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Soil Percolation: A Key to Survival of Landscape Plants

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Eighty to 90 percent of disease and insect problems on landscape plants can be traced back to soil problems. Plants must be adapted to the site if they are to meet our expectations of growing, remain healthy, and attractive. Site characteristics include temperature extremes, amount of light, soil pH, soil volume, and availability of water. Of all of these, too much or not enough water is the most frequent reason newly installed plants fail to become established and thrive. The proper amount of water is far more critical for growth than fertilizer.

It is relatively easy to add water. It is harder to remove it from the soil. This is especially true for soils that are poorly drained. The larger pores in soils are called **macropores**. These pores are filled with either water or air. Soils that are saturated with water have almost no oxygen in them. Without oxygen, plants are unable to absorb water even though it is in great abundance. The inability to absorb water results in wilting of the leaves. This appearance of drought increases the temptation to add more water and compounds the problem of saturated soils. Soils with minimal oxygen allow many plant pathogens to grow. These pathogens kill roots making it even more difficult for plants to absorb water.

It may only take a few hours of being in saturated soils to begin a **mortality spiral**. Once this begins, the plant may never be able to recover. This is why it is important to make sure that soils have the ability to drain before installing plants that require well-drained soils.

Before you head to the nursery, assess the soil. Observing the site and doing a perk test (percolation test) will tell you if you need to consider installing trees and shrubs that are adapted to wet sites (Table 1).

Visual Indicators

Look at the ground. If there is moss on the surface of the soil, it probably remains wet for long periods. Moss often grows on sites that are relatively flat that allow water to stand for long periods. Observe the site after a heavy rain and notice how long water stands.

Table 1. Trees and shrubs for poorly drained sites.

Trees(1) (2)	
Alnus glutinosa	European black alder
Alnus rubra	red alder
Acer rubrum	red maple
Acer saccharinum	silver maple, water maple
Ilex opaca	American holly
Quercus bicolor	swamp white oak
Liquidambar styraciflua	sweetgum
Magnolia virginiana	sweetbay magnolia
Nyssa sylvatica	blackgum
Platanus occidentalis	Eastern sycamore
Platanus x *acerifolia*	London planetree
Salix sp.	willow
Taxodium distichum	bald cypress
Shrubs(1)	
Alnus spicata	speckled alder
Aronia melanocarpa	black chokeberry
Callicarpa japonica	Japanese beautyberry
Calycanthus floridus	Carolina allspice, sweetshrub
Carpinus caroliniana	American hornbeam
Cephalanthus occidentalis	buttonbush
Clethra alnifolia	summersweet
Cornus sericea	red osier dogwood
Dirca palustris	leatherwood
Hamamelis mollis	Chinese witch hazel
Hamamelis virginiana	common witch hazel
Ilex glabra	inkberry holly
Ilex decidua	deciduous holly
Ilex verticillata	winterberry holly
Itea virginica	Virginia sweetspire
Lagerstroemia indica	crapemyrtle
Lindera benzoin	spicebush
Myrica pensylvanica	bayberry
Philadelphus x *virginalis*	mockorange
Physocarpus opulifolius	Eastern ninebark
Salix caprea	Goat willow
Salix discolor	pussy willow
Sambucus canadense	elderberry
Viburnum spp.	viburnum species

(1) It is advisable to drain wet spots particularly where water stands for extended periods of time. The following plants can withstand more soil moisture than most other species. Not all plants are suitable for all sites.
(2) Many flood tolerant species have surface roots that can become a mowing hazard.

Building raised beds or redirecting the source of the water may be all that is needed. Unfortunately raised beds are usually not sufficient for the extensive root systems of large trees. If water cannot be directed away from the site, you will need to select a flood tolerant tree.

The ability of water to enter soil is called **infiltration**. How fast this happens is referred to as the infiltration rate. The ability of water to move through the soil is referred to as **percolation**. Both are important.

Sometimes water is unable to infiltrate into soil because of **hydrophobic mulch** or a **crusting of the soil** surface. Hydrophobic mulch and soil crusting shed water that runs off before it can enter the soil. These soils remain dry even after irrigating or heavy rain. Once saturated, soils that do not percolate can remain wet for long periods.

Ideally soils should be relatively loose. Soils may not percolate because the soil is **compacted**. Water moves downward when the soil is loose. Roots are also able to grow through these soil. Soils that are high in clay or have layers of different materials (i.e. sand, clay, organic matter) will not allow water to percolate through the soil.

The color of the soil is another indication of heavy or compacted soils. Well drained soils are brown or reddish. Blue-gray soils have very little oxygen in them. The naturally occurring iron in the soil has not had sufficient oxygen for it to turn a red color. Blue-gray and white soils are almost always very poorly drained. Plants preferring well-drained soils should never be installed on these soils. Species adapted to wet and flooded sites are more likely to survive.

Poorly drained soil has a distinctly foul odor.

A plug of wet soil, taken from the planting hole where a tree died from being in a water-logged site, indicates that the person installing the tree should have completed a perk test.

Soils that do not drain well often have an offensive or sour smell. Organic matter that decomposes without oxygen releases mercaptans (odor of natural gas or skunk), hydrogen sulfide (rotten egg) and other offensive smells. If the soil does not have a sweet, earthy smell it is likely that it does not drain well.

A perk test will allow us to measure the ability of water to move through the soil profile. This knowledge will allow us to modify the site or select different species that will be more tolerant of saturated soils.

Doing a Perk Test

Visual and physical indicators can be valuable clues to how well a soil drains. The best source of information is to actually test the ability of the soil to drain. This simple, easy test takes relatively little time and is a small investment for plants that can beautify landscapes for many decades. Testing the percolation rate is the best indicator that newly installed plants will thrive.

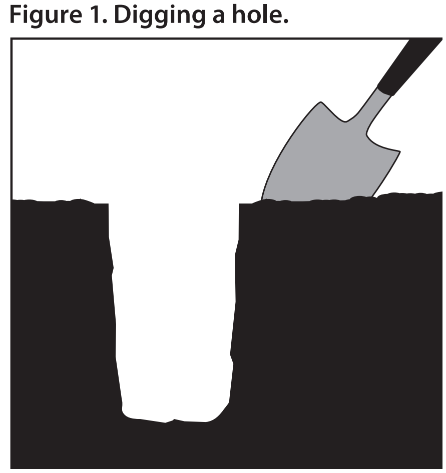
You will need:

- shovel or post hole digger
- water
- yardstick or tape measure

Procedure:

1. Dig a hole in the soil with a shovel or posthole digger (Figure 1). The diameter can be relatively small (3 inches or larger) and should go down at least a foot deep, 18 inches is better. The hole should be as deep as the soil ball is high and can even be the planting hole. You should avoid digging when the soil is wet as the sides of the hole can be glazed. If the soil is glazed the water will not drain and give false results.
2. Fill the hole with water and allow it to drain (Figure 2).
3. Refill the hole with water and measure the amount of time it takes to drain (figures 3 and 4). Ideally the water should drain at the rate of about 2 inches per hour. Anything between 1 and 3 inches per hour is acceptable.

Figure 1. Digging a hole.



Anything significantly less than 1 inch per hour indicates that the site is poorly drained and you will need to improve the drainage or select plants that will grow on waterlogged sites. It is not unusual for planting holes in the same landscape to drain at significantly different rates.

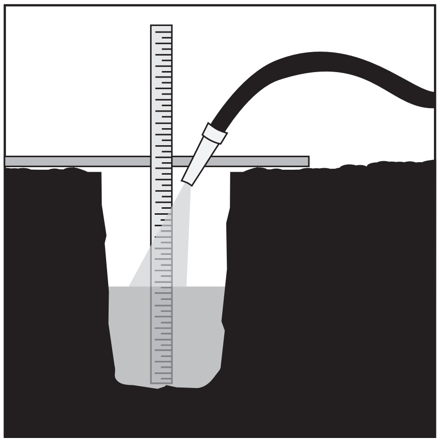


Figure 2. Filling hole with water (yardstick in middle of hole and straight edge across top of hole).

Mitigation of Poorly Drained Sites

Many species of plants are not able to survive on poorly drained soils. Those that do often have surface roots. This is especially true for floodplane species (i.e. silver maple, red maple, sycamore, river birch, willow, poplar and cottonwood). These surface roots can become a mowing hazard, reduce the ability of the tree to anchor itself and are often considered unsightly. Improving drainage on poorly drained soils can be difficult. Water has to go somewhere; either horizontally to a lower place or downward through the soil.

If the site is on a slope, dig a trench from the bottom of the planting hole toward a lower site. Lay a small plastic pipe in the bottom of the hole that will drain excess water downhill until it ultimately comes to the surface. One inch drop for every 5 feet of run is usually sufficient for water to drain. Cover the end of the pipe with a piece of window screen and a handful of rock to improve movement of water from the soil into the pipe. The downhill portion of pipe only has to be near the surface. Redirecting water from areas that are uphill and downspouts on a house can also reduce the amount of water in the plant's root zone. Another option is to install a rain garden. Rain gardens are sunken areas designed to collect water allowing more time for it to infiltrate into the soil. Plants in rain gardens must be able to tolerate wet and dry conditions.

- Do not add sand to poorly drained clay soils. Contrary to what logic would indicate, adding sand to clay soils slows the drainage.
- Do not add large amounts of organic matter to poorly drained soils. When organic matter breaks down in excessively wet soils under low oxygen levels, toxic gases and other byproducts are produced. These byproducts of decomposition are toxic to roots.

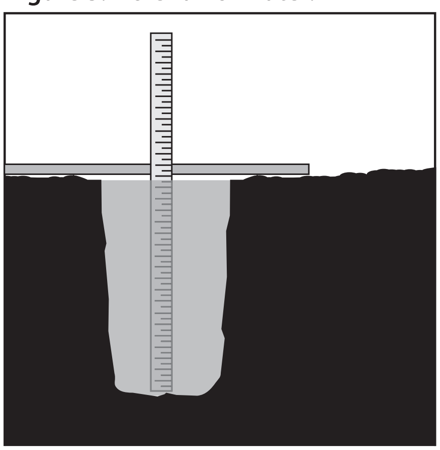


Figure 3. Hole full of water.

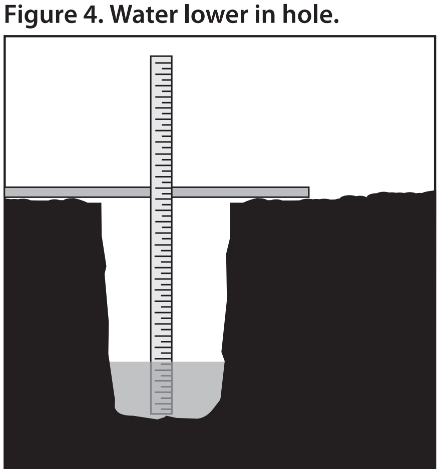


Figure 4. Water lower in hole.

This tree was planted too deeply and the soil did not drain properly (term for water moving through a soil is "percolation;" water moving into the soil is "infiltration").

Soil compaction results in failure of this soil to drain.

- Amending the backfill in planting holes often makes it more difficult for water to drain out of the planting hole.

Building raised beds or berms are another solution. These structures can contain soils uniquely tailored to the cultural conditions of the plant you wish to grow. Raised beds should be large enough to contain all of the root system of the plant at maturity. For this reason these structures are more suitable for vegetable gardens and smaller shrubs than large trees. Raised beds drain better than the surrounding soil so must be watered on a more frequent basis. It is important to not put raised beds or berms over tree roots. This can damage or kill the tree.

Glossary of Terms

compaction - compression of the soil, often as a result of vehicle or heavy equipment traffic, that breaks down the soil aggregates and reduces soil volume and total pore space, especially macropore space. The amount of micropores will increase.

crusting of soil - a thin layer of soil, often resulting from traffic or raindrops that forms an impervious layer.

hydrophobic mulch - a layer of fine organic matter that forms a barrier to water entering the soil. Lightly cultivating the mulch will eliminate this problem.

infiltration - the ability of water to enter the soil. This can be reduced by hydrophobic mulch, crusting of the soil or surface compaction of the soil.

macropore - the relatively large space between soil particles that is filled with air or water and allows for the downward movement of water and root growth. The small pores too small for roots to penetrate are called micropores.

mortality spiral - a sequence of stressful cultural conditions or events that cause the decline and eventual death of a plant.

percolation - the ability of water to move downward in soil once it has entered the soil.

All Photos by William M. Fountain

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