Native Trees for Tucson

VELVET MESQUITE

DESERT WILLOW

DESERT IRONWOOD

FOOTHILL PALO VERDE

Ten Best Practices for Using Native Trees in Urban Environments to Improve Urban Climate Change Resilience

A PROJECT OF

TUCSON CLEAN & BEAUTIFUL

Major funding provided by the Arizona Department of Forestry and Fire Management's Urban and Community Forestry Program and USDA Forest Service.
These institutions are equal opportunity providers.

Native Trees for Tucson


PALO BREA


VELVET MESQUITE


DESERT WILLOW


KIDNEYWOOD


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Native Trees for Tucson


SCREWBEAN MESQUITE


CATCLAW ACACIA


DESERT WILLOW


VELVET MESQUITE


CANYON HACKBERRY


KIDNEYWOOD

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TUCSON IS FACING BIG CLIMATE CHALLENGES

It's getting hotter and drier

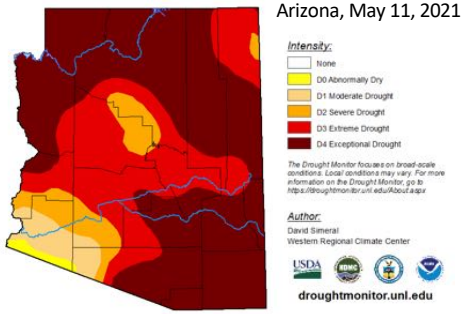
- Tucson is 3rd fastest warming US city
- 2019 and 2020 set heat records
- 2020 was the driest year on record, with only 4.17 inches of rain
- Heat Island effect is raising city temperatures both day and night
- Parking lots and other bare "hardscapes" are especially hot
- Average temperatures could increase 10 degree by 2100
- Urban trees are experiencing major stress and some are dying

We need more shade

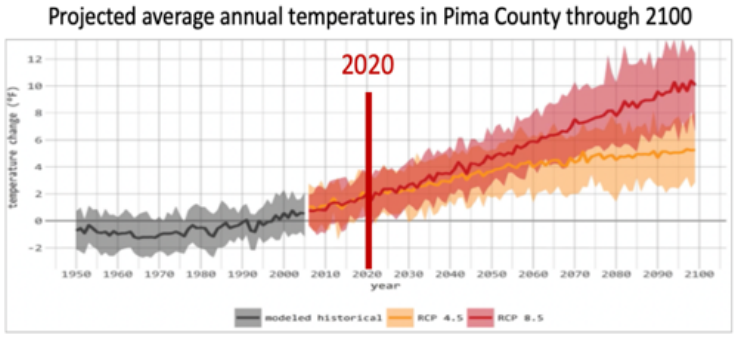
- Greatest concerns for increased heat are neighborhoods with <10% shade
- Average shade in eastern Pima Co. 8%
- Average shade in Tucson <6%
- Average shade in some wards <4%

We must conserve drinking water

- Much of Tucson's water supply comes from CAP water, which originates in the Colorado River
- Due to long-term drought, Arizona needs to reduce its CAP water use
- Residential, commercial and industrial water users need to do their part to conserve water and expand water reuse and recycling to reduce their water needs

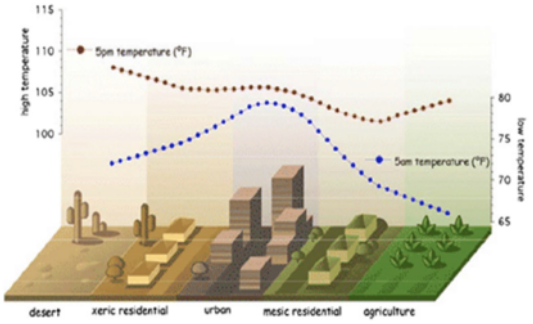


U.S Drought Monitor
Arizona, May 11, 2021



Source: Presentation by Dr. Ladd Keith given at the 2020 On-line Desert Horticulture Conference, Tucson, AZ

Dead non-native Aleppo pine next to a healthy mesquite tree



"Typical profile of Phoenix urban heat island using five predominant land cover types in the metropolitan area (Harlan, et al, 2007)" in International Journal of Biometereorology, by D. Ruddell, P Dixon, published online, October 22, 2013

Residential site with very low tree canopy cover resulting in extreme heat around the house and high electric bills to provide cooling

Residential site with dense tree canopy cover: trees cool the house, soil and adjacent street, and reduce energy costs for cooling

NATIVE TREES ARE ADAPTED TO LOCAL RAIN, HEAT AND DROUGHT CONDITIONS

Trees native to the Sonoran Desert grow in different natural habitats receiving different amounts of water

Low water-use native trees grow naturally on desert flats, slopes and dry washes, often at lower elevations. They get water from direct rainfall, local runoff and from washes and rivers that flow occasionally. They thrive in the desert without supplemental water, but grow larger when they receive more.

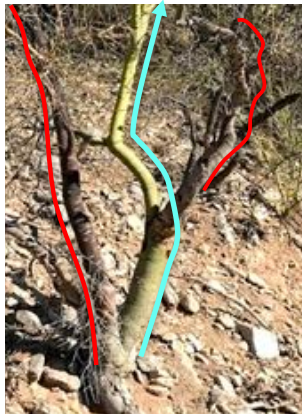
Medium water-use native trees grow naturally along slopes, washes, streams and canyons that receive more rainfall and runoff, and are often found at higher elevations where it is slightly cooler.

Native trees have specific adaptations to the desert

- Broad multitrunk native tree canopies cool branches, trunks and soil below
- Small, velvety leaves deflect ultraviolet rays
- Some trees are drought deciduous, dropping leaves in seasonal dry seasons or severe drought to save water, then growing new leaves when water returns
- Trees can “self-prune” some twigs and branches to focus scarce water on remaining branches
- Trees may skip flowering/seeding cycles and use other adaptive strategies in drought

The natural draping shape of a *low water-use* desert ironwood tree shades the trunk and branches and cools the soil

Leaves are wilting and browning on a *medium water-use* canyon hackberry tree growing in a hot parking lot with inadequate irrigation



A multitrunk *low water-use* foothill palo verde tree on a dry slope has “self-pruned” one trunk plus a large branch

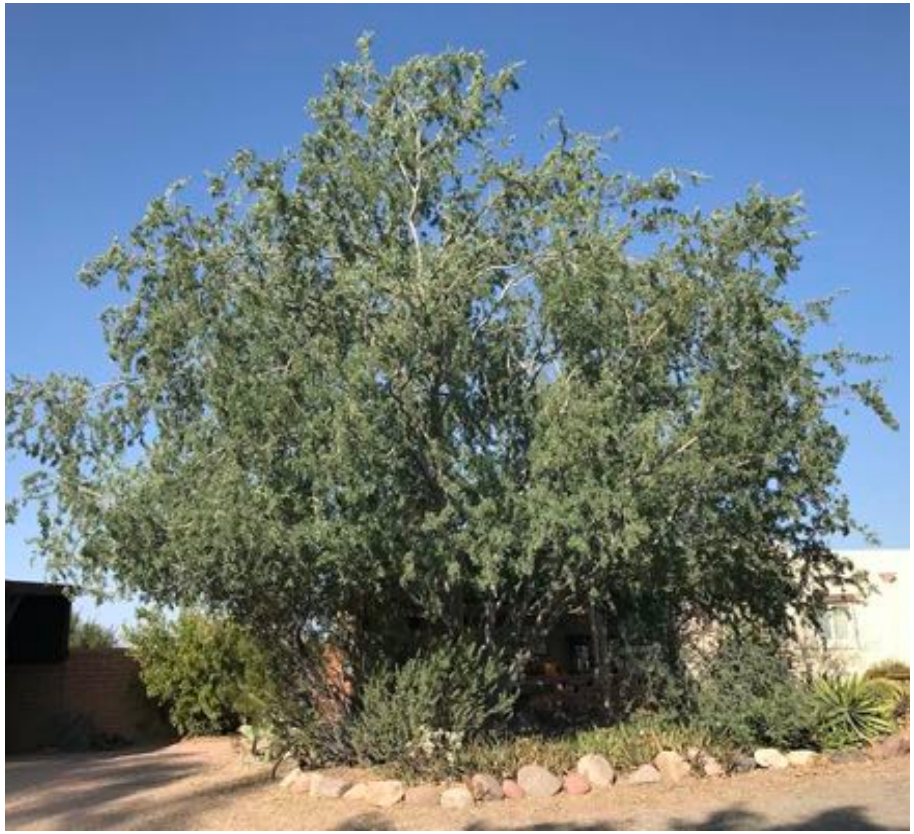
PLANTING NATIVE TREES CAN INCREASE URBAN SHADE AND SAVE DRINKING WATER

By harvesting free urban water supplies we can increase shade while conserving drinking water

- Harvest the rain that falls on homes and yards and runs off residential roofs, driveways, sidewalks and patios
- Harvest stormwater that flows off large building roofs, streets, parking lots and other “hardscapes”
- Harvest graywater from washing machines, baths, showers and bathroom sinks
- Harvest the water that condenses on cold air conditioners and ice machines

Urban native trees given harvested water can grow faster and larger, create deeper shade and avoid natural drought responses

Urban ironwood tree thriving on street runoff



Ironwood planted 12 years ago is thriving on rooftop runoff and (most likely) water from a nearby septic leach field

NATIVE TREES PROVIDE MANY BENEFITS IN ADDITION TO SHADE

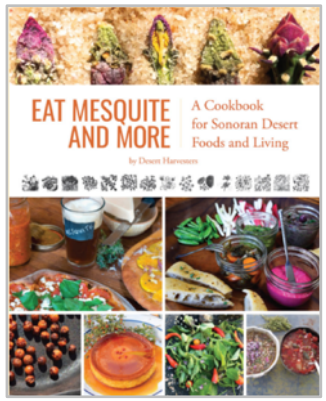
Our versatile native trees…

- Serve as shady “nurse plants” for small saguaros and other native plants
- Have edible fruits, seeds and pods, increasing local food supplies
- Provide beneficial food, shelter and habitat to many co-evolved native insects, birds and other wildlife
- Grow well in low-nutrient desert soils
- Add nitrogen to improve soil quality
- Screen wind, dust and noise
- Cool and calm our environment
- Save energy needed for cooling
- Serve as thorny security barriers
- Honor our cultural and historic traditions
- And some live for hundreds of years

Native trees don’t typically

- Require soil amendments
- Heave pavement and foundations
- Blow over in high winds

Saguaros “nursed” by foothill palo verde tree



Cookbook for using mesquite and other native edibles

Bird nest in berry-rich canyon hackberry tree

Magnificent blooming blue palo verde, Arizona’s state tree

Traditional Tohono O’odham wato built from mesquite wood next to a mesquite tree

Butterfly sipping nectar from a desert willow bloom

Edible screwbean mesquite seed pod

Colorful, harmless nymphs of the giant mesquite bug

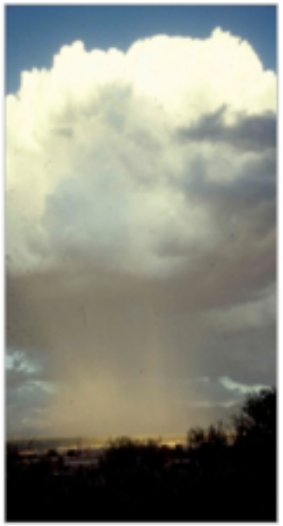
10 BEST PRACTICES TO INCREASE URBAN CLIMATE RESILIENCE WITH NATIVE TREES

1. To save drinking water, grow native trees with harvested rainwater, stormwater, graywater and condensate water
2. Learn native tree needs and characteristics
3. Plant native trees and native understory plants together
4. Plan where to plant to meet your needs and the needs of trees
5. Start with healthy young plants
6. Shape your tree's water harvesting area
7. Plant your tree carefully
8. Add mulch when you plant to keep moisture in the ground
9. Provide establishment watering and ongoing watering using harvested water
10. For good shade and tree health, follow native tree pruning principles

Native trees providing abundant shade

BEST PRACTICE 1

To save drinking water, grow native trees with harvested rainwater, stormwater, graywater and condensate water


RAINWATER


STORMWATER RUNOFF


GRAYWATER

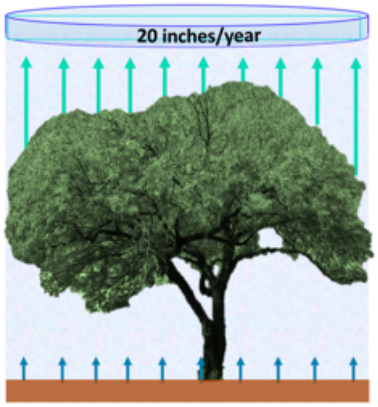

CONDENSATE WATER

Different types of native trees growing in hot urban areas need different amounts of water

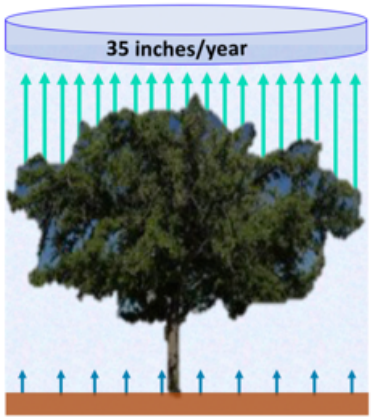
Tree water needs are typically based on *evapotranspiration*—the amount of water transpired from tree leaves and evaporated from soil. Water needs vary depending on the time of year, temperature, wind, humidity, tree type and other factors. Annual average water needs for low water-use native trees and medium water-use native trees are shown below.

Estimated annual evapotranspiration from trees in hot urban areas

LOW WATER-USE TREES



MEDIUM WATER-USE TREES



Low water-use native trees need around 20 inches of water a year for good growth in hot urban areas

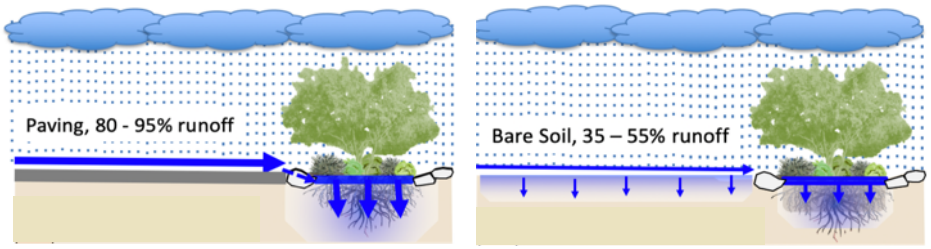
Different sized *low water-use* trees need different amounts of water:
10-foot wide trees need ~ 1,000 gallons/yr
20-foot wide trees need ~ 4,000 gallons/yr
30-foot wide trees need ~ 9,000 gallons/yr

Medium water-use native trees need around 35 inches of water a year for good growth in hot urban areas

Different sized *medium water-use* trees need different amounts of water:
10-foot wide trees need ~ 2,000 gallons/yr
20-foot wide trees need ~ 7,000 gallons/yr
30-foot wide trees need ~ 15,000 gallons/yr

To provide native trees with the water they need, start by harvesting rainfall and runoff

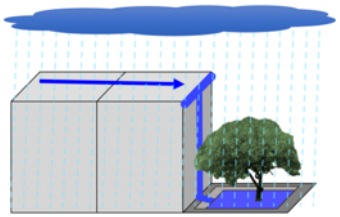
The volume of rainfall and runoff water you can harvest depends on rainfall and the type, slope and area of the surface you are harvesting water from. More water runs off paved or roof surfaces than runs off earthen or vegetated surfaces.

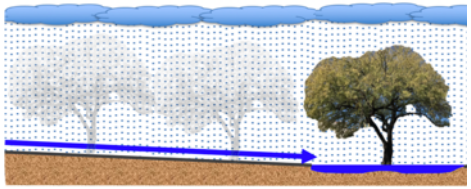


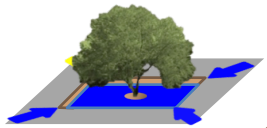
Visualizing catchment ratios can help you provide runoff to support trees (no tape measure needed)

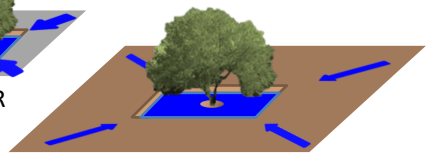
A catchment ratio (CR) compares the land area from which rainfall and runoff water is harvested to the canopy area of the (eventually) full-grown tree using the water. The larger the land area, the more water is provided to the tree.

LOW WATER-USE TREES benefit from a roof/paved CR of around 3-to-1 (3:1) or more, or earthen CR of around 7:1 or more


ROOFTOP 3:1 CATCHMENT RATIO

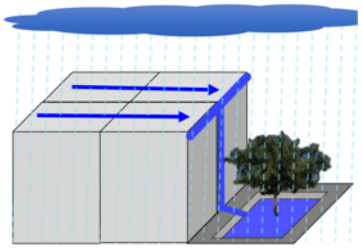

PAVED 3:1 CATCHMENT RATIO

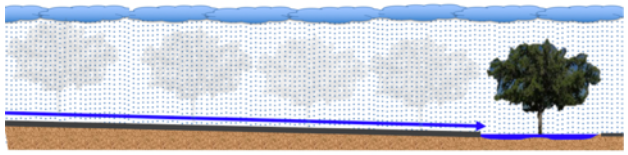

PAVED 3:1 CR

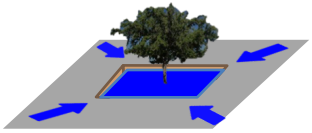

EARTHEN 7:1 CR

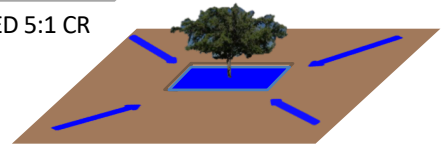
A 20-foot diameter *low water-use* tree needs around 4,000 gallons of water a year. The catchment ratios shown yield around 4,000 gallons of water in a year of average rainfall.

MEDIUM WATER-USE TREES benefit from a roof/paved CR of around 5:1 or more, or earthen CR of around 13:1 or more


ROOFTOP 5:1 CATCHMENT RATIO


PAVED 5:1 CATCHMENT RATIO


PAVED 5:1 CR


EARTHEN 13:1 CR

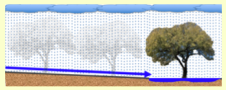
A 20-foot diameter *medium water-use* tree needs around 7,000 gallons of water a year. The catchment ratios shown yield around 7,000 gallons of water in a year of average rainfall

NOTE: For catchment ratios to support trees, water harvesting basins must be large enough to hold and infiltrate rainfall and runoff from large storms. Wide, 12-inch deep basins can typically accomplish this.

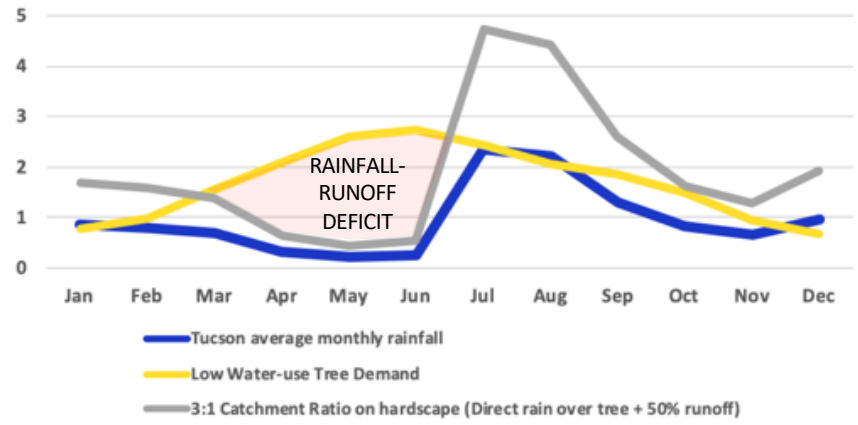
However, harvesting rain and runoff can't meet the needs of all native trees in April, May and June

- These graphs show average monthly water needs for urban trees, average monthly rainfall in Tucson, and the extra water provided each month by a 3:1 catchment ratio for *low water-use* trees and a 5:1 catchment ratio for *medium water-use* trees
- Rainfall varies year-to-year—average rainfall is around 11.5 inches/year, but in 2020 Tucson received less than 5 inches of rain
- Note the differences between average tree needs and available rain and runoff in April, May and June
- ***While native trees can survive in their natural ranges on average rainfall, runoff and local moisture conditions, some low and medium water-use native trees growing in hot urban areas will likely need additional water in April, May and June to provide ongoing shade***

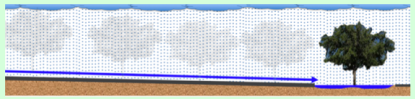
COMPARISON OF AVERAGE MONTHLY LOW WATER-USE TREE NEEDS TO MONTHLY RAINFALL AND RUNOFF



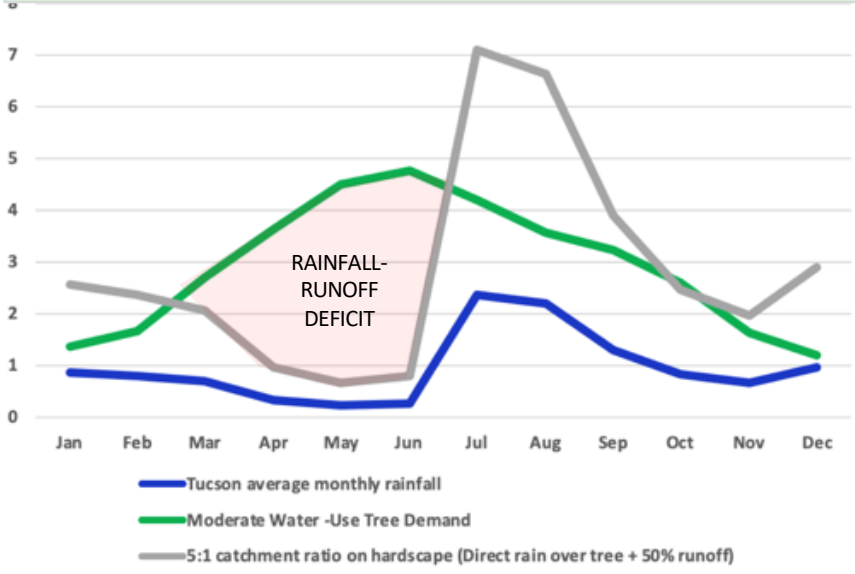
A paved 3:1 catchment ratio meets tree needs about 9 months in an average year



COMPARISON OF AVERAGE MONTHLY MEDIUM WATER-USE TREE NEEDS TO MONTHLY RAINFALL AND RUNOFF

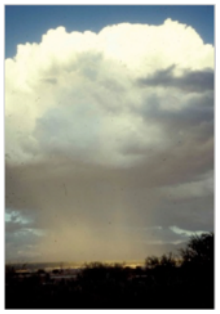


A paved 5:1 catchment ratio meets tree needs about 8 months in an average year

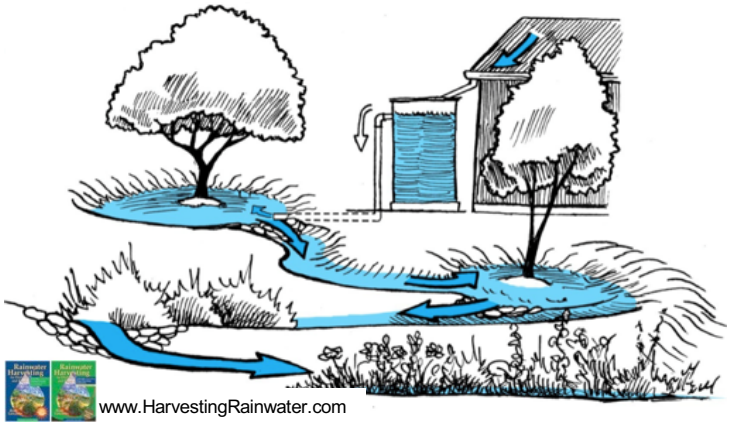


Use additional harvested water supplies to help meet tree needs

Harvesting graywater and condensate water can help meet tree needs when rainwater isn't available.
Collecting rainwater in tanks can provide water to plants when its dry outside.



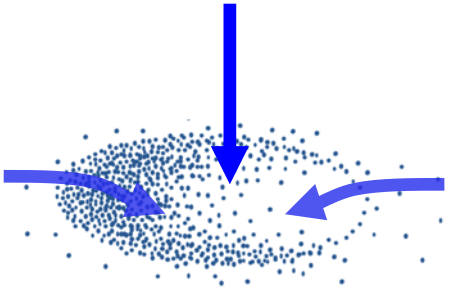
Rain falls right where you need it—on your land. *Passive water harvesting* captures and infiltrates large volumes of rainwater directly into the soil via a living sponge of water-harvesting earthworks, vegetation and mulch



Start at the "top" of the site and zigzag water flow down through multiple basins

How to get started passively harvesting rainwater

- Harvest rainwater from rooftops and higher land areas, and work your way down slope harvesting water throughout a site
- Zigzag water flow down through multiple basins, each one infiltrating more water into the soil
- On flat land, dig simple depressions to harvest direct rainfall
- Raised curbs can help retain more direct rainfall in parking lot planting areas
- On sloping land, build raised earthen berms on the downhill sides of depressions to harvest and infiltrate more water

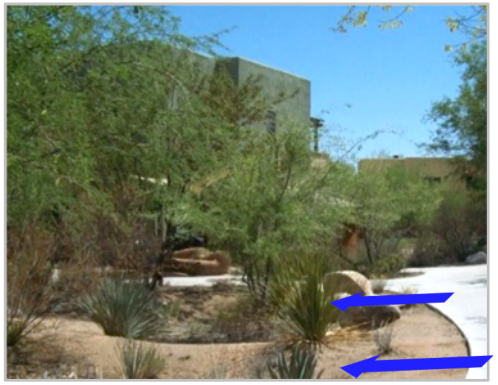


On flat land, dig simple depressions to retain rain where it falls

Raised curbs help hold more direct rainfall in parking lot planting areas

Construction tips for building earthworks

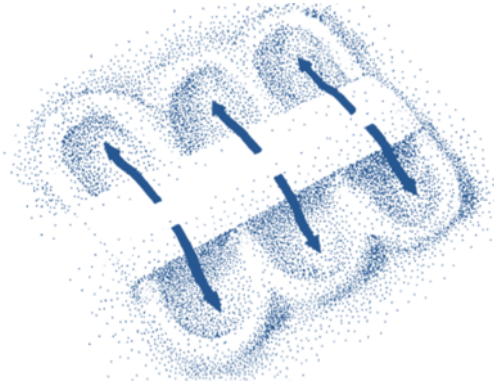
- It's easier to dig when soil is moist—not when it's dry and hard
- Build berms wider than they are tall
- Compact the soil on the top and sides of the raised berm
- DO NOT compact the bottom of basins, this slows down infiltration
- Make gentle slopes going into basins
- You can add rock to the top and outside of berms to stabilize them



On sloping land, construct berms on downhill sides of basins to harvest and infiltrate more rainwater and runoff

Raise paths; sink adjacent basins

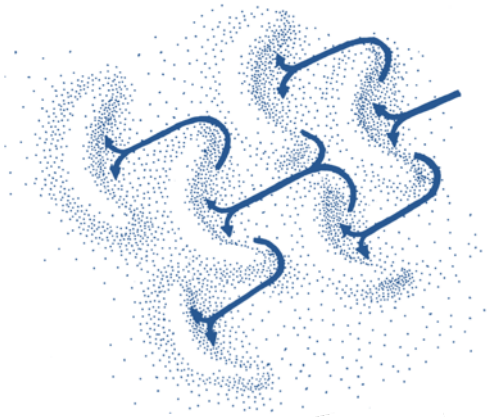
- Raise paths and sidewalks and slope them toward adjacent basins to provide runoff water to plants growing in the basins
- Make paths next to deep basins extra wide for the safety of pedestrians



Water from wide, raised path flows toward basins

Move water down slopes in careful steps

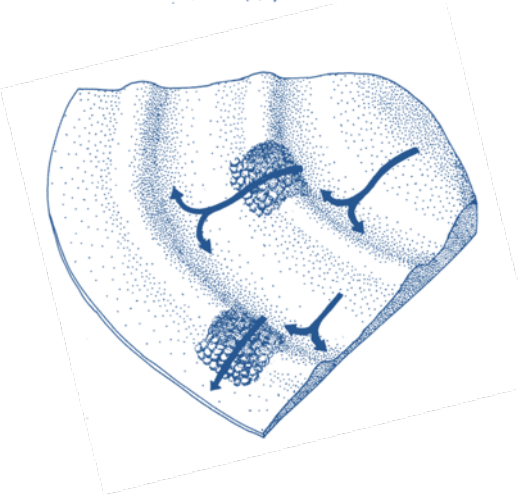
- On longer slopes, construct multiple basins going down the slope so water flows from one basin to the next, each one infiltrating more water
- Overflow spillways can be stabilized with perennial vegetation or rock
- The more gradual the slope and the wider, or more spread out the spillway is (and thus the shallower the flow), the more stable it is

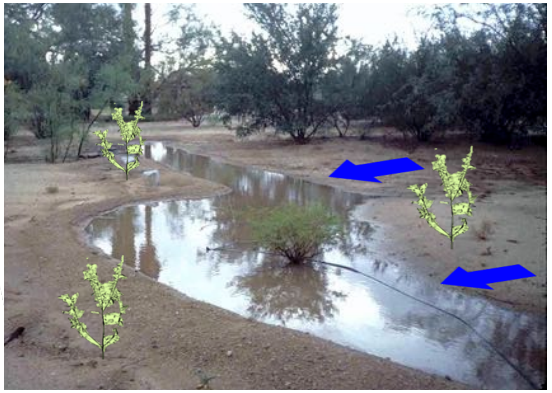


Water flowing from one basin down to the next

Collect water in structures constructed along land contours (lines of equal land elevation)

- Contouring strategies include constructing terraces, constructing contour swales, planting densely on contour and other approaches
- The goal is to slow, spread out and infiltrate water flow before it runs off slopes
- Construct spillways spaced along the berms to direct overflow water safely over the berms in large storms
- Spillways should be several inches below the top of the berm and constructed wide and level
- You can stabilize spillways with perennial vegetation or rock to reduce erosion when water flows over them





A swale constructed along land contour harvests large volumes of runoff water. Good tree planting locations are shown.

Stormwater runoff is rainwater that flows off large "hardscapes"

- Hardscapes include large roofs, parking lots, streets, sidewalks and other large areas of concrete and asphalt
- Harvest runoff in adjacent basins to grow trees that will shade the hardscape
- Curb cuts in parking lots lead stormwater runoff to tree basins in the parking lots
- Curb cuts along streets lead stormwater runoff to street-side tree basins
  - Check your jurisdiction's rules to find out what permits are needed to construct curb cuts along streets
- "Permeable paving" is paving material that provides a hard walking and driving surface, while allowing water to infiltrate through the paving to soil below. Permeable paving may have less water harvesting capacity than open basins if the paving material fills up much of the void space. Several examples of permeable paving include:
  - Specially designed paving blocks with built-in gaps
  - Paving blocks placed on a metal framework above the soil level, allowing water to flow through gaps between bricks to the soil below
  - Porous concrete made with gravel, cement and water, but no sand

Rain running off the roof of large building

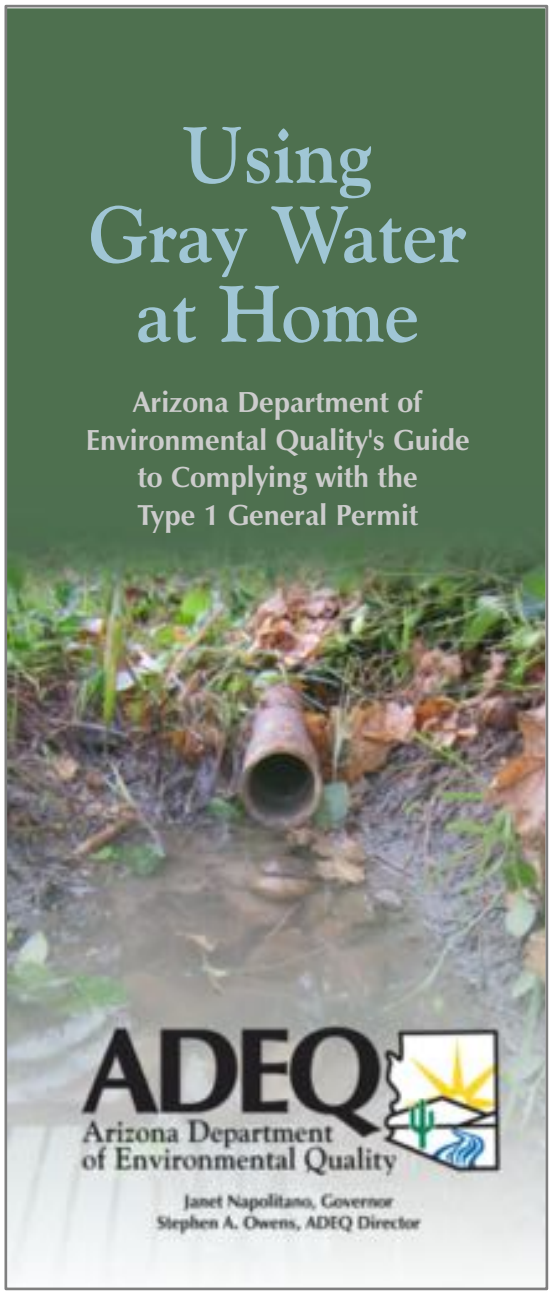
Valuable stormwater runoff collecting in parking lot

Curb openings in a parking lot lead water to large basin

Curb cut on public street leading runoff to basin

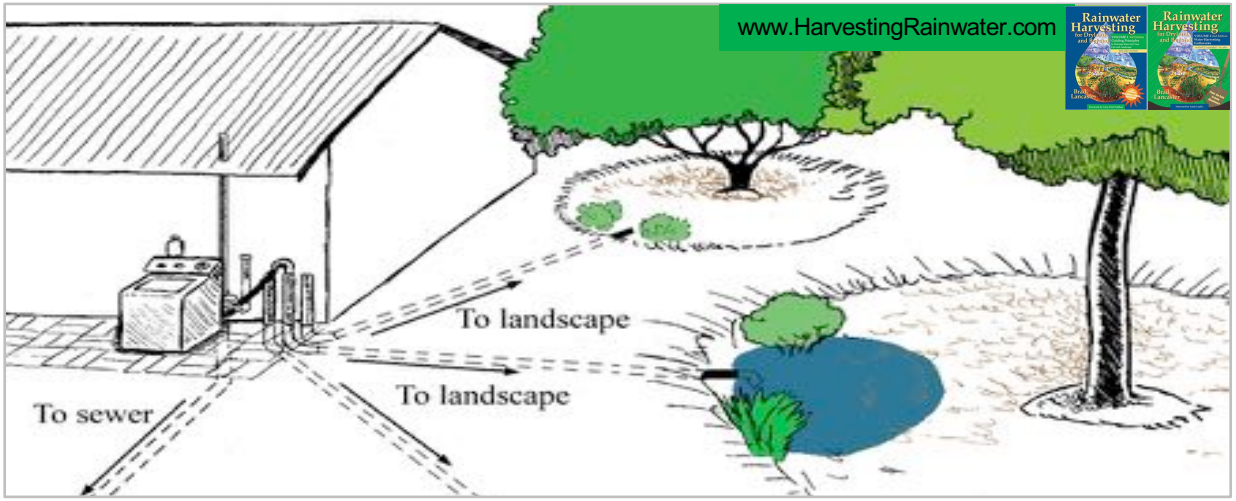
Paving bricks with large gaps in them allow water to infiltrate into soil

Paving bricks rest on a metal framework 6 inches above the soil level. Water flows through gaps between bricks to the soil below



Graywater is a predictable year-round water supply to support trees

The Arizona Department of Environmental Quality provides common sense guidelines for the use of graywater. Graywater is drain water that originates from bathroom sinks, showers, bathtubs and clothes washers that is collected separately from sewage flow. Toilet water is "blackwater" NOT graywater, and must be discharged to septic/sewer. Kitchen sink water requires additional treatment before use in soil. Dishwasher drain water also requires additional treatment, but is much lower quality due to the excessive salts used in dishwater detergents.



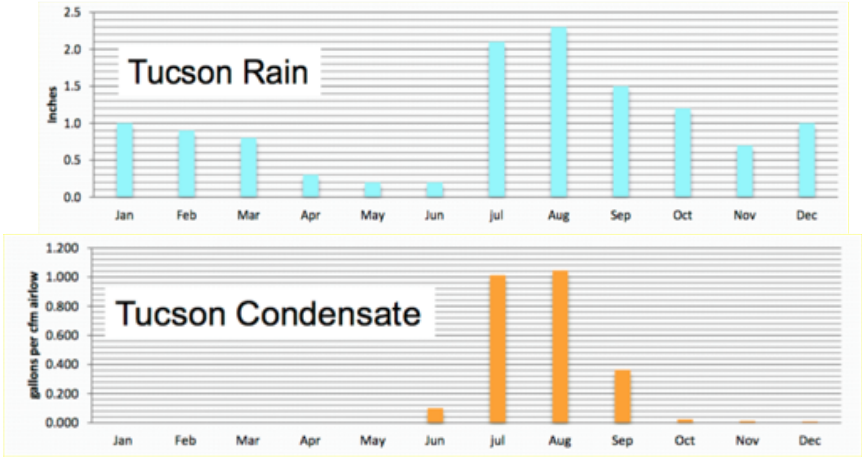
Dos and don'ts for applying graywater to native trees

- Graywater can be piped outside and delivered to the root zone of trees via drip or flood irrigation, but keep surface accumulations of graywater to a minimum
- Avoid human contact with graywater and graywater-irrigated soils
- Use special soaps and detergents that are designed to be safe for plants
- While native desert trees tolerate the salts in graywater, it is important to collect rainwater in graywater basins to dilute these salts
- DO NOT spray graywater
- DO NOT apply graywater to leaves or edible parts of trees
- DO NOT use graywater if your house has a water softener
- DO NOT use washing machine water if you are washing diapers

Condensate is a useful water supply produced when moisture in air condenses on cold surfaces

Moisture in humid air condenses on cooling coils inside air conditioners, ice machines and other cold-producing machines. This water must be discharged from the machines. The discharged condensate water can be harvested to support native trees.

Monthly rainfall and air conditioning condensate supply
Air conditioners produce large volumes of condensate water in July, August and September—hot humid months when air conditioners are heavily used. Even if it doesn't rain, high humidity will yield condensate.



wrrc.arizona.edu/sites/wrrc.arizona.edu/files/Glawe%20UA%20Condensate%20Powerpoint.Nov-12-14.pdf

Residential-scale system: This air conditioning condensate pipe yields over 30 gallons of water every 24 hours in the humid monsoon season. Attaching simple fittings and a hose make it possible to deliver condensate water to a nearby tree basin. *CAUTION: DO NOT ALLOW WATER TO BACK UP IN THE CONDENSATE DISCHARGE PIPE—THIS COULD DAMAGE THE AIR CONDITIONING UNIT*

Commercial-scale system: Air conditioning condensate + rooftop runoff are harvested in an 11,000 gallon tank at University of Arizona. Tanked water, along with tank overflow and greywater from a drinking fountain is directed into the landscape to support a lush native tree garden at Underwood Family Sonoran Landscape Laboratory.

BEST PRACTICE 1. Grow trees using harvested water: Harvest rainwater in tanks

Install a rainwater tank to extend the time when rain is available

- After developing passive water harvesting, consider adding a rainwater tank
- This is called “active water harvesting” because it requires installing a permanent structure and conducting ongoing operation and maintenance
- Tanks come in all shapes, sizes and materials
- Tucson Water customers can apply for a rebate to construct rainwater tanks at https://www.tucsonaz.gov/water/rainwater-harvesting-rebate

Look at the difference water harvesting makes!

This shady, abundant landscape at a Tucson multihousing complex is supported in part by rainwater, stormwater and graywater harvesting, with some supplemental irrigation using potable water

The apartment complex next door has far fewer trees and less shade even though there are many roofs and a large parking lot that could provide harvested water

Roger Road, Tucson, Arizona Google Earth photo dated 8/19/2018

Visualize the difference extensive water harvesting can make!

Low water-use trees (lighter colored trees) are planted throughout the urban landscape, supported primarily by passively harvested rainwater and stormwater

Medium water-use trees (darker colored trees) are placed close to houses and buildings where they can be supported by passively harvested rainwater, stormwater, graywater and condensate water and tanked rainwater

BEST PRACTICE 2

Learn native tree needs and characteristics

The 14 native Sonoran Desert trees described here are listed in order of their drought-tolerance and resilience in the urban environment, starting with the hardy desert ironwood tree

Native trees and understory plants are well adapted to desert heat and dry seasons and grow without irrigation in their natural ranges. The eight *low water-use* native trees described here are the easiest trees to grow to maturity, and can be planted along hot urban streets and in parking lots. Providing supplemental passively harvested rainwater and stormwater helps them grow larger, more dense canopies than in the wild. In extreme urban heat and drought, they may need additional graywater, condensate water and tanked rainwater.

The six heat-tolerant *medium water-use* native trees described here meet urban needs for single-trunk trees, small-stature trees and dense hedge-like trees. Plant them near houses and buildings where they can be supported with passively harvested rainwater and stormwater plus graywater, condensate water and tanked rainwater.

Information provided about each tree includes the following:

- **PHOTO MONTAGE:** Photos illustrate natural and pruned tree shapes, leaves, flowers, seeds, thorns, bark and other visual characteristics of trees.
- **SIZE:** Tree sizes vary considerably depending on water supply, growing location, age, climate, weather conditions and other variables. In unique cases, individual long-lived trees may grow substantially larger than the general ranges shown here.
- **GROWTH RATE:** Typical rates of growth in natural areas are provided. Native trees often grow faster in urban areas when provided with supplemental water.
- **LIFESPAN:** Tree lifespans are estimates—it can be difficult to determine the age of desert trees because they typically lack distinct seasonal growth rings.
- **WATER USE:** Water use information includes recommended catchment ratios and urban water supplies to support different types of native trees.
- **URBAN PLACEMENT:** Recommendations are based on water needs, tree size and other factors.
- **CLIMATE RESILIENCE:** Information addresses tree adaptations and tolerance of extreme conditions.
- **NATURAL RANGE IN ARIZONA:** Maps show where trees naturally occur geographically in Arizona.
- **NATURAL DISTRIBUTION:** Describes and illustrates topography/elevation where trees naturally occur.
- **CHARACTERISTICS:** Information includes tree form, thorns, shade, edible food and other information useful to know when selecting trees.

An urban ironwood tree retains its full dense shade canopy from July through April

In early May, the ironwood drops most leaves and blooms

By late May, the ironwood is setting seed, getting ready to grow new leaves and sprout seeds in July's monsoon rains

BEST PRACTICE 2. Desert Ironwood *(Olneya tesota)* needs and characteristics

Well-pruned desert ironwood, maintaining multiple trunks

Natural tree form

Extreme prune

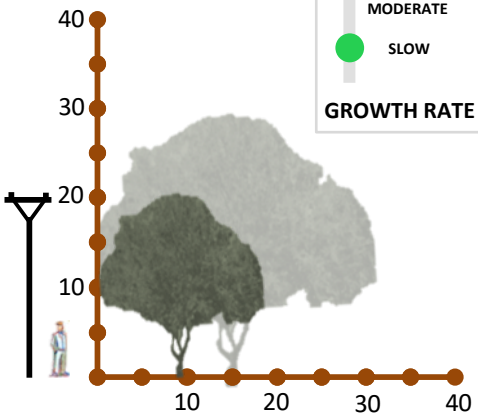
Trunk

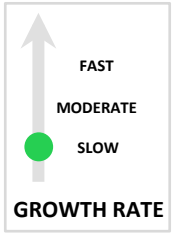
Leaves

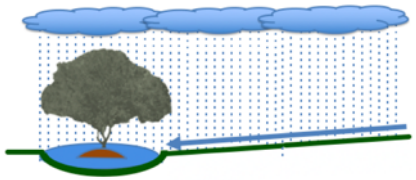
Flowers

Seed pods and thorns

SIZE (feet)







LOW WATER-USE TREE

Recommend 3:1 catchment ratio or greater to harvest rainwater and stormwater. If needed, supplement with graywater, condensate water and/or tanked rainwater.

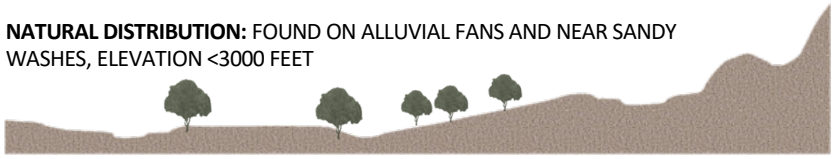
URBAN PLACEMENT

Moderate to large, very long-lived tree. Give it space to grow. Can be planted along streets, in medians and parking lots and around houses and buildings.

CLIMATE RESILIENCE & NATURAL RANGE IN ARIZONA

- VERY DROUGHT TOLERANT, DROUGHT DECIDUOUS
- GROWS IN STRONG SUN; HAIR ON LEAVES PROTECTS FROM HARSH UV RAYS
- ADAPTED TO EXTREME HEAT
- COLD TOLERANT TO 20°F
- SELF SEEDS
- WITHSTANDS HOT DRY WIND

NATURAL DISTRIBUTION: FOUND ON ALLUVIAL FANS AND NEAR SANDY WASHES, ELEVATION <3000 FEET



CHARACTERISTICS

Multitrunk, thorns, evergreen, drought deciduous, fixes nitrogen in soil, casts dense shade, edible seeds and flowers, supports native pollinators and wildlife

LIFESPAN (years)

50 — 100 — 150 — can live a 1000 years or more!

BEST PRACTICE 2. Velvet mesquite *(Prosopis velutina)* needs and characteristics

Well-pruned velvet mesquite, maintaining multiple trunks

Natural tree form

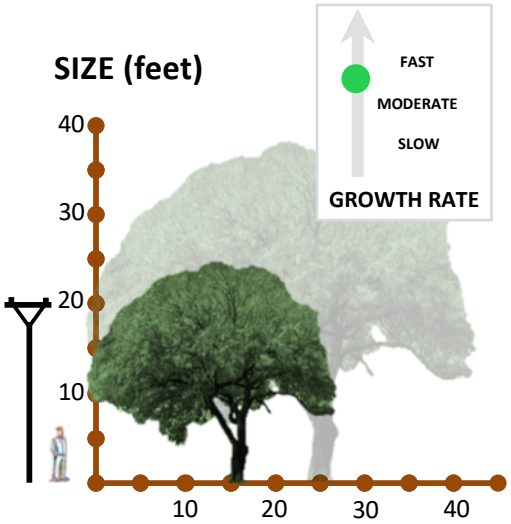
Extreme prune

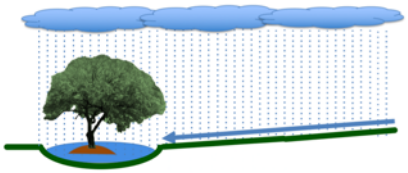
Bark

Leaves, giant mesquite bug nymphs

Flowers

Seed pods





LOW WATER-USE TREE

Recommend 3:1 catchment ratio or greater to harvest rainwater and stormwater.
If needed, supplement with graywater, condensate water and/or tanked rainwater.

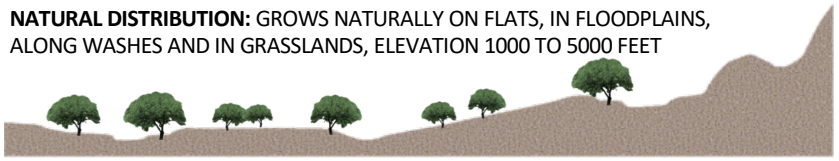
URBAN PLACEMENT

Moderate to large, long-lived tree. Give it space to grow. Can be planted along streets, in medians and parking lots and around houses and buildings.

CLIMATE RESILIENCE & NATURAL RANGE IN ARIZONA

- EXTREMELY DROUGHT TOLERANT
- ADAPTED TO EXTREME HEAT
- SELF SEEDS
- GROWS IN STRONG SUN. VELVETY LEAVES SHIELD UV RAYS
- COLD TOLERANT TO 15°F
- WITHSTANDS HOT DRY WIND

NATURAL DISTRIBUTION: GROWS NATURALLY ON FLATS, IN FLOODPLAINS, ALONG WASHES AND IN GRASSLANDS, ELEVATION 1000 TO 5000 FEET



CHARACTERISTICS

Multitrunk, thorns, deciduous, fixes nitrogen in soil, casts dense shade, edible seed pods, supports native pollinators and wildlife

LIFESPAN (years)

50 100 150 200+

BEST PRACTICE 2. Foothill palo verde *(Parkinsonia microphylla)* needs and characteristics

Well-pruned foothill palo verde, maintaining multiple trunks

Natural tree form

Extreme prune

Trunk

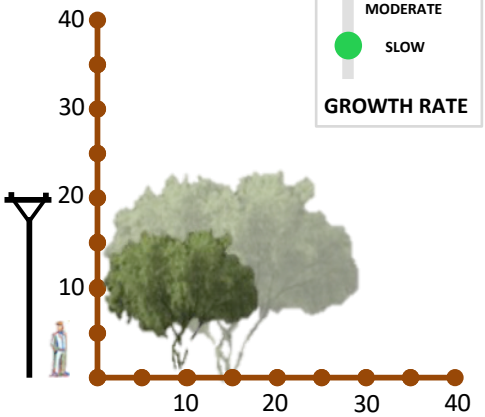
Leaves

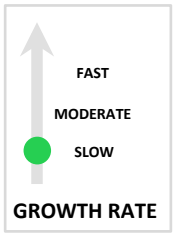
Flowers

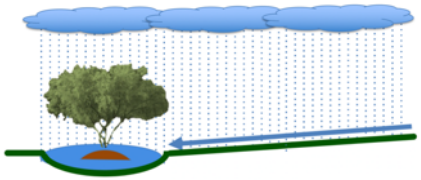
Seed pods

Thorns

SIZE (feet)







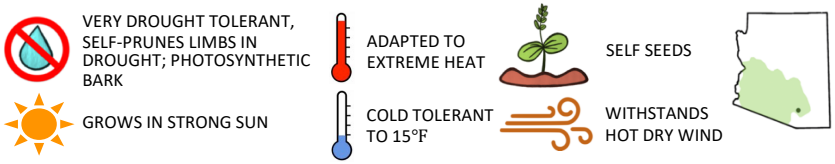
LOW WATER-USE TREE

Recommend 3:1 catchment ratio or greater to harvest rainwater and stormwater.
If needed, supplement with graywater, condensate water and/or tanked rainwater.

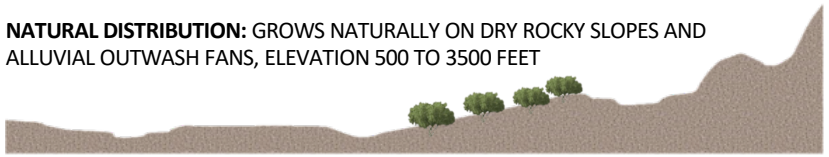
URBAN PLACEMENT

Moderate sized, long-lived tree. Can be planted along streets, in medians and parking lots and around houses and buildings.

CLIMATE RESILIENCE & NATURAL RANGE IN ARIZONA



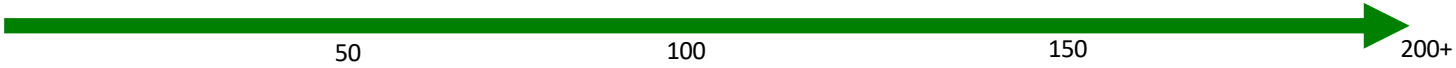
NATURAL DISTRIBUTION: GROWS NATURALLY ON DRY ROCKY SLOPES AND ALLUVIAL OUTWASH FANS, ELEVATION 500 TO 3500 FEET



CHARACTERISTICS

Multitrunk, thorns at end of branches, casts moderate shade, edible seeds and flowers, supports native pollinators and wildlife

LIFESPAN (years)



BEST PRACTICE 2. Blue palo verde *(Parkinsonia florida)* needs and characteristics

Well-pruned blue palo verde tree, maintaining natural form

Natural form

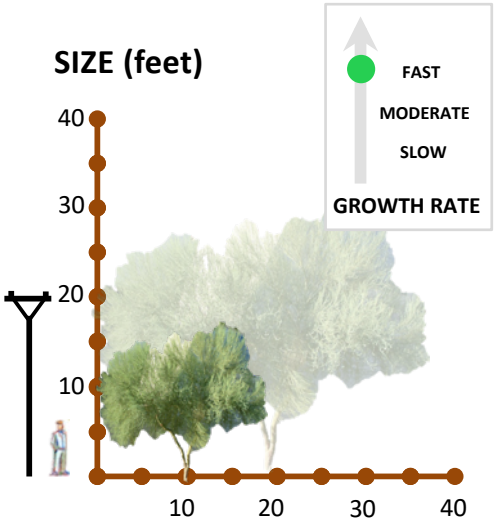
Extreme prune

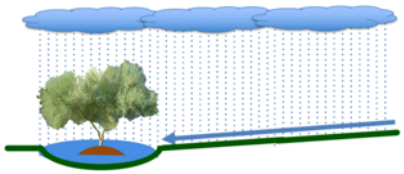
Leaves

Flowers

Seed pods

Trunk

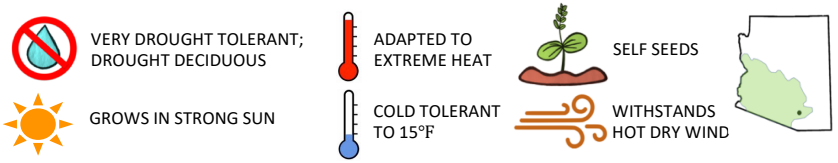




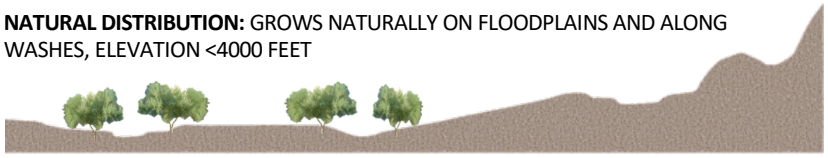
LOW WATER-USE TREE
Recommend 3:1 catchment ratio or greater to harvest rainwater and stormwater.
If needed, supplement with graywater, condensate water and/or tanked rainwater.

URBAN PLACEMENT
Moderate to large, long-lived tree. Can be planted along streets, in medians and parking lots and around houses and buildings.

CLIMATE RESILIENCE & NATURAL RANGE IN ARIZONA



NATURAL DISTRIBUTION: GROWS NATURALLY ON FLOODPLAINS AND ALONG WASHES, ELEVATION <4000 FEET



CHARACTERISTICS
Multitrunk, thorns, winter deciduous, casts dense shade, edible seeds, supports native pollinators and wildlife

LIFESPAN (years)

BEST PRACTICE 2. Catclaw acacia *(Senegalia greggii)* needs and characteristics

Well-pruned catclaw acacia, maintaining multiple trunks

Natural tree form

Extreme prune

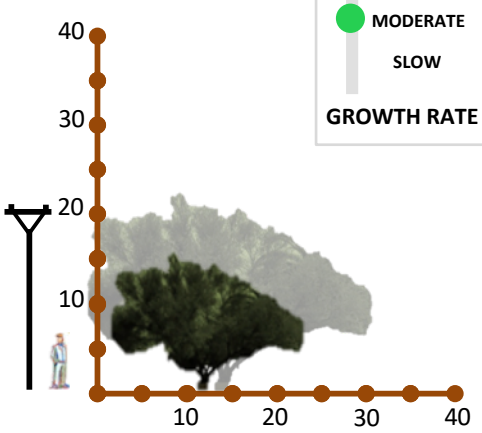
Trunk

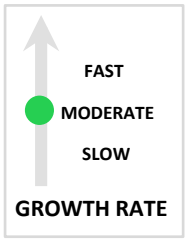
Leaves and thorns

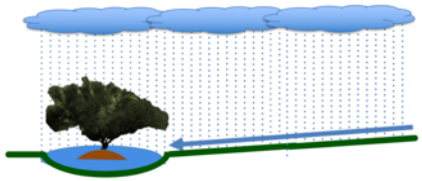
Flowers

Seed pod

SIZE (feet)



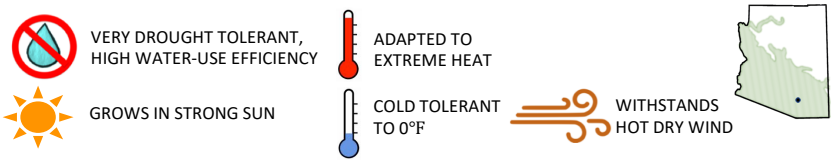




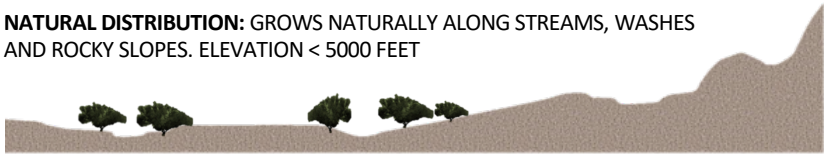
LOW WATER-USE TREE
Recommend 3:1 catchment ratio or greater to harvest rainwater and stormwater.
If needed, supplement with graywater, condensate water and/or tanked rainwater.

URBAN PLACEMENT
Moderate-sized tree. Can be planted along streets, in medians and parking lots and around houses and buildings.

CLIMATE RESILIENCE & NATURAL RANGE IN ARIZONA

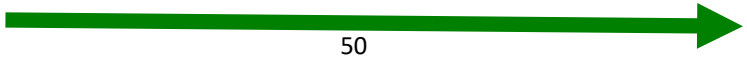


NATURAL DISTRIBUTION: GROWS NATURALLY ALONG STREAMS, WASHES AND ROCKY SLOPES. ELEVATION < 5000 FEET



CHARACTERISTICS
Multitrunk, sharp curved thorns, winter deciduous, fixes nitrogen in soil, casts dense shade, grows in sun or part shade, supports native pollinators and wildlife

LIFESPAN (years)



BEST PRACTICE 2. Palo brea *(Parkinsonia praecox)* needs and characteristics

Well-shaped palo brea tree

Palo brea trees in bloom

Heavily pruned

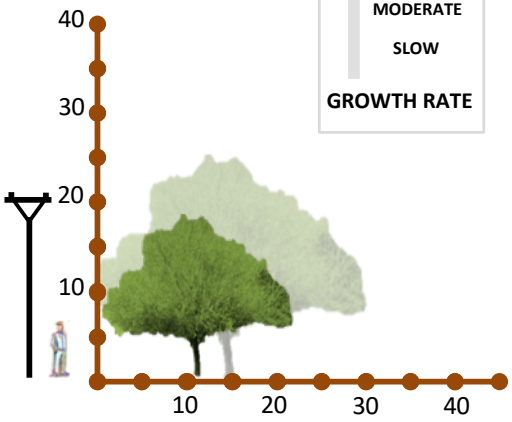
Trunk

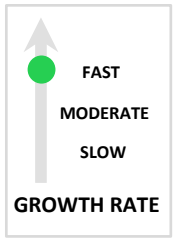
Leaves and thorns

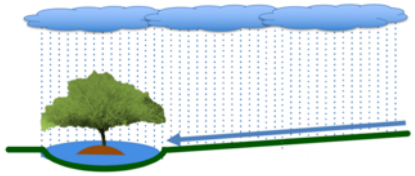
Flowers

Seed pods

SIZE (feet)







LOW WATER-USE TREE
Recommend 3:1 catchment ratio or greater to harvest rainwater and stormwater. If needed, supplement with graywater, condensate water and/or tanked rainwater.

URBAN PLACEMENT
Moderate to large, long-lived tree. Give it space to grow. Can be planted along streets, in medians and parking lots and around houses and buildings.

CLIMATE RESILIENCE & NATURAL RANGE IN ARIZONA

DROUGHT TOLERANT

ADAPTED TO EXTREME HEAT

Range: Sonoran Desert in northern Mexico

GROWS IN STRONG SUN

COLD TOLERANT TO 25°F

WITHSTANDS HOT DRY WIND

NATURAL DISTRIBUTION: GROWS NATURALLY ON DESERT PLAINS, ELEVATION <6500 FEET

CHARACTERISTICS
Single or multitrunk, thorns, semi-evergreen, casts filtered shade, supports native pollinators and wildlife, showy yellow flowers, striking green bark, irregular/random branching pattern, somewhat cold sensitive

LIFESPAN (years)

BEST PRACTICE 2. Whitethorn acacia *(Vachellia constricta)* needs and characteristics

Well-pruned whitethorn acacia

Natural tree form

Leaves and flowers

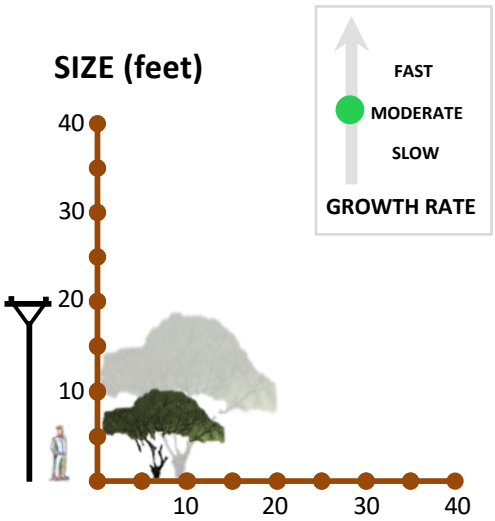
3 trees side-by-side cast deep shade

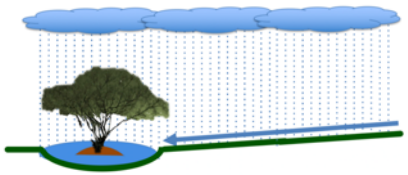
Extreme prune

Seed pods

Thorns

Trunk

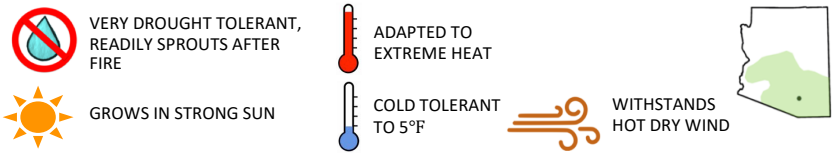




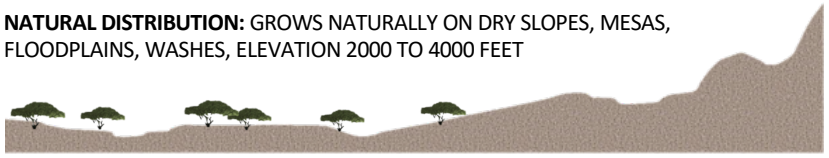
LOW WATER-USE TREE
Recommend 3:1 catchment ratio or greater to harvest rainwater and stormwater.
If needed, supplement with graywater, condensate water and/or tanked rainwater.

URBAN PLACEMENT
Small-sized tree. Can be planted along streets, in medians and parking lots and around houses and buildings.

CLIMATE RESILIENCE & NATURAL RANGE IN ARIZONA



NATURAL DISTRIBUTION: GROWS NATURALLY ON DRY SLOPES, MESAS, FLOODPLAINS, WASHES, ELEVATION 2000 TO 4000 FEET



CHARACTERISTICS
Multitrunk, winter deciduous, fixes nitrogen in soil, casts light shade, supports native pollinators and wildlife, useful security barrier due to long thorns

BEST PRACTICE 2. Desert willow *(Chilopsis linearis)* needs and characteristics

Well-pruned desert willow tree, flowering

Natural tree form

Winter deciduous

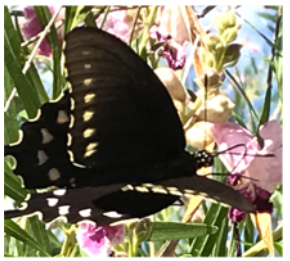
Pruned due to power line

Trunk

Leaves

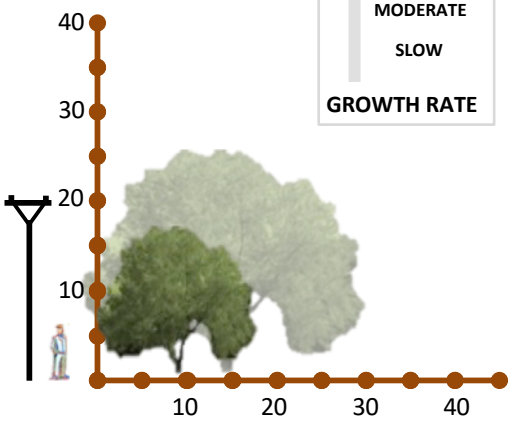
Flowers

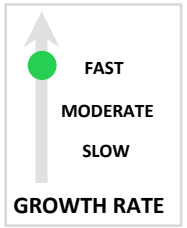
Seed pods

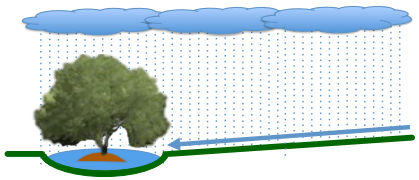


Butterfly sipping nectar

SIZE (feet)







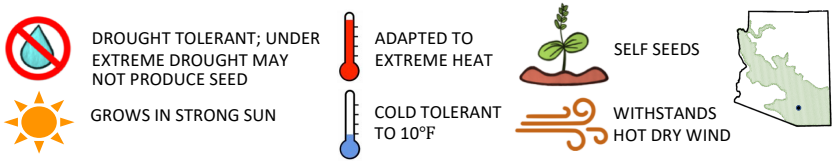
LOW WATER-USE TREE

Recommend 3:1 catchment ratio or greater to harvest rainwater and stormwater.
If needed, supplement with graywater, condensate water and/or tanked rainwater.

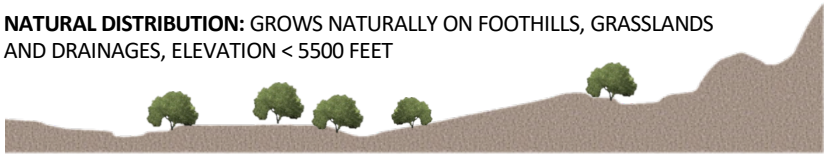
URBAN PLACEMENT

Moderate to large, long-lived tree. Give it space to grow. Can be planted along streets, in medians and parking lots and around houses and buildings.

CLIMATE RESILIENCE & NATURAL RANGE IN ARIZONA



NATURAL DISTRIBUTION: GROWS NATURALLY ON FOOTHILLS, GRASSLANDS AND DRAINAGES, ELEVATION < 5500 FEET



CHARACTERISTICS

Multitrunk, winter deciduous, casts dense shade, supports native pollinators and wildlife, abundant beautiful flowers, interesting seed pods, adaptable shape

LIFESPAN (years)

BEST PRACTICE 2. Canyon hackberry *(Celtis reticulata)* needs and characteristics

Well-pruned canyon hackberry tree with single trunk

Natural tree form

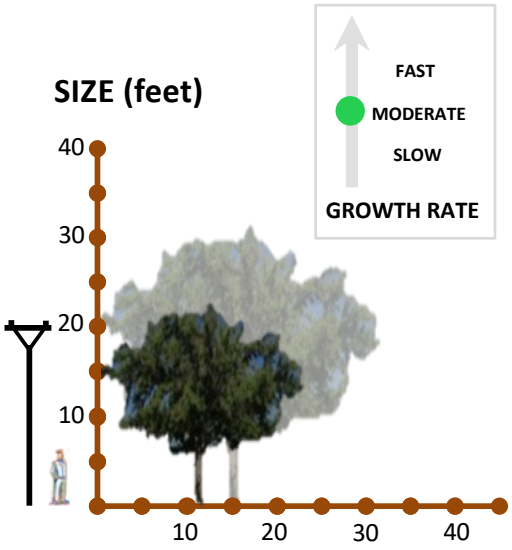
Winter deciduous

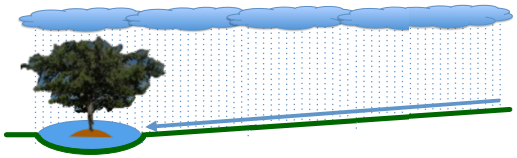
Trunk

Leaves

Tiny flowers, new leaves

Berries, bird nest





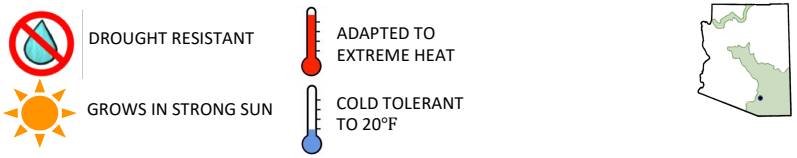
MEDIUM WATER-USE TREE

Recommend 5:1 catchment ratio or greater to harvest rainwater and stormwater. Will need to supplement with graywater, condensate water and/or tanked rainwater.

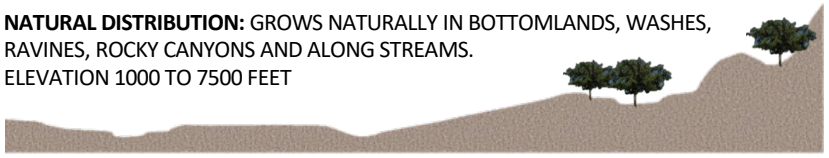
URBAN PLACEMENT

Moderate to large, long-lived tree. Give it space to grow. Plant around houses and buildings where graywater, condensate water and/or tanked rainwater are available to supplement passive rainwater harvesting.

CLIMATE RESILIENCE & NATURAL RANGE IN ARIZONA



NATURAL DISTRIBUTION: GROWS NATURALLY IN BOTTOMLANDS, WASHES, RAVINES, ROCKY CANYONS AND ALONG STREAMS.
ELEVATION 1000 TO 7500 FEET



CHARACTERISTICS

Single trunk, winter deciduous, dense shade, edible berries, supports native pollinators and wildlife, good bird habitat, interesting branch and trunk patterns

BEST PRACTICE 2. Screwbean mesquite *(Prosopis pubescens)* needs and characteristics

Screwbean mesquite pruned to maintain wide canopy

Natural form

Winter deciduous

Extreme pruning

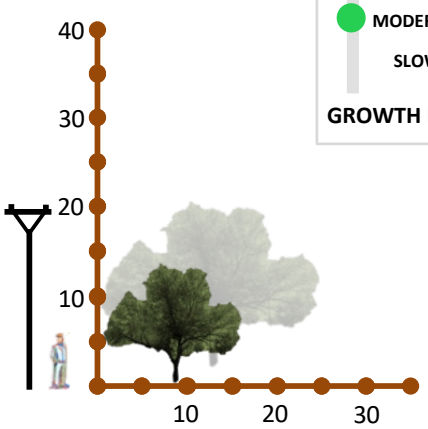
Leaves & thorns

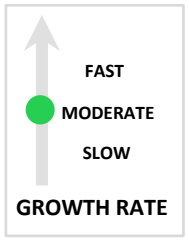
Flower

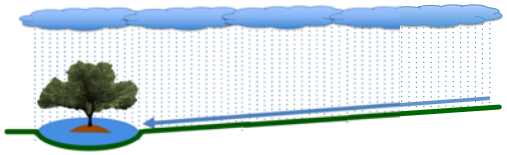
Seed pod

Trunk

SIZE (feet)







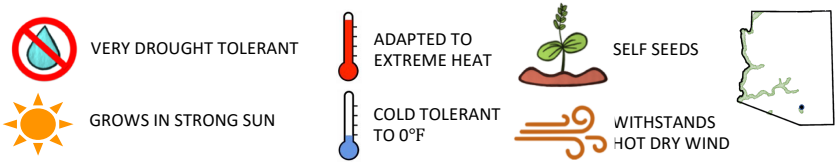
MEDIUM WATER-USE TREE

Recommend 5:1 catchment ratio or greater to harvest rainwater and stormwater. Will need to supplement with graywater, condensate water and/or tanked rainwater.

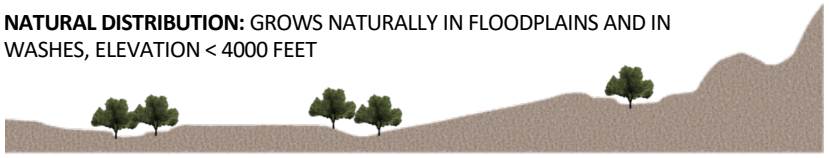
URBAN PLACEMENT

Moderate-sized tree. Plant around houses and buildings where graywater, condensate water and/or tanked rainwater are available to supplement passive rainwater harvesting.

CLIMATE RESILIENCE & NATURAL RANGE IN ARIZONA



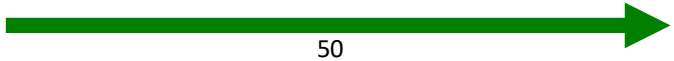
NATURAL DISTRIBUTION: GROWS NATURALLY IN FLOODPLAINS AND IN WASHES, ELEVATION < 4000 FEET



CHARACTERISTICS

Multitrunk, thorns, winter deciduous, fixes nitrogen in soil, grows in sun or part shade, edible pods and seeds, supports native pollinators and wildlife, unusual spiral pod shape, shaggy bark

LIFESPAN (years)



BEST PRACTICE 2. Kidneywood *(Eysenhardtia orthocarpa)* needs and characteristics

Well-pruned kidneywood

Natural form

Pruned to fit space

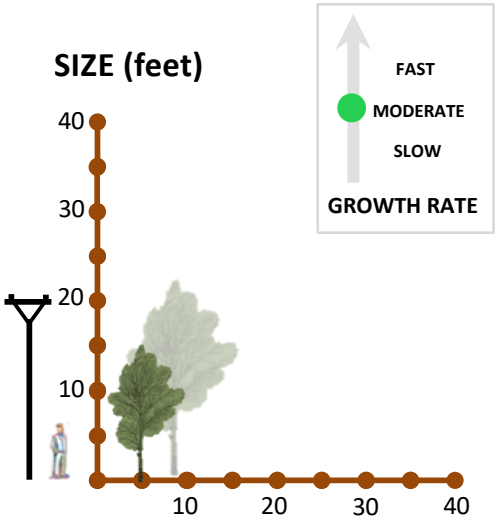
Trunk

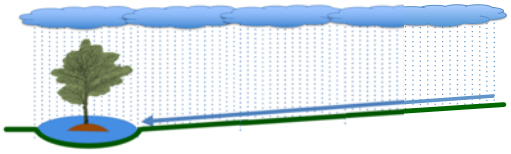
Bird nest

Leaves

Flowers

Seeds





MEDIUM WATER-USE TREE

Recommend 5:1 catchment ratio or greater to harvest rainwater and stormwater. Will need to supplement with graywater, condensate water and/or tanked rainwater.

URBAN PLACEMENT

Moderate-sized tree. Plant around houses and buildings where graywater, condensate water and/or tanked rainwater are available to supplement passive rainwater harvesting.

CLIMATE RESILIENCE & NATURAL RANGE IN ARIZONA

DROUGHT RESISTANT; DROUGHT DECIDUOUS

GROWS IN FULL SUN OR PARTIAL SHADE

ADAPTED TO EXTREME HEAT

COLD TOLERANT TO 15°F

SELF SEEDS

NATURAL DISTRIBUTION: GROWS NATURALLY IN WATERCOURSES AND ON SLOPES AND HILLSIDES WITH PERIODIC SUMMER WATER, ELEVATION < 5500 FEET

CHARACTERISTICS

Single trunk, winter deciduous and drought deciduous, grows in sun or part shade, draws butterflies and other pollinators, fragrant flowers, lacy foliage

BEST PRACTICE 2. Arizona rosewood *(Vauquelinia californica)* needs and characteristics

Arizona Rosewood in its natural form, blooming

Slight prune

Extreme prune

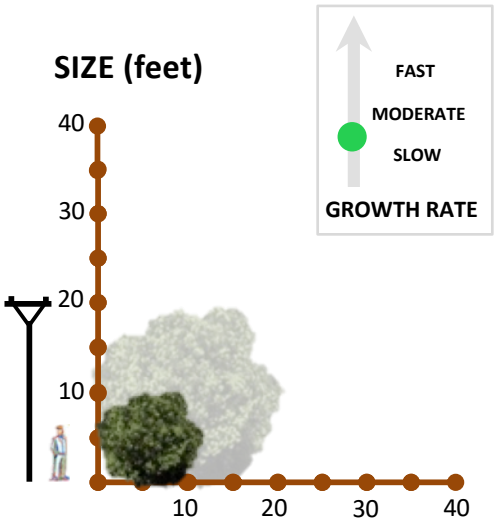
Multiple trunks

Leaves

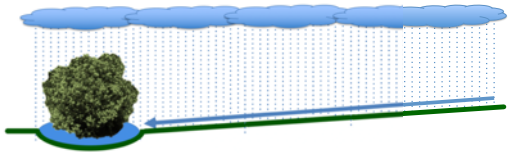
Flowers

Seed pods

SIZE (feet)



LIFESPAN (years) <50



MEDIUM WATER-USE TREE

Recommend 5:1 catchment ratio or greater to harvest rainwater and stormwater. Will need to supplement with graywater, condensate water and/or tanked rainwater.

URBAN PLACEMENT

Large multitrunk shrub. Plant around houses and buildings where graywater, condensate water and/or tanked rainwater are available to supplement passive rainwater harvesting.

CLIMATE RESILIENCE & NATURAL RANGE IN ARIZONA

DROUGHT TOLERANT

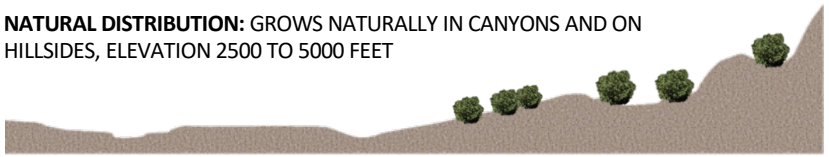
GROWS IN FULL SUN OR PARTIAL SHADE

ADAPTED TO HIGH HEAT

COLD TOLERANT TO 10°F

WITHSTANDS STRONG WINDS; GOOD WINDBREAK

NATURAL DISTRIBUTION: GROWS NATURALLY IN CANYONS AND ON HILLSIDES, ELEVATION 2500 TO 5000 FEET



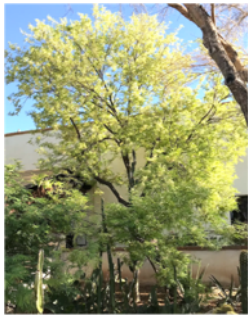
CHARACTERISTICS

Multitrunk, large evergreen shrub, casts dense shade year round, grows in sun or part shade, good windbreak and visual barrier—replacement for oleander

BEST PRACTICE 2. Feather tree *(Lysiloma watsonii)* needs and characteristics

Well-pruned feather tree, maintaining multiple trunks

Deciduous



Spring leaves

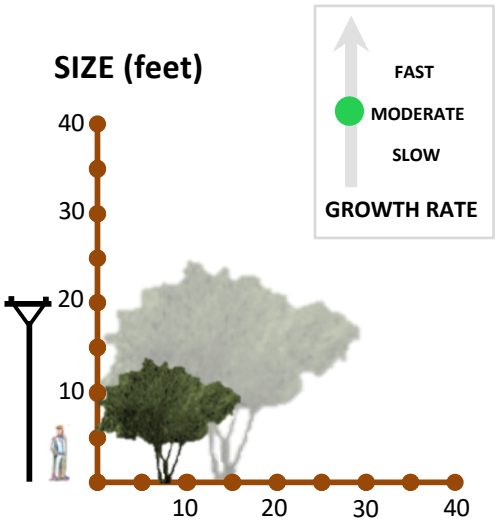
Young trees, well pruned

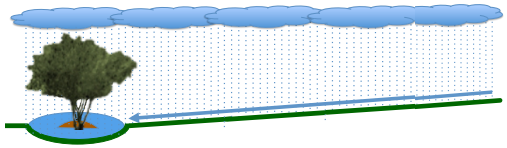
Trunk

Feathery leaves

Flowers

Seed pods





MEDIUM WATER-USE TREE
Recommend 5:1 catchment ratio or greater harvesting rainwater and stormwater. Will need to supplement with graywater, condensate water and/or tanked rainwater.

URBAN PLACEMENT
Moderate-sized shrub or tree. Plant around houses and buildings where graywater, condensate water and/or tanked rainwater are available to supplement passive rainwater harvesting.

CLIMATE RESILIENCE & NATURAL RANGE IN ARIZONA

DROUGHT RESISTANT, DROUGHT DECIDUOUS

GROWS IN STRONG SUN

ADAPTED TO EXTREME HEAT

COLD TOLERANT TO 25°F

AZ Range: Sonoran Desert foothill areas east of Tucson; also grows in Mexico

NATURAL DISTRIBUTION: GROWS NATURALLY ON FOOTHILLS AND WASH HABITATS, ELEVATION 2500 TO 4000 FEET

CHARACTERISTICS
Multitrunk; semi-deciduous; fixes nitrogen in soil; casts filtered shade; supports native pollinators and wildlife; lovely leaves, flowers and seed pods; good patio tree, somewhat cold sensitive

BEST PRACTICE 2. Little leaf ash *(Fraxinus greggii)* needs and characteristics

Well-pruned little leaf ash, tree form

Shrub form

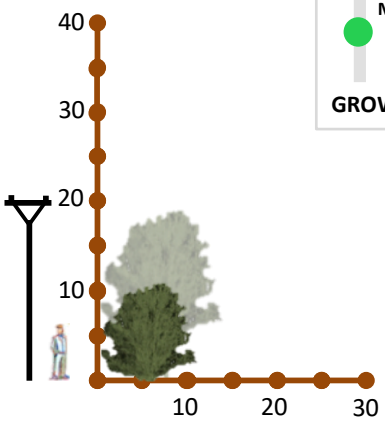
Shaping tree form

Leaves

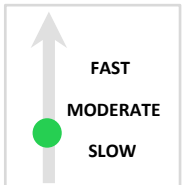
Pruned to fit narrow space

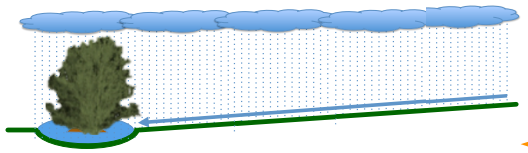
Trunk

SIZE (feet)



LIFESPAN (years) → 50





MEDIUM WATER-USE TREE

Recommend 5:1 catchment ratio or greater to harvest rainwater and stormwater. Will need to supplement with graywater, condensate water and/or tanked rainwater.

URBAN PLACEMENT

Shrub or small tree. Plant around houses and buildings where graywater, condensate water and/or tanked rainwater are available to supplement passive rainwater harvesting.

CLIMATE RESILIENCE & NATURAL RANGE IN ARIZONA

DROUGHT RESISTANT; DROUGHT DECIDUOUS

GROWS IN STRONG SUN

ADAPTED TO EXTREME HEAT

COLD TOLERANT TO 10°F

AZ Range: Southern Arizona

NATURAL DISTRIBUTION: GROWS NATURALLY ON BLUFFS, SLOPES, WASHES AND CANYONS. ELEVATION 2500 TO 7000 FEET

CHARACTERISTICS

Multitrunk shrub that can be pruned to small single-trunk tree, winter deciduous, grows in sun or part shade, no thorns, good patio tree

Native trees have interesting, colorful blooms that attract and help support diverse native pollinators

Latin name	Common name	Pollination Calendar Bloom color and bloom months											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fraxinus greggii	little leaf ash												
Celtis reticulata	canyon hackberry												
Parkinsonia microphylla	foothill palo verde												
Parkinsonia florida	blue palo verde												
Vachellia constricta	whitethorn acacia												
Prosopis pubescens	screwbean mesquite												
Parkinsonia praecox	palo brea												
Senegalia greggii	catclaw acacia												
Prosopis velutina	velvet mesquite												
Eysenhardtia orthocarpa	kidneywood												
Vauquelinia californica	Arizona rosewood												
Lysiloma watsonii	feather tree												
Chilopsis linearis	desert willow												
Olneya tesota	desert ironwood												

Pollinator Calendar prepared by Strategic Habitat Enhancements
www.strategichabitats.com

BEST PRACTICE 3

Plant native trees and native understory plants together

Plant trees and understory plants at the same time for faster development of shade, cooling and diverse native habitat

- When supported by concentrated runoff, native trees and understory plants can grow close together in natural settings, casting deep shade
- Recreate the natural pattern of close-growing native plants in the urban environment by providing abundant rainwater, stormwater, graywater and condensate water to grouped trees and understory
- Grouped plants provide dense continuous shade, cool the soil and support more wildlife and soil life
- Planting native understory plants with each newly planted tree adds color and diversity

Dense understory plants grow under an ironwood tree along a natural wash

Closely spaced catclaw acacia, whitethorn acacia and blue palo verde are supported by a sandy wash

Self-seeded, closely growing, shade-producing foothill palo verde trees are supported by runoff from the parking lot they shade

Ironwood tree and abundant understory plants grow along an urban street

Mesquites, palo verdes, catclaw acacias and diverse understory plants combine to create a dense canopy along a city street

Dense canopy shades the street that provides runoff water to these plants

BEST PRACTICE 3. Plant native trees and understory together: Understory Pollination Calendar

Place understory plants within or near native tree basins. Place cacti outside of basins, never within them.

Latin name	Common name	Type	Pollination Calendar: Bloom color and bloom months											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hesperaloe parviflora	red hesperaloe	Shrub												
Justicia candicans	jacobina	Shrub												
Anisacanthus thurberi	desert honeysuckle	Shrub												
Justicia californica	chuparosa	Shrub												
Calliandra eriophylla	fairy duster	Shrub												
Penstemon parryi	Parry's penstemon	Shrub												
Maurandya antirrhiniflora	snapdragon vine	Vine												
Jatropha cardiophylla	limberbush	Shrub												
Gossypium thurberi	desert cotton	Shrub												
Lycium fremontii	Fremont's wolfberry	Shrub												
Glandularia gooddingii	Goodding's verbena	Shrub												
Dalea pulchra	Santa Catalina prairie clover	Shrub												
Sphaeralcea ambigua	globemallow	Shrub												
Bebbia juncea	chuckwalla's delight	Shrub												
Ferocactus wislizeni	fishhook barrel cactus	Cacti												
Encelia farinosa	brittlebush	Shrub												
Trixis californica	trixis	Shrub												
Larrea tridentata	creosote	Shrub												
Senna covesii	desert senna	Shrub												
Psilostrophe cooperi	western paperflower	Shrub												
Agave murpheyi	Hohokam agave	Succulent												
Chrysactinia mexicana	damianita	Shrub												
Opuntia engelmannii	Engelmann's prickly pear	Cacti												
Cucurbita digitata	coyote gourd	Vine												
Eriogonum fasciculatum	Mohave buckwheat	Shrub												
Asclepias subulata	rush milkweed	Shrub												
Carnegiea gigantea	saguaro	Cacti												
Aloysia wrightii	oreganillo	Shrub												
Simmondsia chinensis	jojoba	Shrub												
Dodonea viscosa	hopbush	Shrub												
Celtis pallida	desert hackberry	Shrub												
Ziziphus obtusifolia	graythorn	Shrub												
Sporobolus wrightii	giant sacaton	Grass												

Strategic Habitat Enhancements

Pollinator Calendar prepared by Strategic Habitat Enhancements
www.strategichabitats.com

BEST PRACTICE 4

Plan where to plant to meet your needs and the needs of trees

What do you want and need from native trees?

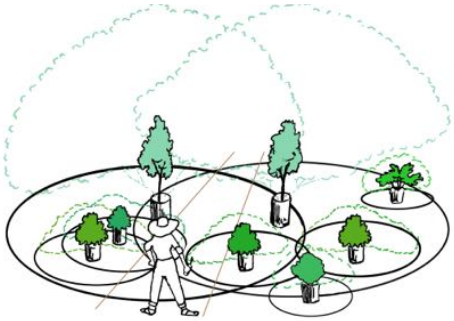
- Year-round shade? Seasonal shade?
- Trees you can walk under?
- Windbreak trees to reduce strong, dry winds?
- Trees that produce edible fruits, seeds or pods?
- Trees that fit in small yards?
- Thorny trees that act as security barriers?
- Bushy trees that provide visual barriers?
- Shady, thornless trees for play areas?
- Trees that buffer traffic and fit in a right-of-way?
- Trees that attract native birds, insects and wildlife?
- Beautiful flowers, leaves, bark and pods?

Keep trees away from overhead/buried utility lines

- Don't plant trees that will grow tall under overhead power lines—if trees grow into power lines, their canopies will need major pruning, which can distort the tree
- Don't plant over buried utility lines—tree roots might impact buried lines and utility work might damage roots or require tree removal
- Call 811 to locate buried lines leading up to your site. Hire private companies to locate buried lines on your site

Plant a safe distance from corners for traffic safety

- Don't plant trees where they will block traffic signs or signals—trimming to increase visibility could distort the trees



SPACING TOO CLOSE

APPROPRIATE SPACING

Give trees the space they need

- Find out how big trees could grow and give them sufficient room around each other, buildings, walls, powerlines and other obstructions
- It is OK to space native trees so their mature canopies eventually grow to touch one another to provide more continuous shade
- Be sure to provide sufficient harvested water to support grouped trees and shrubs

Tree is pruned to prevent powerline conflict and to reduce rubbing on adjacent wall. A smaller stature tree or shrub planted here instead would have prevented utility conflicts.

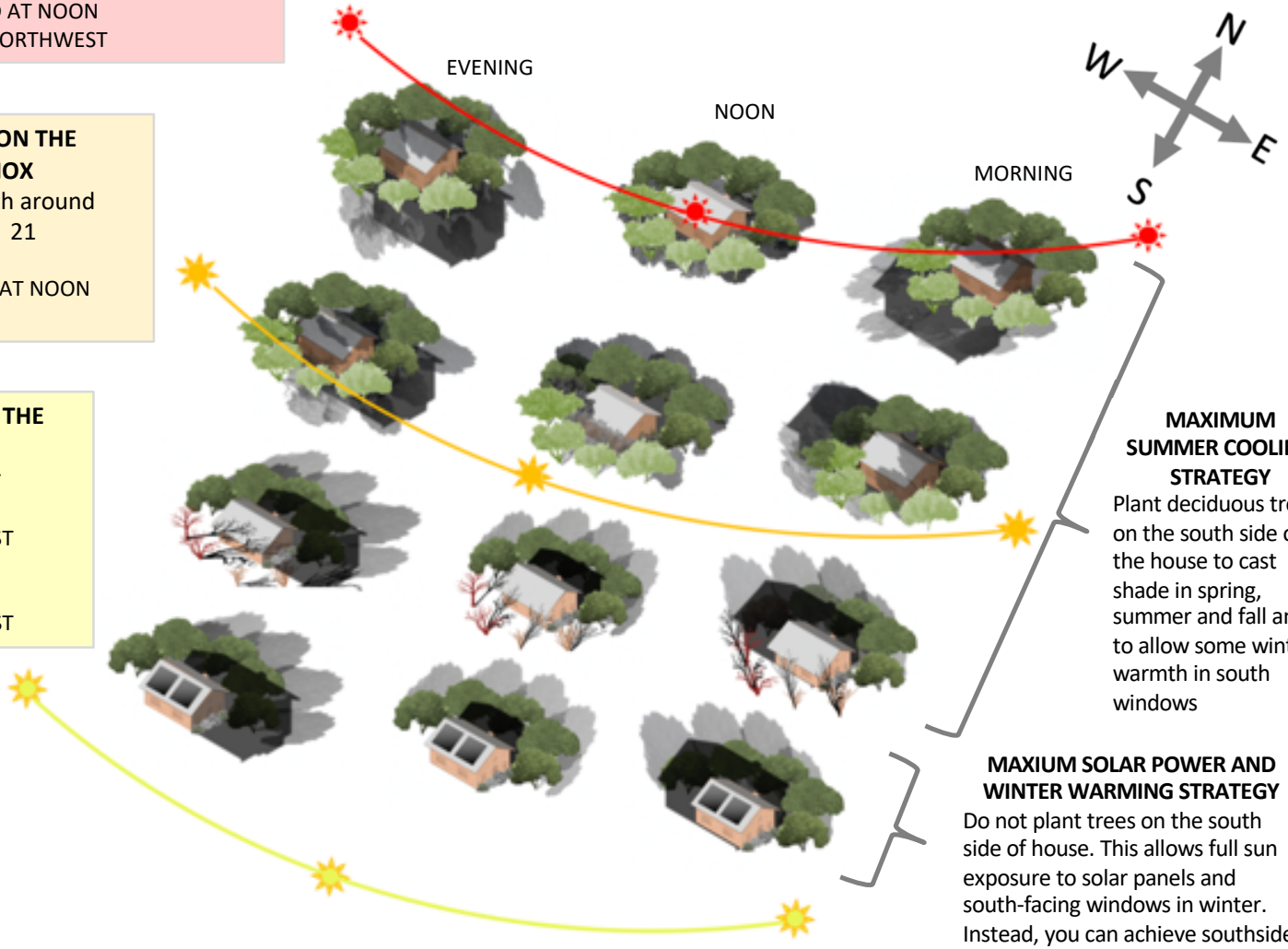
Shading your home can save 20-30% of energy costs

- For maximum summer cooling, plant dense-canopy native trees (dark green trees below) in an arc to the east, north and west of the house, and plant deciduous native trees (light green trees below) southeast, south and southwest of the house
- OR, to have summer cooling plus maximum winter warmth and sun access to solar panels, leave the south side free of trees

SUN'S PATH (RED SUN) ON THE SUMMER SOLSTICE
The longest day of the year is around June 21
- SUN RISES IN THE NORTHEAST
- SUN IS OVERHEAD AT NOON
- SUN SETS IN THE NORTHWEST

SUN'S PATH (ORANGE SUN) ON THE SPRING AND FALL EQUINOX
Days and nights are equal length around March 21 and September 21
- SUN RISES DUE EAST
- SUN IS IN THE SOUTHERN SKY AT NOON
- SUN SETS DUE WEST

SUN'S PATH (YELLOW SUN) ON THE WINTER SOLSTICE
The shortest day of the year is around December 21
- SUN RISES IN THE SOUTHEAST
- SUN IS VERY LOW IN THE SOUTHERN SKY AT NOON
- SUN SETS IN THE SOUTHWEST



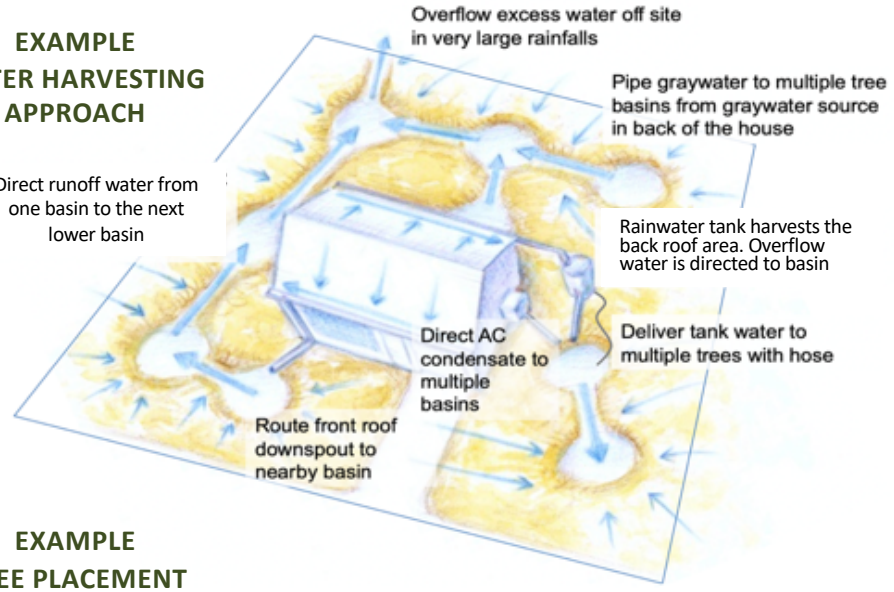
MAXIMUM SUMMER COOLING STRATEGY
Plant deciduous trees on the south side of the house to cast shade in spring, summer and fall and to allow some winter warmth in south windows

MAXIUM SOLAR POWER AND WINTER WARMING STRATEGY
Do not plant trees on the south side of house. This allows full sun exposure to solar panels and south-facing windows in winter. Instead, you can achieve southside shade with roof overhang

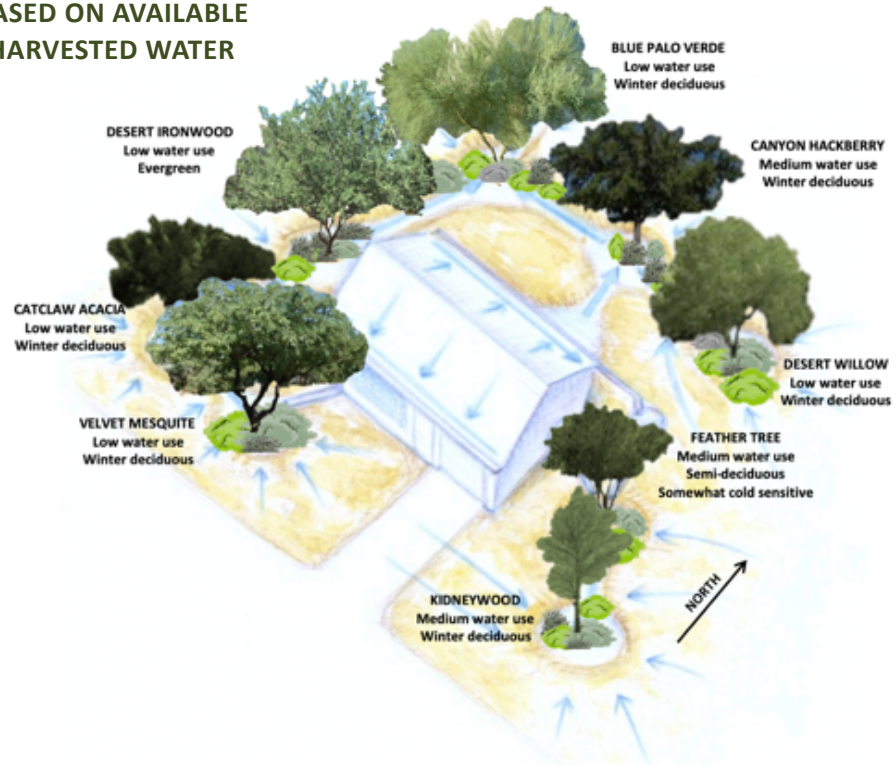
Harvest as much water at your site as possible

- Observe where rainfall flows and pools throughout the site
- Shape multiple water harvesting earthworks starting from the "top" (highest elevation at your site) and going to the "bottom" (lowest elevation) to harvest as much rainfall and runoff as possible
- Take advantage of existing slopes and low spots to create natural-shaped basins set efficiently in the landscape
- Water harvesting basins can stand alone or they can interconnect with one basin overflowing to the next
- Basins can be any shape—they do not have to be round, rectangular or linear
- Direct the water flowing off roofs, driveways, sidewalks, patios and other hardscapes into nearby basins
- You can install rainwater harvesting tanks to collect valuable rooftop runoff from gutters and downspouts to store for later use
- Integrate water harvesting tanks with water harvesting earthworks, delivering water to tree basins using a hose or other distribution system
- Since tanks will periodically overflow, design overflow piping to deliver water to nearby tree basins as well
- Access condensate water from air conditioners and graywater from washing machines, tubs, showers and bathroom sinks. Direct this water to basins planted with trees that need additional support
- Given your site goals, place the native trees you select according to their water needs and the available water supply
  - Place medium water-use trees in basins close to tanked water, graywater and condensate water sources
  - Place low water-use trees in basins throughout the site to provide maximum shade and meet other goals
  - Trees that are planted southeast, south and southwest of structures should be winter deciduous to allow winter sun to warm walls and enter south-facing windows

EXAMPLE WATER HARVESTING APPROACH



EXAMPLE TREE PLACEMENT BASED ON AVAILABLE HARVESTED WATER



BEST PRACTICE 5

Start with healthy young plants

Be selective when purchasing trees from nurseries

- Some native trees cross-pollinate with other species, creating hybrids
- Ask for true native velvet mesquite (feel for "velvety leaves"), blue palo verde, foothill palo verde and palo brea trees to get true native tree characteristics
- Large trees in small pots may have coiled tap roots that need to be straightened when planted
- Container plants "hardened" out in full sun and cold weather will be hardier when planting

Nurture native plant "volunteers"

- Many native trees and understory plants readily self seed and grow into strong, healthy plants
- Trees that self-seed, and tree seeds planted in the ground, grow deeper tap roots than potted transplants
- If plants "volunteer" in good locations, add water harvesting basins and mulch to support their growth

Plant trees and understory plants at the same time for faster development of shade, cooling and diverse native habitat

Young Arizona Rosewoods growing in 5-gallon pots

Native trees grown in tall pots have straight root growth (photo courtesy of Nighthawk Nursery)

A blue palo verde "volunteer" sprouted from a seed in a convenient location

BEST PRACTICE 6

Shape your tree's water harvesting area

Prepare your planting site in the best season for planting the tree

- Ideally, plant when native trees naturally germinate—often the monsoon season. It is easier to dig water harvesting basins once rains have started
- Avoid planting in the hot dry period before monsoons, but if you must plant then, water frequently
- If you plant in the winter, don't plant if there is freeze danger. Protect cold-sensitive trees from hard freezes
- Plant trees and understory plants at the same time to get shade and cooling faster

Plan width and depth of the tree's water harvesting basin

- Wide basins around 12 inches deep typically store ample rain and runoff
- Make basin side slopes gradual
- Well-developed roots will eventually grow beyond the drip line of the mature tree canopy, so wider basins are a good practice, as are additional basins into which the roots can extend
- You can dig deeper, narrower basins if needed due to limited space
- Stabilize steep banks of deep basins with large rock—these also alert pedestrians to the presence of the basins
- DO NOT compact the bottom of basins: compaction slows infiltration
- Do compact the tops and sides of berms

Be careful digging around existing trees

- Avoid disturbing existing tree roots as much as possible—these roots will likely extend well beyond the outer edge of the tree canopy
- If you must dig near existing trees, make sure trees are well watered and not stressed at the time of year you dig

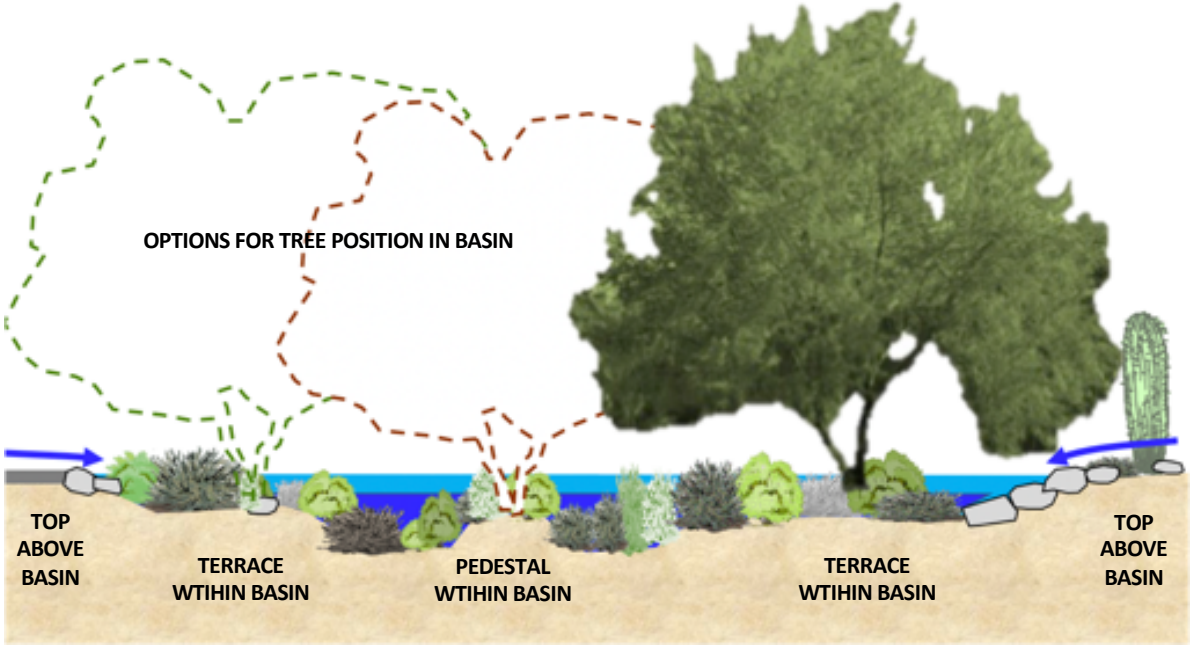
CAUTION: BEFORE YOU DIG water harvesting basins and tree planting holes **CALL 811** to locate buried utility lines in the right-of-way next to your property. Hire a private utility locating service to mark buried lines on your property. Always dig slowly and carefully, and stop if you encounter any buried utility lines.

Tree planting event by Dunbar/Spring Neighborhood Foresters includes shaping a street-side water harvesting basin and planting a tree along with understory plants. Photo: Brad Lancaster

NOTE: Do not put decomposed granite (DG) on catchment areas or in basins—it sheds clay particles that can clog soil pores in the bottom of basins, reducing water infiltration.

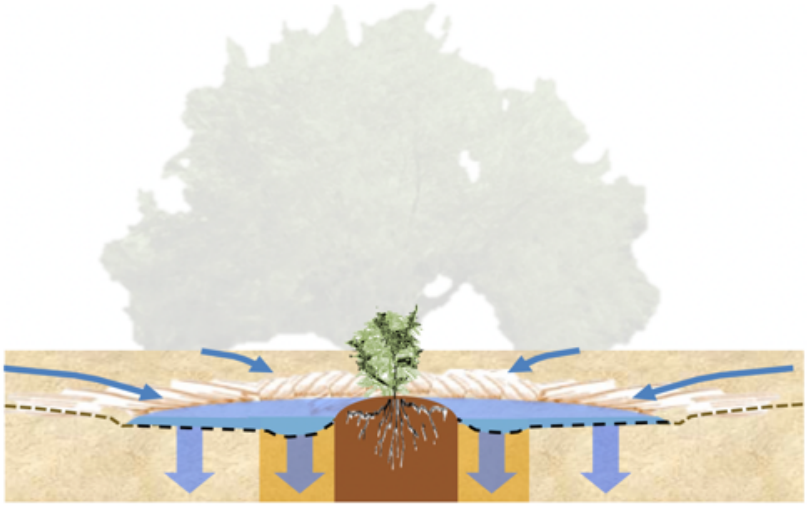
Place the tree on a raised pedestal or terrace to reduce inundation

- To avoid inundating a desert tree trunk, plant the tree on a built-up pedestal in the bottom of the basin or on a raised terrace at the side of the basin
- Tree will be temporarily inundated in very large rainfall events, but water will quickly drain below the exposed trunk
- Place trees that need well-drained soil (Arizona rosewood, foothill palo verde) at the top above the basin—roots can still access moist soil under basin



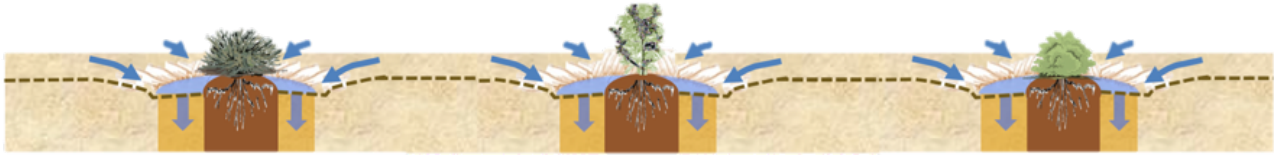
Best practice is to build a wide tree basin

- Build a basin wide enough, or wider, than is needed to support the future width of the mature tree
- Slope the basin bottom gently toward the small newly planted tree
- Raise the tree on a slightly raised pedestal inside the basin to reduce inundation of the trunk in big rain events
- Create a donut-shaped depression just outside the root ball to pool the water and increase infiltration next to the tree roots



If you can't build one wide tree basin, build an array of smaller basins close together

- Plant tree in the central basin and understory plants in basins around it
- Tree roots will grow outward toward water infiltrating into the nearby basins



BEST PRACTICE 7

Plant your tree carefully

Reminder, plant in the best season for the health of the tree

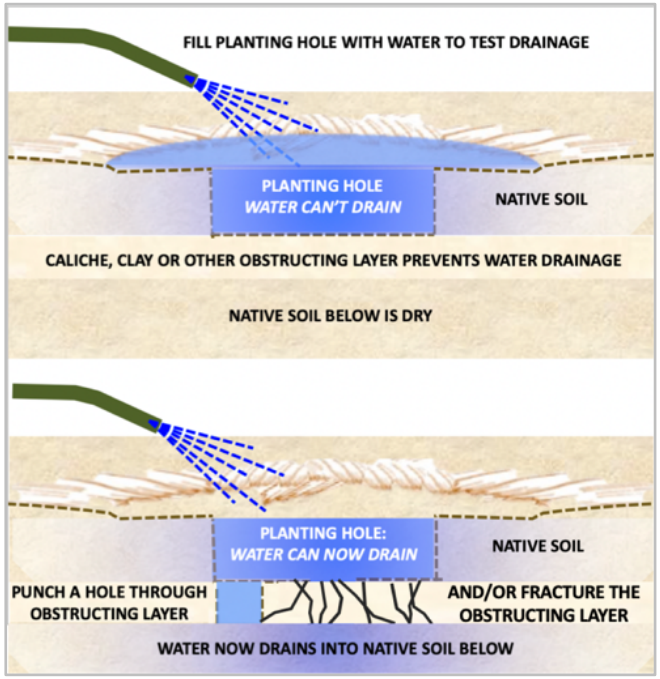
Shape the tree pedestal or terrace within the basin and dig the planting hole

- Create a pedestal or terrace within the basin to plant the tree on in order to keep the trunk above the level of frequent inundation
- Dig a planting hole in the chosen position
- The planting hole should be no deeper than the depth of the root ball
- The hole should be 2 to 3 times as wide as the root ball
- Put the dirt you remove from the planting hole outside the basin to maintain space inside the basin to hold harvested water

Before you plant, check the water harvesting basin and planting hole for proper drainage

- If possible, fill the planting hole and basin with water, then check back every few hours to see if the water has drained
- If the planting hole drains within a few hours, proceed with tree planting
- If it has not drained, break up, fracture or dig through caliche or any other impeding layers to improve drainage

Timing how long this newly dug swale took to drain after a heavy rain was a good way to determine its drainage characteristics: it drained in 12 hours—not bad, but could be improved



If water is slow to drain, you can dig down to punch a hole through any obstructing layer and/or fracture obstructions

To improve drainage in the swale above, a jackhammer is used to punch through a caliche layer and loosen obstructing rocks and cobbles so they can be removed

Remove tree from pot and check root ball

- Gently squeeze the tree pot to loosen soil; if soil is too loose, cut down the side of the pot to release the tree; if the root ball is sturdy, ease the tree out of the pot
- If roots tightly bind the bottom or side of the root ball, loosen roots gently by hand or slice along the bottom and/or side of the root ball to unbind the roots
- If the main root is coiled in the bottom of the pot, try to stretch it downward. If needed, cut off the coiled root portion so the remaining root can grow downward

Plant the tree and provide the first watering

- Position the tree so it will grow straight up
- Check the height of the tree in the planting hole and add or remove soil in the hole to achieve desired height
- Backfill planting hole with native soil, removing large rocks
- Compress backfilled soil slightly to remove air pockets
- Create a donut-shaped depression just outside the root ball to pool water and increase infiltration next to roots
- Water the root ball and surrounding soil during and just after planting
- If watered soil sinks below root ball level, add more soil
- Final soil level should not exceed top of root ball
- Avoid staking trees—swaying in wind strengthens trunks
- Native trees typically do not require soil amendments but do benefit from organic-matter mulch added to basins

Promote long-term infiltration in the basin

- It takes three days to breed mosquitos, so work with slow-draining basins to get them to drain within 24 hours
- Plant understory plants to help perforate the soil
- Use organic-matter mulch to create a living sponge to soak up water and support the growth of soil life
- If necessary, reduce the catchment area draining to basin

Desert ironwood tree formed a mat of roots in the bottom of a 15-gallon pot

Roots are gently loosened by hand to allow roots to grow more easily into the soil

Set root ball in hole to check for correct height; add or remove soil as needed to achieve desired height, then backfill the hole

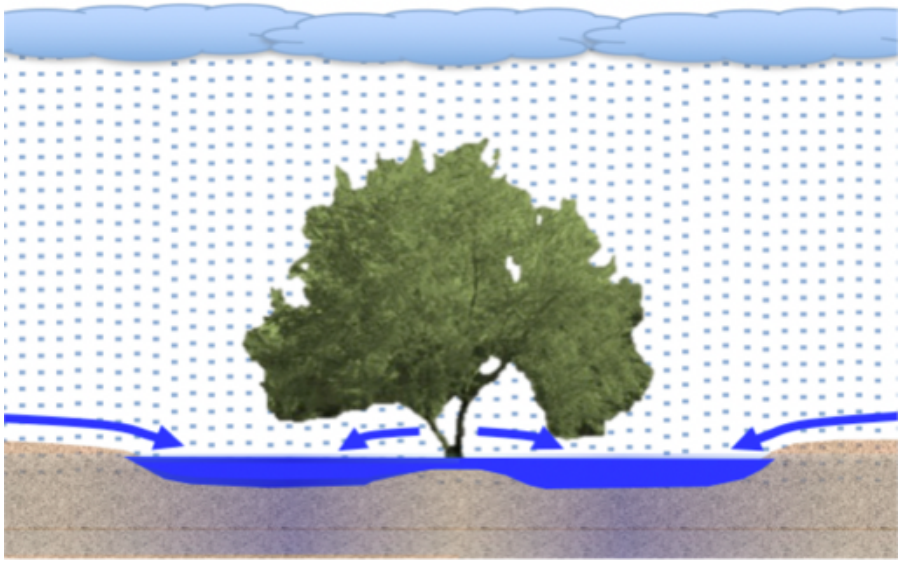
Tree gets first watering in a donut-shaped depression formed just outside the root ball to focus water infiltration in and around the roots

BEST PRACTICE 8

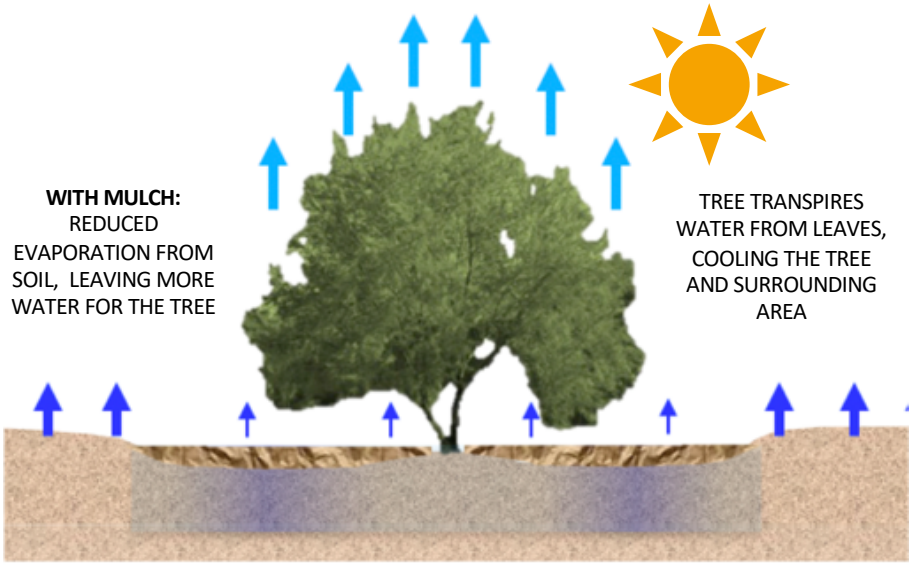
Add mulch when you plant to keep moisture in the ground

Mulch reduces evaporation from soil

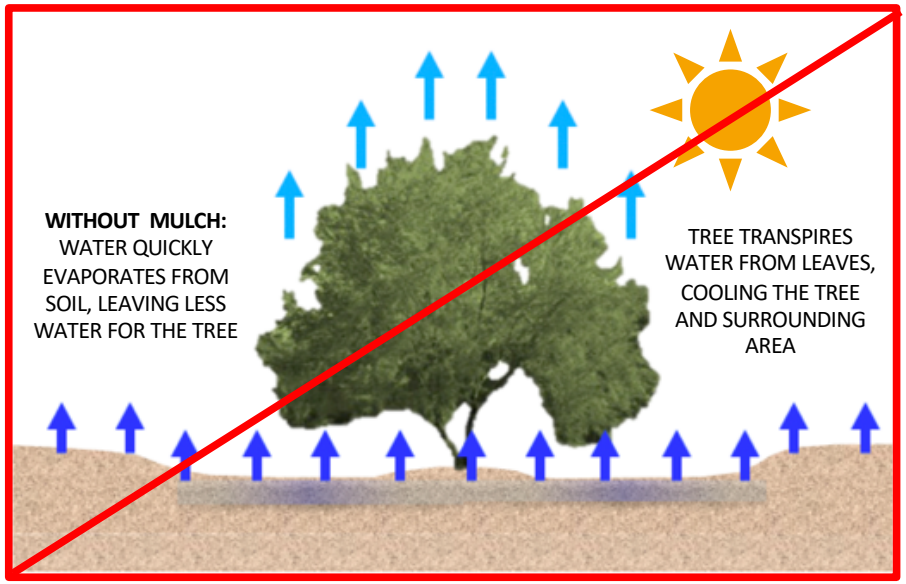
- Average annual Tucson rainfall is around 11.5 inches a year
- Potential evaporation loss of standing water (such as from a swimming pool) averages around 90 inches a year in Tucson
- When the sun comes out after a rainfall, water quickly evaporates from bare soil
- Mulching the soil surface reduces evaporation losses, so water is retained in the soil for a longer period of time for tree roots to access
- Trees naturally lose water through transpiration from leaves, cooling the tree and the surrounding area



Rainfall and runoff infiltrate deeply into the soil of a water harvesting basin



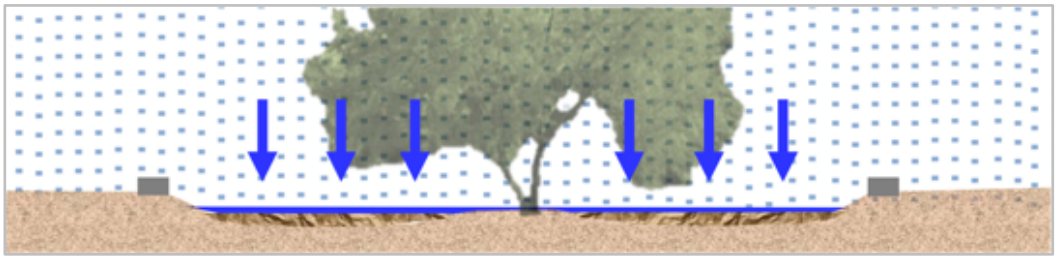
Placing organic-matter mulch in the water harvesting basin reduces the rate of evaporation from the soil. The tree loses water naturally through transpiration.



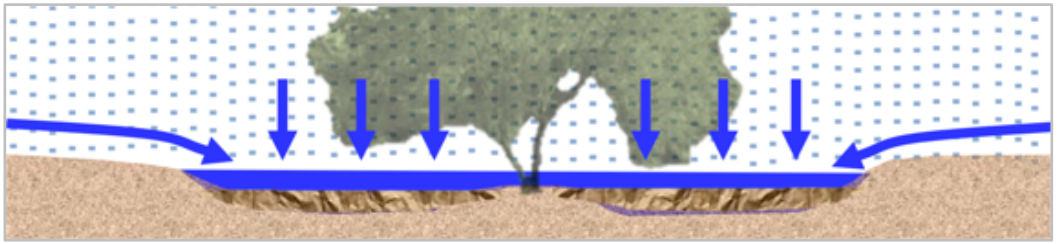
When the sun comes out, water quickly evaporates from bare soil, reducing water available to tree roots. The tree loses water naturally through transpiration.

Organic-matter mulch

- Types of organic-matter mulch used in water harvesting basins include the leaves, flowers, pods and twigs that drop from native trees and shrubs; wood chips; compost and straw
- Organic-matter mulch provides multiple benefits to trees
  - Reduces water loss from soil due to evaporation
  - Insulates the soil from extreme temperatures
  - Decomposes to enrich the soil
  - Provides a moist environment for soil life including microorganisms, insects and wildlife, which in turn penetrate the soil, add organic nutrients and increase water infiltration
- Apply organic-matter mulch at a thickness that can be fully penetrated in an average storm
  - For basins that receive only direct rainfall, place just 1 inch of mulch in order to allow small rainfall amounts to penetrate to the soil below
  - For basins that receive direct rainfall plus runoff, place around 2 inches of mulch, since runoff water can flow under mulch to the soil below
- Be sure the top of the mulch is lower than the elevation of water inlets to basins—too much mulch at inlets could reduce the amount of water entering basins
- Keep mulch 3 to 6 inches away from tree trunks to protect tree bark from prolonged contact with excessive moisture
- Organic-matter mulch might need to be replenished occasionally because it decomposes and can be carried out of basins with overflow water in large rainfall events



Place 1 inch of organic-matter mulch in basins that receive only direct rainfall so small rainfall amounts can penetrate to the soil below



Place two inches of organic-matter mulch in basins that receive both direct rainfall and runoff since runoff water can flow under the mulch layer to the soil below. This deeper mulch further reduces evaporation

Duff collected from under a foothill palo verde tree is used to mulch the donut-shaped depression just outside the root ball of the newly planted desert ironwood tree (page 43). The mulch is pulled away from the trunk to protect the tree bark from prolonged contact with moisture

BEST PRACTICE 8. Add mulch when you plant to keep moisture in the ground

Native trees and understory plants self mulch over time

- As trees and understory plants grow, they increasingly self-mulch by dropping leaves, flowers, pods and twigs into the basin below, naturally replenishing the mulch layer
- Different types of mulch material accumulates at different times of year under native trees
- If needed, you can add more—but don't over mulch
  - Rake organic matter that has fallen on adjacent land, sidewalks or streets into basins where more mulch is needed
  - Cut thin-diameter prunings from trees into 4-inch long sticks or less, and place them flat in basin bottoms below

Foothill palo verde flower mulch

Blue palo verde seed/leaf mulch

Desert willow flower/leaf/pod mulch

Leaf drop collected from under a mature Arizona rosewood tree is applied to form a 2-inch thick mulch layer in the bottom of a large swale planted with a desert ironwood tree and three native understory plants (pages 42 and 43)

Rock mulch placed in large street-side water harvesting basin

Pros and cons of inorganic mulch

- Inorganic mulch, such as rock or gravel, reduces evaporation from the soil it is placed over
- It generally stays in place, though fast moving water can carry it away
- However, inorganic mulch does not contribute nutrients to trees and does not promote soil life
- It is hot in summer, increasing urban heat stress
- It is hard to walk on, and makes it difficult to remove accumulated sediment and weeds
- Thick layers of inorganic mulch displace water storage capacity in basins
- If you decide to use inorganic mulch
  - Select clean, washed rock or gravel and place inorganic mulch in a single layer just one rock high
  - By using a single rock layer you reduce materials costs, minimize the amount of water storage capacity that is displaced and allow vegetation to grow up through the rock
  - Do NOT use decomposed granite (DG) as mulch in water harvesting basins or on the catchment areas that flow to them because DG sheds clay particles that clog soil pores, reducing water infiltration

BEST PRACTICE 9

Provide establishment watering and ongoing watering using harvested water

Water newly planted native trees to get them established

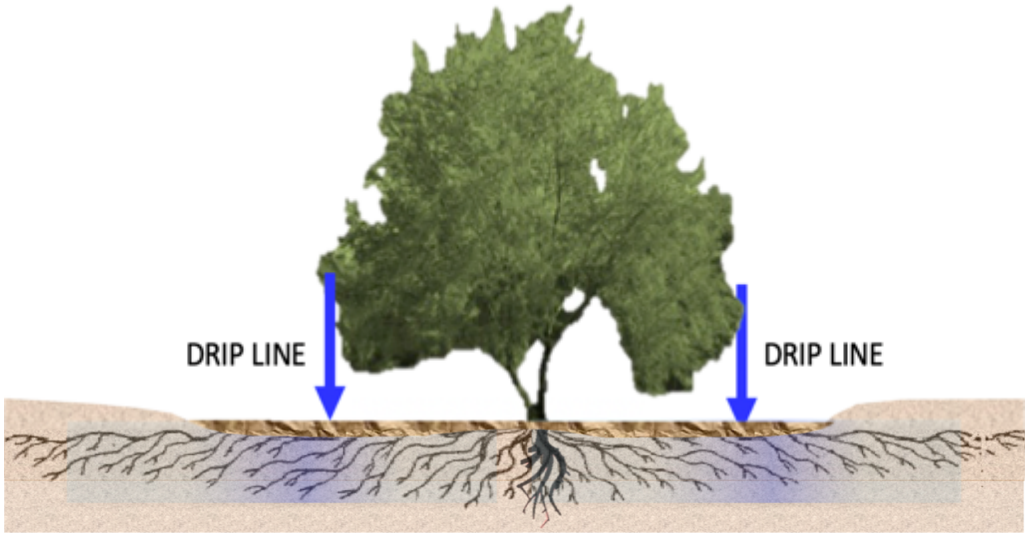
- Water newly planted native trees for one to three years to get them established
- Water to a depth of 12 to 18 inches in order to saturate the root ball and root zone
- Native trees do not require continual high soil moisture
- Watering frequency will depend on the time of year, temperature, rainfall and other factors
- To establish new plantings in hot months, water every other day for the first three weeks after planting, then cut back to a good deep watering once a week
- Eventually water once a month until trees are established
- To avoid installing a drip irrigation system, you can water by hose, or fill a drip bucket (5-gallon bucket with a small hole punched at its base) and place it next to the plant

Provide ongoing deep watering for well-established native trees in hot dry months, if needed

- Inspect tree for signs of drought stress such as wilting leaves, yellowing or dropping leaves and branch die-back
- If plants are showing stress, if possible provide enough supplemental water to soak two to three feet of soil below the mulch layer
- See the next page for a watering strategy using harvested water supplies

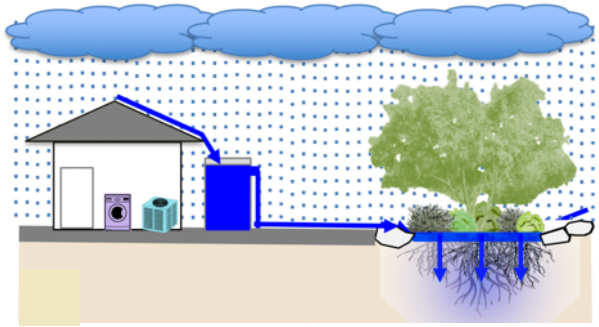
Water your tree deeply at and around the canopy "dripline" rather than right next to the trunk

- As trees grow, tree roots zones may be one and a half times as wide as the tree canopy, or more
- Root depth is generally 1 to 3 feet below land surface
- Stabilizing tap roots may extend deeper
- As trees grow larger, apply water to soil at and around the tree's "dripline"—the outer edge of the tree canopy where rainwater drips off the leaves

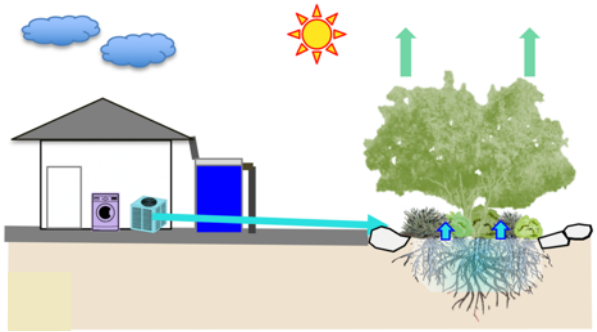


Tree root zones may be one and a half times as wide as the tree canopy, or more. Root depth is 1 to 3 feet below land surface. Provide water at and around the drip line of mature trees.

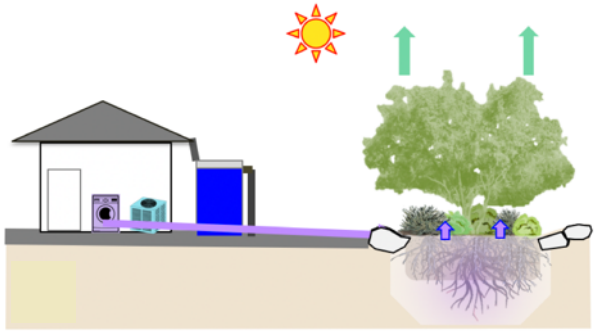
If native trees need to be watered, water deeply using condensate water, graywater and tanked rainwater first. Use drinking water (potable water) only if necessary.



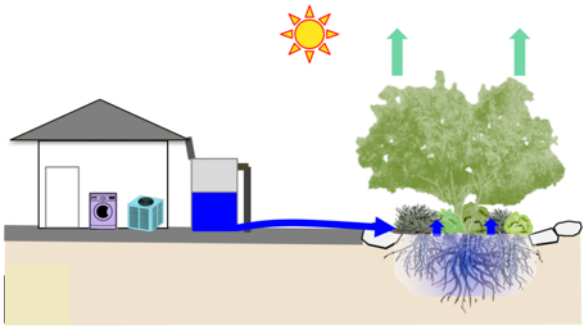
Let natural rainfall and runoff fill your tree basin (and rainwater tank if you have one).



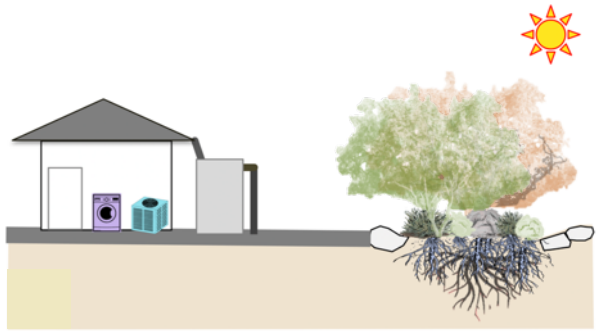
When the tree needs water again, use AC condensate water (light blue hose) if it is available—the more humid it is, the more condensate water will be available.

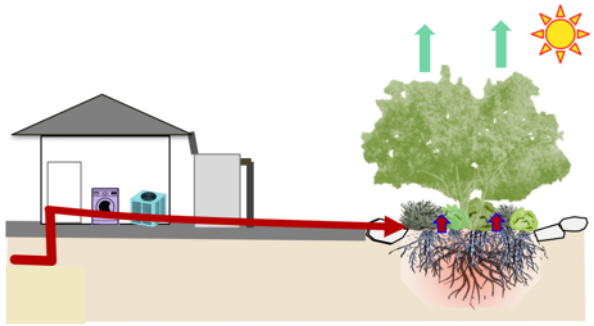


If condensate isn't available, use graywater (purple pipe). Rainwater harvested in the same basin will dilute salts found in graywater.



Use rainwater from a tank (dark blue hose) if other nonpotable supplies aren't available. An empty tank is ready to refill the next time it rains.





If no rainwater, condensate water or graywater is available, low water-use native trees can be left to adapt naturally to very dry conditions by dropping leaves, self pruning branches, deferring leafing out or flowering, or other natural drought responses. However, to support medium water-use trees and low water-use trees that provide important shade or are showing signs of extreme stress, water with potable water (red hose).

BEST PRACTICE 10

For good shade and tree health, follow native tree pruning principles

NATIVE TREE PRUNING PRINCIPLES

The pruning principles described here focus on maintaining the health and beneficial functions of native multitrunk trees. Many of these principles apply to all trees.

The less you prune, the better off your tree will be

- **Abundant leaves fuel growth.** Leaves, along with the green photosynthetic bark on some native trees, convert sunlight to sugar to fuel tree growth
- **Thicker tree canopies provide deep shade.** Deep shade cools the people who walk under trees, the tree's trunk and branches and soil, understory plants and wildlife under the tree
- **Broad canopies deflect strong, drying winds**
- **Hormones made in a tree's branch tips assist in root growth.** More root growth creates more drought-tolerant trees that are well anchored to withstand strong winds

Well pruned native trees in a right-of-way provide a shady walk for pedestrians and shade for cars parked on the street. These trees and understory plants are supported by stormwater runoff from the street and path.

Prune only the parts of trees that are dead, damaged or in the way

- **Wait three years before pruning newly planted trees** to allow young branch tips to encourage root growth
- **Do not prune more than 20 – 25% of a tree at any one time.** Pruning more severely reduces the tree's food source
- **Reasons you might need to prune:**
  - Allow people to walk under shady trees
  - Provide access along paths and streets
  - Remove branches obstructing intersections or traffic sign/signals
  - Remove fuel in wildfire-prone areas
  - Remove limbs that might otherwise drop
  - Remove dead or damaged trunks/branches/branchlets
  - *NOTE: confirm branch is brittle before removing. Some trees drop leaves in heat and drought but branches remain pliable and leaves will grow back when water returns*

Trees do not "heal" wounds, they "seal" wounds, so prune at the right time to help the tree seal pruning wounds

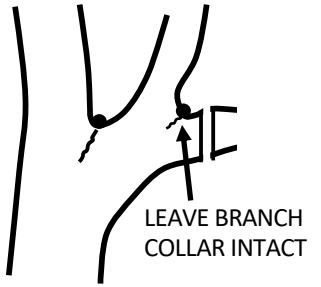
- The best time for major, structural pruning is late winter (February) for several reasons
  - There is a higher risk of fungal infections early in the winter rainy season
  - Many native trees are winter deciduous so you can see branches clearly and easily remove mistletoe
  - Plants will soon undertake spring growth to seal wounds
- You can prune in other seasons if needed to remove rain-induced growth or obstructions
- If you are planning additional pruning, waiting until early summer will incorporate the flush of spring growth

Dead and dying limbs need to be pruned

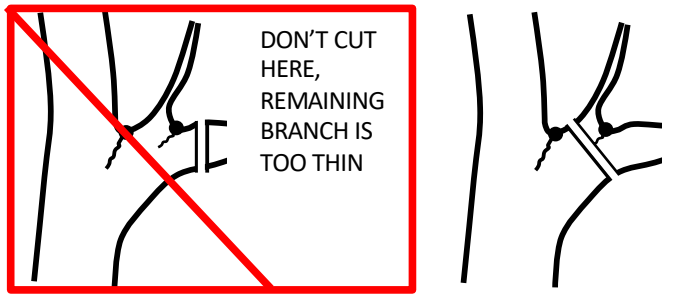
BEST PRACTICE 10. Follow native tree pruning principles

Prune at junctions where branches divide, and where remaining branch is growing up and out

- This maintains the flow of water and energy that supports branches and tree
- Make sure the branch you leave is at least 1/3rd the diameter of the branch you cut off so it can convey the flow of water from the cut branch up to the remaining branch and leaves
- Cut close to branch, leaving branch collar intact



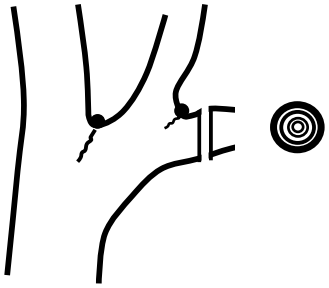
Prune lower branch since upper branch is large enough to reroute the water and energy



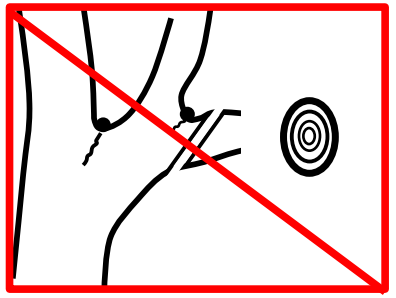
Do not prune lower branch since upper branch is too small to reroute the water and energy. Instead, prune off both right-side branches. Reroute water and energy through the main trunk

Make clean straight cuts perpendicular to branches

- Use sharp pruning tools to make clean cuts
- Make perpendicular cuts that create small circular wounds that the tree can efficiently seal
- Do not make angular cuts creating larger oval wounds that require more work for the tree to seal



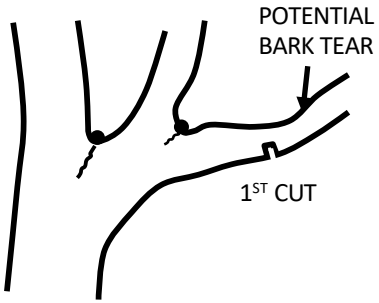
A perpendicular cut creates a small circular wound for the tree to seal



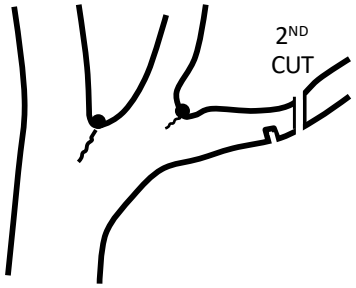
An angular cut creates a larger oval wound that the tree must seal

Use the three-step cut method for larger branches (greater than 5/8 inch diameter)

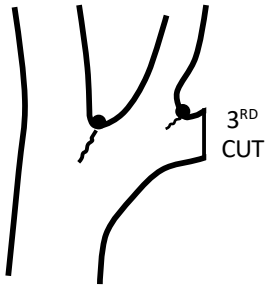
- Using the three-step method avoids stripping off bark that creates a larger wound the tree must seal
- Use a pruning saw to make the three cuts:
  - 1st cut: Place the saw under the branch 3 to 5 inches from the branch collar, then cut upwards ¼ of the way into the branch
  - 2nd cut: Place the saw on top of the branch to the right of the 1st cut and finish the cut downwards
  - 3rd cut: Remove the stub with a perpendicular cut, leaving the branch collar intact



!st cut on underside of branch to the left of potential bark tear



2ND cut to the right of the first cut at potential bark tear location



3rd cut perpendicular to branch to remove stub

BEST PRACTICE 10. Follow native tree pruning principles

Don't leave dead-end stubs

- If you cut a tree branch in a place that leaves a long branch stub, it's like cutting a flowing water pipe in its middle—water and energy flowing through the tree branch into the stub have nowhere to go
- Instead, at a branch junction, make a perpendicular cut just outside the branch collar of the branch you want to remove
- Water and energy are now rerouted to the remaining branch

Well-pruned branch: branch collar is retained without leaving a stub

Badly pruned branches: long branch stubs were left and are now dying back

After removing what must be pruned to meet your goals, leave the rest of the tree in its natural form

- You can prune one side of a tree and leave the rest of the tree intact
- This retains more leaves that cast shade and support tree and root growth

Desert willow pruned front and back to allow access to traffic and parking structure

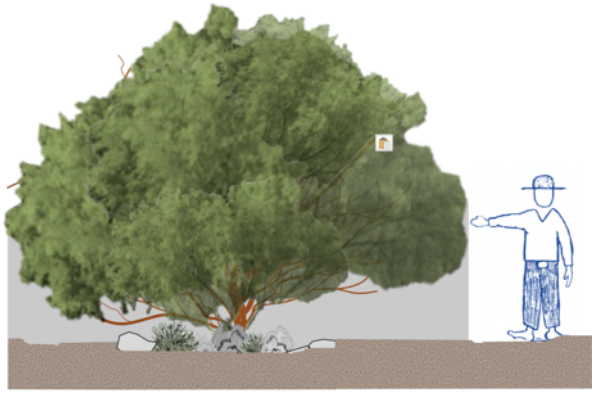
Same tree is not pruned side-to-side because access is not needed. Remaining tree casts shade and supports tree and root growth

Turn prunings into mulch to feed the tree. Cut prunings that are < 1/2-inch in diameter into lengths of 4-inches or less and lay them flat on the ground under the tree so they can decompose to help create a water-holding, nutrient-rich sponge that increases soil fertility

BEST PRACTICE 10. Follow native tree pruning principles

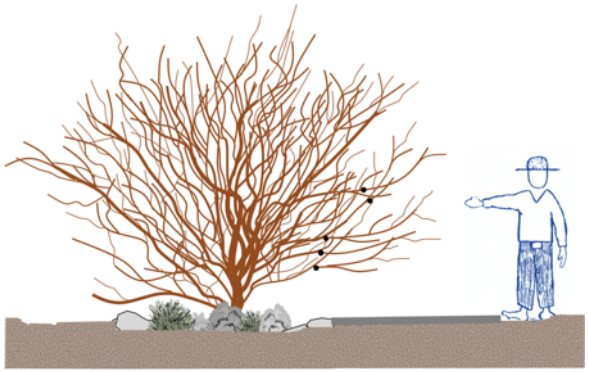
When pruning, determine specific tree-shaping goals you want to meet, then start small, go slow and reassess often

- Begin with small branchlets and branches, pruning back to branch junctions from the bottom up and outside in
- Step back often to see if remaining branches "lift up," reducing the need for further pruning
- Continue pruning until you meet your specific pruning needs, then leave the rest of the tree intact



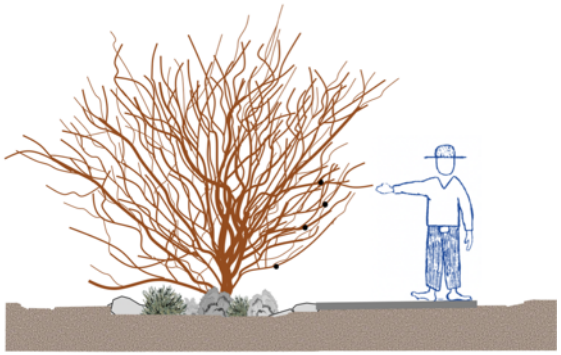
A small multitrunk tree is having a sidewalk constructed next to it

- Tree now needs to be pruned to provide pedestrian access on the right side



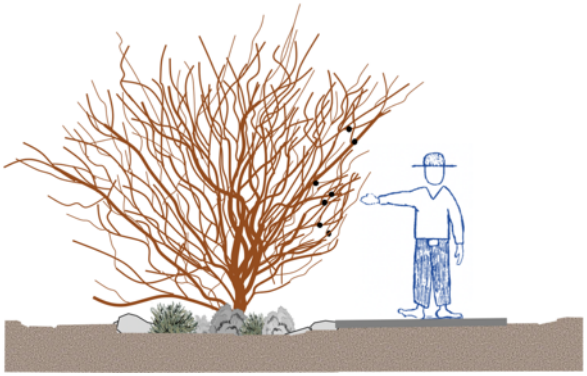
Prune in late winter in order to see branch structure

- Figure out needed pruning to gain sidewalk access
- Prune back to branch junctions from outside in and bottom up, starting with small diameter branchlets



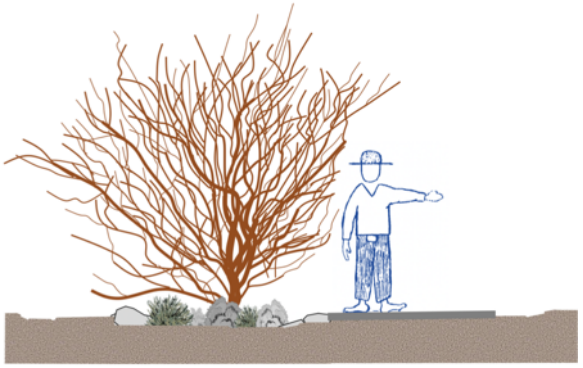
After first pruning round, reassess

- If additional pruning is needed, again prune back to a junction, from the outside in and bottom up



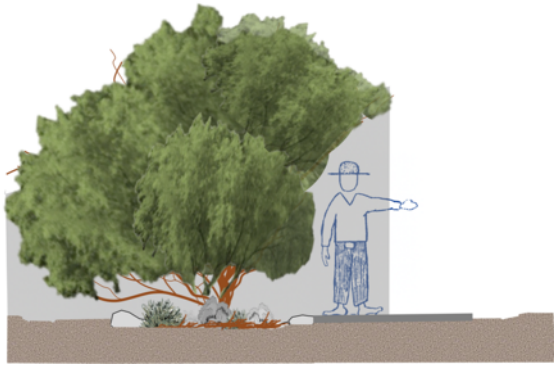
Again, reassess

- If more pruning is needed, do another round of small cuts from the outside in and bottom up



Continue until you gain the needed access

- Leave the rest of the tree intact
- Cut small diameter prunings into 4-inch sticks or less and lay them flat in the bottom of basin for mulch



Access is gained and sidewalk is partly shaded

- The more water, the more the canopy grows, and the more shade is available
- Periodic pruning may be needed to maintain access

Do not remove small branches that sprout from exposed native tree trunks—they feed trees and shade exposed trunks

Blue palo verde tree

Foothill palo verde tree

Desert ironwood tree

Whitethorn acacia tree

Leave enough canopy to shade a tree's remaining trunks and limbs to avoid causing sunburn

- Removing large sections of canopy can expose tender bark to intense sunlight, causing sunburn
- Palo verde trees are particularly susceptible to sunburn
- If possible, prune in late winter to reduce sun damage

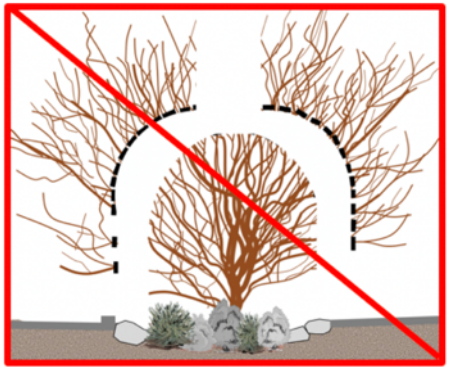
Drastically over pruned foothill palo verde tree with exposed trunk

Unshaded tender photosynthetic trunk of the over pruned foothill palo verde tree is now damaged by sunburn

BEST PRACTICE 10. Follow native tree pruning principles

You can cut a branch off, but you can't put it back on. Extreme pruning permanently distorts trees and shrubs.

- Do not shear the tops or sides of native trees and shrubs, this creates a dense mass of leaves at the ends of cut branches, eliminating light and stressing and weakening the plant's interior structure
- Extreme pruning weakens tree health, exposes trunks to harsh sun and heat, starves trees of food and drastically reduces the shade cast by trees



Do not shear tops or sides of plants

Distorted growth of sheared creosote

Foothill Palo Verde

Natural form

Well-pruned, maintaining natural tree form

Extreme pruning

Velvet Mesquite

Natural form

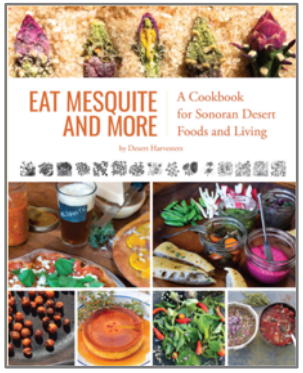
Well-pruned, maintaining natural form

Extreme pruning

MAKE FULL USE OF THE BENEFITS NATIVE TREES PROVIDE

Harvest native trees

Native trees that provide free, local edible fruits, seeds and pods include velvet mesquite, screwbean mesquite, foothill palo verde, blue palo verde, desert ironwood and canyon hackberry. Harvesting food locally increases food security and saves energy and water needed to import foods. ***Before eating any parts of native plants, carefully learn how to identify, harvest and process the plants.***



Plant native trees to support the insects, birds and other wildlife that evolved along with the trees

Celebrate the beauty, culture and heritage that native trees give us

Tucson Clean & Beautiful Inc./Trees for Tucson provides this guidebook and all other project documents at *tucsoncleanandbeautiful.org/native-trees-for-tucson*

Arizona tree and forestry websites with information about trees statewide

- Arizona Department of Forestry and Fire Management *dffm.az.gov/forestry-community-forestry/urban-community-forestry*
- Arizona Community Tree Council *aztrees.org*

Government websites with information about trees, canopy coverage, water conservation and rebates for water harvesting and graywater systems

- City of Tucson Urban Forestry/Million Trees *climateaction.tucsonaz.gov/pages/milliontrees*
- City of Tucson, Water Conservation information and Rebates *tucsonaz.gov/water/residential-and-commercial-conservation*
- Pima Association of Governments - Green Infrastructure prioritization tool and map *gismaps.pagnet.org/pag-gimap/*

University of Arizona websites with information about trees, water use, planting and related topics

- Cooperative Extension – Pima County, Master Gardeners *extension.arizona.edu/pima-master-gardeners*
- Cooperative Extension – Pima County, SmartScape Program *cals.arizona.edu/pima/smartscape/*
- University of Arizona Campus Arboretum *arboretum.arizona.edu*

Organization websites with information about trees, water harvesting, planting, pruning and related topics

- Arizona Native Plant Society *aznps.com/floras/*
- Desert Harvesters *desertharvesters.org*
- Desert Survivors *desertsurvivors.org/plant-lists.html*
- Dunbar/Spring Neighborhood Foresters *dunbarspringneighborhoodforesters.org*
- Mission Garden *missiongarden.org*
- Rainwater Harvesting for Drylands and Beyond *harvestingrainwater.com/rainwater-harvesting-inforesources/*
- Sonora Environmental Research Institute (SERI) *seriaz.org/projects/rainwater-harvesting*
- Sustainable Tucson *sustainabletucson.org*
- Tucson Botanical Gardens *tucsonbotanical.org/class-schedule/*
- Watershed Management Group *watershedmg.org/learn*

A huge, ancient ironwood tree grows in a natural area west of Tucson. Canopy diameter is 55 feet. Height around 40 feet. Circumference at 4 feet above surface is around 10 feet. A 12-foot long picnic table allows people to sit together to enjoy this majestic tree and its deep shade. Desert ironwood trees can live 1000 years or longer.

Plant beautiful, climate resilient, shade-producing, water-saving native trees

More information at tucsoncleanandbeautiful.org/native-trees-for-tucson