Landscaping for Water Conservation

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Cooperative Extension

Salvatore S. Mangiafico, Environmental and Resource Management Agent
Christopher C. Obropta, Extension Specialist in Water Resources
Elaine Rossi-Griffin, Program Coordinator
Caitrín Higgins, Program Associate

Introduction

Despite the fact that New Jersey receives ample rainfall— with average annual precipitation ranging from 38 to 54 inches across the state (NOAA 2002)—there is considerable demand on the state's water resources. With a high population density, highly productive agriculture, and industrial users of water, there is an ever-increasing need to conserve potable water[1] for the benefit of everyone. Excessive drawing from groundwater and surface water sources can deplete aquifers. It also allows for saltwater intrusion in coastal areas and leaves less water available to support wildlife and recreational uses. While precipitation is equally distributed throughout the year on average, variations in weather result in droughts that further tax water resources.

The state continues to see an increase in the amount of potable water used, and a considerable portion of this increase may be attributable to outdoor water use, particularly in summer months. Total freshwater use for New Jersey in 2005 averaged 1,930 million gallons per day, with the largest user being public water supply[2] (USGS 2009). Public water supply combined with domestic well use totaled 1,038 million gallons per day, or about 120 gallons per person per day (Table 1).

While outdoor water use includes recreational uses like filling pools and utility uses like washing vehicles, irrigation of residential landscapes can consume significant quantities of water. As an example, a 10,000 square-foot lawn—which is less than a ¼-acre—watered at an inch per week from May to September, will use 137,000 gallons of water per year. If the cost of this water is $4.60 per thousand gallons[3], the homeowner will spend $630 per year just on this water.

Both public supply and domestic well water are typically potable, so their use for landscape irrigation represents a stress on drinking water supplies. Furthermore, their use diverts water from other beneficial uses such as crop irrigation, recreation, and wildlife habitat.

Luckily, homeowners can decrease their outdoor water use in many ways. Existing landscape plants can be replaced with drought-tolerant alternatives; irrigation systems can utilize smart irrigation technology to irrigate only when soils are dry; stone and mulch can be used for attractive and water conserving landscape features; and rain barrels can be used to catch water for supplementing plant irrigation.

Saving Water, Saving Money

The amount any household will spend on outdoor irrigation can vary greatly. One factor is if the house uses municipal water or water from their own well. Different water companies in the state have different "volume charges" — the rate charged per gallon of water —, and even the same company can charge different rates in different geographical areas.

Likewise, the amount of water a household will use outdoors will depend on what plants they utilize in the landscape and the amount of water the soils can hold. Variations in the amount of rainfall and factors like relative humidity, wind, and temperature also determine the amount of water a landscape will need.

Table 2 presents some estimates of how much water and money can be saved through using more-efficient irrigation, based on a 10,000 square-foot landscape. Since this area is less than a quarter of an acre, these figures would therefore be quadrupled for an acre of landscape.

[1] Potable water is pure enough to be used for drinking. Homes are supplied with potable water from a municipal water system or directly from wells.
[2] "Public supply" is water delivered by a water company or water department to multiple homes or businesses. It could be used for domestic, commercial, or industrial uses. In contrast, "domestic" supply, here, refers to self-supply from privately owned wells, such as a well for a single home.
[3] At the time of writing, this cost is a typical rate for volume charges for public water supply in New Jersey.

RUTGERS
New Jersey Agricultural Experiment Station

Rutgers, The State University of New Jersey
88 Lipman Drive, New Brunswick, NJ 08901-8525
Phone: 848.932.5000

Table 1. Total freshwater withdrawals in New Jersey by water-use category, 2005, in million gallons per day*

Public supply	Domestic (well)	Crop Irrigation	Livestock	Aquaculture	Industrial	Mining	Thermoelectric power	Total
958	80	95	1	9	86	38	663	1930

* Adapted from USGS (2009) Table 2A. Note that figures are for total withdrawals and not for consumptive use. Except for the crop irrigation and livestock categories, consumptive use is typically a relatively small fraction of total withdrawal (Shaffer and Runkle 2007). Water used for landscape irrigation is considered almost entirely consumptive use since most of the water is ultimately lost to evaporation or transpiration.

Table 2. An example of annual savings in water and money for different home lawn and garden irrigation plans for a 10,000 square-foot landscape*

Irrigation plan	Details	Water applied (inches)	Water applied (gallons)	Cost of water
Schedule	1 inch of irrigation per week for 22 weeks	22	137,000	$ 630
Sensored irrigation (dry summer)†	Reference evapotranspiration minus precipitation	10	62,000	290
Sensored irrigation ("typical" year)†	Reference evapotranspiration minus precipitation	7	44,000	200
Zero-irrigation xeriscaping	No irrigation	0	0	0

* Irrigation is assumed from May to September, inclusive. Costs are volume charges only, estimated at $4.60 per thousand gallons.

† "Sensored irrigation" is irrigation scheduled by soil moisture sensors or weather-sensing equipment. Evapotranspiration and precipitation figures are taken from a typical year for a site in central New Jersey (NJDEP 2008), and a year with a dry summer (2010) (NCDC 2011). Actual water used for this method will vary for the plants and soil for the site as well for actual precipitation, and for weather conditions such as humidity, solar radiation, wind, and temperature.

Water Conservation Begins with Good Horticulture

Keeping your landscape plants healthy and happy is an important aspect of having an attractive, water-efficient landscape. Following a few basic guidelines will help ensure healthy, attractive landscape plants:

- Choose plants that thrive in this climate. One tool to help with this is the USDA Plant Hardiness Zone Map.
- Choose plants that thrive in the conditions of your site. This entails first determining if the conditions of your site might be stressful for some plants. For example, if the area is shady or if soils stay wet, finding plants that tolerate these conditions will be important.
- Conduct a soil test to determine the chemical properties of your soil, like pH and phosphorus level. If necessary, amend soils to make them hospitable for your landscape plants.
- Use horticultural information specific to the plants you are growing from reputable sources such as local Cooperative Extension publications and personnel. Along with the other resources mentioned in this publication, good sources of information include the Rutgers Cooperative Extension website (njaes.rutgers.edu/extension/) and eXtension (extension.org/).

Residential properties with significant turf and other high water use landscape areas can consume large amounts of potable water for irrigation, especially in summer months. Photo: Salvatore Mangiafico, Rutgers Cooperative Extension.

The right plant for the climate

For landscape plants to thrive year after year, species and varieties should be chosen that tolerate the local climate. One tool to help with this is the USDA Plant Hardiness Zone Map, which indicates "average annual minimum temperature" and so suggests the degree of cold tolerance required by a plant to thrive in each zone. The zones in New Jersey vary from zone 6a in the northwest of the state, through 6b and 7a for the bulk of the state, and 7b for some areas on the coast and near the Delaware Bay (Fig. 1). Note, though, that elevation, topography, and microclimate can influence the actual coldest temperatures for a specific spot within a zone.

The right plant for the right spot

In order to keep landscape plants thriving, it is important to start with some knowledge about the types of conditions these plants prefer, what stresses they have tolerance for, and how those preferences and tolerances match the conditions of your site.

Some common stresses found in landscapes include:

- low pH, or acidic, soil
- poorly drained, or wet, soil
- sandy and droughty soil
- compacted soil
- low fertility soil – soil low in organic matter or some essential nutrients like nitrogen or potassium

Given limited water resources, water used for landscape irrigation is not available for use in other beneficial uses like agriculture, recreation, and wildlife habitat. Photo: Salvatore Mangiafico, Rutgers Cooperative Extension.

If you determine that any of these conditions exist at your site, one solution is to choose landscape plants that have tolerance for growing in that condition. Alternatively, modifications could be made to the site or the soil to make the site more hospitable for the plants you desire. For example, low pH soils could be limed, compacted soils could be aerated, and droughty soils could be improved with compost or other organic matter.

There are a variety of books and websites on horticulture that are useful for collecting information about the preferences and tolerances of landscape plants you may be interested in. A few sources that may helpful be are given in Table 3, and a list of drought tolerant plants suitable for landscapes in New Jersey is presented in Table 13 at the end of this bulletin.

Figure 1. USDA hardiness zones for New Jersey, indicating the average of lowest winter temperatures for a given location. Note that elevation, topography, and microclimate can influence the actual coldest temperatures for a specific spot within a zone. Reproduced from USDA–ARS (2012). The complete map can be viewed at planthardiness.ars.usda.gov/.

Rutgers Soil Testing Laboratory

Nutrition is critical for plant vitality, and probably the best tool available to determine if plants are receiving proper nutrition is a soil test.

Reasons why soil testing is important include:

- Determining if there is an deficiency or an excess of nutrients
- Saving money on potentially wasted fertilizer and lime
- It is environmentally friendly, since it prevents excess fertilizer application

The basic soil fertility test at the Rutgers Soil Testing Laboratory analyzes the acidity (pH) of the soil and the levels of important macro-nutrients for plants—phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg)—as well as a handful of important micronutrients—including copper (Cu), zinc (Zn), iron (Fe), and boron (B). If you indicate the types of plants being grown, recommendations for lime and fertilizer that should be applied will be included with the results.

Two important principles of plant nutrition:

- Adjusting the pH of the soil according to recommendations is critical for plants to be able to take up nutrients from the soil. If the soil is too acidic or too basic, soil nutrients—even when they are in the soil in high amounts—will be unavailable for plants to use.
- It is also important to remember that plants need all their critical nutrients in sufficient quantities to be healthy—just like people do. For example, if there is a deficiency of calcium in the soil, applying nitrogen or phosphorus fertilizer will not improve the plants' health.

Soil testing every three years is recommended. If there are nutrient or pH problems in your soil, testing every year may be better.

If you are unfamiliar with the physical properties of your soil, you might consider a "soil suitability" or "topsoil evaluation" test that indicates the textural class (whether a soil is a sandy, loamy, or clayey) and the organic matter level in the soil.

It is important to follow the directions for soil sampling, particularly to sample areas with different kinds of plantings separately. For example, areas with rhododendron, azalea, and other acid-loving plants should be sampled separately from turf areas.

Remember that soils tests can only identify problems related to soil acidity and soil nutrients. Plant problems may very likely be caused by other factors like wet soils, insects, plant diseases, or other environmental factors.

For more information and directions on how to soil sample, visit njaes.rutgers.edu/soiltestinglab, or contact the Rutgers Cooperative Extension office in your county, njaes.rutgers.edu/county.

Table 3. A few references with horticultural information for plants for New Jersey. The complete citation for each is given in the *References and Further Reading* section of this bulletin.

Types of plants	Source	Notes
Native plants	Pinto and Melendez (2010). *Incorporating Native Plants in your Residential Landscape*. (http://njaes.rutgers.edu/pubs/publication.asp?pid=FS1140)	Includes preferred moisture, light, and soil conditions for plants.
Turfgrasses	Murphy (1995). *Turfgrass Seed Selection for Home Lawns.* (http://njaes.rutgers.edu/pubs/publication.asp?pid=FS684)	Recommends turfgrass species based on maintenance level, moisture, and light conditions.
Rain garden plants	Obropta et al. (2010). *Rain Garden Manual for New Jersey*. (http://water.rutgers.edu/Rain_Gardens/RGWebsite/rginfo.html)	Lists appropriate plants based on their position in a rain garden, growth form, moisture level, and deer resistance.
Many	USDA–NRCS (2011). *PLANTS Database* website. (http://plants.usda.gov/)	Useful for looking up information on a specific plant. Search by common name or scientific name. Has native status and distribution in the U.S. for many species. Many species include a page of "Characteristics" which include horticultural information like the preferred pH range of the plant and its tolerances for wet or droughty soils.

Native Plants as Part of a Water Conservation Strategy

For New Jersey, plants are considered native plants if they were found in the Northeast or Mid-Atlantic region before European settlement of North America. While a variety of native trees, shrubs, flowering perennials, and other plants are sold for use as landscape plants, many of the plants we traditionally use for landscape plants are not natives. For example, all the turfgrasses commonly used in this region are native to Europe, Asia, or Africa.

Using native plants in landscape plantings is becoming increasingly common in New Jersey. Native plantings may be desirable because they:

- are tolerant of local soils and climate
- may be more drought tolerant, and so conserve water relative to some non-native plantings
- may require fewer inputs of maintenance, fertilizer, and pesticides
- provide habitat and food for local insects, birds, and butterflies
- reflect native landscape identity and local character

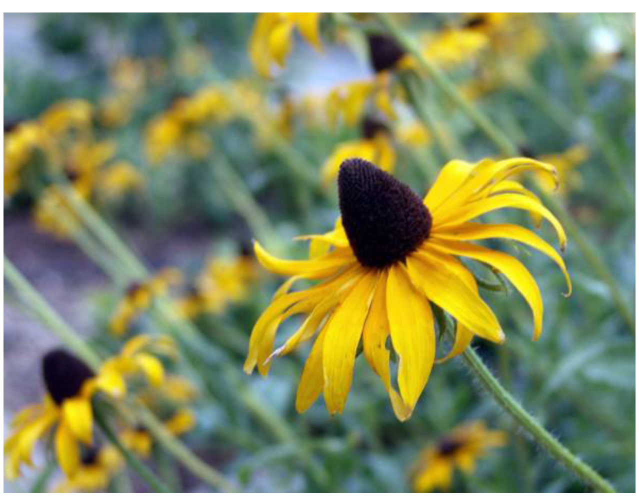
Some available native plants are sold in different varieties and improved cultivars. Improved cultivars are varieties that have been bred to have certain desirable characteristics. For example, they may be dwarf varieties or have attractive flowers or berries. Because of these traits, they are desirable for landscape plantings. However, because these cultivars lack the full genetic diversity of their less-inbred wild ancestors, improved cultivars should be avoided for restoration sites even though they are often appropriate for homeowner landscaping.

While native plantings are generally desirable for their low requirements of water and fertilizer, it is important to remember that different species of native plants have different requirements and tolerances for water, nutrition, and soil conditions, just like non-native plants. Not all native plants will tolerate drought or poor soils. Some are adapted to specific soil and climate conditions, while others are adapted to a much wider range of conditions. When using native plants, it is still necessary to choose plants that are likely to thrive in the conditions of your landscape site.

Table 13 lists drought tolerant plants. Most of those listed are native plants. For a list of plant nurseries that carry native plants in and around New Jersey, see Obropta et al. (2010) or visit the Native Plant Society of New Jersey's webpage on sources for native plants (npsnj.org/sources_native_plants.htm).

Black-eyed Susans and purple coneflowers, two drought-tolerant native flowers. Photo credit: Don Knezick, Pinelands Nursery & Supply, Columbus, NJ.

Butterfly weed, Asclepias tuberosa, is a native plant that attracts butterflies, hummingbirds, bees, and other insects. Photo credit: Elizabeth Boyajian.



Black-eyed Susan, Rudbeckia hirta, is a native plant, and is also the state flower of Maryland. Photo credit: Elizabeth Boyajian.

Eastern purple coneflower, Echinacea purpurea, is native to the eastern United States and Canada. Photo credit: Rutgers Cooperative Extension Water Resources Program.

Irrigation Efficiency

The term "irrigation efficiency" is used to indicate how much of the water applied to plants is being used beneficially. Usually by "beneficial use," we mean water that is used to satisfy the needs of the plants. When thinking about water-conserving landscaping, enough water should be used to keep plants healthy and attractive. Water that is not being used beneficially might include water that is sprayed onto a sidewalk or driveway or leaks from a pipe. Additionally, water that is being applied to plants but is applied in excess is not being used beneficially.

What is Xeriscaping?

Xeriscaping is a term used for landscape practices that reduce or eliminate the need for irrigation. The term is typically used in the arid climates like in the Western U.S., where it invokes scenes of home yards landscaped with cactuses and rock beds. The principles of xeriscaping, though, can be applied equally well to yards in New Jersey. The underlying principle is to use drought tolerant plants that are appropriate for the local climate and non-living landscape features that don't need water.

Advantages of xeriscaping include:

- conserves water
- may require less maintenance and fewer inputs of fertilizers and pesticides
- plants are better able to survive droughts and water restrictions
- allows for the use of native plants
- can result in a more aesthetically interesting landscape and higher home value

Typical practices of xeriscaping include:

- using native and drought tolerant plants
- using mulch, stone, and native rocks
- reducing the area of turf and of plants that require frequent irrigation
- using water-efficient irrigation when necessary

If One Drop is Good, Isn't Two Drops Better?

It is natural to think that if water is necessary for plant health, that applying extra water to plants should be harmless. In fact, overwatering plants not only wastes water, but it can also harm plants. It is a common tendency of people to overwater plants if they are not aware of how much water plants need and the amount of water they are applying. Landscape plants are probably more commonly injured by overwatering than by drought conditions.

Overwatering plants and irrigating too frequently can promote fungal diseases that infect the roots and stems. If the soil drainage isn't ideal, waterlogged soils can lack oxygen necessary for plant root survival. In fact, many plants remain just as healthy and attractive receiving deficit irrigation, which means giving plants less water than they otherwise could use. Mushy soils, moss, mold, fungi, yellowing of leaves, and wilted leaves may be signs of overwatering, though other conditions could also produce these symptoms.

Additionally, overwatering can cause an excess of water moving down through the soil or unnecessary runoff. This water can remove valuable nutrients from the soil and carry them to groundwater or surface waters where they act as pollutants.

In general, it is best to water plants deeply and infrequently, allowing the soil to dry between waterings. However, there are certain cases when more frequent watering is indicated, including:

- hot, dry weather
- sandy soils with low organic matter
- plants that do not tolerate dry soils well
- plants in containers

How Much Water Do Plants Need?

Determining the amount of water plants need in an accurate way is not simple. This is because there are several factors that influence the amount of water that should be applied to plants:

- The amount of evapotranspiration, which is the amount of water taken up by plants from the soil plus the water evaporated from the soil directly. Because weather strongly affects evapotranspiration, it varies greatly by location and season of the year. Weather factors influencing evapotranspiration include: relative humidity, wind, solar incidence, and temperature. Other factors influence the amount of evaporation from the soil, for example if the soil is or is not covered with mulch.
- The amount of precipitation. Simply, the amount of water plants will need from irrigation is decreased by the amount of rainfall. While precipitation amounts are fairly uniform across the year in New Jersey, periods of drought or unusually high rainfall caution against relying on precipitation for plant needs in some cases.
- Plant tolerances. Some plants are much more tolerant of drought and dry soils than other plants.
- Soil factors. Soils vary greatly in their abilities to infiltrate and hold water. As an example, a soil with a low infiltration capacity may not become fully wetted during an intense storm where the rain falls too quickly for the soil to absorb it. On the other hand, a very sandy soil may not hold much water, and so will require more frequent irrigations than one with a larger water holding capacity.

Soil properties that affect irrigation amounts and timings

Soil texture

A soil's texture describes the distribution of the sizes of the mineral particles in the soil: the percentage of sand, silt, and clay particles. The U.S. Department of Agriculture recognizes 12 primary soil textures, with specific names such as sand, sandy loam, loam, and silt loam (NRCS no date). Soil textures are sometimes generalized into the categories: sandy, loamy, or clayey; or light, medium, or heavy (Table 4). Soil texture can be determined by a test from the Rutgers Soil Testing Laboratory (njaes.rutgers.edu/soiltestinglab/services.asp).

A soil's texture affects other physical properties of the soil that are important in determining the amount and frequency of irrigation, including plant-available water holding capacity, infiltration capacity, aeration, drainage, and susceptibility to compaction. Table 5 lists generalized ratings of these properties for some soil textures.

Table 4. Correspondence of general terms for soil textures.

General texture	General texture	Farmers and gardeners
Sandy	Coarse	Light
Loamy	Medium	Medium
Clayey	Fine	Heavy

Table 5. Generalized physical properties of soils of different textures.*

	Sandy soils	Loams	Clayey soils
Plant-available water holding capacity	Low	High	Medium
Infiltration capacity	High	Potentially high	Potentially low
Aeration	High	High	Potentially low
Drainage	Typically high or excessive	Typically high	Potentially low
Susceptibility to compaction	Low	Medium	High

* Note that the physical properties of soils of different textures also depend upon other characteristics of the soil, including soil structure, organic matter content, and compaction. Values in this table are generalizations and do not hold in all cases.

Soil structure

Soil structure describes the way individual sand, silt, and clay particles hold together to form relatively larger aggregates. Soil structure is particularly important for clayey and other fine soils, since those soils with good structure act more like loam soils and can have higher water holding capacity, infiltration capacity, aeration, and better drainage. A soil's structure is improved with the action of growing roots and some soil-dwelling organisms. The structure of many soils can be improved with the addition of organic matter, such as is accomplished by incorporating compost into a soil. Also, clayey soils that are low in calcium should be amended with lime or gypsum according to soil test recommendations to improve their structure.

Plant-available water holding capacity

Different soils hold different amounts of water that is available for plants to use. Precipitation or irrigation in excess of this amount is likely to percolate deeply into soil beyond where plant roots are able to utilize it. A soil's texture, structure, and organic matter content each affect a soil's plant-available water holding capacity. While unstructured clays can hold a large amount of water, much of this water is held too tightly for plant roots to extract, leaving only a moderate amount of plant-available water. Sands with low organic matter contents have a low capacity to hold water.

Table 6 lists general estimates for the amount of plant-available water different soil textures can hold. Values are listed as the inches of water held per foot of soil.

The total water a soil can hold for plants to use is the product of the effective depth of the soil and the water holding capacity from Table 6. The effective depth of the soil is the depth to which the majority of plant roots will be able to take water from the soil. The effective depth may be limited by the depth that the roots naturally extend or by any subsurface layers that limit root penetration or water storage such as bedrock, hard pans, or a change in texture. For example, if there is two feet of loam soil with a plant whose roots can reach down to two feet, the total plant-available water that soil can hold for that plant is

$$2 \text{ feet} \times 1.6 \text{ inches/foot} = 3.2 \text{ inches of water}$$

But if the plant roots reached down only to one foot, the effective soil depth would be only one foot, and the soil would hold only half this amount of water for the plant to use.

The majority of the roots of most landscape plants tend to grow near the surface of the soil. Nominal rooting zones for plants are given in Table 7. However, if you are unsure of the subsurface conditions of the soil or the actual rooting depth of the plant, assuming an effective depth of one foot is usually reasonable.

The amount of plant-available water a soil can hold will affect the frequency and amount of precipitation

[4] In this simplified model, the fact that water may rise upward from below the root zone is ignored.

or irrigation that will be useful to plants. Soils with a low water holding potential are considered droughty and will need to be irrigated more frequently with less water. Soils with a high water holding potential can be watered less frequently and with more water.

Soil infiltration capacity

The infiltration capacity of a soil is the rate at which a soil can take in water. A soil's infiltration capacity is influenced by its texture and structure, and specifically the size and connection of pore spaces in the soil. While there is no accepted evaluation of what is considered a high infiltration capacity, a soil with a rate of greater than about two inches per hour will absorb water during all but the most intense of rain storms. The infiltration capacity affects the rate at which irrigation can be applied—called the precipitation rate for sprinklers—since an application in excess of this capacity is liable to pond or create surface runoff.

Drainage and aeration

How quickly excess water in the soil will drain from the root zone of a soil depends upon the size and connection of the pore spaces in the soil. Soils with large, connected pores will allow excess water to drain relatively quickly and provide good aeration to plant roots. Many plants have difficulty growing in soils that are wet for extended periods, while others tolerate these conditions. Avoiding overwatering poorly drained soils is particularly important. It should be noted, though, that some soils are poorly drained based on their place in the topographic landscape: given certain conditions, soils at the bottom of slopes or in kettles are likely to be wetlands regardless of the physical characteristics of the soils. Likewise, dense layers below the topsoil may reduce the rate at which excess water drains.

Susceptibility to compaction

Compacted soils are likely to have small pore spaces that hold limited water and air. Clayey soils are susceptible to having their structure degraded if they receive traffic when wet or are worked when wet (Mangiafico 2011). Compacted soils make a difficult environment for many plants to grow since aeration is poor. Considering irrigation, compacted soils may have low infiltration capacities and low plant-available water.

Table 6. Generalized plant-available water holding capacity of soils of different textures.*

Texture	Plant-available water holding capacity (inches of water per foot of soil)
Sand	0.5
Sandy loam	1.2
Loam	1.6
Silt loam	2.3
Clay loam	1.5
Clay	1.0

* Note that the plant-available water holding capacity of soils of different textures depend upon other characteristics of the soil, including soil structure, organic matter content, and compaction. Values in this table are generalizations and do not hold in all cases.

Table 7. Nominal rooting depth of landscape plants.*

Texture	Root depth (feet)
Turf	1.0
Ground cover	1.0
Vegetable	1.0
Flowers	1.0
Shrubs	1.5
Trees	2.0

* Values indicate the maximum depth where the majority of plant roots are found. Values in this table are generalizations and do not hold in all cases. Also note that the actual depth that plant roots may be limited by bedrock, hardpan, abrupt changes in the texture or chemical properties of the soil.

A hand-held penetrometer being used for precise measurements of soil compaction in a rain garden. The device is about three feet tall and has a dial on the top that reports soil strength in pounds per square inch. Photo credit: Rutgers Cooperative Extension Water Resources Program.

Determining the amount of irrigation plants need

The precise timing and scheduling of irrigation involves answering two questions: How much to water plants, and how often to water plants. The answers to the two questions are related: during dry, hot weather, plants may need to be irrigated both more often and with more water. But the two answers are sometimes inversely related: given the same weather conditions and plants, soils with a higher water holding capacity can be watered less often with more water, while soils with a lower water holding capacity will need to be watered more often but with less water.

A water-balance approach

One simple approach to determine when and how much to water plants is to think of the soil as a reservoir of water available for plants (Fig. 2, page 14). In this approach, the major pathway by which soil water is depleted is by evapotranspiration. Evapotranspiration is the amount of water taken up and transpired by plants along with any evaporation from the soil. Water is added to the soil by either precipitation or irrigation, and the plant available soil water is the balance of these additions or subtractions. One complication, though, is that if water is added to the soil in excess of its soil water holding capacity, any excess drains out of the plant root zone[5].

Determining the water holding capacity and excess drainage

Table 7 gives the nominal rooting depth of landscape plants. While there is plenty of variation depending on plant species, soil conditions, and irrigation schedule, most herbaceous plants have a majority of their roots within the top foot of soil. It is therefore usually assumed that the effective rooting depth of the soil is one foot, especially since the conditions of the subsoil may not be known. This way, the values from Table 6 can be used for the value for available water holding capacity for the soil. In the water-balance approach, water in the soil in excess of this value can be assumed to be lost to excess drainage.

Determining evapotranspiration

Actual evapotranspiration is affected by weather—particularly humidity, temperature, and wind—, the plants grown, soil coverings like mulch, and the available water in the soil. Table 8 gives average weekly values for reference evapotranspiration for a few locations in and around New Jersey. Reference evapotranspiration is a technical term that approximates how much water a cool-season turfgrass would use under certain conditions. Assuming the weather of an average year, peak evapotranspiration in New Jersey occurs in July, and is between 1 and 1-½ inches per week. Reference evapotranspiration is usually abbreviated ETo.

The actual evapotranspiration occurring at a site can be determined with fairly complicated weather-measuring instruments, or by using a standard water pan and measuring how quickly the water evaporates. Alternately, a relatively simple device called an atmometer measures evaporation through a filter to estimate plant transpiration. These approaches are sometimes justified in agricultural situations.

For homeowners, actual local evapotranspiration can be found on a website hosted by United Water for sites in Haworth, NJ; Toms River, NJ; West Nyack, NY; and Wilmington, DE (unitedwater.com/et-lawn-water.aspx).

[5] In reality, there are other fluxes of water into and out of the plant root zone—for example, water draining below the root zone may move up again as the root zone dries; and water might move laterally from upslope—but these can be ignored in this simple model.

Determining precipitation

Precipitation can be easily obtained by use of a rain gauge on site or by following local weather reports. Table 9 lists average weekly values for precipitation for locations around New Jersey. While average precipitation is fairly uniform across months in New Jersey, it should be remembered that droughts and periods of unusually wet weather are common.

Irrigation timing

In general, applying necessary irrigation water once per week will satisfy landscape needs while watering deeply. However, soil texture and effective soil depth may also need to be taken into consideration for determining irrigation frequency. Most of the soil textures listed in Table 6 will hold at least enough water in one foot of soil to replace evapotranspiration for a week. It should be noted, though, that pure clay soils and sandy loams may need split applications of water during the hottest part of the year if no rain supplements soil water. Likewise, pure sand soils may need split applications whenever irrigation is needed.

Another consideration for determining irrigation timing is that many municipalities throughout the state have adopted water ordinances restricting outdoor irrigation. Local ordinances typically have restrictions on the time of day or day of week that lawns can be watered. As the summer months approach, it is advisable to check with the municipality to verify that the irrigation schedule complies with local laws.

A small rain gauge installed in the Rutgers Cooperative Extension Water Resources Program demonstration rain garden in New Brunswick, NJ. Photo credit: Jillian Thompson, Rutgers Cooperative Extension Water Resources Program.

Plant water needs for specific plants

Whatever approach is used to determine irrigation needs, it should be remembered that not all landscape plants need as much water as is indicated by reference evapotranspiration values. Some plants may do well receiving this full value of water, while other plants do just as well with watering significantly below this value.

The percentage of reference evapotranspiration that plants use or need is called the plant factor (PF), species factor, or crop coefficient (Kc). Precisely determining the plant factor for landscape plants is not an easy task. In the western U.S. and in other places where water resources are limited, scientific studies have been conducted to determine the most efficient way to irrigate agricultural crops to maximize their crop yield. However, these studies may not be very useful for our landscape plantings, since the plants are different, and our landscapes are often planted with a heterogeneous mix of trees, shrubs, herbaceous plants, and mulches. The usefulness of these studies for New Jersey landscapes is further brought into question since the climate in which these studies were conducted is different from that of New Jersey. Landscape plants, furthermore, are assessed according to their appearance and function, not according to crop yield like agricultural plants.

Table 10 lists generalized plant factors for different categories of landscape plants. It is apparent from these values, however, that within any category of landscape plants, different species have quite different water needs. It is also apparent from the low values in the range of plant factor values given that drought tolerant trees, shrubs, and groundcovers need relatively little water. Table 13 lists some native and non-native plants that are drought tolerant. In general, a comprehensive list of plant factors for landscape plants in New Jersey has not been developed.

Plant factors for turfgrasses have been determined to larger extent than for other landscape plants. Table 11 lists typical values for plant factors for turfgrasses commonly used in New Jersey.

Table 8. Average weekly reference evapotranspiration values (ETo) for locations around New Jersey.*
Note that because evapotranspiration depends upon humidity, temperature, wind, and solar radiation, values in table may not be indicative of actual ETo for a given year.

	Apr.	May	June	July	Aug.	Sep.	Oct.	Sum for Apr.–Oct.
	inches / week							inches
Bear Creek, PA	0.8†	1.0	1.1	1.2	1.0	0.7	0.5†	23.6†
Manhattan, NY	0.8	0.9	1.1	1.4	1.1	0.7	0.5	25.5
Mineola, NY	0.9	1.1	1.3	1.4	1.2	1.0	0.7	29.8
New Brunswick, NJ	0.8†	1.0	1.2	1.5	1.3	0.8	0.5	28.3†
Newark, DE	0.7†	0.9	1.1	1.2	1.0	0.7	0.5†	23.9†
Pleasantville, NJ	0.8	1.0	1.1	1.2	1.0	0.7	0.5	24.3
Runyon, NJ	0.7†	0.9	1.0	1.0	0.9	0.8	0.5	22.2†
Summit, NJ	0.7	0.9	0.9	1.0	0.8	0.6	0.4	20.4

* Adapted from NOAA (1982). Values from available evaporation pan data from 1952–1981. Data converted to ETo values with a pan constant of 0.8 (FAO, 1998).
† Value for April or October estimated using values for other sites.

Table 9. Average weekly rainfall for select locations in New Jersey.*

	Apr.	May	June	July	Aug.	Sep.	Oct.	Sum for Apr.–Oct.
	inches / week							inches
Atlantic City (marina)	0.7	0.7	0.6	0.8	0.9	0.7	0.6	22.2
Audubon	0.9	1.0	0.9	1.0	1.0	1.0	0.7	28.5
Belvidere	0.9	1.0	1.0	1.0	0.8	1.0	0.8	28.5
Cape May	0.8	0.8	0.7	0.8	0.9	0.8	0.8	23.8
Millville	0.8	0.9	0.8	0.8	1.0	0.8	0.7	25.2
Morris Plains	1.1	1.2	1.0	1.2	1.0	1.2	0.9	33.3
New Brunswick	1.0	1.0	0.9	1.1	1.0	1.0	0.8	29.9
Sandy Hook	0.9	0.9	0.8	0.9	0.9	0.8	0.8	26.1
Somerville	0.9	1.0	0.9	1.0	1.0	1.1	0.8	29.6
Sussex	1.0	1.0	1.1	0.9	0.9	1.0	0.8	30.0
Toms River	0.9	0.9	0.8	1.0	1.1	0.9	0.8	28.9
Wanaque	1.0	1.0	1.0	1.0	0.9	1.1	0.8	29.8

* Adapted from NOAA (2002). Data are from 1971–2000. Note that local areas may receive more or less rain than indicated. Note that annual variations include periods of droughts or unusually wet weather, so that the indicated rainfall may not estimate actual rainfall for any given year.

Table 10. Plant factors, or species factors, for landscape plants*.

Vegetation type	Plant factor range	Plant factor as a percentage
Trees	0.2–0.9	20–90%
Shrubs	0.2–0.7	20–70%
Groundcovers	0.2–0.7	20–70%
Turf	0.6–0.8	60–80%

* Adapted from USGBC (2008). Plant factors or classifications for specific landscape species can be gleaned from Costello and Jones (1994), Pittenger et al. (2001), Fu (2003), St. Hilaire et al. (2008), or Romero and Dukes (2009). However, values and classifications should be interpreted cautiously as they were determined in studies in climates different from that of New Jersey or may not be research-based.

Table 11. Plant factors, or species factors, for turfgrasses*.

Turfgrass species	Plant factor range	Plant factor as a percentage
Fine-leafed fescues	0.8–1.0	80–100%
Kentucky bluegrass	0.7–1.0	70–100%
Perennial ryegrass	0.7	70%
Tall fescue	0.6–0.8	60–80%
Zoysiagrass	0.8	80%

* Compiled from Fu (2003) and Romero and Dukes (2009). Values and classifications should be interpreted cautiously as they may have been determined from climates different from that of New Jersey.

Using the water balance approach

If reasonable estimates for each component in the water balance approach were known, the amount of water available in the soil for plants could be tracked in the same manner as keeping track of the balance in a checkbook. In agricultural situations where crops are valuable and water is expensive, this approach is sometimes used. For homeowners and landscape managers, however, following this approach with such precision is probably unwarranted.

Instead, the essential principles of the approach could be followed to irrigate landscapes relatively efficiently:

- The approximate irrigation needed can be estimated by subtracting weekly precipitation from weekly reference evapotranspiration. Average values from Tables 8 and 9 could be used, and values could be adjusted for current weather conditions. Alternatively, more accurate values from local rain gauges or websites could be used.
- Irrigation should not be applied in excess of the soil water holding capacity, listed in Table 6, and assuming an effective soil depth of one foot. This may require splitting applications of water or delaying watering after a small rain for soils with low water holding capacity.
- This approach assumes plants will need as much water as cool season lawn. Drought tolerant plants may need less than the full amount indicated by reference evapotranspiration.

Figure 3 shows an average weekly water deficit for New Brunswick, NJ. Assuming average evapotranspiration and precipitation, a water deficit occurs in June, July, and August of between 0.3 and 0.4 inches per week.

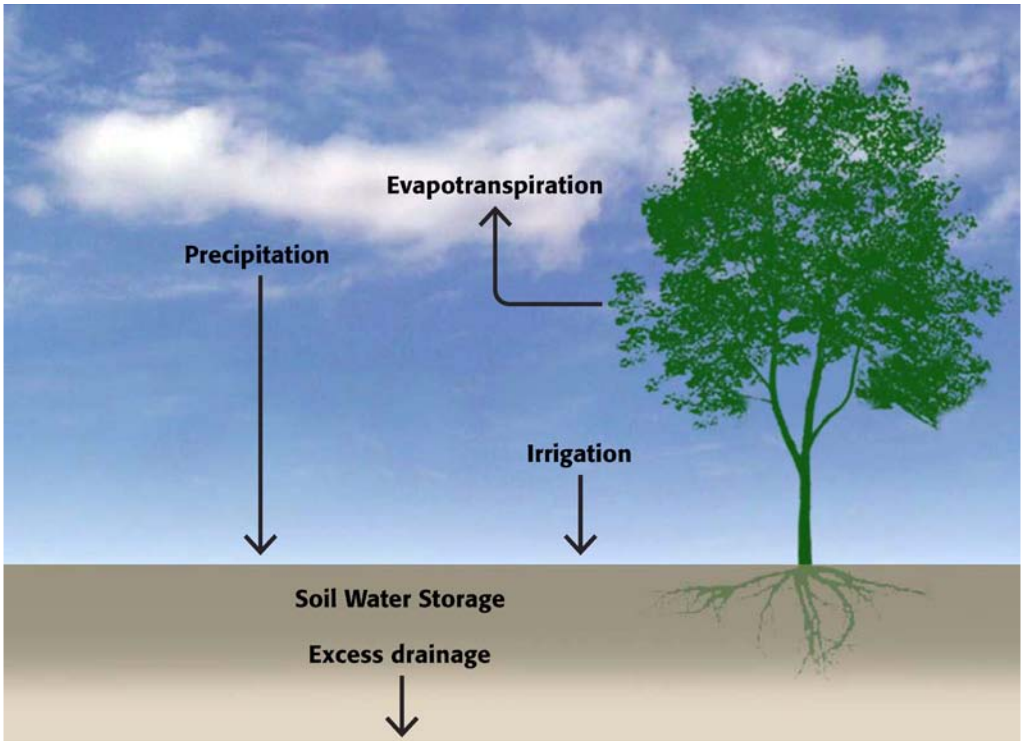


Figure 2. A simplified representation of a water balance for plant available water held in the soil. Figure by Caitrín Higgins.

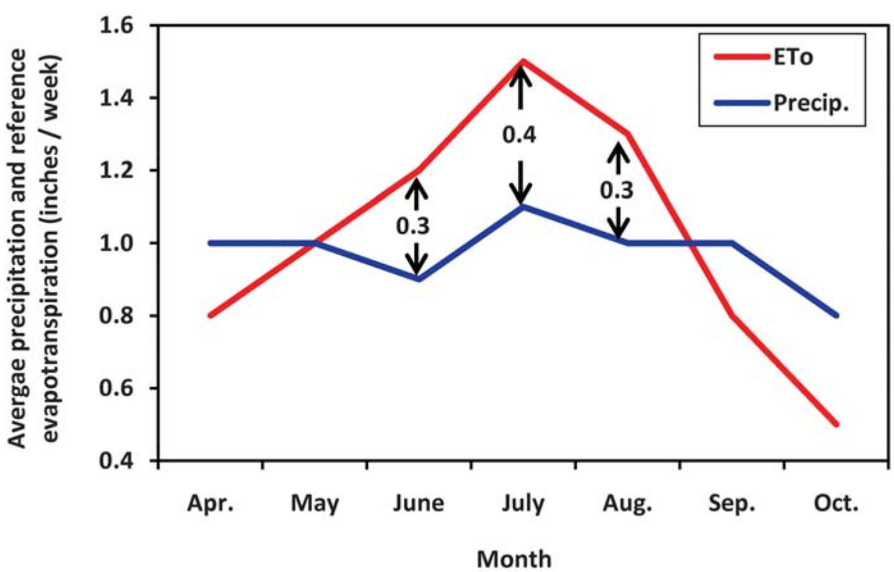


Figure 3. Average weekly precipitation (Precip.) and reference evapotranspiration (ETo) for New Brunswick, NJ. During the summer months, average evapotranspiration exceeds precipitation by 0.3 inches per week in June and August, and 0.4 inches per week in July. Total irrigation deficit for June, July, and August is 4.2 inches. Note that annual variations in weather include variations in evapotranspiration and precipitation, so that this data may not be indicative of actual conditions for any given year. Data from NOAA (1982), FAO (1998), and NOAA (2002).

Example 1 – Simple

Crop:	Generic groundcover
Location:	New Brunswick
Soil:	Sandy loam
Month:	May
Rain this week:	0.6 inches

Step 1: Determine rooting depth of the plants

» Look up on Table 7, Groundcover

Rooting depth = 1 foot

Step 2: Determine plant water need

» Look up on Table 8, New Brunswick, May

Reference evapotranspiration (ETo) = 1 inch per week

» Adjust this value for recent weather, if known

» For this example, assume generic groundcover is not drought-tolerant, so plant need equals *ETo*.

Plant Need (PN) = 1 inch per week in May

Step 3: Subtract weekly precipitation

» Use rain gauge or local weather

Rain this week (ppt) = 0.6 inches

» Subtract *ppt* from *PN* to determine irrigation deficit

Irrigation deficit (ID) = 0.4 inches

Step 4: Determine water-holding capacity of soil

» Look up on Table 6, Sandy loam

Water holding capacity (WHC) = 1.2 inches in top foot of soil

Step 5: Determine amount of irrigation to apply

» Because *WHC* is greater than (*ppt* + *ID*), assume the soil can hold both the rainfall and irrigation

Irrigation to apply = 0.4 inches this week

Example 2 – Split irrigation applications on sand soil

Crop:	Flowers
Location:	New Brunswick
Soil:	Sand
Month:	July
Rain this week:	0.5 inches

Step 1: Determine rooting depth of the plants
- » Look up on Table 7, Flowers

Rooting depth = 1 foot

Step 2: Determine plant water need
- » Look up on Table 8, New Brunswick, July
  Reference evapotranspiration (*ETo*) = 1.5 inch per week
- » Adjust this value for recent weather, if known
- » For this example, assume flowers are not drought-tolerant, so plant need equals *ETo*.

Plant Need (PN) = 1.5 inch per week in July

Step 3: Subtract weekly precipitation
- » Use rain gauge or local weather

Rain this week (ppt) = 0.5 inches

- » Subtract *ppt* from *PN* to determine irrigation deficit

Irrigation deficit (ID) = 1.0 inches

Step 4: Determine water-holding capacity of soil
- » Look up on Table 6, Sand

Water holding capacity (WHC) = 0.5 inches in top foot of soil

Step 5: Determine amount of irrigation to apply
- » Since *WHC* = *ppt*,
  if it just rained, the top foot of soil is at its water-holding capacity
- » Since *Plant Need* is about 0.2 inches per day,

Wait 2 or 3 days after rain, then apply 0.5 inches
Then wait 2 or 3 more days, and apply 0.5 inches
For a total of 1.0 inches, which is the ID for the week.

Example 3 – A drought-tolerant planting requires less water

Crop:	Native wild flowers: black-eyed Susan, false indigo, butterfly weed (*Rudbeckia hirta*, *Baptisia australis*, *Asclepias tuberosa*)
Location:	New Brunswick
Soil:	Sandy loam
Month:	July
Rain this week:	0.5 inches

Step 1: Determine rooting depth of the plants

» Look up on Table 7, Flowers

Rooting depth = 1 foot

Step 2: Determine plant water need

» Look up on Table 8, New Brunswick, July

Reference evapotranspiration (ETo) = 1.5 inch per week

» Adjust this value for recent weather, if known

» Find these plants in Table of Drought Tolerant Plants at the end of this publication

» Look up drought-tolerance of these plants in PLANTS Database (http://plants.usda.gov/), or other source

Drought tolerance = medium to high

» Look up Table 10 for Species Factor for plants
Use range for Ground Covers or Shrubs, since flowers not specified
Pick a medium-to-small value to match medium-to-high drought tolerance

Species Factor (SF) = 0.45

» Multiply *ETo* x *SF* to determine Plant Need

Plant need (PN) = 0.675 inch per week in July

Step 3: Subtract weekly precipitation

» Use rain gauge or local weather

Rain this week (ppt) = 0.5 inches

» Subtract *ppt* from *PN* to determine irrigation deficit

Irrigation deficit (ID) = 0.175 inches

Step 4: Determine water-holding capacity of soil

» Look up on Table 6, Sandy loam

Water holding capacity (WHC) = 1.2 inches in top foot of soil

Step 5: Determine amount of irrigation to apply

» Because *WHC* is greater than (*ppt* + *ID*), assume the soil can hold both the rainfall and irrigation

Irrigation to apply = 0.175 inches this week

Example 4 – Excess rainfall in one week decreases irrigation need for next week

Crop:	Generic groundcover
Location:	New Brunswick
Soil:	Silt loam
Month:	May
Rain this week:	2.0 inches

Step 1: Determine rooting depth of the plants

» Look up on Table 7, Groundcover

Rooting depth = 1 foot

Step 2: Determine plant water need

» Look up on Table 8, New Brunswick, May

Reference evapotranspiration (ETo) = 1 inch per week

» Adjust this value for recent weather, if known

» For this example, assume generic groundcover is not drought-tolerant, so plant need equals *ETo*.

Plant Need (PN) = 1 inch per week in May

Step 3: Subtract weekly precipitation

» Use rain gauge or local weather

Rain this week (ppt) = 2.0 inches

» Subtract *ppt* from *PN* to determine irrigation deficit

Irrigation deficit (ID) = – 1.0 inches

So, excess precipitation (EP) = – 1.0 x ***ID = 1.0 inches***

Step 4: Determine water-holding capacity of soil

» Look up on Table 6, Silt loam

Water holding capacity (WHC) = 2.3 inches in top foot of soil

» Since *WHC* is greater than *ppt*,

The soil can hold the entire rainfall

» So, the water left in soil for the next week = *EP*

Water held by soil for next week = 1.0 inch

And, apply no irrigation this week

Example 5 – Excess rainfall in one week drains below root zone

Crop:	Generic groundcover
Location:	New Brunswick
Soil:	Sandy loam
Month:	May
Rain this week:	2.0 inches

Step 1: Determine rooting depth of the plants

» Look up on Table 7, Groundcover

Rooting depth = 1 foot

Step 2: Determine plant water need

» Look up on Table 8, New Brunswick, May

Reference evapotranspiration (ETo) = 1 inch per week

» Adjust this value for recent weather, if known

» For this example, assume generic groundcover is not drought-tolerant, so plant need equals *ETo*.

Plant Need (PN) = 1 inch per week in May

Step 3: Subtract weekly precipitation

» Use rain gauge or local weather

Rain this week (ppt) = 2.0 inches

» Subtract *ppt* from *PN* to determine irrigation deficit

Irrigation deficit (ID) = – 1.0 inches

So, excess precipitation (EP) = – 1.0 x ID = 1.0 inches

Step 4: Determine water-holding capacity of soil

» Look up on Table 6, Sandy loam

Water holding capacity (WHC) = 1.2 inches in top foot of soil

» Since *WHC* is less than than *ppt*,

The soil cannot hold the entire rainfall

» So, water lost to drainage = *ppt – WHC*

Water lost to drainage (LD) = 0.8 inch*

» So, water held by soil for next week =*ppt – LD – PN*

Water held by soil for next week = 0.2 inch

And, apply no irrigation this week

————————————

* In most cases, plants will be able to recover some of this drained water from underlying soil layers. This example assumes instead that that water is lost.

Determining the applied amount of irrigation

When irrigation is used in a water-conserving landscape, it is critical to know the amount of water applied by the irrigation system, whether it is an automated and designed system or a hand-held hose.

- Precipitation rate. The amount of water delivered by an irrigation system in a given time period is usually called the precipitation rate of the system. For sprinklers the rate is usually expressed in inches/hour. For micro-irrigation emitters like drip stakes, bubblers, and micro-sprinklers, precipitation rate is usually expressed in gallons/hour. Once the precipitation rate for a zone is known, adjustments to the amount of water the irrigation system delivers can be accomplished with proportional changes in the time the system runs.
- Measuring the amount of irrigation. Determining the amount of water delivered by an irrigation system can be done by simply measuring the amount of water the system will deliver into shallow straight-sided cans (such an empty tuna can) placed on the ground. Typical recommendations are to set out at least six cans in an irrigation zone. The system is then run normally until a measurable amount of water is collected in each can, at least ¼ to ½ inch. The depth of water in the cans can be measured with a ruler, and the amount of water the system delivers in inches is simply the depth of the water in the can. The precipitation rate can then be calculated by dividing the water depth by the time the system ran, as long as the time is expressed in hours.
- Using manufacturer's data. The amount of water an irrigation system delivers can also be estimated from data published by the sprinkler manufacturer. A sprinkler's precipitation rate varies with changes in line pressure and the spacing of the sprinklers, so both must be known to look up the correct value. Furthermore, the model name and nozzle number for the sprinklers must be known.

Determining Soil Water Content

A different approach to determine how much water landscapes may need is to monitor the amount of water in the soil at a given time, thereby determining how dry the soil is. The amount of water held by the soil can be determined accurately with a variety of scientific instruments, some of which can be employed in smart irrigation controllers to schedule irrigations only when the soil is sufficiently dry. (This is discussed in the section on Water Conserving Irrigation Technology, page 21.)

Soil moisture can also be estimated by visual inspection or feel. While this method is technologically simple, it requires experience since different textures will have a different feel at different water contents. Details on assessing the water content of soils by feel can be found in Storlie (1992). A soil probe may be useful for extracting a soil core from the root zone for inspection by this method.

A soil probe can be handy to sample soil to determine how moist it is, as well as for extracting cores from the root zone for soil testing.
Photo credit: Rutgers Cooperative Extension Water Resources Program.

Water Conserving Irrigation Technology

Smart Water Application Technology, or SWAT, may help homeowners and landscape irrigators better manage water use, and thereby maintain lawns and gardens without overwatering. SWAT irrigation systems rely on controllers that automatically calculate and deliver the needed amount of water. While they may require initial professional installation and calibration, SWAT controllers are designed to be relatively simple enough to use for those without a technical background in horticulture or experience with irrigation controllers.

These technologies are based either on weather-sensing controllers or soil-moisture controllers. Weather sensing controllers rely on sensors that estimate evapotranspiration either from onsite sensors of temperature and solar radiation or from a remote station that sends current information to the controllers. Both weather-sensing and soil-moisture controllers may require initial set-up with parameters for the site-specific soils and vegetation, and other factors such as slope and shadiness of the site. The wide array of products use a variety of technologies and proprietary algorithms, and their complexity and sophistication also vary (St. Hilaire et al. 2008). More information about the attributes of specific controllers can be found at Pittenger et al. (2004) and Irrigation Association (2011). While SMART controllers can efficiently irrigate landscapes without overwatering, cost and the difficulty of initial set-up may make them unattractive to some homeowners and irrigation managers. In 2009, the U.S. Environmental Protection Agency estimated that less than 10 percent of the 13.5 million irrigation systems on residential lawns in the U.S. used weather-based controllers to schedule irrigation (USEPA 2009c).

In general, it is difficult to determine the potential for how much water can be saved by implementing SWAT systems in New Jersey. This is both because these technologies have often been evaluated in arid climates different from that of New Jersey, and because actual savings will depend upon the degree of inefficiency of the previous irrigation system. A 2003 study conducted by the University of California Cooperative Extension found that using weather-sensing controllers did not assure either water conservation or acceptable plant performance (Pittenger et al. 2003). While they found SWAT controllers to be generally easy for the user to operate, they still required initial professional set-up and follow-up to ensure proper irrigation scheduling and amounts.

Summary of Water-Conserving Irrigation Strategies

Table 12 summarizes some strategies for water-conserving irrigation scheduling methods.

Using mulches to conserve water

Mulches include organic materials like shredded wood and bark as well as inorganic materials like gravel and native stones. Their use helps to conserve water by reducing evaporation from the soil. In addition, these materials make attractive landscape features that do not need irrigating.

The most common and attractive organic mulches include wood chips and shredded or chunked bark materials, and these function well as mulches. Other organic materials that are sometimes used for organic mulches include grass clippings, tree leaves, and straw. Using these materials requires some caution, however, since grass clippings may introduce weed seeds into beds or may produce a foul odor if tightly packed and damp. Likewise, tightly packed and damp tree leaves can form a dense mat that can prevent air and water from reaching plant roots. Caution is urged with stone mulches as well, since they may cause the soil or plant materials to heat up more than they otherwise would.

Advantages of organic mulches include:

- reducing evaporation from soil and retaining soil moisture
- reducing weed growth
- improving soil by adding organic matter as the mulch decays
- providing an attractive landscape bed

In order to suppress weed growth, organic mulches can be applied two to three inches deep around trees and shrubs and up to two inches in herbaceous perennial beds. For trees and shrubs, the mulch should be kept a few inches away from trunks and stems. Keeping mulch at the recommended depth and away from trunks and stems will discourage insects, fungal diseases, and rodents, while letting the soil receive sufficient water.

Inorganic mulches and landscape features can include pea gravel, larger river stone, and native rocks.

Perforated plastic weed cloth can be used under a layer of mulch to decrease evaporation from soil while allowing water and air to enter the soil.

River stone is used to channel water through the demonstration rain garden at Village Elementary School in Holmdel, NJ. Stone can be used as a decorative, water-conserving landscape feature. Photo credit: Rutgers Cooperative Extension Water Resources Program.

Table 12. Summary of water-conserving irrigation scheduling methods.

Method	Details	Notes
Schedule based on average evapotranspiration and precipitation	Use Tables 8 and 9 for average evapotranspiration and precipitation, adjusting for actual weather when possible.	Can make more precise by incorporating plant factors for plants grown.
Schedule based on actual evapotranspiration and precipitation	Use local weather or rain gauge for precipitation amounts. Use United Water Resources websites for actual evapotranspiration.	Can make more precise by incorporating plant factors for plants grown.
Smart Irrigation Controllers	Uses sensors and weather information to manage watering times and frequency. The system can turn off sprinklers automatically during rain, high wind, or low temperature.	Capable of very precise and efficient irrigation. Once installed and calibrated, should require little input from the homeowner or user. May require sophisticated set-up and calibration of controller.
Xeriscape	Choose drought tolerant plants that will not need irrigation under most circumstances. Use non-living landscape features. Consult Table 13 for a list of drought tolerant plants.	
Other methods	Other methods include watching plants for signs of wilt or drought stress; and inspecting soil regularly for water content by feel.	May require some experience or expertise.

Rainwater Harvesting for Water Conservation

Collecting and storing rainwater is one way to have water for supplemental irrigation of landscape plants while conserving potable water. Systems to collect rain water range from simple rain barrels made from recycled food barrels (Bakacs and Haberland 2010, Haberland et al. 2010) to larger, more complex systems (Mangiafico et al. 2011). Water from larger systems can supply irrigation systems while a soaker hose can be attached to rain barrels to water landscape plants.

Significant water can be saved by using collected rainwater instead of potable water. As an example, a 1-inch rain falling on a 100-square-foot section of roof will produce 60 gallons of water. Further, a 55-gallon barrel filled and used each week from May to September collects 1200 gallons of water.

Collected rainwater is typically relatively good quality, and is suitable for irrigating ornamental plants. It should be remembered, though, that harvested rainwater may contain contaminants from atmospheric deposition or animal droppings, and so should be cautiously if at all for vegetable gardens (Mangiafico and Obropta 2011).

A rain barrel collects water from the roof of a house. The water is then used to irrigate ornamental plantings. Photo credit: Michele Bakacs, Rutgers Cooperative Extension.

A larger rain harvesting system at Samuel Mickle School in East Greenwich, NJ. The collected water is pumped through an irrigation system that supplies an ornamental garden. Photo credit: Elaine Rossi-Griffin, Rutgers Cooperative Extension.

Rain Gardens as Water Conservation Feature

A rain garden is a landscaped, shallow depression that captures, treats, and infiltrates stormwater runoff. They are usually landscaped to be aesthetically pleasing gardens. How they differ from traditional gardens, however, is that they are planted slightly below grade in a shallow dug basin so that they can capture and store runoff water.

A rain garden can be planted with any of a variety of grasses, wildflowers, and woody plants that are adapted to the soil and the specific site conditions. Using native plants with deeper root systems facilitates infiltration and also sustains the landscape through periods of drought that sometimes occur in New Jersey summers.

Typically, rain gardens are used to mitigate the impacts of stormwater runoff from residences and municipal buildings. But they can also be used as a landscaped feature to conserve water. The ways that rain gardens conserve water include:

- Rain gardens usually incorporate native plants and mulched ground cover. By installing a rain garden, these can replace more water-needy plants in the landscape.
- Rain gardens are commonly used to capture runoff from roofs or paved areas. Once in the garden, this water then recharges the soil moisture or deeper groundwater. In this way, water that would normally run from roofs or pavement into the stormwater infrastructure is instead used beneficially onsite. This has the effect of either decreasing the need for future irrigation of the landscape or recharging groundwater for future use.

A rain garden at the Holy Nativity Lutheran Church in Wenonah, NJ.
Photo: Christine Boyajian, Rutgers Cooperative Extension Water Resources Program.

Moss in Your Landscape: Are You Watering Too Much?

Some people enjoy seeing moss growing on the soil under trees or on a shady rock, and moss beds can be attractive landscape features. But not everyone welcomes moss if it encroaches into turf or other landscapes areas.

If moss is able to encroach on to a lawn area, the probable cause is that the turf plants are under stress and not growing well. Some factors that might give moss the advantage are:

- poorly-drained or wet soils
- compacted soils
- low soil fertility
- shadiness
- low soil pH
- turf that is mowed too low or otherwise stressed

Overwatering a shady area or one with compacted or low-pH soils will exacerbate moss problems.

Some solutions to discourage moss:

- choose turf species or other landscape plants that thrive in wet soils
    - o for turf species appropriate for shady and poorly-drained areas, see Murphy (1995)
    - o for native landscape plants appropriate to wet areas, see Obropta et al. (2010)
- avoid over-irrigating
- aerate compacted soils
- find turf species or other landscape plants that thrive in shade
- soil test and follow recommendations to adjust soil pH and soil nutrients
- follow recommended cultural practices for turf

For more information on moss in lawns, see Costaris and Heckman (2004).

Moss can be a beautiful plant on the forest floor, but it is not always welcome in lawns and landscapes. Photo credit: Sal Mangiafico, Rutgers Cooperative Extension.

U.S. EPA WaterSense Criteria for Outdoor Landscaping

One method of designing outdoor landscapes to be water-efficient is to follow U.S. Environmental Protection Agency (USEPA) WaterSense criteria.

The WaterSense criteria include guidelines to conserve water both indoors and outdoors of newly constructed single-family homes. If a new home meets these criteria and is constructed by a WaterSense builder partner, the house can qualify for the WaterSense label. While they are intended to guide landscape plans for new homes, these criteria can also be used to design a water-conserving landscape during renovations on existing properties.

In this program, water-efficient landscape design can be achieved two ways:

- The first option is to design the landscape area using the WaterSense Water Budget Tool. This tool is a spreadsheet available on the USEPA website that calculates the expected water use of the proposed landscape plants and compares it to the expected water use of the same area of cool-season turfgrass. The proposed landscaping must achieve at least a 30% reduction from turf cover to be considered water-efficient.
- The second option simply limits the amount of turfgrass cover to 40% of the landscaped area.

In addition to requiring common-sense water-conservation practices such as mulch covering on bare soil and water recirculation for all ornamental water features, the program also stipulates how irrigation systems must be designed. Specifically, systems:

- must be designed or installed by a WaterSense irrigational partner
- are required to be audited to be sure the systems have a reasonably high uniformity of water distribution
- must be equipped with technology that stops irrigation during periods of rainfall or sufficient moisture, such as rain sensors or soil moisture sensors
- are required to have a programmable controller

In New Jersey, NJDEP's New Jersey Landscape Irrigation Contractor Examining Board's Certification Program has received the WaterSense label, so professionals who have this certification can apply to be WaterSense Landscape Irrigation Professional Partners (epa.gov/watersense/outdoor/cert_programs.html, nj.gov/dep/exams/lic.htm).

For more information on the WaterSense program and WaterSense-qualifying landscaping, see USEPA (2009a), USEPA (2009b), USEPA (no date a), and USEPA 2009 (no date b).

A home built to EPA's WaterSense specifications for new homes. The home pictured here in Egg Harbor Township, NJ is a new construction built to meet USEPA WaterSense guidelines for both indoor and outdoor water conservation. The landscaping is composed of 40% turfgrass and 60% water-conserving gardens. Project partners included New Jersey Water Savers, Doebley and Dad Construction Company, and New Jersey American Water Company. Photo credit: Gene Doebley.

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This bulletin replaces Landscaping for Water Conservation by Theodore Shelton and Bruce Hamilton, Rutgers Cooperative Extension, 1992.

Evaluate your landscaping needs

- ☐ Consider the goals of your landscaping design: aesthetic, recreational, and wildlife attraction.
- ☐ Determine plants and non-living features that will meet these goals.

Choose appropriate plants and practice good horticulture

- ☐ Evaluate your site for areas that will that impact your plant selections: wet areas, sunny and shady areas, sandy and clayey soils, soils that shallow to bed rock, septic field location.
- ☐ Have soils tested for pH and nutrients. Consider having soils tested for organic matter content and texture. Either amend soils according to soil test recommendations or choose plants that will thrive in the native soil conditions.
- ☐ If soils are low in organic matter, amend soils with organic materials to increase the water holding capacity. If clayey soils have poor structure, amend with lime or gypsum according to soil test recommendations to improve the soil structure.
- ☐ Choose drought tolerant plants.
- ☐ Consider using native plants.
- ☐ Use mulch to cover bare soil in gardens and beds.
- ☐ For turf areas, choose relatively drought tolerant species like tall fescue and fine-leafed fescues.
- ☐ Consider replacing irrigated turf areas with drought-tolerant groundcovers, mulched beds, or non-living landscape features. Consider wildflowers and groundcovers; vegetable and ornamental gardens; trees, shrubs, perennials, and ornamental grasses; stone, mulch, and gravel.

Improve irrigation system and practices

- ☐ Know your plants and their water requirements.
- ☐ Base irrigation on weather and plant needs.
- ☐ Schedule irrigation frequency and amounts based on knowledge and tools that indicate soil moisture, recent evapotranspiration, and recent precipitation.
- ☐ Water plants deeply and infrequently when possible.
- ☐ Measure the amount of water used in irrigation.
- ☐ Consider a SMART irrigation system.
- ☐ Consider low-volume irrigation systems like drip stakes and micro-sprayers.

List of Drought-tolerant Plants

Table 13. List of select drought tolerant plants for New Jersey.

TREES	
American Hornbeam	*Carpinus caroliniana*
Black Oak	*Quercus velutina*
Blackjack Oak	*Quercus marilandica*
Chestnut Oak	*Quercus prinus*
Eastern Red Cedar	*Juniperus virginiana*
Eastern Redbud	*Cercis canadensis*
Fragrant Sumac	*Rhus aromatica*
Hackberry	*Celtis occidentalis*
Honeylocust	*Gleditsia triacanthos*
Northern Red Oak	*Quercus rubra*
Sassafras	*Sassafras albidum*
Scarlet Oak	*Quercus coccinea*
Shagbark Hickory	*Carya ovata*
Shortleaf Pine	*Pinus echinata*
Staghorn Sumac	*Rhus typhina*
Virginia Pine	*Pinus virginiana*
Washington Hawthorn	*Crataegus phaenopyrum*
White Ash	*Fraxinus americana*
White Oak	*Quercus alba*
SHRUBS	
Arrowwood Viburnum	*Viburnum dentatum*
Bayberry	*Myrica pensylvanica*
Bearberry	*Arctostaphylos uva-ursi*
Blackhaw Viburnum	*Viburnum prunifolium*
Bush Cinquefoil	*Potentilla fruticosa*
New Jersey Tea	*Ceanothus americanus*
Lowbush Blueberry	*Vaccinium angustifolium*
Mapleleaf Viburnum	*Viburnum acerifolium*
Pasture Rose	*Rosa Carolina*
St. John's Wort	*Hypericum perforatum*
Witchhazel	*Hamamelis virginiana*

PERENNIALS/GRASSES	
Alum-root	*Heuchera Americana*
American Beachgrass	*Ammophila breviligulata*
Asters	*Aster* spp.
Beardtongue	*Penstemon* spp.
Birdfoot Violet	*Viola pedata*
Bitter Panic Grass	*Panicum amarum*
Black-eyed Susans and Coneflowers	*Rudbeckia* spp.
Blue False Indigo	*Baptisia australis*
Blue Lupine	*Lupinus*
Bluestem Grasses and Broomsedges	*Andropogon* spp.
Bowman's Root	*Gillenia trifoliate*
Christmas Fern	*Polystichum acrostichoides*
Coneflowers and Echinacea	*Echinacea* spp.
Culver's Root	*Veronicastrum virginicum*
Cup-plant	*Silphium perfoliatum*
Dense Blazing-star	*Liatris spicata*
Early Saxifrage	*Saxifraga virginiensis*
Eastern Columbine	*Aquilegia Canadensis*
Goldenrod	*Solidago* spp.
Hyssop-leaved Boneset	*Eupatorium hyssopifolium*
Indian Grass	*Sorghastrum nutans*
Little Bluestem	*Schizachyrium scoparium*
Marginal Woodfern	*Dryopteris marginalis*
Maryland Senna	*Senna marilandica*
Milkweeds and Butterfly Weed	*Asclepias* spp.
Moss phlox	*Phlox subulata*
Northern Wild Senna	*Senna hebecarpa*
Partridge-pea	*Chamaechrista fasciculate*
Prairie Coneflower	*Ratibida pinnata*
Rock Harlequin	*Corydalis sempervirens*
Spotted Beebalm	*Monarda punctata*
Starry Campion	*Silene stellata*
Tall Larkspur	*Delphinium exaltatum*
Three-toothed Cinquefoil	*Sibbaldiopsis tridentate*
Tickseeds and Coreopsis	*Coreopsis* spp.
Upright Prairie Coneflower	*Ratibida columnifera*
Whorled Rosinweed	*Silphium trifoliatum*
Wild Bergamot	*Monarda fistulosa*
Wood Lily	*Lilium philadelphicum*

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THE STATE UNIVERSITY OF NEW JERSEY

Rutgers, The State University of New Jersey
88 Lipman Drive, New Brunswick, NJ 08901-8525
Phone: 848.932.5000