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Figure 1. Salt damage on avocado can mimic drought damage. *Photo:* UC ANR.

DROUGHT TIP

Keeping Plants Alive under Drought or Water Restrictions

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This publication provides credible information on how to keep outdoor plantings alive during drought and under water restrictions. Topics covered include symptoms of water stress, tips to conserve water in your current landscape, methods to help specific plants survive drought, and considerations and tips regarding planting a drought-resistant landscape.

Plants that do not receive enough water eventually show signs of water stress. During a drought or under water restrictions aimed at water conservation, keeping plants alive can be particularly difficult. Although plants vary in the amount of water they require for optimal growth and development, most exhibit characteristic symptoms when they are in need of water. Because plants need to be watered before irreversible damage occurs, it is crucial to check plants regularly for symptoms of drought. Also ensure that damage identified as drought stress is not due to other conditions that can mimic drought such as salts (fig. 1), disease, insects, and frost.

Symptoms of Water Stress

Common symptoms of water stress include

- wilting or drooping leaves that do not return to normal (without additional water) by morning
- curled or yellow leaves that may fold or drop, along with potential twig drop
- leaves that lose luster and become grayish or bluish (fig. 2)

Figure 2. Drought damage on leaves of a rose plant. *Photo:* J. K. Clark.

- sunburned leaves (especially on the south side of the tree)
- new leaves that are smaller or stem sections that are closer together than normal
- lawn grasses that retain a footprint for several minutes

Tips to Reduce Water Waste in Your Current Landscape and Garden

Correct Sprinkler System Problems

The irrigation delivery system is often the real water waster, rather than the plants themselves. This is particularly true of sprinkler systems used to water turf and groundcovers. Avoid expending a lot of time and labor replacing a perfectly good landscape with a new one only to discover that the original cause of your water waste still exists. On average, 20 to 40 percent of water applied to lawns and groundcovers by sprinkler systems is wasted due to too high rates of application, system leaks, low or tilted heads, broken sprinklers, unmatched sprinklers, and incorrect water pressure and sprinkler spacing. You can greatly improve the distribution uniformity (evenness of water applied across your lawn or groundcover planting) and fine-tune the performance of your system by checking it for these problems and performing a uniformity and precipitation rate test, as described in the UC ANR publication Lawn Watering Guide for California, anrcatalog.ucdavis.edu/pdf/8044.pdf.

Typical sprinkler systems use fan spray heads that apply water much faster than the soil can absorb it, leading to wasted water that runs off the soil surface. Consider replacing sprinklers with multistream rotary heads that apply water much slower (about one-quarter of the rate of fan spray heads).

Water Based on Climate Zone

Water needs vary across the state based on climate zones. As figure 3 illustrates, reference evapotranspiration (ETo) rates are much lower in the San Francisco Bay area than in Riverside and Palm Springs. Evapotranspiration is the loss of water into the atmosphere from the soil and plant surfaces (evaporation) and through plant stomata

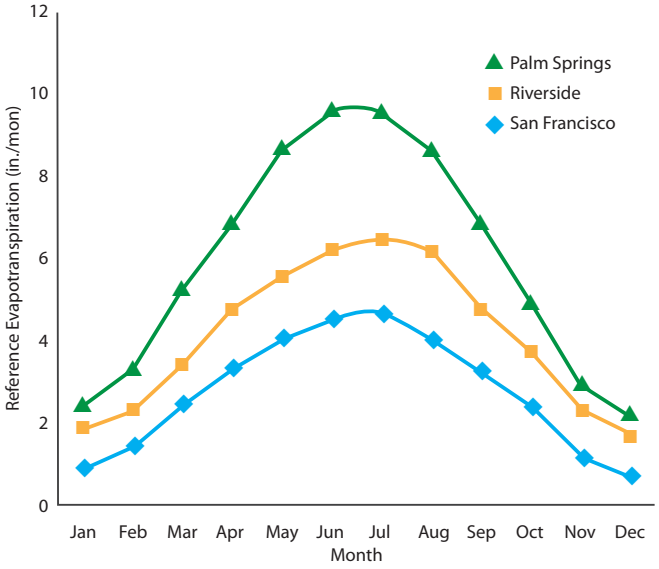

Figure 3. Monthly reference evapotranspiration (ETo) in the San Francisco Bay Area, Riverside, and Palm Springs. *Source:* R. Snyder, UC Davis Land, Air and Water Resources.

(transpiration). Reference ET is the amount of water taken up by established, healthy, cool-season turfgrass receiving unlimited water. Plant water demand and ET are closely related, although most mature, well-established landscape plants remain healthy even when irrigated below their ET. Note that the highest water demand occurs during summer and the lowest occurs during winter. This is true throughout California in all climate zones. A list of ETo zones in California can be found at the California Irrigation Management Information System (CIMIS) website, http://www.cimis.water.ca.gov/Content/pdf/CimisRefEvapZones.pdf.

Regardless of which ETo zone you reside in, remember to adjust automatic timers quarterly to match water need with water applied. In particular, reduce the amount of water applied to your landscape going into the fall. Not doing so leads to wasted water and unhealthy plants prone to disease-forming pathogens and other disorders.

Irrigate Slightly Below the Root Zone

A simple and effective way to irrigate below the root zone, which encourages deeper rooting and enhances drought resistance, is to gently dig into the soil to determine how deeply the water penetrates

the soil following irrigation. Look for a difference in soil color. Wet soil is usually darker than dry soil; this can help you determine how deeply the water is penetrating.

Irrigate Based on Soil Texture

Water plants growing in sandy soil more often but for shorter periods of time than those growing in heavy clay soil. This reduces water waste and the chance of groundwater pollution from fertilizers and pesticides leaching below the root zone in sandy soils and water and chemical runoff from the surface of clay soils. Use the feel method (fig. 4) to determine the texture of your soil. Figure 5 illustrates the drainage patterns that occur from irrigating sandy soils and soils high in clay. Note how much longer it takes

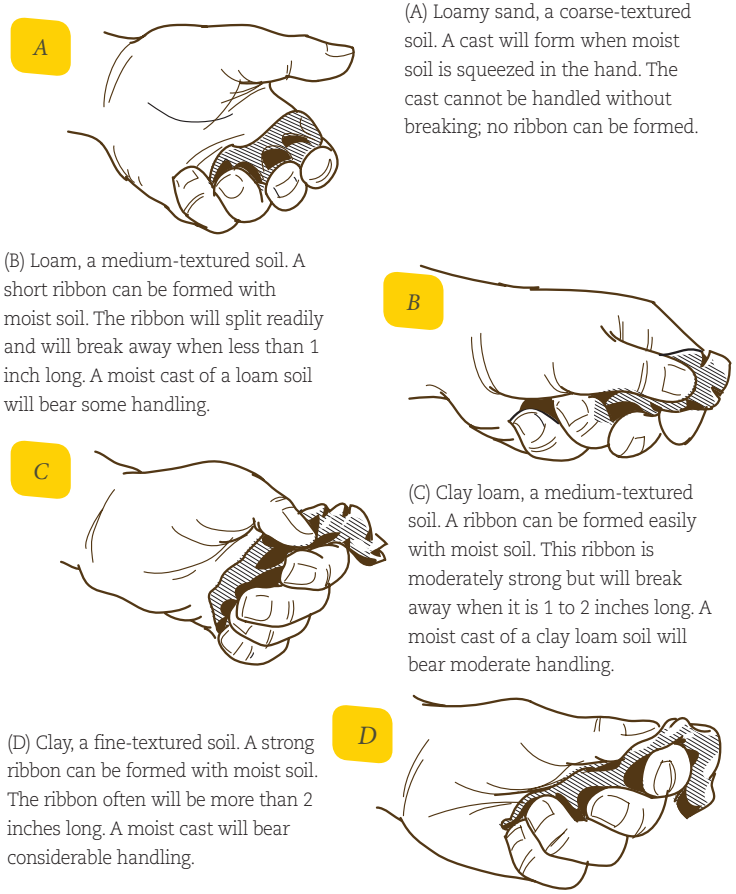

Figure 4. Determining soil texture by the feel method.

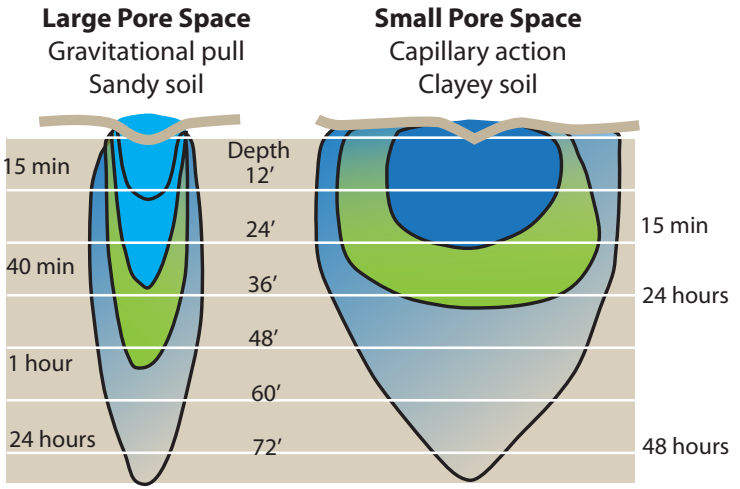

Figure 5. Comparative movement of water downward and outward in sandy and clayey soils. *Source:* Whiting and Wilson 2014, fig. 7.

the same amount of water to penetrate deeply into a clay soil compared with a sandy soil and how much farther the water spreads horizontally in the clay soil. Clay soils need to be watered longer during each watering but less often than sandy soils.

Irrigate Early in the Morning

Soil evaporation is lower early in the morning than later in the day. While evaporation is also low at night, fungal diseases may develop, particularly when overhead systems that wet leaves are used. Since wind is usually milder in the morning, less water is wasted during morning irrigations than later in the day, as well.

Don't Irrigate Plants Showing Signs of Physiological Drought

In the heat of a midsummer day, many plants cannot absorb available water as quickly as necessary to compensate for water lost due to evapotranspiration. This leads to temporary midday wilting known as physiological drought, which will not be alleviated by adding more water. Affected plants will recover on their own during the evening and should appear normal (erect) by morning.

Avoid Summer Planting

Converting a thirsty landscape to a drought-tolerant one should be done in fall (preferably) or spring rather than during the heat of summer. New transplants need more frequent and shallow irrigations than established plantings until roots expand into native soil.

Consider Installing a "Laundry to Landscape" Graywater System

The State of California and most local jurisdictions have lifted or greatly lessened restrictions on systems that allow landscape plants to be irrigated with water from a washing machine if certain conditions are met. The updated code and its provisions for use of graywater to irrigate landscapes can be found in its entirety at the California Department of Housing and Community Development Codes and Standards website, www.hcd.ca.gov/codes/shl/2007CPC_Graywater_Complete_2-2-10.pdf. Contact your local city or county public works department for specific information on local laws that may be more restrictive. Also see the UC ANR Drought Tip Use of Graywater in Urban Landscapes in California, anrcatalog.ucdavis.edu/Details.aspx?itemNo=8536, for more information.

Consider Installing a Rainwater Harvesting System

Rainwater harvesting systems collect rainfall from roofs and channel it via gutters, pipes, or swales, keeping it on the landscape rather than allowing it to run off. Properly functioning rainwater harvesting systems can significantly reduce the need for supplemental irrigation in areas of measurable rainfall.

Mulch

Apply and maintain a layer of mulch 3 to 4 inches deep around garden plants and trees to keep the water in and weeds out (fig. 6). Be sure to keep mulch at least 1 foot away from tree trunks to avoid wet trunks and crowns, which can be subject to disease-forming pathogens.

Avoid Overfertilizing

Applying too much nitrogen leads to an overabundance of leaf production and the need for more water. Most mature landscape plants will get through a season or two with no supplemental fertilization. Fruit trees and vegetables require adequate nutrients for crop production. When water is scarce, fruit trees should not be fertilized; while the crop may be sacrificed, this practice reduces the water requirement and helps keep the tree alive. Annual vegetables may get by on slow-release nutrients supplied by organic matter and compost.

Control Weeds

Weeds usually outcompete garden plants for water. Pull them when they are small, making sure to remove all the roots.

Dust Off the Old Broom

Sweep garden debris off of sidewalks and driveways rather than hosing them off.

Figure 6. A 3-inch layer of wood chip mulch conserves water, reduces weeds, and slows water runoff. *Photo:* G. Frank, gardensbygabriel.com.

Studies have shown that California native oaks may benefit from supplemental summer irrigation during prolonged drought even though they are relatively drought tolerant. However, they are also easily over-irrigated, leading to fungal diseases such as oak root fungus (Armillaria mellea) and crown rot (Phytophthora spp). Letting the soil dry out some between irrigations helps prevent these diseases. Keep water at least 10 feet away from tree trunks and apply most water in the outer two-thirds of the root zone, which may extend two to three times the canopy of the tree.

Methods to Keep Plants Alive during Drought or Water Restrictions

Trees

Most homeowners wisely choose to use whatever water is available to save their mature landscape ornamentals and fruit trees. If it hasn't rained, watering older trees slowly and deeply with a garden hose to a depth slightly below the current root zone once in mid-spring and once or twice again in midsummer will keep most established trees alive for at least one season. Trees growing in sandy desert soils may require more frequent irrigations to keep them alive. Two seasons or more of drought stress can cause severe damage and death of some species, even in cooler coastal areas. Drought-stressed trees are often more prone to damage from diseases and insects as well.

Mature trees growing in lawns often become reliant on shallow, frequent irrigations that favor turf health over tree health. This problem worsens when turf is removed or is left to go dormant and the water source for the trees stops. It is critical to continue to water your trees under these situations. In the long run, installing a permanent drip system or soaker hose that allows water to be applied slowly and deeply is recommended. A temporary irrigation system that includes an inline drip tube or a multistream rotary sprinkler with a hose connection and a timer can also be used. Specific information on implementing this system is found at the UC Davis California Center for Urban Horticulture website,

http://ccuh.ucdavis.edu/public/drought/tree-ring-irrigation-contraption-tric-1/tree-ring-irrigation-contraption-tric.

Although fruit and nut trees can be kept alive during severe water shortages for a season or two, fruit production may be greatly reduced or stop altogether. To produce a standard crop, deciduous fruit and nut trees need water applied steadily from bloom until harvest. Citrus trees need adequate soil moisture during spring to set fruit and steady water in summer and fall to produce acceptable size, number, and quality of fruit. Mature trees have extensive root zones that often grow laterally two to three times the canopy width and 2 to 3 feet deep, depending on the soil texture, compaction, and irrigation. Active water uptake by roots occurs in this area. Move drip lines and emitters farther away from the trunk as trees mature. Irrigating too close to tree trunks can result in crown and root rot and does not apply water into the root uptake zone of the tree.

Figure 7. Plant only family favorites and avoid an oversized garden that is larger than your needs. *Photo:* UC ANR Green Blog, ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=13130.

Vegetables

Vegetables are not drought-resistant plants and are difficult to maintain during a drought. It is often wise to reduce the overall size of the garden and plant only your favorite types of vegetables when water is limited (fig. 7). Scheduling irrigation based on the water needs of the specific crop during critical periods of growth is essential for vegetable production. Hydrozoning (placing plants with similar water needs in the same area of the garden) allows gardeners using automated drip irrigation systems to target water applications based on water needs of individual zones, reducing water waste.

Mixing organic soil amendments (such as compost) evenly into garden soil 6 inches to 1 foot deep helps retain soil moisture in the rooting area of the plant, which can significantly lengthen the interval between irrigations before drought symptoms develop. While the plant still requires the same amount of water, stretching the time a plant can go between waterings can make the difference in whether garden plants live or die during a drought or under water restrictions. This is especially true of tomatoes, beans, lettuce, and root crops such as carrots that require regular watering and are not tolerant of long dry periods. Vine crops such as cucumbers and squash often fare better than most types of vegetables during drought and can be kept alive by watering once or twice a week throughout the season. As a rule of thumb, water is most critical during the first few weeks after sowing vegetable seeds, immediately after transplanting seedlings and small plants, and during flowering and fruit production. Remember to add a 3-inch layer of mulch on top of the soil between plants to reduce evaporation from the soil surface.

Shrubs

Most established shrubs can survive long periods of dry soil. Even if there has been no rain, one thorough spring watering and one or two thorough waterings in the summer keeps most mature shrubs alive for at least one season. As with other plants, prolonged drought can cause severe branch dieback and eventual plant death.

Groundcovers

Groundcovers often survive on about half the amount of water they would receive under optimal conditions, although some dieback may occur. To avoid serious drought stress, water them once every 3 to 6 weeks from April through September, depending on location and soil conditions.

Lawns

Warm-season grasses, such as bermudagrass, zoysiagrass, and buffalograss, are more drought efficient than cool-season grasses, such as tall fescue and ryegrass, and may survive several weeks of dryness even after partial dormancy. Conversely, cool-season grasses may die within a month or two of receiving no water. Signs of drought include wilted leaves and a bluish-gray appearance followed by yellow leaves that eventually turn brown. Established lawns, like all mature plants, prefer infrequent, deep irrigations over frequent, shallower ones.

Once a lawn stops receiving adequate moisture, it will gradually turn brown and go dormant. A lawn that recently turned brown from drought can often be revived with thorough watering, but it may be difficult to save a lawn that has been deprived of water for several weeks. This depends on the turf species, soil texture, length of time since last irrigation, weather, and other parameters. During a water shortage, gradually reducing the amount of water applied to your lawn to one-half of that recommended in the UC ANR Lawn Watering Guide, anrcatalog.ucanr.edu/IntegratedPestManagement/8044.aspx, will help ensure the survival of warm- and cool-season lawns.

Additional methods to reduce water waste in your lawn are to maintain the highest recommended mowing height based on species and to reduce fertilization rates to one-half or less of recommended rates. Specific information on these topics may be found in the UC ANR publication Managing Turfgrass during Drought, https://anrcatalog.ucdavis.edu/pdf/8395.pdf.

Figure 8. Beautiful, drought-efficient landscapes save water and time. *Photo:* Christine Holmquist Landscape Design, www.cholmquistgardens.com/portfolio/.

Considerations and Tips for Planting a Drought-resistant Landscape

The heat of summer is not the time to remove and replace your current landscape plants with drought-resistant species. Plants that are not established, even drought-resistant natives, require more frequent watering than the same species growing for a season or two that have developed deeper, more extensive root systems. Fall is the best time to establish native plants, and fall or spring are good times to swap thirsty plants with more drought-efficient non-natives (fig. 8).

Keep in mind that the irrigation delivery system is often the real water waster, not the plants. This is particularly true of sprinkler systems used to water turf and groundcovers. Avoid expending a lot of time and labor only to discover that the original cause of your water waste still exists. While cool-season lawns are not drought resistant, warm-season turf takes about the same amount of water as many other plants. To reduce water waste and improve the performance of lawns, maintain even water distribution across the lawn and follow the tips listed above in the section "Lawns."

Tips for Planting a New Water-Efficient Landscape

- Select water-efficient plants that grow well in your climate. Use Sunset climate zones (www.sunset.com/garden/climate-zones/climate-zones-intro-us-map) rather than USDA cold hardiness zones, since Sunset zones are smaller and more precise. The exception is in cold, mountain regions, where USDA zones are often a better choice.
- Apply water directly into the root zone of newly planted ornamentals until roots become established and expand outward and downward.
- Hydrozone. Place plants with similar water needs together in high, medium, low, and very low categories and irrigate them accordingly. This is especially important when landscape and edible plants are irrigated by automated systems allowing precise scheduling valve by valve.
- Mix soil amendments (compost, etc.) evenly and deeply into sandy and clay soils (40% or more by volume) at least 6 inches deep before planting small herbaceous and woody plants to improve water retention in sandy soils and drainage in clay soils. Avoid adding soil amendments to holes dug for individual trees since roots often grow in circles in the confines of the amended soil rather than expanding outward and downward into unamended soil. This practice can result in poor anchorage and support for the maturing tree and can lead to tree failure.
- Drip-irrigate areas of your landscape not planted in turf and groundcovers unless you are regularly home to ensure that plants receive adequate water (particularly during the first few weeks after planting). Drip systems apply water directly into the root zone of the plant, greatly minimizing evaporation from soil. In addition, drip systems apply water much more slowly than do sprinkler systems, reducing surface runoff (fig. 9).
- Download other free UC ANR resources such as Sustainable Landscaping in California, anrcatalog.ucanr.edu/Details:aspx?itemNo=8504, for additional ideas to save water, recycle organic matter, reduce waterway pollution, reduce pests, conserve energy, and attract wildlife.

Figure 9. Drip-irrigated drought-efficient landscape on slope with mulch minimizes runoff. *Photo:* Terra Divina Ecological Landscape Design, www.ecolandesign.com/california.html.

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