Water and Irrigation

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Water in Arizona

- Although January 2023 was the 14th wettest in 129 years, Yavapai County is often in a state of drought
- Arizona's Colorado River water right was reduced by 18% in 2022 (21% next year)
- As populations grow, there is concern that this is placing higher demands on a limited water supply

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What do we hope to learn about water and irrigation?

- **How water interacts with our environment**
- **How plants utilize water**
- **How, when, and where to irrigate plants**

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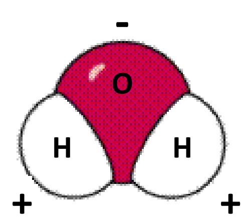
Molecular Structure of Water

H_2O

- One oxygen atom
- Two hydrogen atoms



Not symmetrical

- Electrons spend more time near the oxygen and less near the hydrogen
- Water molecule is polar

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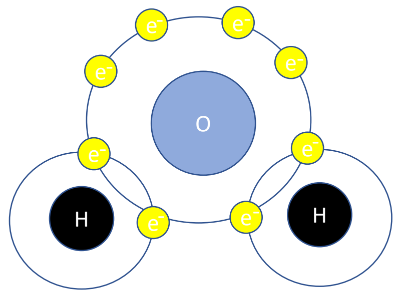
Idealized bonding



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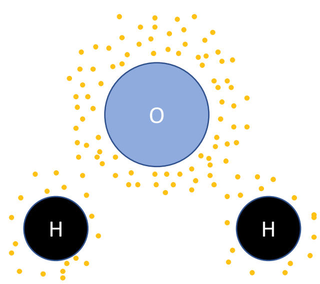
Reality of bonding



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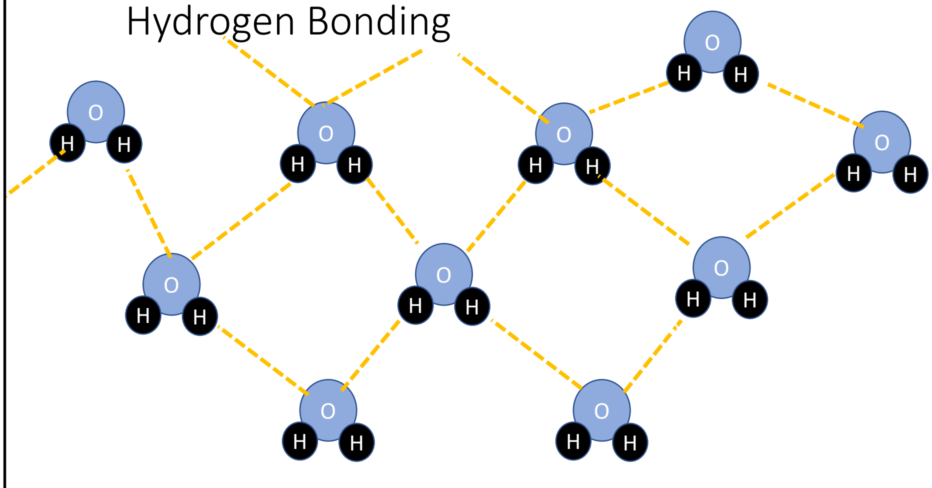
Hydrogen Bonding



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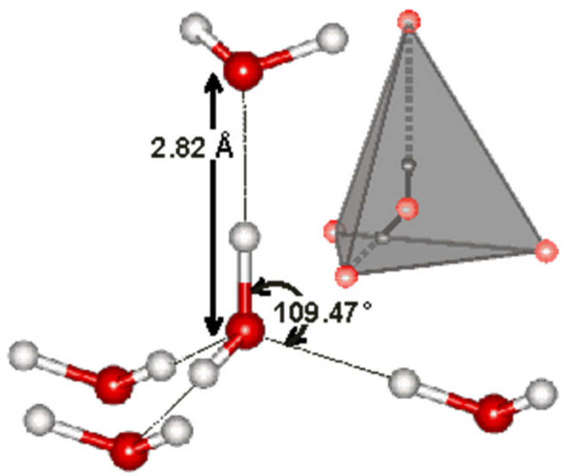
Hydrogen Bonding



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Special properties of water

- Physical States:
  - Heat Capacity
  - Evaporative cooling of water
  - Ice is less dense than liquid water
- Cohesion- water sticks together through hydrogen-bonding
- Adhesion-water sticks to other things
- Surface Tension
- Capillary Action
- Solvent-nature of water
- Pure water has a pH of 7 (neutral)
- Pure water does not conduct electricity

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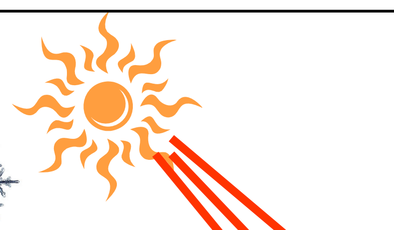
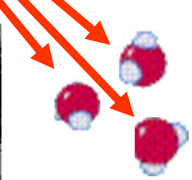
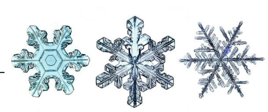
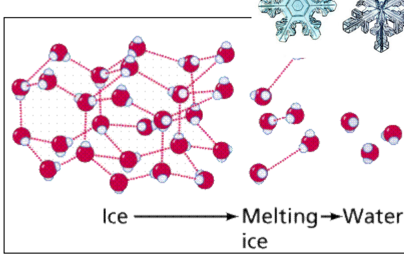
Physical States









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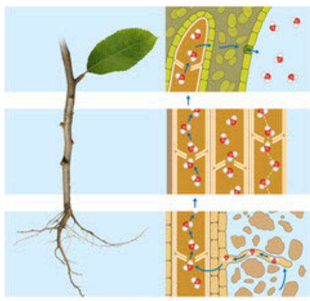
Cohesion

- The attraction water to itself – “Co”=together



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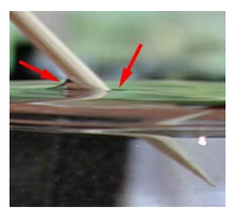
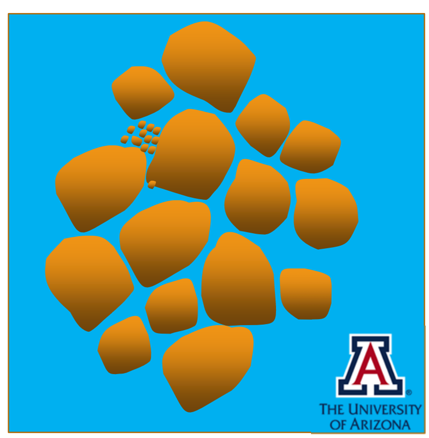
Adhesion



- The attraction of water to other surfaces/substances



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Surface Tension

- Interaction between hydrogen bonding and the earth's gravitational pull

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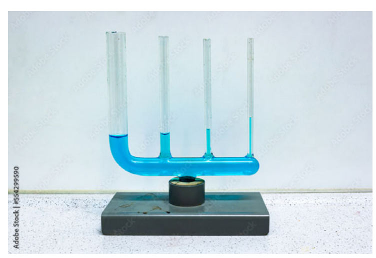
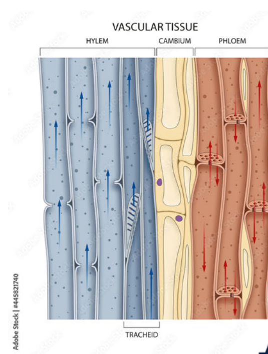
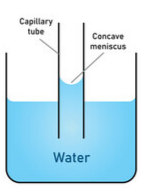
Capillary Action

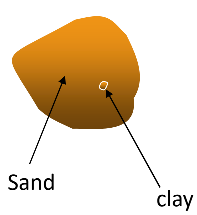
- "Wettable" surfaces cause a film of water to partially pull away from other water molecules and cling to the surface.
- Capillary action is important in soil and plant/water relations.







Adhesion



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pH: Alkalinity/Acidity

- The measurement of the H+ ions found in that substance
- The scale goes from 0 to 14
- 7 is neutral
- Below 7 is acidic
- Above 7 is alkaline (or basic)
- One pH unit represents a ten-fold change in H+ concentration

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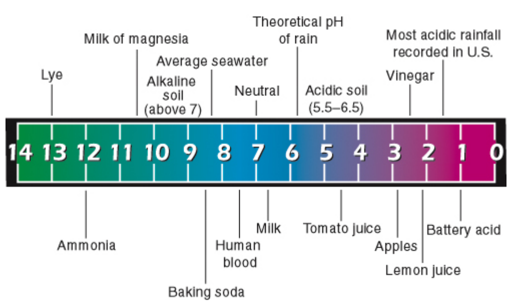
The pH Scale



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Solvent Properties

- Interacts with other polar and charged compounds
- Is repelled by non-polar compounds
- Small size allows it to saturate areas
- Can convey other substances in solutions

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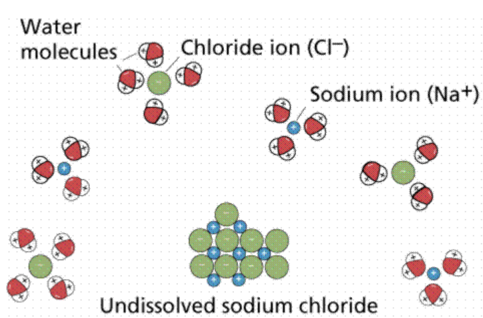
Sodium Chloride in Solution



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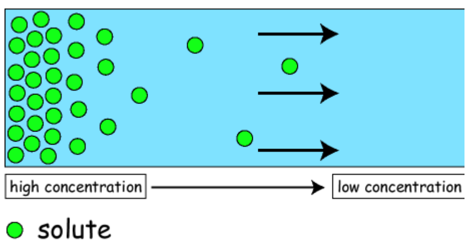
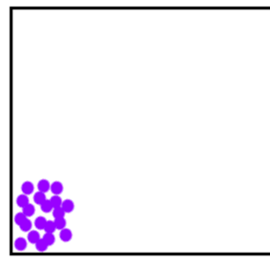
Diffusion

- The tendency of substances to move from areas of high concentration to areas of low concentration
- At equilibrium, they remain as far apart as possible





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Osmosis

- Osmosis is the net movement of water across a selectively permeable membrane driven by a difference in solute concentrations on the two sides of the membrane
- The water moves from the area of higher solute concentration to the area of lower solute concentration until equilibrium is reached

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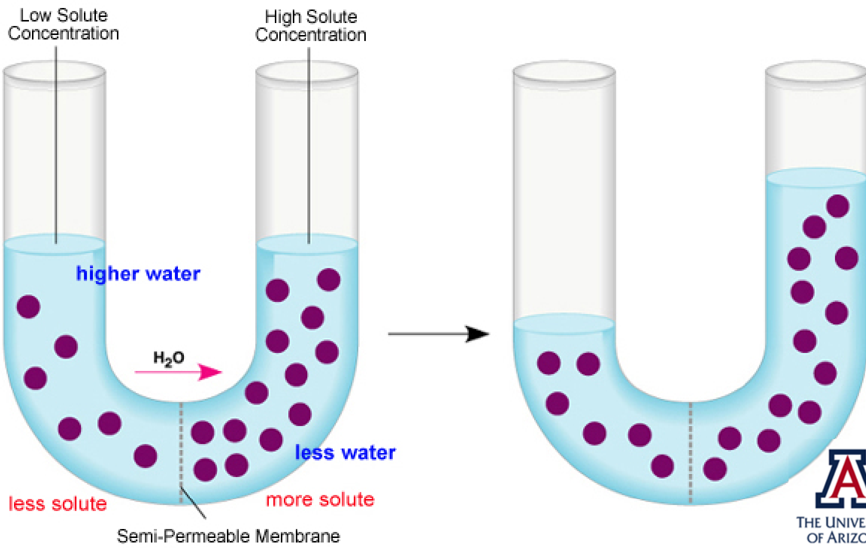
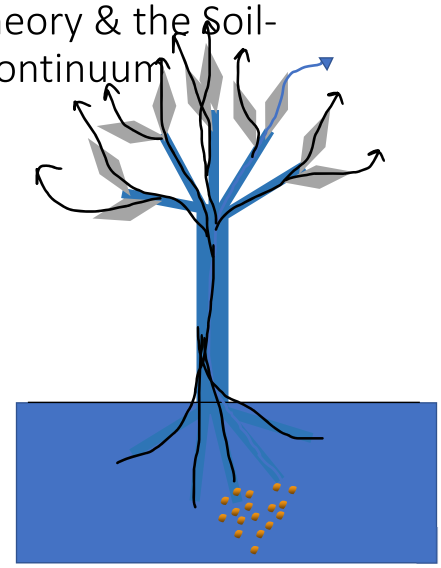
Osmosis

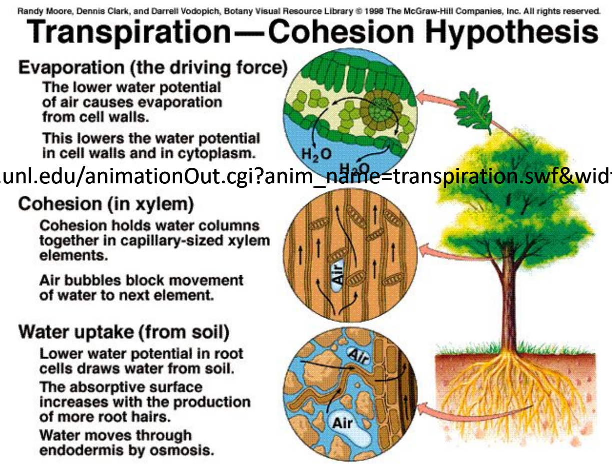


Cohesion-Tension Theory & the Soil-plant-Atmospheric continuum

- Water moves from high to low <u>concentrations</u>
- Concentration is highest in wet soil and lowest in dry atmosphere



Evapotranspiration (Et)



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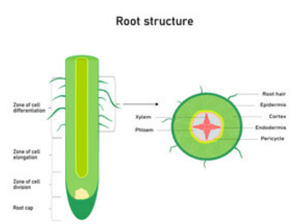
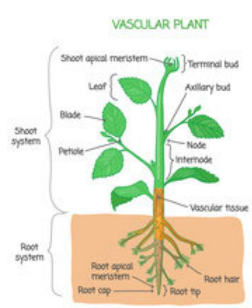
Roots

- Principle site of water and nutrient uptake S
- Size of root system depends on:
  - Competition
  - Soil type
  - Water and nutrient availability
- Root hairs-ephemeral, fine structures that maximize surface area of the roots
- Lateral roots-formed when insufficient resources are encountered





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Budbreak

- When soils warm up, plants become active
- Need to provide nutrient and water to buds
- Plant use water to expand first leaves
- “Bleeding”-water moving up plants prior to bud break
- How do plants pull up water if there are no leaves to transpire??

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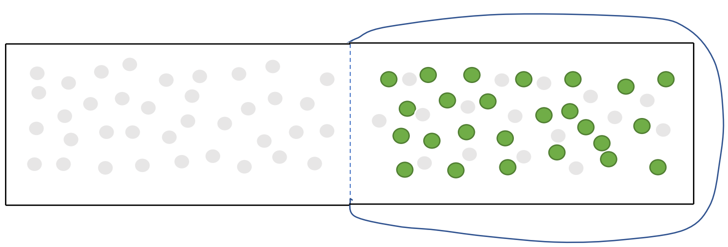
Bud Break: Osmosis Creates Root Pressure



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Irrigation

- Art and Science of providing to proper quantity of water to plant roots when it is needed
- Plants and irrigation techniques should be suited to:
  - Climate (macro and micro)
  - Topography
  - Soil
  - Available water (quality and quantity)

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How does water behave in soil?

1. Gravity moves it in (infiltration)
2. Gravity + Capillary Action moves it down and horizontally (percolation)
3. Evaporation and transpiration removes water from soil
4. Capillary action moves it upward
5. Diurnal effect
   - Day - dries
   - Night - equilibrates

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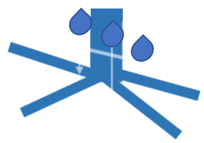
How Water moves through Soil

- Infiltration: movement of water into soil
- Deep percolation: water lost below the root zone
- Runoff: when more water is applied than can infiltrate



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How water moves through soil

- Sandy soils hold less water than clay
  - Need to be watered less, more frequently to avoid deep percolation
- Clay soil hold more water than sand, but water infiltrates more slowly
  - Prone to runoff, need to be watered less frequently

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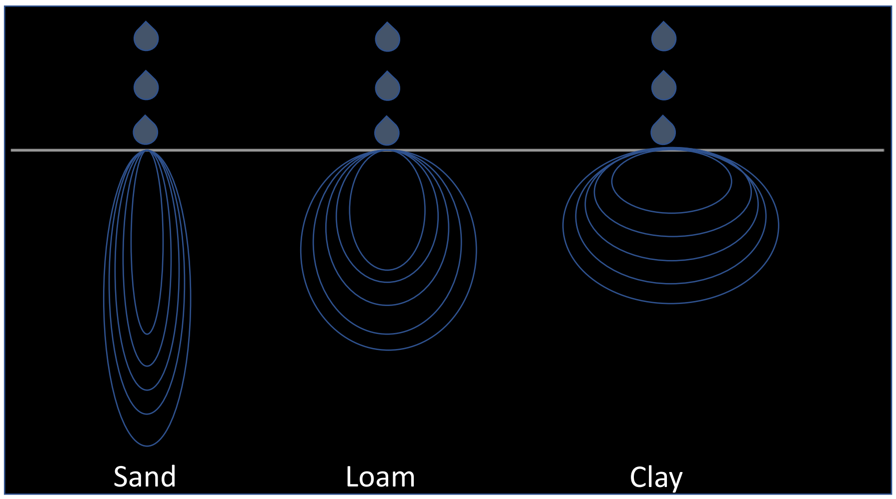
How water moves through soil



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Available Soil Water

Water is held too tightly for plants	Plant Available Water	Water drains from soil

Dried soil — Wilting point (plants die) — Field capacity — Saturated soil

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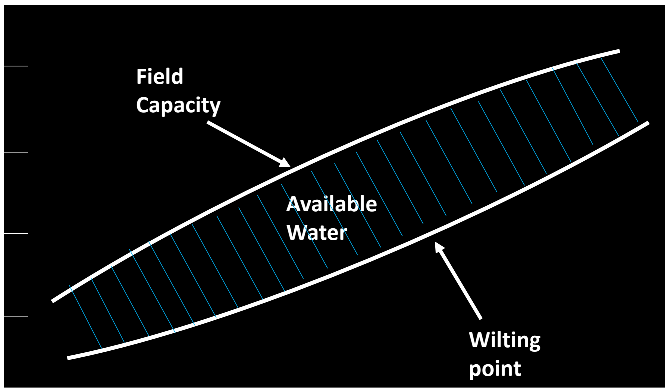
Water Availability



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Assessing the drainage of your site

Perform a Drainage Test:

1. Dig a hole the size of a 5-gallon bucket
2. Fill hole with water
3. Let the soil absorb water for an hour or two
4. Fill again with water
5. Hole should drain within 24 hours; if it doesn't, you have a drainage restriction such as a caliche layer

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How much water do plants require?

- Most water plants is lost through transpiration
- Most needs to be replaced through irrigation/precipitation
- Soil water is also lost through soil evaporation

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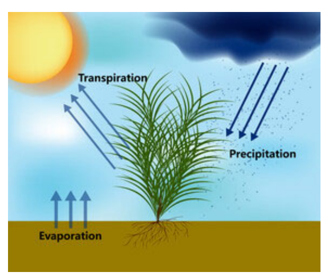
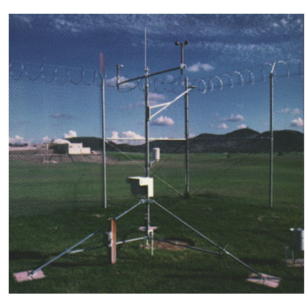
Transpiration + Evaporation =Evapotranspiration (Et)

- Evapotranspiration is the sum of both (Et)
- Usually talked about as inches per day (volume)
- ET is a function of:
  - Temperature
  - Relative humidity
  - Solar radiation
  - Wind speed
- Different plants have different Et demands





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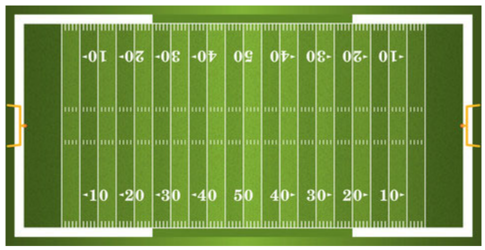
Acre/Feet

- Common large-scale measurement of water
- The volume of water with an area of a acre one foot deep
- Football field =1.32 acres



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Wine Grape Evapotranspiration

$ET_{grapes} = ET_0 \times K_c \times K_{RDI} / Eff$

Evapotranspiration: total water evaporated from a land surface

ET_0 = Reference evapotranspiration based on full-grown alfalfa or clipped grass

K_c = Crop Coefficient for well-watered grapevine (<1.0)

K_{RDI} = percentage of vine ET used for Regulated Deficit Irrigation (RDI) ($\leq$ 1.0)

Eff = Irrigation system efficiency (>.85)

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Origins of Drought Resistance in Wine Grapes

- Early Cultivation (8000 BP) began in dry regions of the "Old World"
  - Eastern Mediterranean
  - Fertile Crescent
  - Southern Caucasus

$ET_{grapes} = ET_0 \times K_c \times K_{RDI} / Eff$

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Wine Grapes are Water-Efficient

Crop	Water Requirement (acre-ft)/acre/year
Alfalfa	4-6'
Cotton	5'
Bermudagrass	3-5'
Habiturf®	3' or less
Wine grapes	1.5-3'
Native Landscaping	N/A

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- Water use is often measured as evapotranspiration

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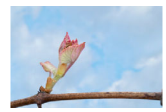
Wine Grapes Employ Deficit Irrigation



$$ET_{grapes} = ET_0 \times K_c \times K_{RDI} /Eff$$

- **Budbreak to Fruitset**: Irrigation to full Et_{grapes}
- **Fruitset to Veraison** (color change): employ deficit irrigation (K_{RDI})
- **Veraison to Harvest**: employ deficit irrigation (K_{RDI})
- **Harvest to dormancy**: If growth has stopped, soil profile should be filled

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Drip Irrigation Efficiency (Eff)

$$ET_{grapes} = ET_0 \times K_c \times K_{RDI} /Eff$$

Irrigation Delivery	Efficiency
Furrow/Flood	40-50%
Overhead Sprinkler	60-75%
Drip Irrigation	85-95%

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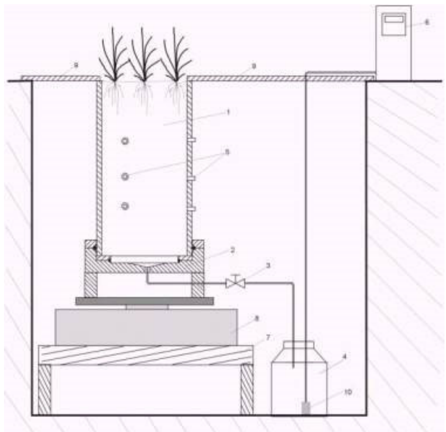
Lysimeters are used to measure actual water use



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Weight of water on/in soil

- Table is 3’ x 6’ (36 ft^2)
- 1 inch of water on that table weighs…
- 187 lbs
- 6 inches of water = 1,122 lbs
- Soil compaction can occur during flood irrigation
- Water also displaces air potentially leading to plant stress

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Useful Constants/Conversions

- Weight: 62.416 pounds per cubic foot at 32°F
- Weight: 8.33 pounds/gallon, 0.036 pounds/cubic inch
- Density: 1 gram per cubic centimeter (cc) at 39.2°F
- 1 gallon = 4 quarts = 8 pints = 128 ounces = 231 cubic inches
- 1 liter = 0.2642 gallons = 1.0568 quart = 61.02 cubic inches
- 1 Acre-Foot = 325,851 gallons = 43,560 cubic feet

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How deep to water

- 1 inch of water will:
  - Go 12" deep in a sandy loam
  - 8-10" deep in a loam
  - 4-6" deep in a clay loam
- To irrigate each soil to a three-foot depth, you need to apply:
  - 3" on a sandy loam
  - 4" on a loam
  - 6" on a clay loam

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Probe sold in Master Gardener office used to check watering depth

Soil core can be used to check water as well

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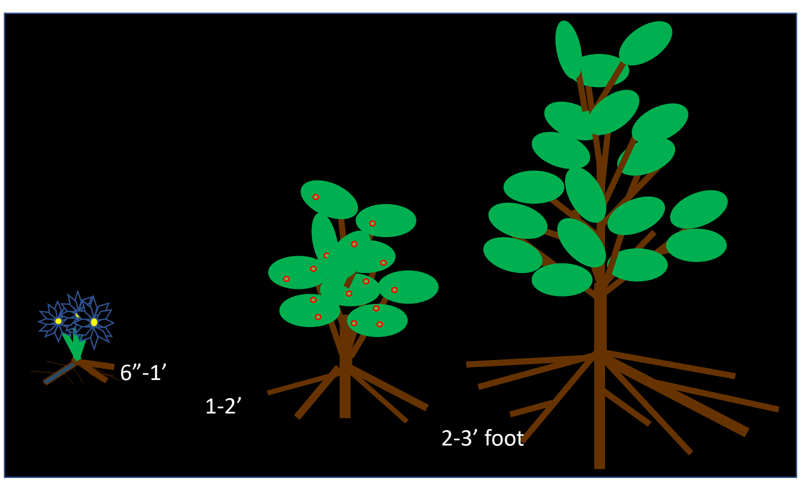
One, Two, Three Rule



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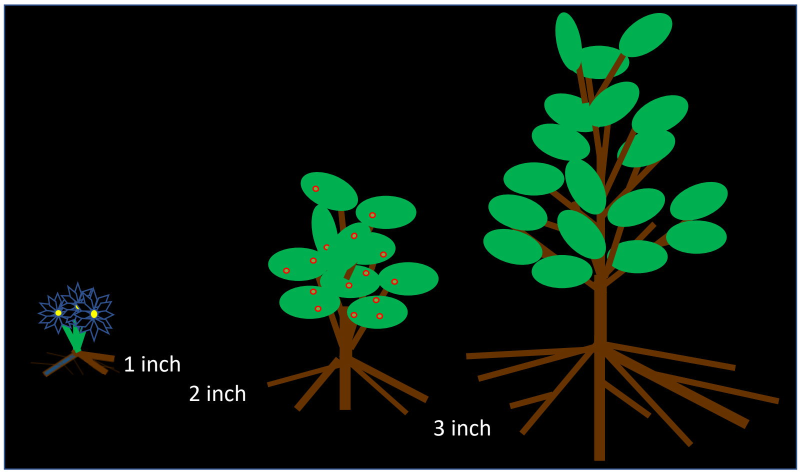
One, Two, Three Rule



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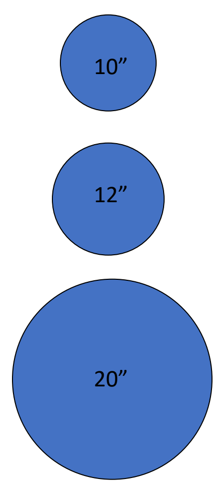
What area do I need to water: Terry Mikel's Law of Pizza

- As the radius of the root system doubles, the area of the root system increases by four times
- $A=\pi r^2$
- 10" pizza = 79 in^2
- 12" pizza = 113 in^2
- 20" pizza = 314 in^2



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How to know when to water: Look….

- Check in the morning
- New leaves smaller
- Internode length shortening
- Wilted leaves
- Change in leaf color (darker, duller, grayer)
- Yellowing basal leaves
- Dropping leaves

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The "Feel" Test

- Dig down about 6-8"
- Water when about 50% of soil moisture is depleted
- Eventually you will learn the soil and plants

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"Feel" Test

Available Moisture	Sand	Sandy Loam	Clay Loam	Clay
Close to 0%	Dry, loose, falls through fingers	Dry, loose, falls through fingers	Dry clods that break into powder	Hard clods, difficult to break
50% or less	Dry, won't form a ball	Dry, won't form a ball	Crumbly, but will form a ball	Pliable, will form a ball
50% to 75%	Dry, won't form a ball	Forms a ball temporarily	Forms ball, pliable	Forms ball, will ribbon
75% to field Capacity	Sticks together slightly, weak ball	Weak ball, breaks easily	Forms a ball, very pliable, slick	Easily ribbons, feels slick
Field Capacity	Squeeze; leaves hand moist	Squeeze; leaves hand moist	Squeeze; leaves hand moist	Squeeze; leaves hand moist
Above Field Capacity	Free water released	Free water released	Free water released	Free water released

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Irrigation tips:

- Water deeply and infrequently
  - Encourages plants to root deeper
  - Lower proportion lost to evaporation
- Make sure your system is efficient
  - Check for leaks, clogs, uniform sprinkler distribution
- Irrigate early in the morning or at night, reducing evaporation before percolation
- Adjust your watering schedule as needed:
  - Plant Species
  - Plant age
  - Rain events
  - Heat
  - wind

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Irrigation Methods-Drip

- Frequent, slow and precise application of water through emitters
- Tube or tape that may have emitters installed or be blank
- Emitters are made in different sizes
- Emitters can plug, animals can chew

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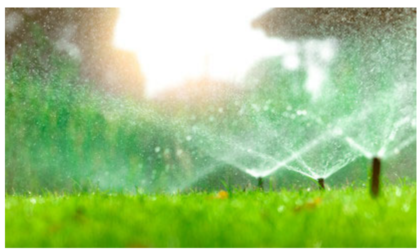
Irrigation Methods-Sprinkler heads

- Excellent for turf and ground covers
- Not as good for trees and shrubs
- Need a good design (consider hiring a professional to design the system)
- Still need repair and maintenance
- Do not mix and match incompatible nozzles and head types or brands.



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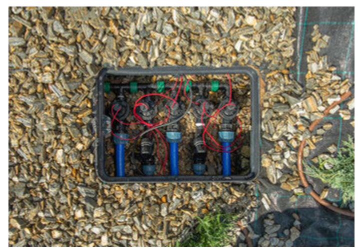
Irrigation Methods-Automatic Timers

- Reset times for different times of year
- Check system periodically to make sure it is working correctly
- Turn off after rains



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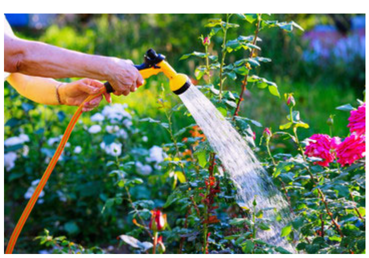
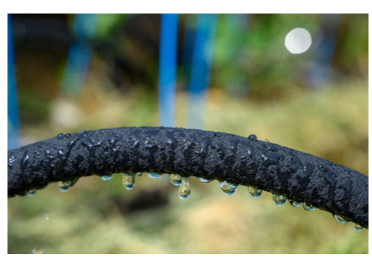
Irrigation Methods-Other

- Soaker hoses work great for trees, shrubs, vegetables, and annuals
- Good, old fashioned hose spraying works well for natives that only need periodic watering during drought





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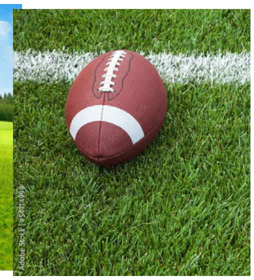
Turfgrass in the United States

- Constitute the largest irrigated crop in America (almost 40 million acres)
  - Vast majority are residential lawns





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Turf Benefits vs Costs

The Good:
- Color
- Texture
- Ability to withstand foot/tire traffic

The Bad:
- High Water use
- High Fertilizer use
- High Pesticide use
- High costs
- Frequent mowing
- Pathogens
- Some turf extremely invasive

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Alternative: Native Plant Landscaping

Plants that occurred in the region before the settlement of Europeans

Velvet Mesquite (Prosopis velutina)

Parry's Agave (Agave parryi)

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Native Plant Management

- Give water and manage weeds during first 2 years of establishment
- Give supplemental water during extremely hot, dry summers
- Be mindful of microclimate
- Contact landscape architect

Arizona Cypress (Cupressus arizonica)

Parry's Penstemon (Penstemon parryi)

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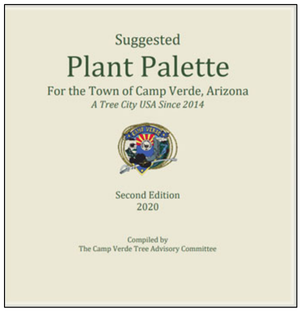
Native Plant Resources



www.campverde.az.gov

cals.Arizona.edu/yavapaiplants/

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Alternative : North American Turfgrasses

Example: Buffalograss (Bouteloua dactyloides)

Advantages

- Drought resistant
- Slow-growing
- Low nutrient requirement

Disadvantages

- Some sensitivity to foot traffic
- Less resistant to invasive weeds
- Color (grey/green) less aesthetically appealing
- Under winter/water stress conditions, will go dormant

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Alternative : North American Turfgrass Example: Habiturf ®

- Developed at the University of Texas at Austin Ladybird Johnson Wildflower Center
- **62 % Buffalograss** (bouteloua {formerly Buchloe} dactyloides)
  - Perennial, C4 turfgrass
- **30% Blue Grama** (bouteloua gracillis)
  - Perennial, C4 bunchgrass
- **8% Curly-mesquite** (Hilaria belangeri)
  - Perennial, C4 bunchgrass
- Available at Douglas King Company:

  www.dkseeds.com

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Review

The performance of native and non-native turfgrass monocultures and native turfgrass polycultures: An ecological approach to sustainable lawns

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ARTICLE INFO ABSTRACT

- **Weeds:**
  - Total weed cover was lower in native compared to non-native plots
  - High-diversity assemblage had 63% less dandelion than the bermudagrass plot
- **Mowing:**
  - Bermudagrass grew much faster between mowing periods than natives
- **Composition:**
  - High-diversity assemblage ended with:
    - 3 co-dominants (>25% each): blue grama, buffalograss, curly-mesquite
    - 2 sub-dominants (<5% each): hairy and Texas grama
    - Hairy tridens and Poverty dropseed were undetectable

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Horticultural vs. Ecological Approaches

Horticultural Approach
- Select and modify a single species (monoculture)
- Fit a wide range of requirements
- Requires heavy management

Ecological Approach
- Mimic a plant community
- Accounts for multiple biotic and abiotic processes
  - Soil
  - Rainfall
  - Pathogens
  - Grazing
  - Weeds

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Potential Cons and Pros of Native Polyculture Turf

Cons
- Color (blue/green)
- Foot traffic?
- Go dormant/brown with drought or cool season

Pros
- Dormant grass may be preferable to xeriscape in some scenarios
- Water and Nutrient efficiency
- Reduced maintenance

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Water & Irrigation Wrap-Up

- The special properties of water make life possible
- Soil, weather, and plant type dictate irrigation scheduling
- Do not overwater or fertilize native and/or drought tolerant plants and cause them to grow too much
- Do not assume that just because a plant is native and/or drought tolerant that it does not need irrigation
- Plants need some water in winter, evergreens also need adequate water in winter

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