellia	Shrubs
Catalpa sp.	Catalpa	Trees
Chamaecyparis sp.	False Cypress	Trees
Cornus sp.	Dogwood	Shrubs or trees
Cupressocyparis leylandii	Leyland Cypress	Trees
Dahlia sp.	Dahlia	Perennials
Dianthus sp.	Pink	Perennials, biennials, and annuals
Dichondra micrantha	Ponyfoot Dichondra	Ground cover
Digitalis sp.	Foxglove	Perennials or biennials
Fuchsia sp.		Shrubs
Gardenia sp.	Gardenia	Shrub
Hebe sp.	Hebe (Veronica)	Shrubs
Hedera helix	English Ivy	Vine
Helianthus sp.	Sunflower	Annuals and perennials
Hibiscus rosa-sinensis	Chinese Hibiscus	Shrub
Hydrangea sp.	Hydrangea	Shrubs or vines
Ilex sp.	Holly	Shrubs or trees
Lilium sp.	Lily	Bulbs
Magnolia sp.	Magnolia	Shrubs or trees
Musa sp.	Banana	Perennial (some tree-like in size)
Paeonia sp.	Peony	Perennials or shrubs
Petunia hybrida	Common Garden Petunia	Annual
Populus sp.	Poplar	Trees

Rhododendron sp.	Rhododendron	Shrubs
Rosa sp.	Roses	Shrubs
Salix sp.	Willow	Trees or shrubs
Syringa sp.	Lilac	Shrubs
Thuja orientalis	Oriental Arborvitae	Shrub
Viburnum sp.	Viburnum	Shrubs and small trees
Vinca sp.	Periwinkle	Perennial
Viola sp.	Pansy	Annuals and perennials
Zantedeschia sp.	Calla	Rhizomes**

* These plants will survive on low amounts of water, but require considerable watering to achieve optimal results

** **Rhizome:** a thickened modified stem that grows horizontally or along the soil surface

Appendix B: Tree selection table

***Botanical/* Common name**	**Group**		**Size (height x width) meters**	**Form**								**Special features**			**Color of bloom**								**Flowering months**	**Growth rate**			**Sun exposure**			**Water usage**	
	Evergreen	Deciduous		Fastigate	Columnar	Spreading	Rounded	Pyramidal	Weeping	Picturesque	Palm-like	Edible fruit	Fragrant	Attracts birds	Purple/lilac	Pink	Red	Orange	Yellow	White	Insignificant	None		Slow	Moderate	Fast	Full sun	Partial shad	Shade	No watering once established	Some watering once established
Acacia cyanophylla l Mimosa	x		6x5			x													x				3-4			x	x			x	
Albizia julibrissin l Silk Tree		x	6x8			x										x							5-6			x	x	x			x
Brachychiton populneus l Bottle Tree	x		10-15x6	x																	x		4-6		x		x			x	
Callistemon viminalis l Bottlebrush	x		7x5						x								x						4-5				x				x
Casuarina casuariana / Australian Pine	x		12x7	x																		x	-		x		x			x	
Ceratonia siliqua l Carob	x		8x8				x					x									x		-		x		x			x	
Cersis siliquastrum l Redbud		x	4x4			x										x							3-4		x		x	x		x	
Chamaerops humilis l European Fan Palm	x		3x1.5								x										x		-	x			x				X
Cupressus glabra l Smooth Arizona Cypress	x		10x4	x																		x	-		x		x			x	
Cupressus sempervirensl Italian Cypress	x		10x2		x																	x	-			x	x			x	
Cycas revoluta l Sago Palm	x		2x0.7								x											x	-	x				x	x		X

***Botanical/* Common name**	**Group**		**Size (height x width) meters**	**Form**								**Special features**			**Color of bloom**								**Flowering months**	**Growth rate**			**Sun exposure**			**Water usage**	
	Evergreen	Deciduous		Fastigate	Columnar	Spreading	Rounded	Pyramidal	Weeping	Picturesque	Palm-like	Edible fruit	Fragrant	Attracts birds	Purple/lilac	Pink	Red	Orange	Yellow	White	Insignificant	None		Slow	Moderate	Fast	Full sun	Partial shad	Shade	No watering once established	Some watering once established
Elaeagnus angustifolia l Russian Olive		x	7x6			x							x								x		6-7	x			x	x			x
Ficus carica l Edible Fig		x	8x8							x		x		x							x				x		x			x	
Ficus nitida l Laurel Fig	x		5x5				x														x			x			x	x			x
Grevillea robusta l Silk Oak	x		20x10	x														x	x				5-6			x	x	x			x
Lagerstroemia indica l Crape Myrtle		x	5x4			x									x	x							6-8		x		x	x			x
Ligustrum lucidum l Glossy Privet	x		6x4				x												x				6-7			x	x			x	
Melia azedarach / China-Berry		x	10x8			x										x							4-5		x		x			x	
Olea europaea l Olive	x		6x6				x					x								x			3-5		x		x			x	
Parkinsonia aculeata l Jerusalem Thorn		x	6x6			x													x				3-5			x	x			x	
Phoenix dactylifera l Date Palm	x		15x5								x	x									x			x			x	x			x	
Pinus halepensis l Aleppo Pine	x		18x10	x																		x	-		x		x			x	
Pistacia palaestina l Wild Pistachio		x	4-15x 4-10				x														x				x		x			x	
Punica granatum l Pomegranate		x	5x5				x					x					x						5-6		x		x				x

***Botanical/* Common name**	**Group**		**Size (height x width) meters**	**Form**								**Special features**			**Color of bloom**								**Flowering months**	**Growth rate**			**Sun exposure**			**Water usage**	
	Evergreen	Deciduous		Fastigate	Columnar	Spreading	Rounded	Pyramidal	Weeping	Picturesque	Palm-like	Edible fruit	Fragrant	Attracts birds	Purple/lilac	Pink	Red	Orange	Yellow	White	Insignificant	None		Slow	Moderate	Fast	Full sun	Partial shad	Shade	No watering once established	Some watering once established
Quercus coccifera l Common Oak	x		10x8				x														x			x			x			x	
Schinus molle l Pepper Tree	x		8x8						x										x				6-7			x	x			x	
Sophora japonica l Japanese Pagoda Tree		x	5x5			x														x			6-7		x		x	x		x	
Tamarix aphylla l Tamarisk	x		4x6	x												x							4-6		x		x				x
Ulmus glabra l Scotch Elm		x	15x8			x															x					x	x	x		x	
Washingtonia filifera l Washingtonia	x		15x3								x										x			x			x			x	

Appendix C: Ornamental selection table

Botanical/ Common name	Group		Size (height x width) meters	Texture			Type							Special features			Color of bloom									Flowering months	Growth rate			Sun exposure			Water usage			
	Evergreen	Deciduous		Fine	Medium	Coarse	Tree	Shrub	Vine	Succulent	Ornamental grass	Annual	Perennial	Edible fruit	Fragrant	Attracts butterflies	Blue	Violet/lilac	Pink	Red	Orange	Yellow	White	Insignificant	None		Slow	Moderate	Fast	Full sun	Partial shade	Shade	No watering	Once a month	Twice a month	Once a week
Aeonium arboreum l Schwarzkopf	x		0.6x 0.4			x				x												x				11-1		x		x	x			x		
Agapanthus orientalis / Lily of the Nile	x		0.5x 0.4		x								x				x						x			6-8			x	x	x					x
Agave palmeri l Foxtail Agave	x		1.5x 1			x				x												x				6-7	x			x	x		x			
Alcea rosea l Hollyhock		x	1-2x 4			x							x						x							5-9			x	x						x
Aloe nobilis/ Golden-tooth Aloe	x		0.2x 0.3			x				x											x					4-5		x		x	x		x			
Argyranthemum frutescens/ Marguerite			1x1	x				x															x			5-10			x	x						x
Artemisia arborescens/ Faith Raven	x		1x 0.5	x				x														x				5-6			x	x				x		
Berberis thunbergii / Japanese Barberry		x	1x1		x			x														x		x		4-5		x		x	x			x		
Bougainvillea sp. / Bougainvillea	x		6x 2-3		x				x									x	x		x	x	x			5-10		x		x						x
Buddleia davidii / Butterfly Bush		x	1-2x1		x			x								x		x	x				x			5-10			x	x						x
Campsis radicans/ Trumpet Vine		x	10x 2		x			x	x												x					6-8			x	x						x
Canna indica / Indian-shot	x		1.5x 0.4			x							x							x	x	x				5-10			x	x						x
Carissa macrocarpa / Natal Plum	x		1x1		x			x															x			3-11			x	x	x			x		
Coreopsis auriculata / Coreopsis	x		0.3x 0.3	x									x									X				4-10			x	x						x
Drosanthemum floribundum / Rosea Ice Plant	x		0.05 x0.4	x						x									x							3-4			x	x	x			x		

Botanical/ Common name	Group		Size (height x width) meters	Texture			Type							Special features			Color of bloom									Flowering months	Growth rate			Sun exposure			Water usage			
	Evergreen	Deciduous		Fine	Medium	Coarse	Tree	Shrub	Vine	Succulent	Ornamental grass	Annual	Perennial	Edible fruit	Fragrant	Attracts butterfly	Blue	Violet/lilac	Pink	Red	Orange	Yellow	White	Insignificant	None		Slow	Moderate	Fast	Full sun	Partial shade	Shade	No watering	Once a month	Twice a month	Once a week
Echeveria imbricata / Hen and Chickens	x					x				x									x							5-6		x		x	x			x		
Iris sp. / Bearded Iris	x		0.4x 0.2			x							x					x								4			x	x	x				x	
Juniperus horizontalis / Juniper	x		0.6x 1	x				x																	x	-	x			x					x	
Kalanchoe sp.	x		0.4x 0.4			x				x																11-12		x			x	x		x			
Kniphofia uvaria / Torch Lily	x		0.7x 0.5			x							x								x	x				4-5			x	x				x		
Lantana camara / Lantana	x		1.5x 1.5		x			x								x			x		x	x				5-10			x	x					x	
Lavandula angustifolia / Lavender	x		0.8x 0.80	x				x							x			x								5-6		x		x						x
Leonotis leonurus/ Lion's Ear		x	0.7x 0.7	x				x													x					5-10			x	x	x					x
Myrtus communis/ Myrtle	x		2.5x 1.5	x				x															x			6-8		x		x	x					x
Nerium oleander 'Nana' / Oleander	x		0.7x 0.7		x			x											x				x			6-10		x		x					x	
Pelargonium domesticum / Regal Geranium	x		0.8-0.5			x		x					x						x							5-9			x	x	x				x	
Pennisetum setaceum / Fountain Grass	x		1x 0.7	x																				x		-			x	x	x				x	
Phormium tenax / New Zealand Flax	x		1.5x 1			x							x							X						6-7		x		x					x	
Plumbago capensis / Cape Plumbago	x		3x 1.5		x			x	x																				x	x	x				x	
Rosmarinus officinalis / Rosemary	x		1x 0.7	x				x							x			x								3-5			x	x					x	

Botanical/ Common name	Evergreen	Deciduous		Fine	Medium	Coarse	Tree	Shrub	Vine	Succulent	Ornamental grass	Annual	Perennial	Edible fruit	Fragrant	Attracts butterfly	Blue	Violet/lilac	Pink	Red	Orange	Yellow	White	Insignificant	None		Slow	Moderate	Fast	Full sun	Partial shade	Shade	No watering	Once a month	Twice a month	Once a week
Salvia coccinea / Sage	x		1x 0.7	x				x							x	x				x						6-9			x	x	x				x
Santolina chamaecyparissus / Lavender Cotton	x		0.3x 0.4	x				x														x				5-6			x	x				x	
Senecio cineraria / Dusty Miller	x		0.7x 0.5		x			x					x									x				5-6			x	x				x	
Tecomaria capensis / Cape Honeysuckle	x		8x 2-3		x			x	x											x						6-9		x		x					x
Teucrium fruticans / Bush Germander	x		1x 0.7	x				x										x								5-6		x		x					x
Yucca Aloifolia / Spanish Bayonet	x		4x 1.5			x		x															x			5-6		x		x				x	

Appendix D: Native selection table

***Botanical* / Common name**	**Group**		**Texture**			**Type**						**Special features**			**Color of Bloom**							**Flowering months**	**Sun exposure**		**Water usage**		
	Evergreen	Deciduous	Fine	Medium	Coarse	Shrub	Vine	Flower	Bulb	Annual	Perennial	Edible fruit	Fragrant	Attracts birds and butterflies	Blue	Violet / lilac	Pink	Red	Orange	Yellow	White		Full sun	Part shade	No watering	Once a month	Twice a month
Achillea biebersteinii / Yarrow			x					x			x									x		4-5	x		x		
Adonis palaestina / Palestine Pheasant's Eye			x					x		x								x				3-5	x		x		
Alcea setosa / Hollyhock					x			x			x						x					4-6	x		x		
Anchusa strigosa / Prickly Alkanet			x					x			x				x							5-6	x		x		
Anemone coronaria / Common Anemone			x					x			x							x				2-4	x				x
Anthemis palaestina / Palestine Chamomile			x					x		x											x	5-6	x		x		
Asphodelus aestivus / Asphodel				x					x		x					x						3-5	x		x		
Asphodelus fistulosus / Asphodel				x					x		x						x					3-5	x		x		
Astragalus spinosus / Milk Vetch		x	x			x																3-5	x			x	
Capparis spinosa / Egyptian Caper				x																	x	4-8	x	x	x		

***Botanical* / Common name**	**Group**		**Texture**			**Type**						**Special features**			**Color of Bloom**							**Flowering months**	**Sun exposure**		**Water usage**		
	Evergreen	Deciduous	Fine	Medium	Coarse	Shrub	Vine	Flower	Bulb	Annual	Perennial	Edible fruit	Fragrant	Attracts birds and butterflies	Blue	Violet / lilac	Pink	Red	Orange	Yellow	White		Full sun	Part shade	No watering	Once a month	Twice a month
Chrysanthemum coronarium / Crown Daisy			x					x		x										x		3-5	x			x	
Cistus creticus / Pink Rock-Rose	x			x		x											x					4-6	x		x		
Cistus salviifolius / White Rock-Rose	x			x		x															x	4-6	x		x		
Coridothymus capitatus / Conehead thyme	x		x			x										x						7-8	x		x		
Erodium gruinum / Stroke Bill				x				x			x				x							2-4	x			x	
Euphorbia macroclada / Spurge	x			x		x														x		4-8	x		x		
Ferula communis / Common Giant Fennel			x					x			x									x		3-5	x		x		
Globularia arabica / Arabian Globularia	x		x			x										x						4-5	x		x		
Ixiolirion tataricum / Ixiolirion			x					x			x					x						3-5	x	x	x		
Linum pubescens / Pink Flax			x					x		x							x					3-5	x	x		x	

***Botanical* / Common name**	**Group**		**Texture**			**Type**						**Special features**			**Color of Bloom**							**Flowering months**	**Sun exposure**		**Water usage**		
	Evergreen	Deciduous	Fine	Medium	Coarse	Shrub	Vine	Flower	Bulb	Annual	Perennial	Edible fruit	Fragrant	Attracts birds and butterflies	Blue	Violet / lilac	Pink	Red	Orange	Yellow	White		Full sun	Part shade	No watering	Once a month	Twice a month
Lonicera etrusca / Italian Honeysuckle	x			x			x						x	x							x	4-7	x	x		x	
Lupinus varius / Lupin			x					x		x						x						3-4	x			x	
Malva sylvestris / Common Mallow				x				x		x							x					4-8	x	x		x	
Muscari commutatum / Grape Hyacinth			x						x		x					x						1-3	x	x	x		
Narcissus tazetta / Polyanthus Narcissus				x					x		x										x	12-1	x	x	x		
Notobasis syriaca / Syrian Thistle					x			x		x						x						3-5	x		x		
Ononis natrix / Sticky Restharrow	x		x			x														x		4-9	x		x		
Ranunculus asiaticus / Large Ranunculus			x					x			x							x				2-5	x	x		x	
Retama raetam / White Broom		x	xx			x															x	3-4	x		x		
Sarcopoterium spinosum / Prickly Shrubby Burnet		x				x																3-5	x		x		

***Botanical* / Common name**	**Group**		**Texture**			**Type**						**Special features**			**Color of Bloom**							**Flowering months**	**Sun exposure**		**Water usage**		
	Evergreen	Deciduous	Fine	Medium	Coarse	Shrub	Vine	Flower	Bulb	Annual	Perennial	Edible fruit	Fragrant	Attracts birds and butterflies	Blue	Violet / lilac	Pink	Red	Orange	Yellow	White		Full sun	Part shade	No watering	Once a month	Twice a month
Sternbergia clusiana / Oporanthus				x					x		x									x		9-12	x	x		x	
Tulipa stylosa / Tulip				x					x		x							x				2-4	x	x		x	
Urginea maritima / Squill					x				x		x										x	8-10	x		x		

Glossary

Accent plant: a plant with special characteristics that attracts attention due to its flowering color, leaf texture, height, or form, and usually is used to provide a focal point to a particular grouping of plants.

Annuals: herbaceous plants that complete their growing cycle in a single season and must be planted anew each year.

Border: annuals or perennials developed to form rows or masses placed along a path, or at the edge of a planter.

Bud break: projection on stem of undeveloped shoot, leaf, and/or flower.

Catchment area: is any area from which water can be harvested, such as rooftops, paved areas, and driveways.

Drip irrigation: a method of watering landscapes in which water is released evenly and slowly through emitters at a constant and specific rate.

Drip line: the line beyond the outer edge of the plant's foliage.

Emitter: a device used in a drip irrigation system to deliver water to a plant's root zone at a constant and specific rate, and at a low volume and pressure.

Establishment period: the length of time needed for plants to clearly show root and foliage growth.

Growing season: the period from early spring to late summer when plant growth occurs.

Hardscaping: the inorganic components of the landscape design (paved areas).

Herbaceous plants: nonwoody plants that have flexible, green stems.

Herbicides: chemical agents used to destroy or inhibit plant growth.

Leaching: the movement of soluble salts or contaminants in the soil below the root zone.

Leaching (of fertilizers)**:** the movement of fertilizers in the soil below the root zone. Leached fertilizers are wasted and find their way into the groundwater, where they might have adverse environmental effects.

Maintenance: keeping the landscape and plants well cared for and in a healthy condition.

Microclimates: climates of localized spaces that differ from the overall climate of the area, such as under a tree, or at the top of a hill or in between buildings.

Mulch: organic or inorganic material applied to a planting bed as a top-dressing to serve a number of purposes that include retaining moisture, inhibiting weed growth, controlling erosion, and reducing soil compaction and salt buildup. Mulches also serve as an aesthetic element in the landscape. Typical mulches include compost, bark chips, and inert materials such as decomposed granite and river run rock.

Oasis area: small, highly visible and highly maintained, and lushest area of the landscape - such as the public zone, or area around the patio - that contains high water-use plants. The plants in these zones need to be watered regularly in the absence of rainfall.

Perennials: herbaceous or woody plants that continue to live from year to year.

Pesticides: legal poisons that kill plant-infecting organisms by contact or ingestion.

Pruning: cutting off parts or branches of a shrub or tree to improve shape or growth.

Shearing: the uniform cutting or clipping of plant materials with large scissors or shears.

Slow-release fertilizer: fertilizing materials (natural or synthetic) that require microbial, chemical, and/or physical breakdown to become available to plants.

Softscaping: the planted areas of the landscape.

Specimen tree: a tree with particularly impressive characteristics embodied in its flowers, leaf texture, or form. Specimen trees can be planted alone or in groups, usually in the most important areas of the garden, and generally are installed as mature plants, when their true form and unique, individual character has begun to emerge. Specimen plants tend to be more expensive than plant materials used en masse.

Spray irrigation: a method of watering landscapes using a mechanical device that releases water into the air in a series of droplets approximating rainfall.

Succulent: a plant that stores water in its leaves and stems, and occasionally in its roots. The water-storing part of a succulent is swollen, often greatly so. This attribute creates conspicuous and often striking growth forms, and therefore, most succulents can be used as accents if they are large enough to be readily noticed.

Transpiration: loss of moisture from plants through leaves and other parts of the plant.

Water harvesting: capturing rainfall for use in irrigation and different domestic uses.

Water stress: a condition that occurs when a plant's demand for water exceeds the supply.

Water-use zone: the zoning or grouping of plant materials according to their water needs.

Weed: aggressive, prolific, exotic species that are opportunistic and grow obstinately in exposed soil.

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Web sites:

http://www.csbe.org (Web site of the Center for the Study of the Built Environment. Site includes extensive section on Water Conserving Landscapes.)

http://www.ces.uga.edu/pubs/pdf/B1073.pdf (Web site of the College of Agricultural and Environmental Sciences at the University of Georgia. Site includes a 44-page downloadable guide to developing water-wise landscapes. File is in PDF format.)

http://www.edcmag.com/CDA/ArticleInformation/features/BNP Features Item/0,4120,19385,00.html (Web site of the *Environmental Design and Construction* Magazine. Includes article on rainwater harvesting by Stephen Beers entitled "Sourcing Water from the Sky.")

http://www.environment.gov.jo/wateresources.html (Web site of the Environment Encyclopedia in the Jordanian National Information System. Site includes information on water resources in Jordan.)

http://www.twdb.state.tx.us/publications/reports/RainHarv.pdf (Web site of the Texas Water Development Board. Site includes a 60-page downloadable guide to rainwater harvesting. File is in PDF format.)