Biosystems Engineering and Soil Science

RAIN GARDENS FOR TENNESSEE: A BUILDER'S GUIDE

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What is a Rain Garden?

A rain garden catches rooftop and driveway runoff at UT's West Tennessee AgResearch and Education Center in Jackson, Teneessee.

Building a rain garden is one way to practice conservation landscaping and environmental stewardship. A rain garden is a planted depression that is positioned to capture runoff from impervious surfaces (like rooftops or driveways) and designed to infiltrate it into the ground. Rain gardens are used to improve the quality of your yard and decrease impacts of runoff on local natural waterways. As urbanization occurs, the amount of impervious surfaces in a watershed increases, causing more runoff than had previously occurred when the landscape was in native forest or meadows. Rain gardens help restore natural water balance while replacing maintenance-intensive turf with native plants. Rain gardens can easily be incorporated into neighborhoods, schoolyards and small-scale commercial landscaping.

Benefits

Building a rain garden creates many benefits for private property owners as well as communities as a whole. On a small scale, rain gardens help slow down rainwater runoff, decreasing the potential for soil erosion and improving soil quality over time. They can also increase property values by adding landscaping and aesthetic appeal to a yard. Using a rain garden to catch runoff may also decrease the need for costly irrigation. The native plants in a rain garden are also good sources of food and shelter for native birds, beneficial insects and other local wildlife.

At a larger scale, using rain gardens in developing watersheds will help improve water quality in our drinking water sources and recreational areas. When it rains in developed areas, rainfall runs off of impervious surfaces into a storm drainage system, which is a direct conduit to local streams and rivers. This runoff carries pollutants like sediment, nutrients (fertilizers), bacteria, metals, oils and gasoline. It also runs quickly to streams and accumulates in large volumes, causing streambanks to fail and channels to erode. All of these factors combine to degrade aquatic ecosystems and water quality. Rain gardens capture the "first flush" of water from impervious surfaces and soaks that water down into the ground. As the water percolates through soil, sediments are filtered out, plants remove nutrients, oils are absorbed, and other toxic chemicals like herbicides and pesticides are broken down by microorganisms. The cumulative effect of multiple rain gardens throughout a watershed decreases the potential for erosion of stream channels and sedimentation, which clogs the sensitive benthic habitat (or the stream bottom). Rain gardens also create urban wildlife habitat and can be linked with other conservation landscaping areas to create corridors throughout a city.

Deciding to Build

Rain gardens can be adapted to fit in many spaces, but there are several key considerations to make before deciding to build. First, go outside when it rains and take an assessment of where runoff comes from, how it flows across the property, and where it eventually goes. Some key features to note are the location and connection of gutter downspouts, drop inlet grates and storm drains, and swales and ditches. Take note of spaces where runoff could be intercepted using a rain garden and make sure that overflow during large rain events can be diverted safely back into drainage ways. Then call 8-1-1 to have underground utilities marked to be sure there are no lines running through potential sites. Be sure to account for electrical, water, sewer, cable, phone, gas, and any other lines you may have running through the property.

Rain gardens should not be placed in existing steam buffers, floodplains, forests or wetland. These areas are hydrologically sensitive and already perform an important natural function in the ecosystem. Preserve these areas on your property as they are. The flowchart below is a road map to aid in the siting, designing and building of rain gardens.

A road map to aid in the effective planning, siting, designing and building of rain gardens to minimize runoff from and enhance the natural balance of your yard.

Siting and Designing

Selecting a Site

Rain gardens are ideally located near downspouts or along low-lying areas that already collect runoff. The topography (or slope) of your property will have the biggest influence on site selection. Look for flat areas with less than 12 percent slope. This means that there is less than 6 feet of fall over a span of 50 feet (or equivalent). Locate the garden at least 10 feet from building foundations or basements, 15 feet from septic fields, as far as possible from trees, and in as much sun exposure as possible.

Disconnecting the roof downspouts from the storm drain system may be necessary in order to capture the runoff in the rain garden. To do this, cut the downspout just above the soil surface around the base of the house. Then use a downspout extension and a splash pad to guide the runoff toward the garden. Make sure that the yard is sloped such that the runoff will go to the garden. Some grading to create a shallow swale may be necessary to convey the water as needed.

Since rain gardens soak water into the ground, the soils at the site need to have adequate infiltration. To evaluate this, perform a simple percolation test by digging a 12-inch diameter hole to a depth of about a foot. Scarify the sides of the hole to break up any slicking that may have been caused by the shovel (particularly important for clayey soils). Fill the hole with water and allow it to drain through gravity at least twice. This will saturate the soils around the site to simulate saturated conditions of rain events. Fill the hole again and measure the depth of water. Now, monitor the water level over time to determine the filtration rate, which is the depth of water moving into the soil (leaving the hole) over time. For example, if the 12-inch hole drains completely in 18 hours, then the infiltration rate is 12 inches per 18 hours, or 0.66 inches/hour. Generally, if the hole drains in less than 24 hours, then the soils are fast draining and suitable for a rain garden. If the hole drains in 24-48 hours, then the soils are slow draining and you will need to take extra steps during construction to amend the soils and increase infiltration. If the hole does not drain, there may be a confining layer that is impeding water movement. You may choose to dig down further and repeat the test, or choose another site. If the deeper hole drains, then you could excavate down to that soil layer for your garden. This decision hinders on the accessibility of excavation equipment and a place to dispose of the excess soil.

Sizing

The size of the garden depends on how much rainfall will be captured (in terms of volume) and soil infiltration rate. Sizes generally range from 100-350 square feet. Determining a garden size for a 1-inch rain will catch the majority of rain events (about 90 percent) and meet requirements for local stormwater programs if you live in a regulated community. Since the goal is to capture a volume of runoff, the garden surface area (or footprint) and the depth are important factors. The depth of water to be captured in the garden is called the bowl depth. A bowl depth of 4-5 inches is generally a good target for residential rain gardens to ensure that the garden area is reasonably small and that the captured water will infiltrate easily within a couple of days.

To find the garden size needed, first consider the contributing drainage area (CDA), or the area that drains to the selected site. Take note of the impervious surfaces (rooftop, pavements, walkways, etc.) and the pervious areas (turf, flowerbeds, etc.). If you see portions of the yard shed water in relatively small storms, consider these areas as impervious. Now, measure the total area of the impervious surfaces that drain to the garden. This is your total CDA. The table below shows the relationship between impervious surface and generated runoff assuming that there is negligible storage on the surface. For every 100 square feet of rooftop (or other impervious surface), about 62 gallons of runoff may be generated in a 1-inch rainfall.

Impervious Surface (square feet)	Runoff Volume in 1" Rainfall (cubic feet)	(gallons)
100	8	62
250	21	156
500	42	312
750	63	468
1000	83	623
1500	125	935
2000	167	1247

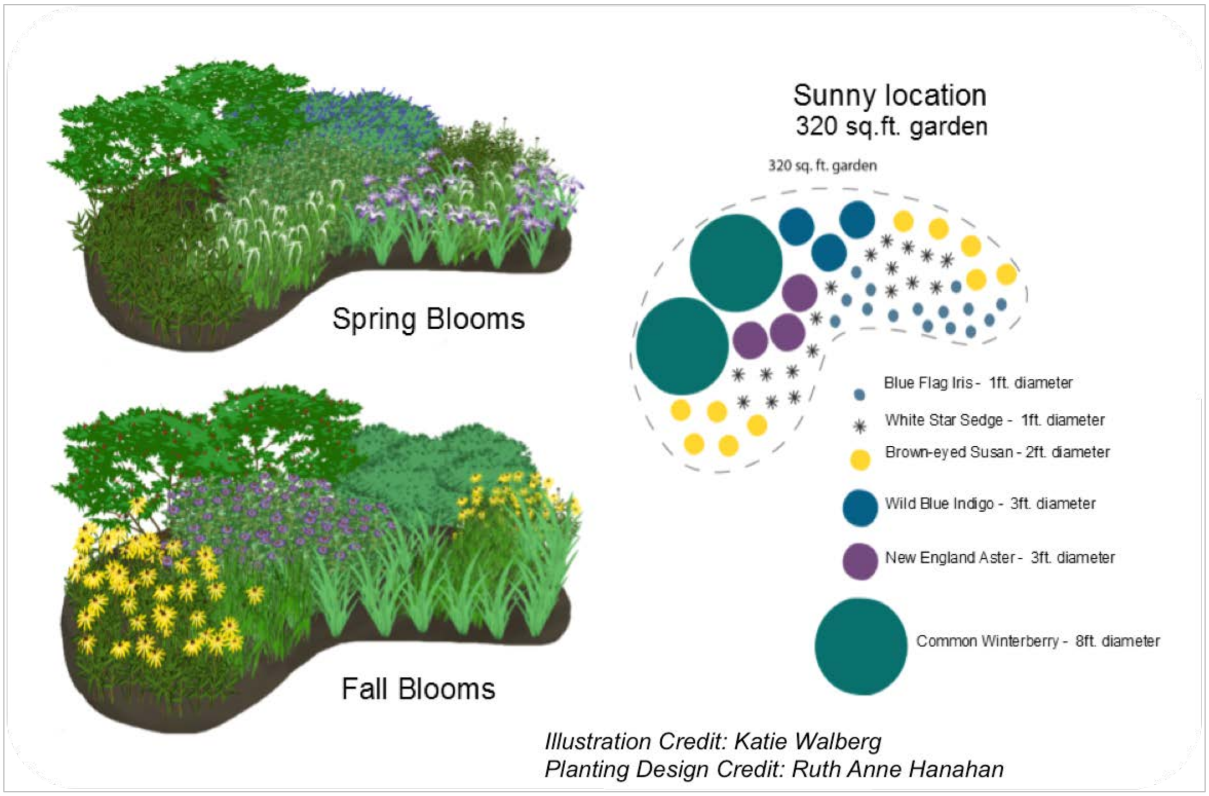
Now to determine the footprint size, revisit the percolation test results and apply a sizing factor. Consider the rain garden to act like a cup with a porous sponge for a bottom. The faster the soil drains, the more runoff that can "stacked up" in cup and drain out the bottom within a couple of days; the slower the soil drains, the more the runoff needs to be spread out over a wide sponge. If the soils are fast draining, multiply the CDA by 10 percent. If the soils are slow draining, multiply the CDA by 15 percent. This will give you the size (or surface area) that the garden needs to be to capture the first inch of rainfall. These sizing factors were determined using a computer model developed by the University of Tennessee to design infiltration infrastructure like rain gardens. If the determined footprint size is not available in your selected space, then simply use the available space to capture a portion of the 1-inch rain. Infiltrating the first half-inch is better than none at all.

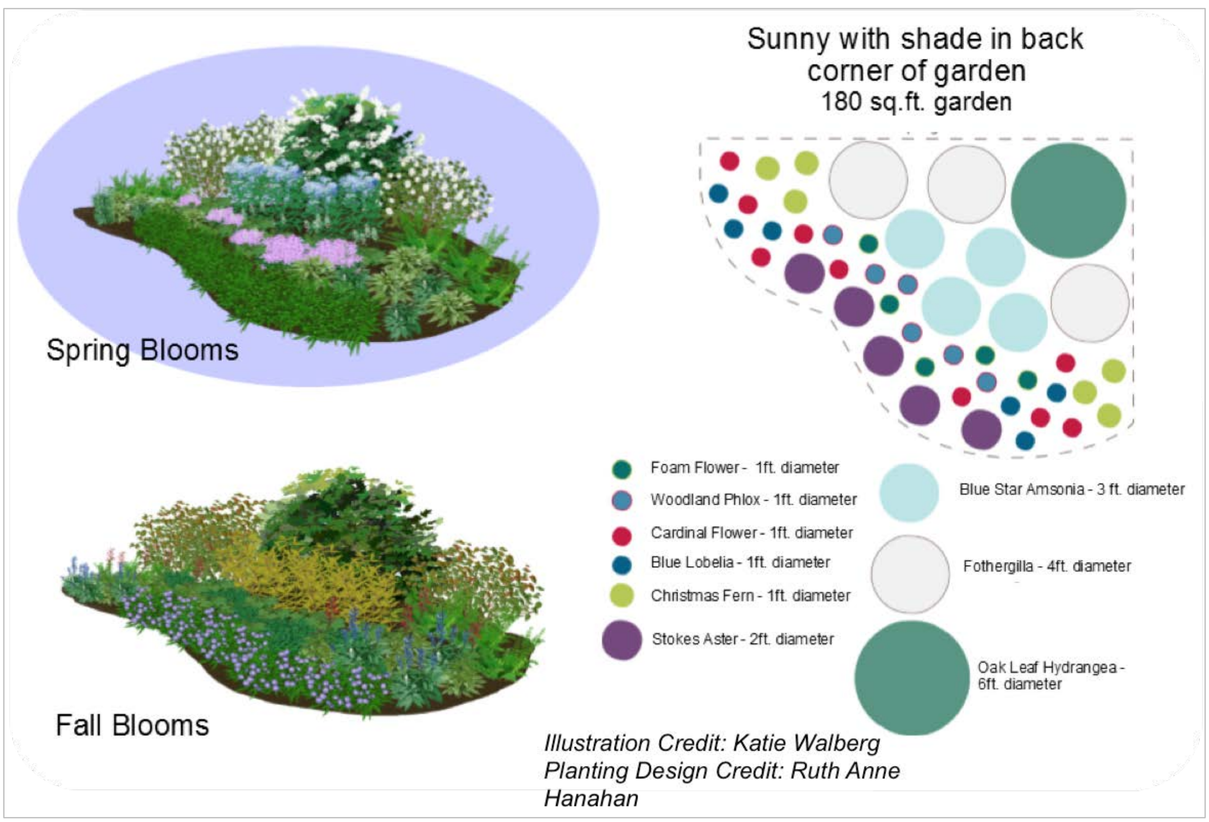
Garden Layout

Now that the garden size is set, the next step is to integrate the garden into the selected space in your yard. Use construction flags to mark out the perimeter of the garden, creating a jellybean shape that lies along a contour (or along the same elevation) with dimensions needed to get close to the target size. Determine where concentrated and sheet flow enters the garden and where the overflow needs to be in order to guide it to existing drainage infrastructure without causing erosion. For concentrated inflows, align the garden so that the inflow takes the longest path possible through the garden before it reaches the overflow. If the area is sloped, then use an earthen berm along the low side to create the cup-like depression.

Plant Selection

Native perennial plants will establish best in a rain garden because they are hardy, have extensive root systems, can survive in both wet and dry soil conditions, and are adapted to local climate conditions. Natives do not require fertilizers and absorb more water than standard turf or non-natives. Create a plant palette with variable plant heights, shapes, blooming color, fall foliage and textures. Envision the garden like a bullseye with three concentric rings: 1) the outside ring that lies at the highest elevation, which will stay the driest, 2) the middle ring that is the sloped or transitional area, and 3) the center bullseye that lies lowest and stays wet the longest. Consider these soil moisture conditions in the planting design. Also consider the time of year the plants bloom or change color to maximize visual color appeal year-round. Specific perennials will attract pollinators and other beneficial insects. Berry-producing plants and dense, clumping grasses are good food and fiber resources for urban wildlife and birds. Use the plant list at the back of this document and example gardens below to help guide your planting design.


Sunny location
320 sq.ft. garden
320 sq. ft. garden
Spring Blooms
Fall Blooms
Blue Flag Iris - 1ft. diameter
White Star Sedge - 1ft. diameter
Brown-eyed Susan - 2ft. diameter
Wild Blue Indigo - 3ft. diameter
New England Aster - 3ft. diameter
Common Winterberry - 8ft. diameter
Illustration Credit: Katie Walberg
Planting Design Credit: Ruth Anne Hanahan


Sunny with shade in back
corner of garden
180 sq.ft. garden
Spring Blooms
Fall Blooms
Foam Flower - 1ft. diameter
Woodland Phlox - 1ft. diameter
Cardinal Flower - 1ft. diameter
Blue Lobelia - 1ft. diameter
Christmas Fern - 1ft. diameter
Stokes Aster - 2ft. diameter
Blue Star Amsonia - 3 ft. diameter
Fothergilla - 4ft. diameter
Oak Leaf Hydrangea - 6ft. diameter
Illustration Credit: Katie Walberg
Planting Design Credit: Ruth Anne Hanahan

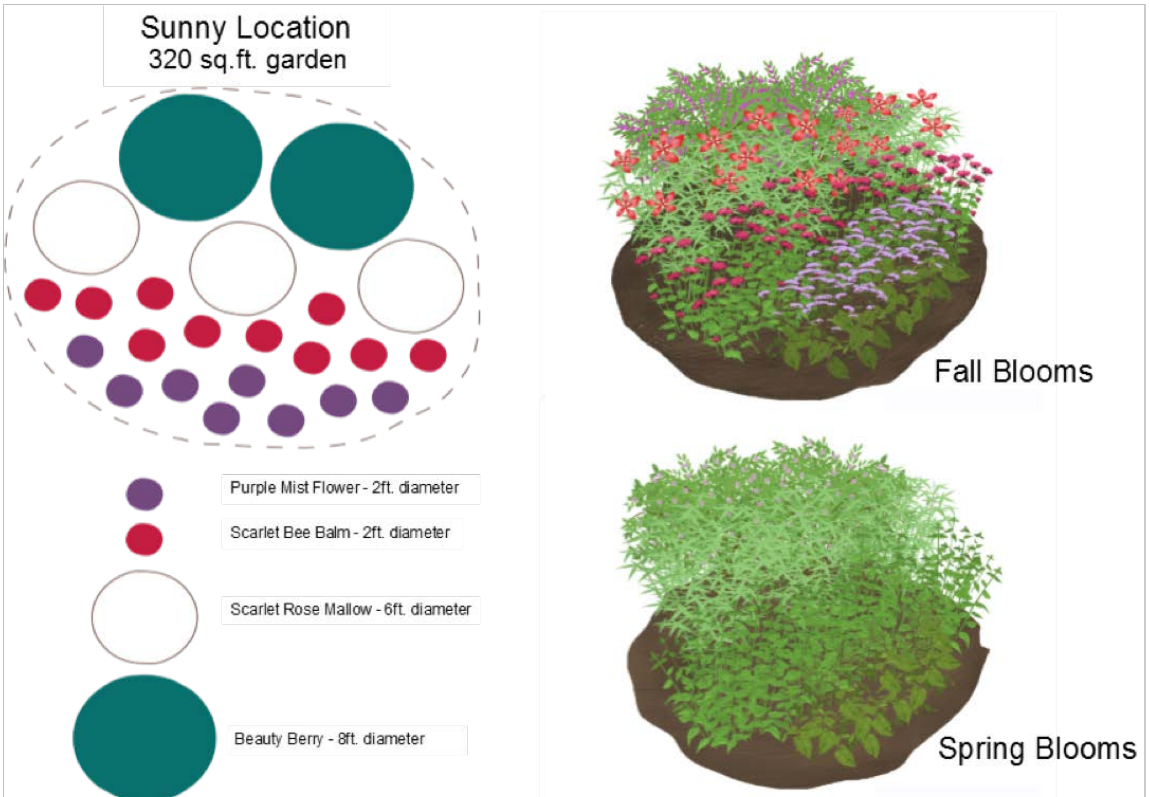


Illustration Credit: Katie Walberg
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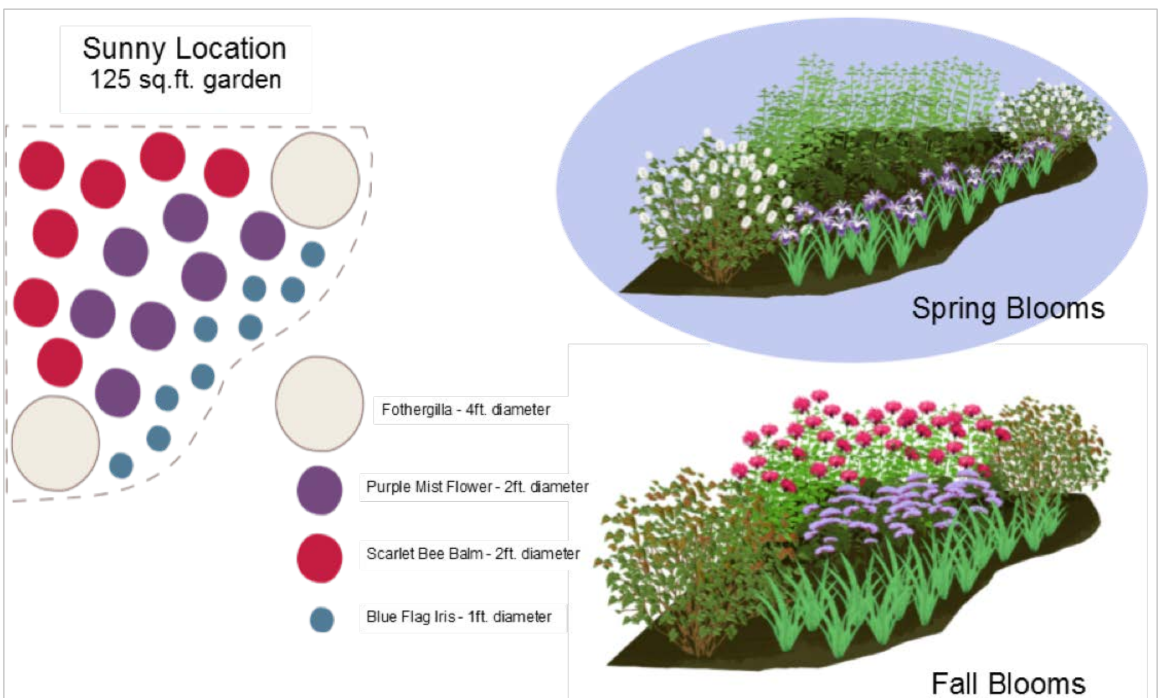

Illustration Credit: Katie Walberg
Planting Design Credit: Ruth Anne Hanahan

Building the Garden

The best time to build a rain garden is in dry weather in early spring or late fall. Springtime will have relatively looser, moister soils for digging and ensure there is enough rainfall after planting to get your plants established before the dry, stressful summer. Late fall is preferable because water tables are generally low and plants have entered their dormant phase. This means that they will not feel as much stress during planting and come out of dormancy in the natural spring cycle.

The first step in building is to dig the rain garden bowl. Determine the needed depth of excavation by adding 4-5 inches to the 8 or 4 factor determined through the percolation test. This will account for the mulch that will be added to the garden later and a small "freeboard" that will ensure excess water will only flow out of the intended overflow area (and not erode other areas). It will be beneficial to use any existing fall that there may be at the site. You may set up a level using two wooden stakes (one at each end of the garden) and either a bubble or picture-handing level. Use this fall over the area to reduce the amount of digging necessary.

Consider renting excavation equipment if possible. A small-bucket track hoe is ideal while a bobcat or tractor with a bucket may also be adequate. A push tiller will be needed to loosen the subsoil at the bottom of the bowl after excavation to make planting easier and ensure plant roots can penetrate into soils.

Follow these steps to build the rain garden:

1. Dig or excavate the bowl. Place good topsoil on a tarp and clay subsoils on a separate tarp. The topsoil may be spread back in the bottom of the bowl if needed for planting. Dig to a depth of 8 inches — 5 inches to accommodate the ponded runoff and 3 inches for the mulch. If topsoil needs to be replaced into the garden after excavation, then account for this depth as well.
2. Build an earthen berm out of the clay subsoil to the needed height to gain the determined bowl depth. Tie the clay berm into the existing ground around the garden so that there is a relatively level rim around the entire bowl.
3. Till the bottom 3-6 inches of the bowl to aid in easy planting and encourage infiltration.
4. Replace a layer of topsoil as needed for plant layer.
5. Create an overflow spillway in the berm, about a foot wide and about 1inch sunk into the berm. Use flat flagstone or seeded natural fiber matting here to protect from erosion.
6. Use stones to armor the inflow areas and slow down water if there is high concentrated inflow.
7. Layout and plant plants in their desired location. Plant them shallow to allow for the additional mulch.
8. Cover all exposed soil with 3 inches of triple-shredded, hardwood mulch (or sod around the edges).
9. Water the plants immediately and as needed until plants are well established.

Document the plant placement with photos and with flags to that after the dormant season, you have a reference to help you remember where plants should be coming up. Over time, the plants will migrate into spaces that best suite their light and soil moisture adaptations. Keep a log of plant health and make changes to the design as you observe the garden through multiple seasons.

Seeing Results

Keep in mind that once your rain garden is built, it is considered "in line" and will catch runoff in during the next rain. Be prepared by ensuring all bare soil is covered and erosion-prone areas are armored as needed. Plants may take up to several months to become well established, depending on the time of year and climate pattern. If plants appear to not be suited for the saturation or sun exposure of their initial planting location, then move them around the garden until they take hold in a different location. Once established, the plants should be relatively low maintenance. Replace mulch at least one to two times a year and as needed after large rains. During the first one to two years, plants will spread and fill into their spaces. After about three to four years, the garden will likely be filled with plant material, and the underlying mulch will be covered completely.

A rain garden in Tennessee will receive a large amount of annual rainfall. The table below shows regional rainfall information for parts of Tennessee and estimates of rain garden runoff capture for a single rain garden in calendar year 2013. Rainfall data was obtained from the National Oceanic and Atmospheric Administration (data sets missing multiple days of record, but no more than 14 days annually).

	Knoxville	Nashville	Memphis	Chattanooga
Total Annual Rainfall 2013 (in)	68	56	64	63
Total Annual Rainfall Capture for one Rain Garden (in)*	30	33	26	32
Estimated Annual Rain Garden Volume Capture (gal)*	13250	14360	11310	13900
Percent of Annual Rainfall Capture (in/in)	45%	59%	40%	51%

**Based on capturing runoff from 700 square feet of rooftop area and a 24-hour drain time.*

In summary, we use rain gardens to take advantage of rainfall by infiltrating runoff into the ground and help prevent erosion and pollution downstream. Rain garden sizes are dependent on the contributing drainage area and soil infiltration rates in your yard. The average home size in the U.S. is 2,700 sq ft. If we assume the average home is two levels, then the average home rooftop is approximately 1,400 sq ft. If a rain garden is designed to catch half of the rooftop runoff during a storm that delivers 1 inch of rain, then that rain garden will capture up to **430 gallons** during that one storm. If every house in a 30-home neighborhood had a similar rain garden, then that would amount to almost 13,000 gallons of runoff soaked into the ground every time it rains an inch in Tennessee.

Rain Gardens for Tennessee Plant List

Perennial Native Forbes

Planting Location*	SCIENTIFIC NAME	COMMON NAME	HEIGHT (ft)	BLOOM COLOR	BLOOM TIME	SPACING (ft)	LIGHT NEEDS
M, U	*Amsonia tabernaemontana*	Blue Star	3	Blue	March-May	3	Sun/Part Shade
M, U	*Aquilegia canadensis*	Columbine	2-3	Pink/Yellow	April-May	1	Part Shade
L, M, U	*Asclepias incarnata*	Swamp Milkweed	3-4	pink	May-June	3	Part Shade
L, M, U	*Aster novae angliae*	New England Aster	4	deep pink-purple	Aug-Sept	4	Sun
L, M, U	*Baptisia australis*	Blue Wild Indigo	4	Blue-purple	May-June	3	Sun
L, M	*Catha palustris*	Marsh Marigold	1-1.5	Yellow	March-May	1	Sun/Part Shade
L, M	*Chelone glabra*	White Turtlehead	3	White	Aug-Oct	2.5	Sun/Part Shade
L, M	*Chelone lyonii*	Pink Turtlehead	3	Pink	Aug-Oct	2.5	Sun/Part Shade
U	*Echinacea purpurea*	Purple Coneflower	3-5	Purple	July-Sept	2	Sun/Part Shade
L, M, U	*Eupatorium coelestinum*	Mistflower	2	Lavender Blue	Aug-Sept	2	Sun/Part Shade
L, M, U	*Eupatorium maculatum - atropurpureum*	Joe Pye Weed, Queen of Meadow	up to 6	Mauve	July-Sept	4	Sun/Part Shade
L, M, U	*Eupatorium maculatum - 'Gateway'*	Dwarf Joe Pye Weed	4-5	Mauve	July-Sept	4	Sun/Part Shade
M, U	*Geranium maculatum*	Wild Geranium	1-2	Pale Pink-Lilac	April-May	1	Part Shade/ Shade
L, M, U	*Helianthus angustifolius*	Swamp Sunflower	5-8	Yellow	Sept-Oct	3	Sun
L, M, U	*Hibiscus coccineus*	Scarlet Rose Mallow	6	Scarlet Red	July-Sept	6	Sun
L, M, U	*Hibiscus moscheutos*	Rose Mallow	3-8	White w/ Maroon Eye	July-Sept	4	Sun
M, U	*Iris cristata*	Crested Iris	0.5 - 1	Pale Blue	April	1	Part Shade/ Shade

L, M	*Iris fulva*	Copper Iris	2-4	Reddish -Copper	May-June	1-2	Sun/Part Shade
L, M	*Iris versicolor*	Blue Flag Iris	1-3	Blue	May-June	2	Sun/Part Shade
L, M	*Lobelia cardinalis*	Cardinal Flower	1-4	Red	July-Sept	2	Sun/Part Shade
L, M	*Lobelia siphilitica*	Great Blue Lobelia	1-4	Blue	Aug-Oct	2	Sun/Part Shade
L, M	*Monarda didyma*	BeeBalm	2-4	Scarlet Red	July-Sept	2	Sun/Part Shade
M, U	*Monarda fistulosa*	Wild Bergamont	2-4	Pink-Violet-Purple	July-Sept	2	Sun/Part Shade
M, U	*Phlox maculata*	Meadow Phlox	2-4	Reddish -Purple	June-Sept	3	Sun/Part Shade
M, U	*Rudbeckia triloba*	Brown-Eyed Susan	3-5	Gold Yellow	July-Oct	3-4	Sun
L, M, U	*Solidago rugosa*	Rough-Leaf Goldenrod	5	Yellow	Aug-Oct	3-4	Sun/Part Shade
L, M, U	*Solidago rugosa, 'Fireworks'*	Fireworks Goldenrod	4	Yellow	Aug-Oct	3-4	Sun/Part Shade
M, U	*Tiarella cordifolia*	Foam Flower	1	White	April-May	1	Part Shade/ Shade
L, M, U	*Vernonia gigantia*	Ironweed	4-7	Bright Purple	Aug-Oct	3	Sun/Part Shade
M, U	*Actaea pachypoda*	White Baneberry, Misty Blue Doll's Eyes	2	White	March-May	2	Shade
M, U	*Liatris spicata*	Dense Blazing Star	2-6	Purple-Pink	July-Sept	2	Sun
L, M, U	*Ratibida pinnata*	Grey Headed Coneflower	3-4	Yellow	July-Sept	2-3	Sun
M, U	*Boltonia asteroides*	Pink Beauty, False Aster	4	Pink-white	Aug-Oct.	4	Sun

L, M, U = lower, middle, or upper planting ring

Native Shrubs

Planting Location*	SCIENTIFIC NAME	COMMON NAME	HEIGHT (ft)	BLOOM COLOR	BLOOM TIME	SPACING (ft)	LIGHT NEEDS
L, M, U	*Aronia arbutifolia*	Red Chokeberry	6-10	White	April-May	8	Sun/Part Shade
L, M, U	*Aronia melanocarpa*	Black Chokeberry	5-9	White	April-May	5	Sun/Part Shade
M, U	*Callicarpa americana*	American Beauty Berry	5-7	Pink	June-Aug	5	Part Shade/ Shade
L, M, U	*Cephalanthus*	Buttonbush	8-12	White	June-Aug	10	Sun/Part

	occidentalis						Shade
M, U	*Clethra alnifolia, 'Hummingbird'*	Summersweet, 'HB	3	White	July-Aug	3	Sun/Part Shade
M, U	*Clethra alnifolia, Ruby Spice"*	Summersweet, 'RS'	6	Pink	July-Aug	5	Sun/Part Shade
L, M, U	*Cornus stolonifera*	Red/Yellow Twig Dogwood	6-9	White	May-June	6	Sun/Part Shade
L, M, U	*Euonymus americanus*	Hearts-a-burstin	4-6	White/Pi nk	May	5	Part Shade/ Shade
M, U	*Fothergilla gardenii*	Dwarf Fothergilla	3-5	White	April-May	4-5	Sun/Part Shade
L, M, U	*Hamamelis vernalis*	Vernal Witchhazel	6-10	Yellow-Red	Jan-March	8	Sun/Part Shade
M,U	*Hydrangea quercifolia*	Oakleaf Hydrangea	5-10	White	June-July	6	Part Shade/ Shade
M, U	*Ilex glabra*	Inkberry	6-10	White	May	8	Sun/Part Shade
L, M, U	*Ilex verticillata*	Common Winterberry	6-10	White	May	8	Sun/Part Shade
L, M, U	*Itea virginica*	Virginia Sweetspire	3-5	White	May-June	4	Sun/Part Shade
M, U	*Lindera benzoin*	Spicebush	6-12	Yellow	April	6	Part Shade/ Shade
L, M, U	*Physocarpus opulifolius*	Ninebark	5-10	Pinkish White	May	8	Sun/Part Shade
L, M, U	*Rhododendron viscosum*	Swamp Azalea	3-8	White	May-June	5-7	Part Shade/ Shade
L, M, U	*Rosa palustris*	Swamp Rose	6-7	Dark Pink	June-July	6	Sun/Part Shade
M, U	*Viburnum dentatum*	Arrowwood Possumhaw	6 -12	Creamy White	May-June	6-12	Part Shade/Sha de
L, M, U	*Viburnum nudum*	Smooth Witherod Viburnum	6	Creamy White	May-June	7-8	Part Shade/ Shade

L, M, U = lower, middle, or upper planting ring

Perennial Native Ferns

Planting Location*	SCIENTIFIC NAME	COMMON NAME	HEIGHT (ft)	SPACING (ft)	LIGHT NEEDS
M, U	*Athyrium filix-femina*	Lady Fern	2-3	1	Shade
M, U	*Matteucia struthiopteris*	Ostrich Fern	2-3	2	Shade

L, M, U	*Osmunda cinnamomea*	Cinnamon Fern	4	2	Shade
L, M	*Osmunda regalis*	Royal Fern	2-5	2	Shade
M, U	*Polystichum acrostichoides*	Christmas Fern	2-4	1	Shade

L, M, U = lower, middle, or upper planting ring

Perennial Native Grasses

Planting Location*	SCIENTIFIC NAME	COMMON NAME	HEIGHT (ft)	SPACING (ft)	LIGHT NEEDS
L, M, U	*Andropogon gerardii*	Big Blue Stem	4-8	2	Sun
L, M, U	*Andropogon glomeratus*	Bushy Blue Stem	3-4	2	Sun
L, M, U	*Carex stricta*	Tussock Sedge	2-3	1.5	Part Shade/ Shade
L, M	*Chasmanthium latifolium*	River Oats	3	2	Part Shade/ Shade
L	*Juncus effusus*	Soft Rush	4	1	Part Shade/ Shade
L, M, U	*Panicum virgatum, ' heavy metal'*	Metal Blue Switchgrass	3-5	3	Sun
L, M, U	*Panicum virgatum, 'northwind'*	Northwind Switch Grass	5	3	Sun
L, M, U	*Rhynchospora colorata*	White Star Sedge	2	2	Sun
L, M, U	*Schizachyrium scoparium*	Little Bluestem	3	2.	Sun
L	*Scirpus cyperinus*	Woolgrass	6	1	Sun/Part Shade
M, U	*Sorghastrum nutans*	Indian grass	3-6	2-3	Sun/Part Shade

L, M, U = lower, middle, or upper planting ring

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