Tree Roots and Oxygen

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Tree roots need nutrients, water and oxygen to thrive and perform their important functions of absorption, anchorage, and conduction. We're pretty good at treating nutrient deficiencies and adjusting irrigation timers but we're not so good at making sure trees can breathe. Because oxygen is essential for cell metabolism in root tissue, when oxygen levels drop, roots suffer. And when roots don't function well, the entire tree is affected. This article focuses on several factors that impact oxygen in the root zone.

Overwatering

Root cell respiration relies on ambient oxygen found in the pore spaces between soil particles. When these soil pore spaces are filled with water, cell respiration stops until the soil dries out again. When water persists in the soil profile for an extended period of time, root health is compromised leading eventually to root death. And when roots die, there is a corresponding effect on plant parts above. Most plants can only handle 3 or 4 days of saturated conditions before permanent injury occurs.

Of all places on the planet, one wouldn't expect overwatering to be a problem in Southwest desert communities like Phoenix. But it is a problem due to a couple of factors. The first is overcompensation. Because of our dry climate, people wrongly assume their trees need more water than they do. They either water too deeply or too often. Water on top of water is never helpful and often harmful. Overwatering is a good example of a little more of a good thing not always being better. Unfortunately, people think that water for their trees is like Vitamin C for humans, that you can't get enough. But neither is true! People don't realize they are killing their trees with kindness by never allowing the root zone to dry out.

Another factor contributing to overwatering is an underestimation of the high water-holding capacity of desert clay soil. Clay soil particles are small and flat in shape. They nestle on top of one another, creating a tight soil matrix that absorbs and holds water better than any other soil type. The typical clay soil saturation profile is wider than it is deep. Water doesn't enter into clay soil easily and it doesn't escape easily. Consequently, the top 4 or 5 inches of soil can be as dry as baked adobe while the soil below is still moist. Unknowingly, people continue to water their trees day after day, assuming the trees need it based only on the dry surface soil. But the soil in the root zone below remains saturated. A little-known fact is that as the soil surface dries, water held in the lower soil profile can, through capillary action and evaporation, move upward again in the soil and be made available a second time to tree roots.

Wet clay soils are also perfect infection courts for pathogens including Texas Root Rot, a common tree killer in the Phoenix area. This soil borne fungal pathogen can be latent in the soil for years but only activated when certain conditions are met. Texas Root Rot requires elevated soil temperatures and the presence of water. When do we receive most of our inquiries for Texas Root Rot? It's almost always in late summer when we have triple digit temperatures and the daily monsoon rain cycle adds to the already heavily irrigated root zones of susceptible tree species.

Phytophthora is another fungal pathogen that loves over-wet conditions. The drip, drip, drip of irrigation emitters too close to the root collar has caused the death of many mature trees. And if the saturation mark is buried beneath several inches of decomposed granite, the fungal activity may go unnoticed until it's too late. There is much discussion about keeping water away from the base of trees to minimize the risk of infection. But many don't realize that the water isn't the problem. It is the constant presence of water against the trunk tissue that creates an environment conducive to fungal infection. Many trees with emitters close the trunk have no problem at all because the infrequent irrigation cycle allows the area to dry out completely before watering again. Is it safer to keep emitters and their saturation pattern away from the root collar? Absolutely. But it's usually the high frequency of irrigation and lack of oxygen in the area that leads to problems.

So let your soil breathe!

During normal summer weather, set the irrigation timer to allow a deep saturation through the entire root zone and then allow the soil profile to dry out before the next watering cycle. And during the monsoon, turn off your automatic irrigation timer until the rains subside. Saturated root plates can also lead to entire tree failure in high winds.

If you're not sure if the soil is still holding water at lower depths, use a soil probe to find out. A 4-foot soil (or tile) probe is a simple tool to check soil moisture in the deeper soil levels around your trees. We like using a 4-foot fiberglass probe with a metal tip and T-handle, available online from various suppliers. After a deep soaking, monitor the soil with the probe every few days. After pushing it past the crust of dried surface soil, the probe should slide easily into the soil to the depth of available water. Until there is more resistance to the probe, no irrigation is needed. When you can't push the probe into the soil, it's time to water again.

A low-tech, old school method to monitor available water is to watch for leaf wilt. For example, if your tree shows late afternoon leaf curling 10 days after watering, set your timer to irrigate every 8 or 9 days. Ideally, the soil profile should nearly dry out before watering again. Following irrigation, oxygen reenters the soil pore spaces, promoting healthy root respiration.

Soil Compaction

Another common cause for low soil oxygen is compacted soil. When serious soil compaction takes place, soil pore space is reduced resulting in lower water and oxygen infiltration and diminished root activity. Clay soils are more susceptible to soil compaction than other soil types, especially when wet. The flat shape and small size of the soil particles contribute to clay's high risk of compaction. Clay soil is common in the desert. This is a big plus for desert plants because clay has great water holding capacity. But that capacity can become a liability if not understood and managed well.

To prevent compaction, avoid pedestrian and vehicular traffic following irrigation of clay soils. Compaction due to compressing wet clay soils can cause irreparable damage to the soil and trees that grow in them. Remedial measures to reverse or combat the effects of compaction include vertical mulching and radial trenching. But these treatments are limited in their effectiveness. The best way to deal with soil compaction is to prevent it from ever occurring. Simply stay off wet or moist clay soils. If activity is unavoidable, designate specific, limited ingress and egress routes to minimize compacted areas.

On a park property that receives flood irrigation, a project manager informed me that they wait at least 5 days after an irrigation cycle to conduct any business in and around the park trees. This is a great policy to help prevent damage to the roots that rely on adequate soil oxygen to remain functional and healthy.

Roots Too Deep

Tree roots don't do well when they are too deep in the soil. They grow naturally at an optimum depth of soil for water and oxygen availability but deep enough to be insulated from temperature extremes. When for various reasons tree roots are too deep in the soil, they struggle to survive. Some adapt by sending roots from the original root system into the upper layers of soil where there is more oxygen. Some trees develop adventitious roots from the buried trunk tissue. But these new root systems seldom provide long-term water and nutritional needs for optimal tree health. These roots also can lose their normal outward orientation and wrap around the main stem or buttress roots. Even if a tree survives deep planting, it may have to deal with future stem- or root-girdling roots.

The most common cause of trees too deep in the soil is that planting holes are dug too deep at the time of installation. Unfortunately, this is sometimes done intentionally to help stabilize a tree and not have to use stakes! Another common cause is when nurseries bury the root collar when bumping up trees to larger containers. The result is these trees are too deep in the container even before they are planted in the landscape. Before buying a tree, look for the root collar to be sure it isn't too deep. Beware…if you don't see the flare. Finish landscaping materials such as fill dirt, compost or even decomposed granite can also cap oxygen from reaching the root zone. Plant trees at grade, even a little proud to allow for settling, then use stakes to stabilize the tree for the first season. If applying mulch, only apply a thin layer over the original root ball planted at grade. Dispose of excess soil and avoid large tree wells that tend to erode and send soil

back over the root ball. Another problem related to deep planting is that soil can wick water against the trunk tissue. As with overwatering, this provides an environment conducive to bacterial or fungal pathogens that can destroy the vascular cambium and lead to tree decline or death. Trunk tissue is not well-adapted to excessive moisture. Remember to plant roots, not trees!

If root problems are identified early, there are remedial measures that can be taken. Young trees planted too deep can sometimes be reset. Older trees planted too deep can be re-landscaped by removing excess soil above the root collar and either gradually sloping to the surrounding grade or building a terrace between the two grades. We have used rip rap or landscape bricks to prevent erosion as we step down to the new soil surface. If roots are found when excavating soil above the root collar, we normally remove them. The cost/benefit ratio favors losing the smaller new roots growing in the excess top soil and having better oxygen to the original root system.

“As go the roots, so go the shoots,” reminds us that root health usually predicts shoot health. Unfortunately, this connection can be missed when diagnosing biotic and abiotic tree problems. Because the trunk, branches, and leaves are so easily seen, we often begin and end problem diagnosis focusing only on these obvious tree parts. So the next time you’re diagnosing a tree issue, watch for signs and symptoms above ground that may trace back to overwatering, compacted soil or excessive planting depth. One or more of these factors affecting soil oxygen may be the key that unlocks your diagnostic problem.