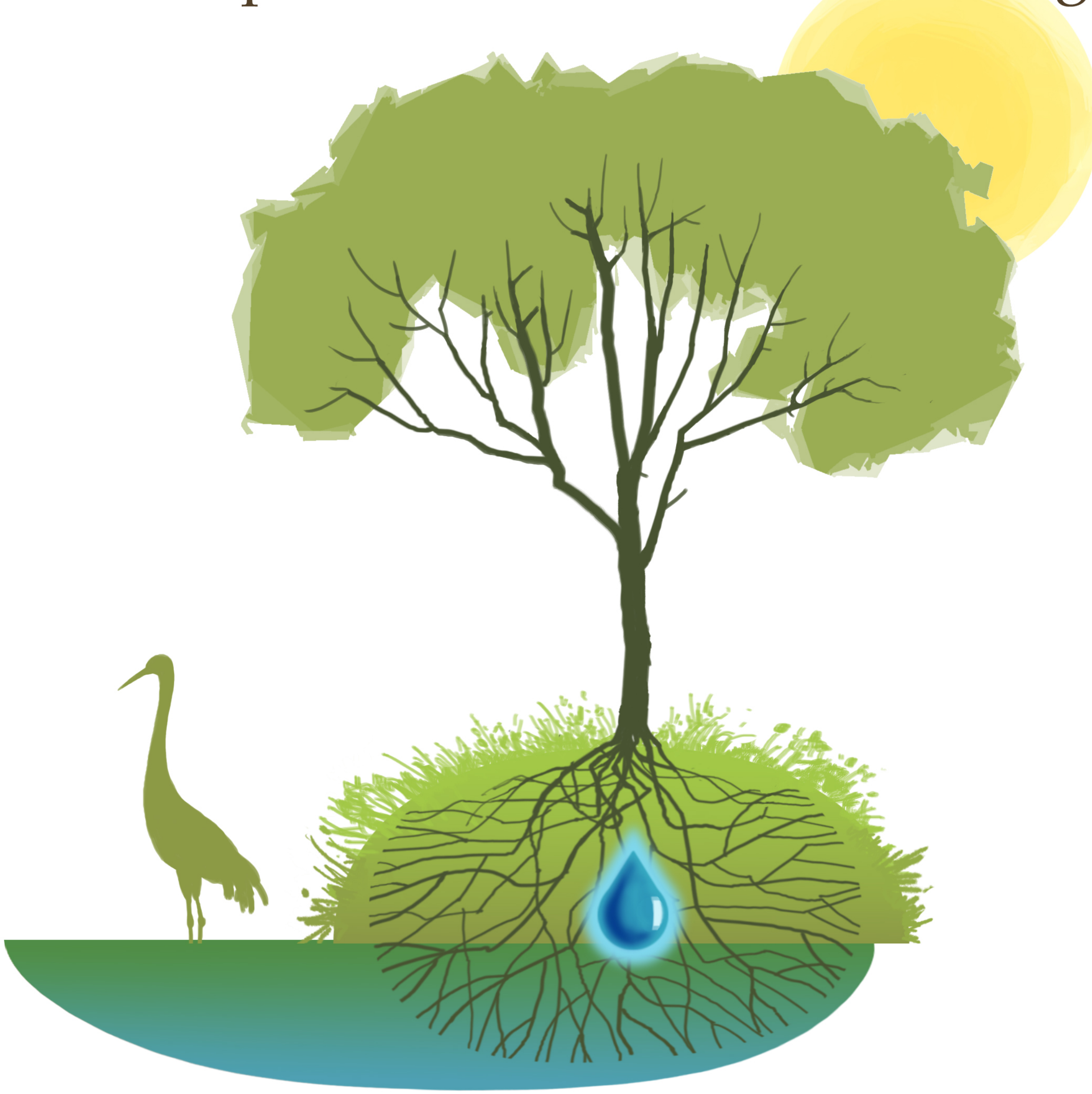
green gardens group

Los Angeles, CA

February 2015

Watershed Wise Landscape Professional Training



education consulting design community

When one tugs on a thing in Nature, he finds it attached to the entire world. **John Muir**

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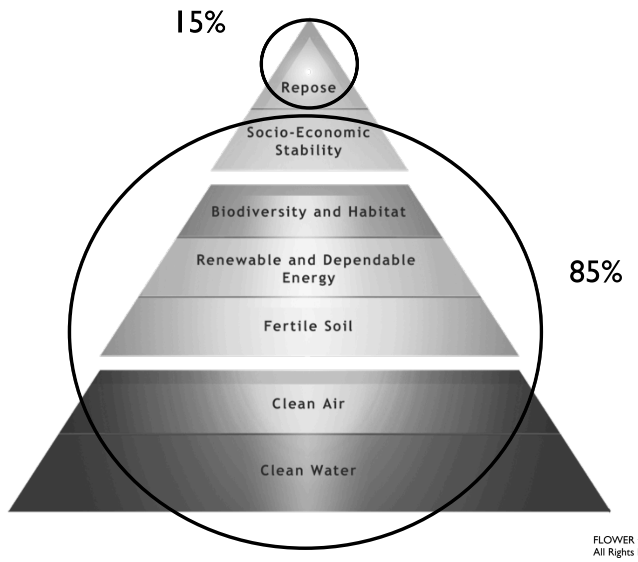
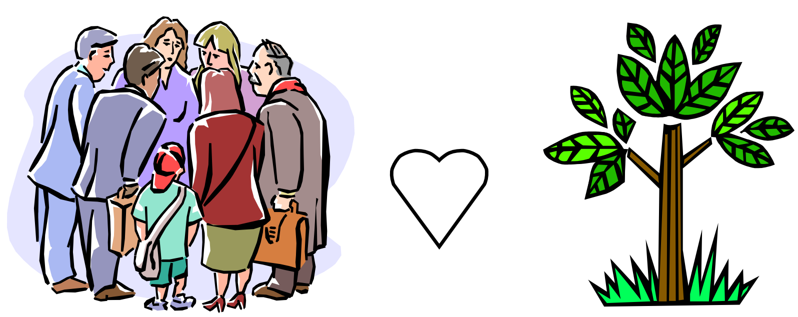
Watershed Wise Landscapes Have **Inner** Beauty



The Natural Human State is BIOPHILIA



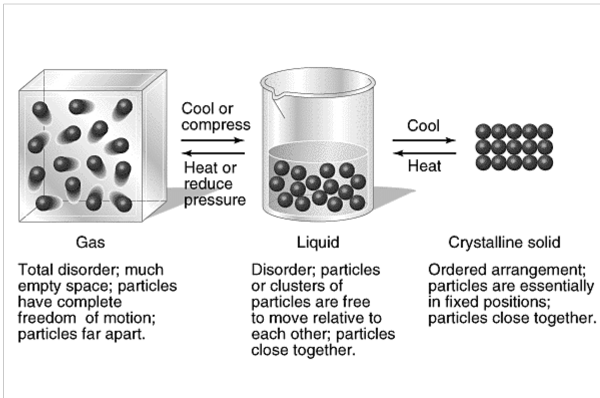
BIOPHILIA: the "love of life or living systems."

You Are Needed to Change the World

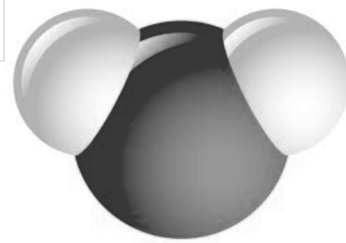
Environmental & Workforce Non-profit Organizations
Water Agencies
Stormwater/Bureaus of Sanitation
Entrepreneurs
Residential and Commercial Property Owners
Community Organizers
Media Outlets
Manufacturers of Equipment and Technology
Nurseries and Landscape Supply Outlets
City Planners
Developers/Builders
Local Business Owners
State and Federal Government
Parks and Recreation Departments/Open Space
Flood Control

Our Water Woes Are Global AND Local

Water Is a Unique Molecule



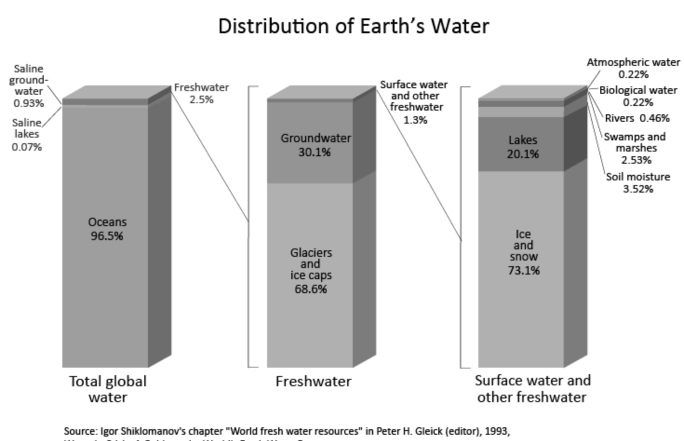
It can exist simultaneously in a gas, liquid and solid state.



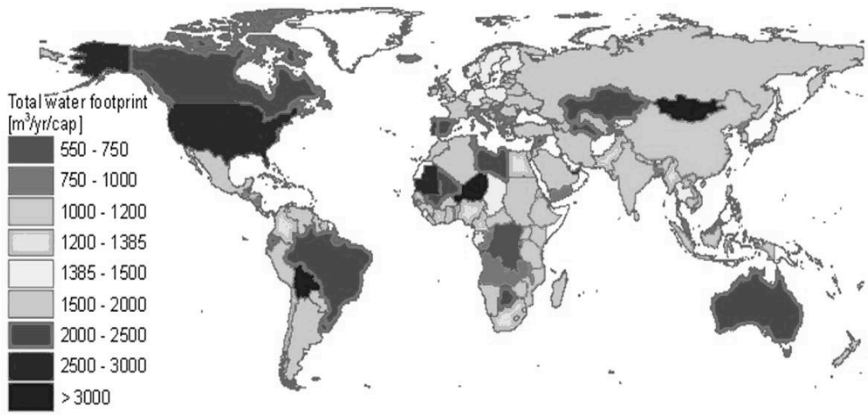
It looks like "Mickey Mouse" with its 2 Hydrogen atoms bound to 1 Oxygen atom.

70% of Earth's Fresh Water Is Locked in Ice

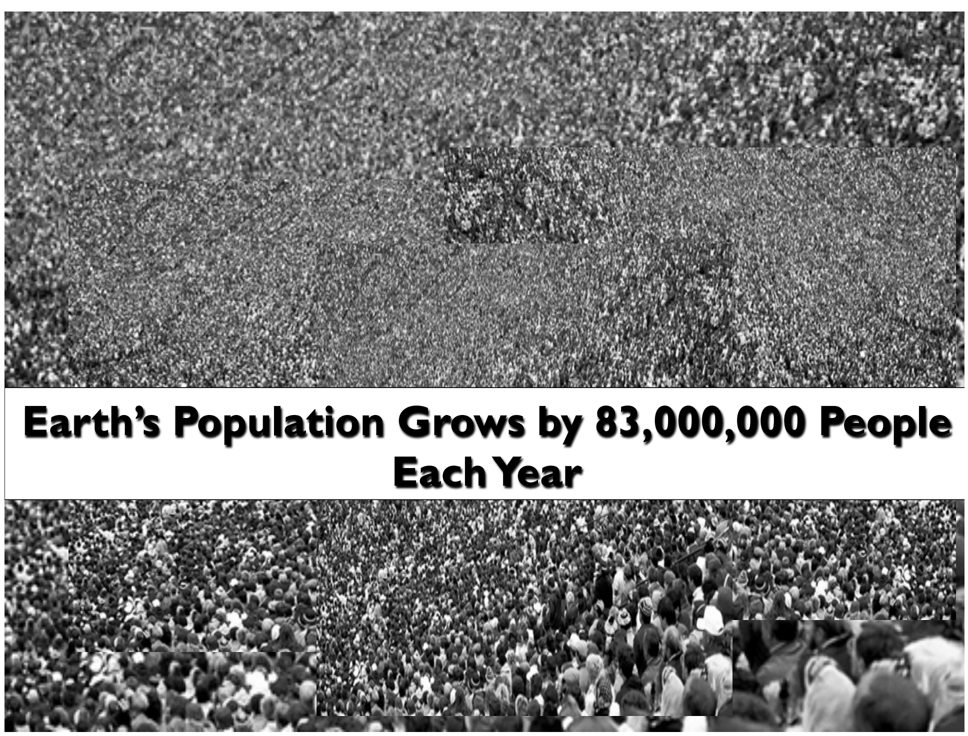
Only 3% of earth's water is fresh water, and of this, 70% is locked in ice. Most of the rest of it is in groundwater. This means that only 1% of earth's water is available to all on earth that need water. Humans are 75% water.



Per Capita Water Use by Country

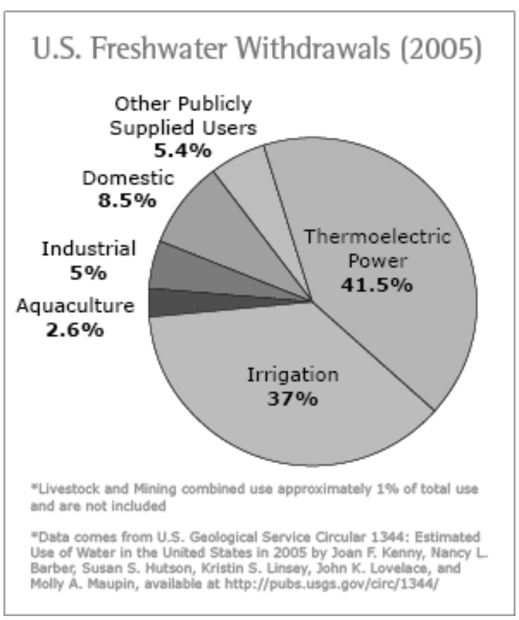


We cannot sustain our per capita use



Imagine If You Had to Walk an Avg. of 3.7 Miles/Day for Water….As Many Women & Children Do

A Huge Amount of Freshwater Services Agriculture



Makes one think about supporting more organic and water efficient practices in farming.

And We Have an Uneasy Relationship with Water in the Environment

Drinking Water Is Regulated by Environmental Protection Agency: Safe Drinking Water Act of 1974

1. Treated to meet national safety standards.
2. Tested multiple times per day.
3. Immediate notification if quality is not met.

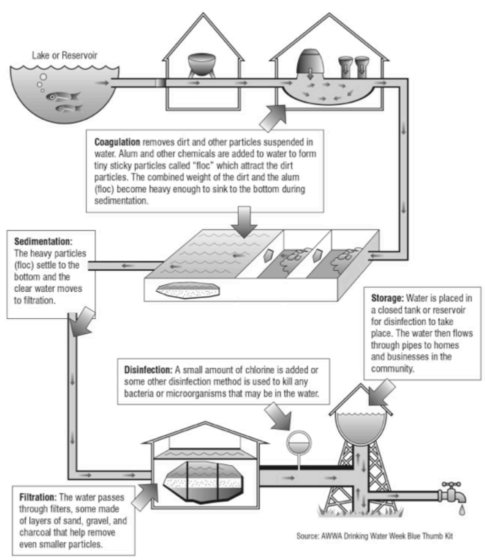
Potable or Drinking Water

All Water On Earth Has Been Here Since The Beginning

Yes, water is dinosaur pee

In Southern California, water also contains whatever happened upstream in Las Vegas...

All Drinking Water Is Recycled or Treated in Some Way

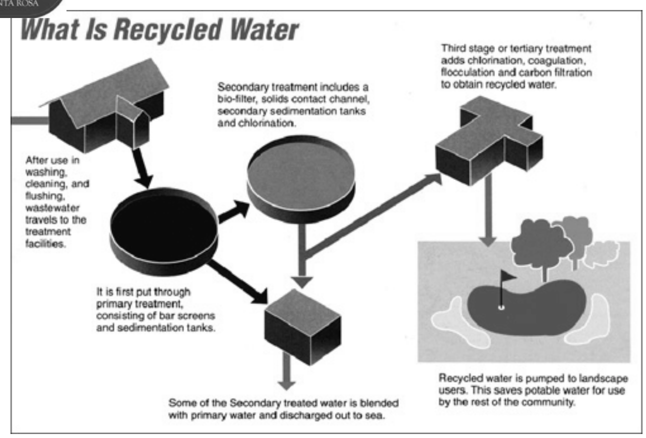


Filtration removes particles, minerals, organic matter, microorganisms.

Clarifies water & enhances effectiveness of disinfection.

Waste Water Is Treated and Then Dumped

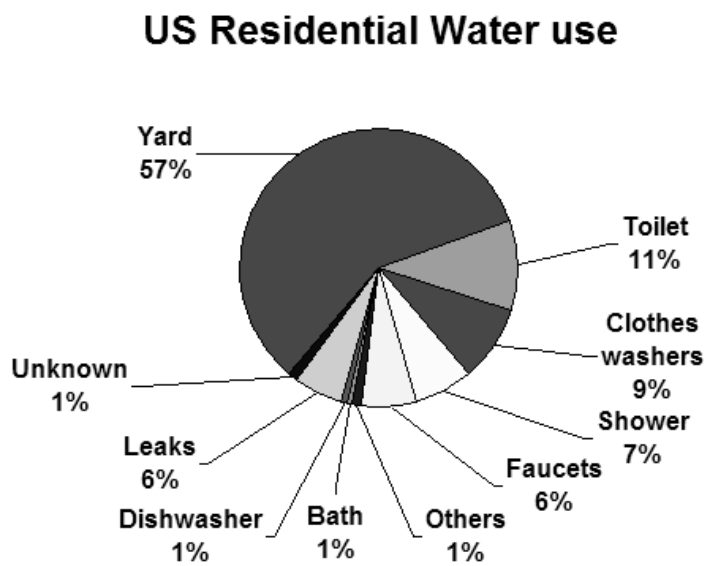
That which is not used in landscapes or for industrial use is often dumped into the ocean.

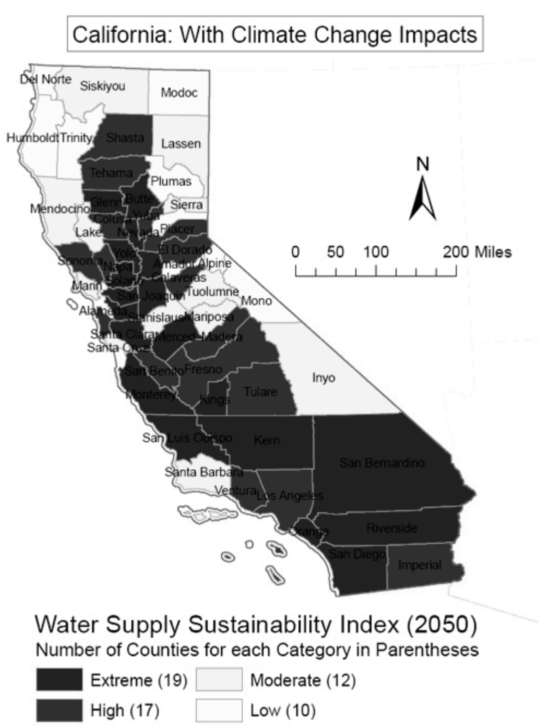


Why Don't We Directly Drink Waste Water? Three Major Threats to Our Water Supply

1. Anti-bacterial products
2. Pharmaceuticals & antibiotics from human waste
3. Plastic & microbeads in cosmetics

We've Gotten Good at Conserving Water Indoors



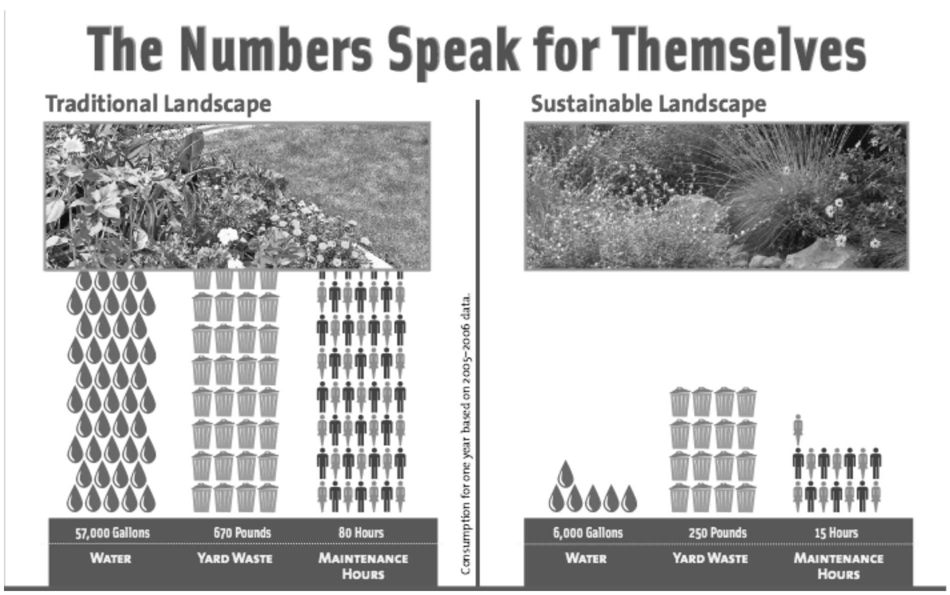


With 60%+ of CA drinking water going to the Landscape, and climate change upon us, we need to concentrate on the Outdoors.

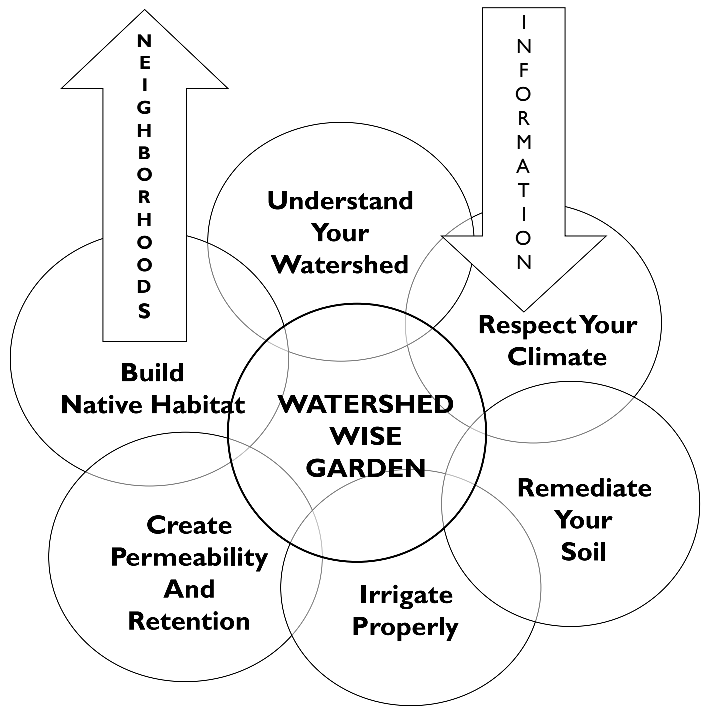
And Get Watershed Wise in Our Landscapes

We will prove that using landscapes as environmental solutions brings many more benefits than simply water conservation.

Watershed Wise Landscapes Work



City of Santa Monica, CA

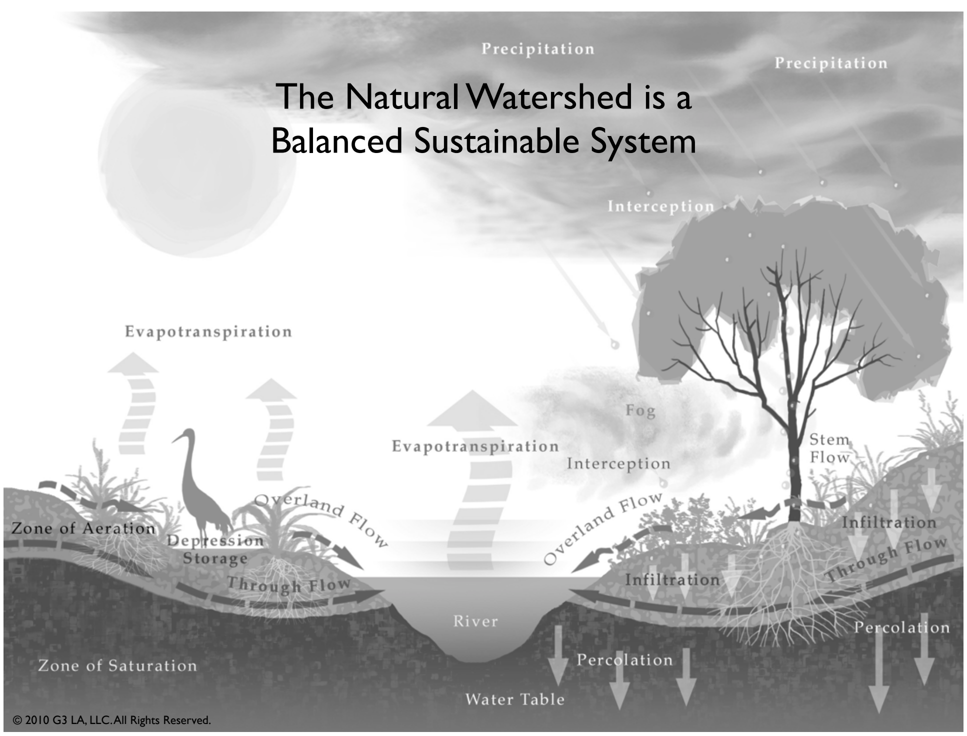

NEIGHBORHOODS
INFORMATION
Understand Your Watershed
Respect Your Climate
Build Native Habitat
WATERSHED WISE GARDEN
Remediate Your Soil
Create Permeability And Retention
Irrigate Properly

Understand Your Watershed

A watershed is the area of land where all of the water that is under it or drains off of it goes into the same place. *US EPA*

Introducing:

- Watershed Functions
- First Flush
- Using A Watershed Evaluation Model



In the **Natural Environment**, *interception, infiltration,* and *percolation* are *slowing, spreading,* and *soaking* all land-based water through soil and plants before it flows into waterways, allowing soil and plants to clean and store water until evapotranspiration takes it back into the atmosphere. The **Built Environment** doesn't have these natural processes.

Depletion Affected by:

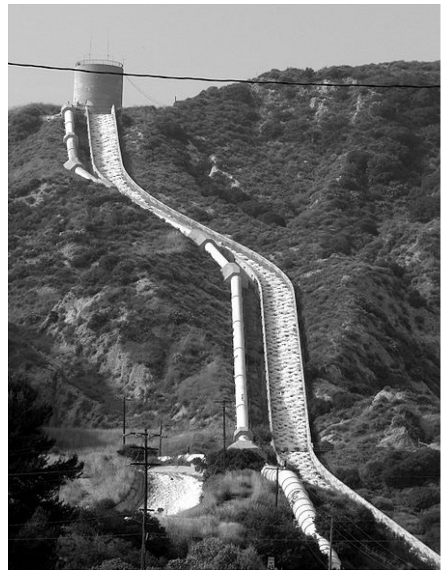
- Environmental Factors
- Population Growth
- Agriculture

Ground Water and Surface Storage are not being replenished.

WATERGYA:
Nexus of Energy & Air Quality in Water Conservation

WATERGYA connects Water with the Energy required to transport, clean, and heat it. As water is conserved, so too is the embedded energy. When energy is conserved, greenhouse gases are reduced, and Air Quality is improved.

For example, approximately 20% (and growing) of California's electricity resources are devoted to transporting, cleaning and using water.

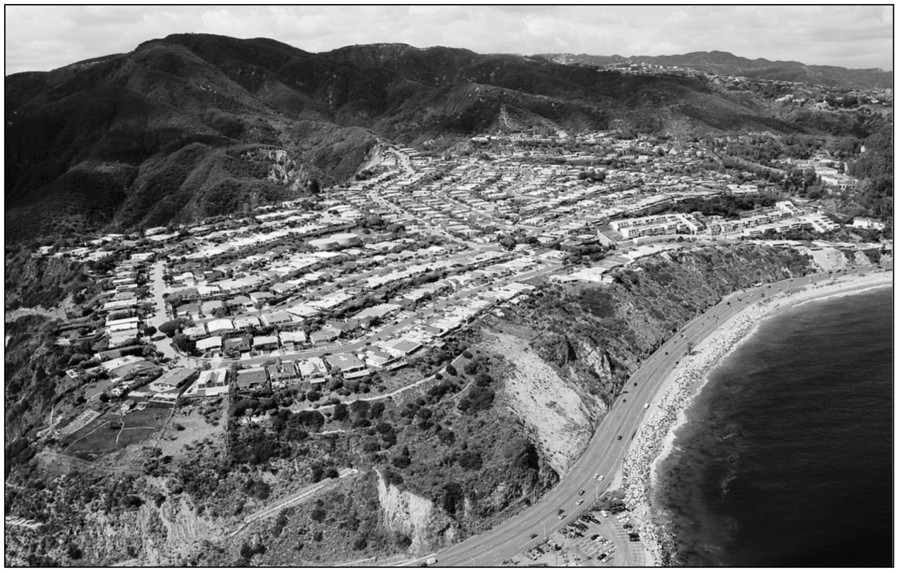


We Waste Drinking Water with Dry Weather Runoff

Hundreds of millions of gallons of potable water run off our landscapes and impermeable urban environment on a **DRY** day.

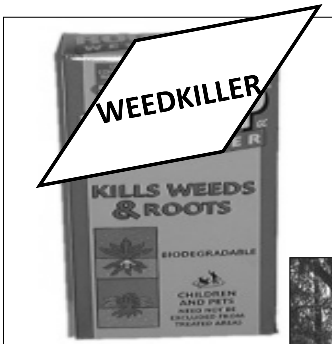
This runoff carries pollutants directly into our waterways year round.

Our Developments Destroy Native Habitat



We Treat Our Soil like Dirt (Compaction!)

We Depend on Chemical and Fossil Fuel Inputs



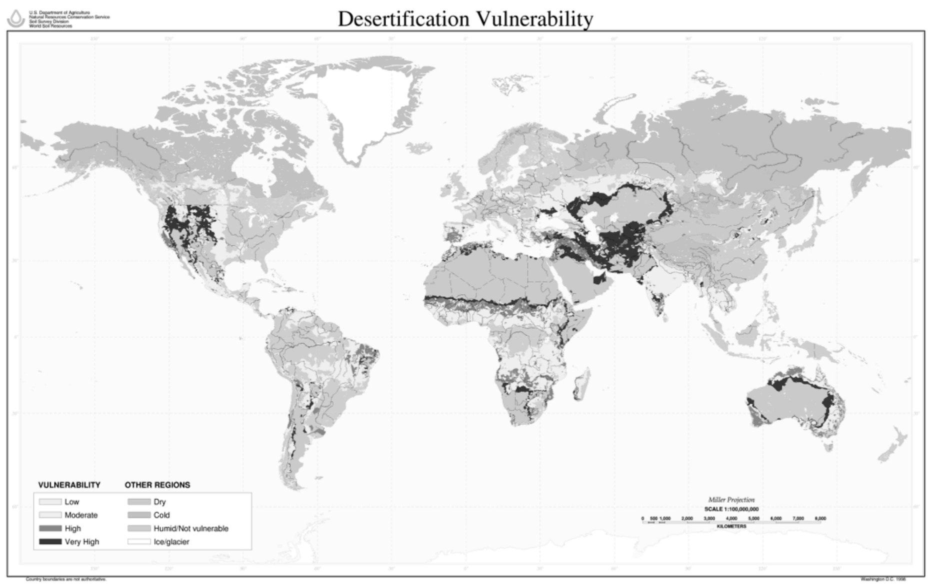
580 million gallons/year, nationally, for mowing.

Synthetic fertilizers and herbicides are fossil fuel-based.

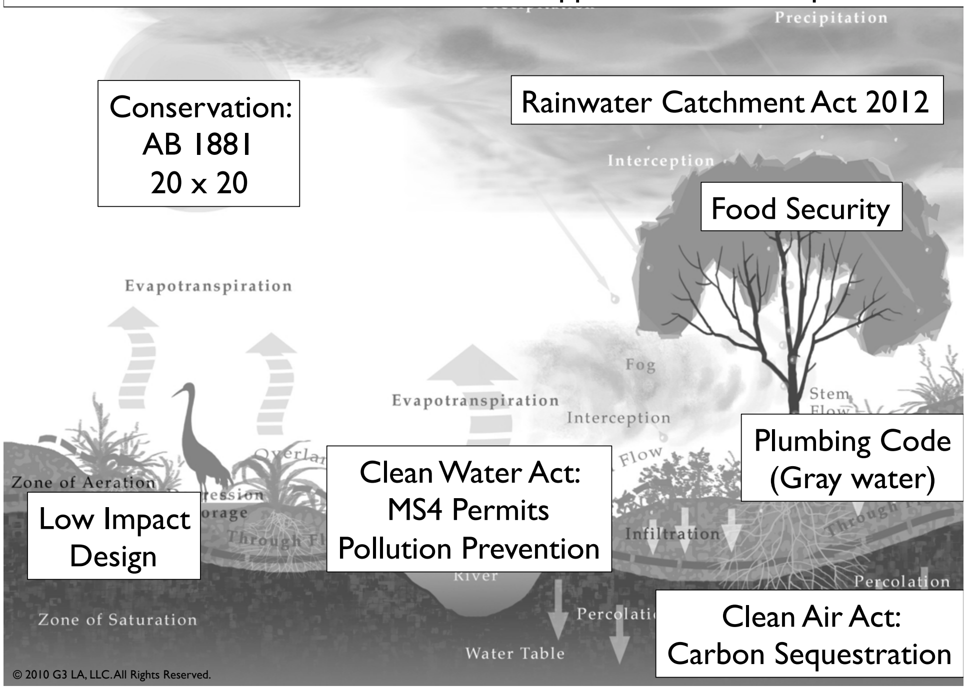
70% of fertilizers run off the landscape into the ocean nationally.

We Generate Green Waste and Greenhouse Gases

This Results in the Disease of Desertification



The Answer Lies in a Watershed Approach to Landscapes



Concentrate on Retaining the First Flush

First Flush:
The first ¾-1 inch of rain after a dry period.

It Carries Street Pollution (Seen and Unseen)…

To Storm Drains …

Through the Flood Control System . . .

During a storm, billions of gallons of water may run through the storm drain and flood control system.

This pollutes our waterways.

Increased runoff also means decreased groundwater recharge.

To Our Oceans and Beaches . . .

Killing Life . . .

Image courtesy of Heal the Bay.

Start Treating Your Property as **a Mini-Watershed**

Conservation - Saving resources like water, soil, energy, air quality. Preserving and enhancing habitat and ecological functions of the watershed.

Permeability - Disconnecting impermeable surfaces. Breaking up hard surfaces to allow water to spread out and sink into the ground. Creating soil that is biologically active and holds on to water.

Retention - Holding water on the property for the benefit of soil, plants, and habitat, rather than allowing it to run off into the storm system. Grading to capture water and allow it to sink into the ground water or throughout the landscape. Elimination of dry weather and wet weather runoff.

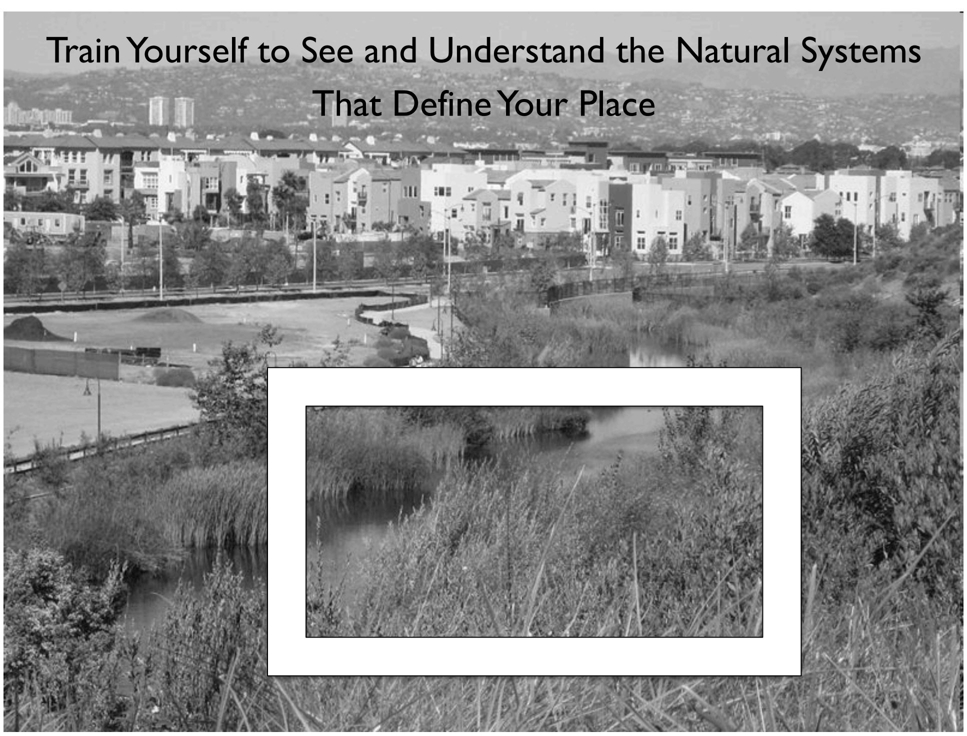
Apply C.P.R. To Revive Waterways

C.P.R.™ used courtesy of Surfrider Foundation.

Respect Your Climate

Introducing:

- Evapotranspiration and Plant Factor
- Plant & Landscape Water Requirements
- Effect of Irrigation Efficiency on Landscape Water Requirement
- Water Budgets, Hydrozones, Designed Water Use
- Determining Distribution Uniformity



Observe Where You Live

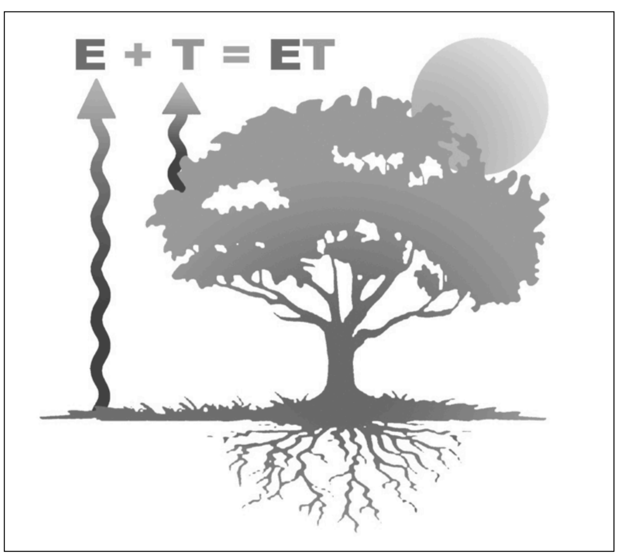
Design To Mirror Your Native Environment

In **THIS** Place, How Much Water Does Your Landscape **Require**?

Landscape water requirements are different for various **plants** . . .

. . . and **soils**

ET = Evapotranspiration



The amount of water lost from the soil surface

(EVAPORATION)

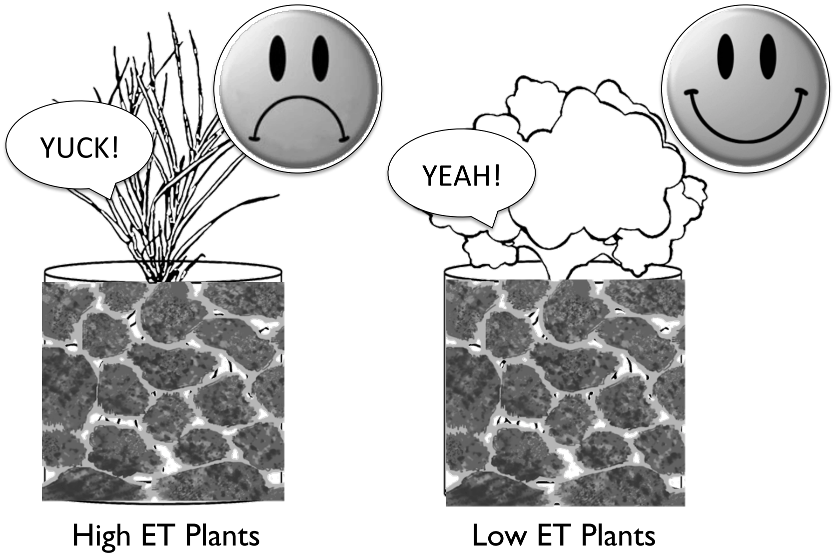
+

The amount of water lost through the plant leaves

(TRANSPIRATION)

ET is expressed in INCHES of water per time period

Transpiration Is Like Plant Sweat



ETo - Reference Evapotranspiration Rate

ETo, or "Observed ET," is the observed evapotranspiration rate for maintaining a field of healthy cool season turf grass, 4"-7" in height, grown in full sun at any given site, with no prevailing microclimate conditions, and adequate water supply.

ETo answers the question:
Where Are We?

ETpf – Specific Plant Evapotranspiration Rate

Any ET data other than ETo is called the PLANT FACTOR (ETpf or PF), and is the Percent (%) of ETo required by a particular plant to stay healthy with adequate water supply in any given site, taking into account prevailing microclimate conditions.

PLANT FACTORS are always compared to ETo and are expressed as High, Medium, Low, or Very Low ET.

ETpf answers the question: **What's There?**

Observed ET and the Plant Factors Help Determine Plant Water Requirements

ETo is always the baseline water requirement in a particular environment, and the Plant Factors are expressed as a PERCENTAGE of ETo.

ETo describes the climate in which the garden is located and ETpf describes what is happening in a specific garden.

For each particular Climate Zone, one may characterize different kinds of plant material based on whether it is Very Low, Low, Medium, or High water use IN COMPARISON with cool-season turf grass (ETo).

Knowing the Plant Water Requirements (PWR) is the Basis of **Watershed Wise Landscape Design**

High ET Plants

Medium ET Plants

ET data tells you how much water the plants in your landscape need to stay healthy
IN YOUR AREA:

Low ET Plants

ETo Tells Us Where We Are It Describes the Climate

Annual ETo = 46"

In **This Place**, Cool Season Turf grass needs 46" to be healthy if maintained at 4"-7" in an open field and adequately irrigated for optimum growth.

Use ETo to Describe a Place and Determine Landscape Water Requirements

ETo data is organized by California Reference Evapotranspiration Zones.

Each Zone has a different ETo, based on different **weather conditions:** solar radiation and wind, for example.

Distinguishing the appropriate Zone is somewhat of an art, and takes practice.

Try to evaluate differences between the ETo Zones.

www.cimis.water.ca.gov

California Irrigation Management Information System

ETo (CLIMATE) TEAMS

Purpose:

1. Group people by similar ETo (climate) rates.
2. Create 9 teams of 5-6 people
3. Enable each team to develop a profile of the "Place" which corresponds to the ETo range of the group, reinforcing the importance of ETo as an answer to the question, "Where Are We?" and a number that describes climate.

Preparation:

- Random Annual ETo rates are printed on name tags. The ETo rates range across the 18 areas in CA from 33 to 71.
- Tables each have sheet of paper labeled Group A – I with spaces for names to be signed-in under the letter.
- Tables each have a table tent and a SHARPIE PEN for writing their average. ETo and a characteristic or city that corresponds with their Avg. ETo.
- Each day the tables are renamed, so people do not sit in the same seats two days in a row.

Activity 1 Cue: After first Biology Break, corresponding with "How Much Water Does Your Landscape Really Require?"

1. Stand up, bring your bags, etc. with you; "we are changing seats."
2. Line up around the room from lowest to highest number (do not discuss what these numbers are YET!).
3. Count off 1-5.
4. Sit down in groups of 5 at the tables indicated A – I
5. Sign in on the sheet of paper at the table – This is your classroom team, and each day you will be required to sit with your same team.

Time: 10 minutes

Activity 2 Cue: Understanding ETo Helps Us Understand Our Climate

1. Determine your average ETo and discuss amongst yourselves the characteristics of the place that is described by this ETo.
2. Write down as many characteristics as you can think of, and try to add the name of a city or two that would be located in this ETo
3. Make your table tent with your defining characteristic or city on it.
4. Select one person from the group to report to the class on your ETo Climate.
5. Go around the room and each group explains their ETo – 1 minute each.

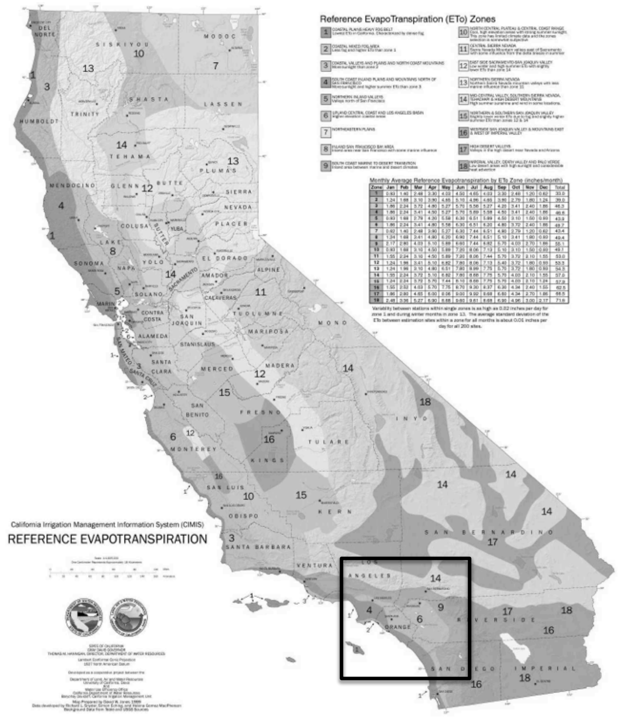
Time: 10 minutes discussion, 10 minutes total presentation to class

Appendix A—Table 1
Reference Evapotranspiration Rates for Selected Cities*

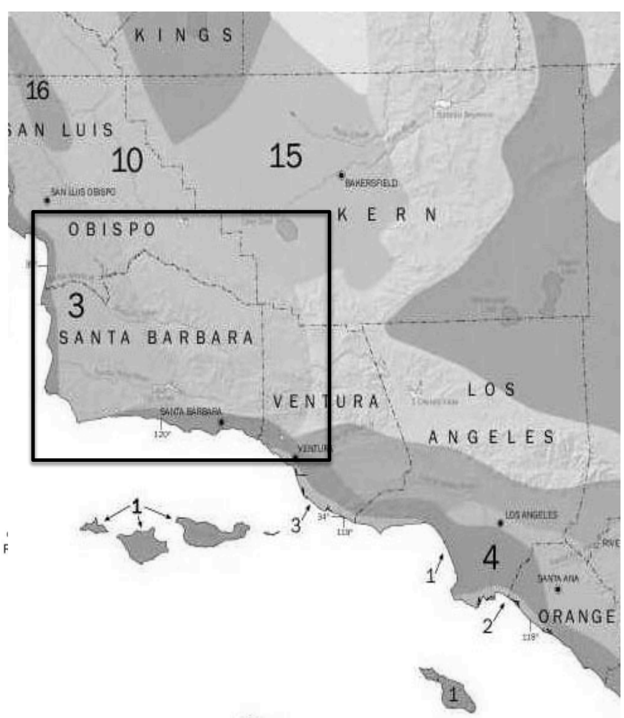
Daily Average Reference Evapotranspiration by ET_o Zone (inches per day)

ET_o Zone	City	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	Santa Monica	0.03	0.05	0.08	0.11	0.13	0.15	0.15	0.13	0.11	0.08	0.04	0.02
2	Santa Cruz	0.04	0.06	0.10	0.13	0.15	0.17	0.16	0.15	0.13	0.09	0.06	0.04
3	Monterey/Salinas	0.06	0.08	0.12	0.16	0.17	0.19	0.18	0.17	0.14	0.11	0.08	0.06
4	San Diego	0.06	0.08	0.11	0.15	0.17	0.19	0.19	0.18	0.15	0.11	0.08	0.06
5	Santa Rosa	0.03	0.06	0.09	0.14	0.18	0.21	0.21	0.19	0.15	0.10	0.05	0.03
6	Los Angeles	0.06	0.08	0.11	0.16	0.18	0.21	0.21	0.20	0.16	0.12	0.08	0.06
7	Alturas	0.02	0.05	0.08	0.13	0.17	0.21	0.24	0.21	0.16	0.09	0.04	0.0[illegible]
8	San Jose	0.04	0.06	0.11	0.16	0.20	0.23	0.24	0.21	0.17	0.11	0.06	0.0[illegible]
9	San Bernardino Pasadena	0.07	0.10	0.13	0.17	0.19	0.22	0.24	0.22	0.19	0.13	0.09	0.0[illegible]
10	Paicines	0.03	0.06	0.10	0.15	0.19	0.24	0.26	0.23	0.17	0.10	0.05	0.0[illegible]
11	Sonora	0.05	0.08	0.10	0.15	0.19	0.24	0.26	0.24	0.19	0.12	0.07	0.0[illegible]
12	Fresno	0.04	0.07	0.11	0.17	0.22	0.26	0.26	0.23	0.18	0.12	0.06	0.0[illegible]
13	Quincy	0.04	0.07	0.10	0.16	0.21	0.26	0.29	0.25	0.19	0.12	0.06	0.03
14	Sacramento	0.05	0.08	0.12	0.17	0.22	0.26	0.28	0.25	0.19	0.13	0.07	0.0[illegible]
15	Bakersfield	0.04	0.08	0.12	0.19	0.24	0.27	0.28	0.25	0.19	0.13	0.07	0.0[illegible]
16	Hanford	0.05	0.09	0.13	0.19	0.25	0.29	0.30	0.27	0.21	0.14	0.08	0.0[illegible]
17	Needles	0.06	0.10	0.15	0.20	0.26	0.30	0.32	0.28	0.22	0.14	0.09	0.06
18	Palm Springs	0.08	0.12	0.17	0.23	0.28	0.32	0.31	0.28	0.23	0.16	0.10	0.07

* For comprehensive descriptions of each zone and to locate your region in a zone, see the California Irrigation Management Information System (CIMIS) color map opposite this page.



What is the relevant
ETo Zone for
Orange County?



What is the relevant
ETo Zone for
Santa Barbara?

Santa Barbara has several zones, including 10 (Mid-central Valley) and 4 (South Coast Island Plains and Mountains North of San Francisco)

The coastal regions are clearly different, and are best described by 1, 3 or 4, while the interior of the county is predominantly 6 and 10.

The Channel Islands are completely different at 1.

Understanding ET Helps Us Understand Our Place

What is the July ETo for Santa Ana?

What is the July ETo for Santa Barbara?

Why are Santa Ana and Santa Barbara ETo rates different in the month of July?

__________________ __________________

__________________ __________________

__________________ __________________

Reference EvapoTranspiration (ETo) Zones

1 COASTAL PLAINS HEAVY FOG BELT
Lowest ETo in California. Characterized by dense fog

2 COASTAL MIXED FOG AREA
Less fog and higher ETo than zone 1

3 COASTAL VALLEYS AND PLAINS AND NORTH COAST MOUNTAINS
More sunlight than zone 2

4 SOUTH COAST INLAND PLAINS AND MOUNTAINS NORTH OF SAN FRANCISCO
More sunlight and higher summer ETo than zone 3

5 NORTHERN INLAND VALLEYS
Valleys north of San Francisco

6 UPLAND CENTRAL COAST AND LOS ANGELES BASIN
Higher elevation coastal areas

7 NORTHEASTERN PLAINS

8 INLAND SAN FRANCISCO BAY AREA
Inland area near San Francisco with some marine influence

9 SOUTH COAST MARINE TO DESERT TRANSITION
Inland area between marine and desert climates

10 NORTH CENTRAL PLATEAU & CENTRAL COAST RANGE
Cool, high elevation areas with strong summer sunlight. This zone has limited climate data and the zones selection is somewhat subjective

11 CENTRAL SIERRA NEVADA
Sierra Nevada Mountain valleys east of Sacramento with some influence from the delta breeze in summer

12 EAST SIDE SACRAMENTO-SAN JOAQUIN VALLEY
Low winter and high summer ETo with slightly lower ETo than zone 14

13 NORTHERN SIERRA NEVADA
Northern Sierra Nevada mountain valleys with less marine influence than zone 11

14 MID-CENTRAL VALLEY, SOUTHERN SIERRA NEVADA, TEHACHAPI & HIGH DESERT MOUNTAINS
High summer sunshine and wind in some locations.

15 NORTHERN & SOUTHERN SAN JOAQUIN VALLEY
Slightly lower winter ETo due to fog and slightly higher summer ETo than zones 12 & 14

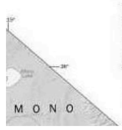
16 WESTSIDE SAN JOAQUIN VALLEY & MOUNTAINS EAST & WEST OF IMPERIAL VALLEY

17 HIGH DESERT VALLEYS
Valleys in the high desert near Nevada and Arizona

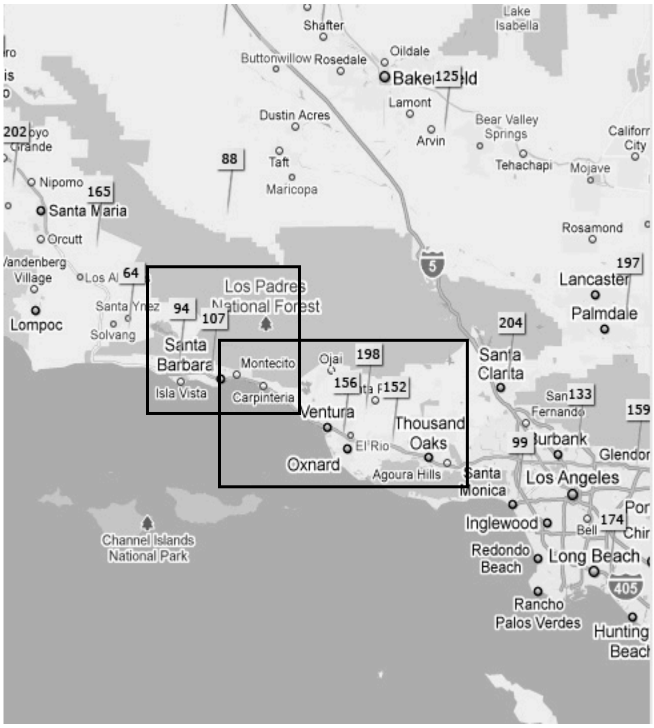
18 IMPERIAL VALLEY, DEATH VALLEY AND PALO VERDE
Low desert areas with high sunlight and considerable heat advection

Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.40	2.48	3.30	4.03	4.50	4.65	4.03	3.30	2.48	1.20	0.62	33.0
2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0
3	1.86	2.24	3.72	4.80	5.27	5.70	5.58	5.27	4.20	3.41	2.40	1.86	46.3
4	1.86	2.24	3.41	4.50	5.27	5.70	5.89	[illegible]	4.50	3.41	2.40	1.86	46.6
5	0.93	1.68	2.79	4.20	5.58	6.30	[illegible]	5.89	4.50	3.10	1.50	0.93	43.9
6	1.86	2.24	3.41	4.80	5.58	6.30	6.51	[illegible]	4.80	3.72	2.40	1.86	49.7
7	0.62	1.40	2.48	3.90	5.27	6.30	[illegible]	6.51	4.80	2.79	1.20	0.62	43.4
8	1.24	1.68	3.41	4.80	6.20	6.90	7.44	6.51	5.10	3.41	1.80	0.93	49.4
9	2.17	2.80	4.03	5.10	5.89	6.60	7.44	6.82	5.70	4.03	2.70	1.86	55.1
10	0.93	1.68	3.10	4.50	5.89	7.20	8.06	7.13	5.10	3.10	1.50	0.93	49.1
11	1.55	2.24	3.10	4.50	5.89	7.20	8.06	7.44	5.70	3.72	2.10	1.55	53.0
12	1.24	1.96	3.41	5.10	6.82	7.80	8.06	7.13	5.40	3.72	1.80	0.93	53.3
13	1.24	1.96	3.10	4.80	6.51	7.80	8.99	7.75	5.70	3.72	1.80	0.93	54.3
14	1.55	2.24	3.72	5.10	6.82	7.80	8.68	7.75	5.70	4.03	2.10	1.55	57.0
15	1.24	2.24	3.72	5.70	7.44	8.10	8.68	7.75	5.70	4.03	2.10	1.24	57.9
16	1.55	2.52	4.03	5.70	7.75	8.70	9.30	8.37	6.30	4.34	2.40	1.55	62.5
17	1.86	2.80	4.65	6.00	8.06	9.00	9.92	8.68	6.60	4.34	2.70	1.86	66.5
18	2.48	3.36	5.27	6.90	8.68	9.60	9.61	8.68	6.90	4.96	3.00	2.17	71.6

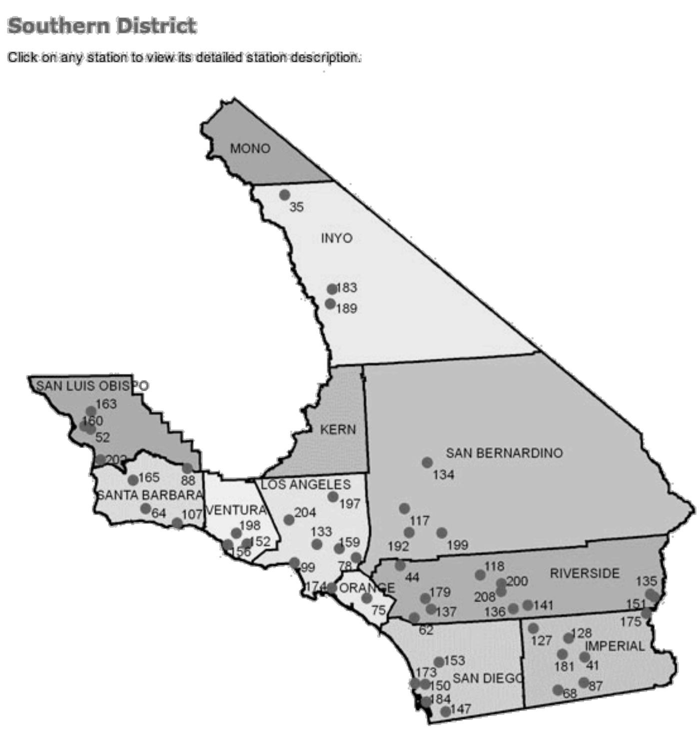


Variablity between stations within single zones is as high as 0.02 inches per day for zone 1 and during winter months in zone 13. The average standard deviation of the ETo between estimation sites within a zone for all months is about 0.01 inches per day for all 200 sites.



The Station Location Map allows you to hone in on the stations nearest your site.

In Montecito, is the climate better represented by the stations in Ventura? Or Santa Barbara?



CIMIS (California Irrigation Management Information System)

Monthly Average ETo Report

Rendered in ENGLISH Units.
Printed on January 29, 2012

Number	Name	Region
44	U.C. Riverside	Los Angeles Basin
52	San Luis Obispo	Central Coast Valleys
62	Temecula	South Coast Valleys
75	Irvine	South Coast Valleys
77	Oakville	North Coast Valleys
99	Santa Monica	Los Angeles Basin
147	Otay Lake	South Coast Valleys
153	Escondido SPV	South Coast Valleys
210	Carmel	Monterey Bay

You can make custom reports to keep track of projects in various regions and more easily select relevant stations.

Stn	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
44	2.49	2.91	4.16	5.27	5.94	6.56	7.22	6.92	5.35	4.05	2.94	2.56	56.37
52	2.21	2.50	3.80	5.08	5.70	6.19	6.43	6.09	4.87	4.09	2.89	2.28	52.13
62	2.74	2.71	3.79	4.79	5.48	6.19	6.79	6.75	5.29	4.18	3.41	2.87	54.99
75	2.18	2.49	3.67	4.71	5.18	5.87	6.29	6.17	4.57	3.66	2.59	2.25	49.63
77	1.03	1.53	2.93	4.71	5.82	6.85	7.21	6.44	4.87	3.53	1.64	1.17	47.73
99	1.79	2.12	3.30	4.49	4.73	5.03	5.40	5.38	3.94	3.40	2.42	2.22	44.22
147	1.27	1.85	3.26	4.70	5.94	6.99	7.77	6.80	5.21	3.53	1.97	1.22	50.51
153	2.81	2.76	3.78	5.31	6.10	6.97	7.08	6.83	5.67	4.15	3.31	2.56	57.33
210	1.21	1.54	2.88	4.08	4.56	5.16	4.47	4.30	3.20	2.75	1.50	1.23	36.88

Monthly Average ETo Report

California Irrigation Management Information System
Department of Water Resources
Office of Water Use Efficiency
Rendered in ENGLISH units
Printed on January 29, 2012

Number	Name	Region
75	Irvine	South Coast Valleys

Stn	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
75	2.18	2.49	3.67	4.71	5.18	5.87	6.29	6.17	4.57	3.66	2.59	2.25	49.63

Using The ET Information For Irvine

What does the 49.63 represent?

What does the 6.29 represent?

How would I figure Daily ETo using the March data?

Is the March Daily ETo useful in July?

Convert Inches to Gallons

One inch of water over one square foot (sf) = 0.62 Gallons of Water Convert 1 inch to 1 gallon by: MULTIPLYING inches by 0.62

Convert the Annual Irvine ETo into Gallons Per Year.

Convert Inches to Gallons

In March we need 3 inches of water per square foot of planted area.

How many gallons does that represent?

1 sf x 3”/sf x 0.62 gal/inch/sf = **1.86 gal/sf**

Use ETo to Calculate Landscape Water Requirements

Let’s assume that turf landscapes = 100% ETo

Use the G3 Questions to help you organize your data and set up solutions to the word problems you encounter.

1. **How Big?** - How large is the landscaped area?
2. **Where Are We?** - Where is the landscaped area located?
3. **What’s There?** - What kind of plant material, irrigation or hardscape is in the landscaped area?

CIMIS (California Irrigation Management Information System)

Monthly Average ETo Report

Rendered in ENGLISH Units.
Printed on July 1, 2011

Number	Name	Region
45	San Diego	South Coast Valleys
49	Oceanside	South Coast Valleys
74	Escondido	South Coast Valleys
78	Pomona	Los Angeles Basin
99	Santa Monica	Los Angeles Basin
133	Glendale	Los Angeles Basin
159	Monrovia	Los Angeles Basin
184	San Diego II	South Coast Valleys
197	Palmdale	Los Angeles Basin
207	Borrego Springs	Imperial/Coachella Valley

Stn	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
45	1.83	2.20	3.42	4.49	5.25	5.67	5.86	5.61	4.49	3.42	2.36	1.83	46.43
49	2.08	2.40	3.70	4.79	5.35	5.72	6.06	5.98	4.60	3.61	2.44	1.99	48.72
74	2.53	2.66	3.91	5.34	6.12	6.88	7.34	7.00	5.49	4.21	3.00	2.48	56.96
78	1.72	2.03	3.37	4.54	5.00	5.80	6.51	6.39	4.69	3.48	2.27	1.71	47.51
99	1.79	2.12	3.30	4.49	4.73	5.03	5.40	5.38	3.94	3.40	2.42	2.22	44.22
133	2.20	2.45	3.64	4.74	5.31	6.06	6.75	6.66	5.01	3.95	2.73	2.31	51.81
159	1.59	2.20	3.66	5.08	6.83	7.80	8.67	7.81	5.67	4.03	2.13	1.59	57.06
184	2.07	2.42	3.44	4.61	5.07	5.33	5.66	5.59	4.33	3.56	2.39	2.03	46.50
197	2.02	2.61	4.55	6.19	7.30	8.85	9.77	8.99	6.52	4.66	2.68	2.05	66.19
207	2.66	3.54	5.94	7.74	9.72	10.14	9.31	8.33	6.93	5.45	3.41	2.22	75.39

Exercise #1
Calculate "Drive-By" Landscape Water Requirements

The lawn in your client's Escondido home covers 1,000 sq. ft.

<u>QUESTIONS:</u>

How many inches of water are needed for this lawn in the month of July?

How Big is the landscape area?

Where Are We (hint: place and time of year)?

What's There in the landscape and what would be the Plant Factor we'd apply?

How many gallons of water are needed for this lawn in the month of July?

How many gallons of water are needed for this lawn annually?

What If the Landscape Is NOT TURF?

We determine the Plant Water Requirement (PWR) by ADJUSTING ETo with Plant Factor (pf) to reflect the different plant choices in our landscape.

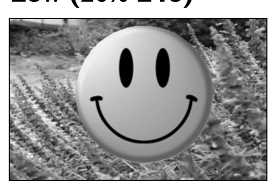
Every Plant Has Its Own Plant Factor (PF) (Expressed as % of ETo)

High PF = 70 - 100% ETo
Medium PF = 40 - 60% ETo
Low PF = 10 - 30% ETo

High = (100% ETo)

Medium (50% ETo)

Low (20% ETo)



Remember ETpf tells you how much water the plant needs compared to ETo to stay healthy in your area: High, Medium, or Low.

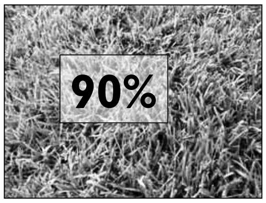
Determine The Plant Water Requirement (PWR)

If ETo = 47”

What is the PWR of Each Plant?

High = (47” x 90%)

PWR = 42.3“ / sq. ft. / year

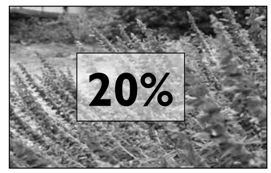


Medium (47” x 50%)

PWR = ? “ / sq. ft. / year

Low (47” x 20%)

PWR = ?



PWR = (ETo x PF)

Determine the Plant Water Requirements

Plant Factors can be used to calculate comparative water requirements of different planting scenarios for a particular property.

Plant Species Factors (Plant Factors) are published in a file called:

Water Use Classifications of Landscape Species

(WUCOLS IV 2014)

www.ucanr.edu/sites/WUCOLS

WUCOLS categorizes California plant material into SIX REGIONS.

The Art of Determining Plant Water Requirements

Number	WUCOLS Region	Sunset climate zones*	CIMIS ET_0 zones**	Representative Cities
1	North-Central Coastal	14, 15, 16, 17	1, 2, 3, 4, 6, 8	Healdsburg, Napa, San Jose, Salinas, San Francisco, San Luis Obispo
2	Central Valley	8, 9, 14	12, 14, 15, 16	Auburn, Bakersfield, Chico, Fresno, Modesto, Sacramento
3	South Coastal	22, 23, 24	1, 2, 4, 6	Irvine, Los Angeles, Santa Barbara, Ventura, Vista
4	South Inland	18, 19, 20, 21	9	Corona, Escondido, Pasadena, Riverside, San Bernardino, Santa Paula
5	High and Intermediate Desert	11	14, 17	Apple Valley, Barstow, Bishop, Lancaster, Lone Pine, Tehachapi
6	Low Desert	13	18	Borrego Springs, Blythe, Death Valley, El Centro, Needles, Palm Springs

*See Brenzel, K. N., ed., *Sunset Western Garden Book* (2012).

**See CIMIS ET_0 Zone Map, http://wwwcimis.water.ca.gov/cimis/cimiSatEtoZones.jsp

There Are NO Absolutes

Estimated species water needs (inches per month)[2] for JULY

ET_o Zones	WUCOLS REGION	ET_o	LOW 0.1	0.2	0.3	MEDIUM 0.4	0.5	0.6	HIGH 0.7	0.8	0.9
	NORTH CENTRAL										
4	Novato	5.8									
1, 2	San Francisco	4.6-4.9									
8	Concord	7.4									
8	San Jose	7.4									
3	Monterey	5.5									
6	San Luis Obispo	6.5									
	CENTRAL VALLEY										
14	Auburn	8.6									
14	Sacramento	8.6									
12	Modesto/Stockton	8.0									
12	Fresno	8.0									
15	Bakersfield	8.6									
14	Redding	8.6									
	SOUTH COASTAL										
4	Santa Barbara	5.8									
4	Ventura	5.8									
6	Los Angeles	6.5									
1, 2	Laguna Beach	4.7-4.9									
4	San Diego	5.8									
	SOUTH INLAND VALLEY										
9	San Fernando	7.4									
9	Pasadena	7.4									
9	Riverside	7.4									
9	Ramona	7.4									
9	San Bernardino	7.4									
	HIGH DESERT										
17	Palmdale	9.9									
17	Lancaster	9.9									
17	Victorville	9.9									
17	Bishop	9.9									
17	Independence	9.9									
	LOW DESERT										
18	Palm Springs	9.6									
18	Coachella	9.6									
18	Needles	9.6									
18	El Centro	9.6									

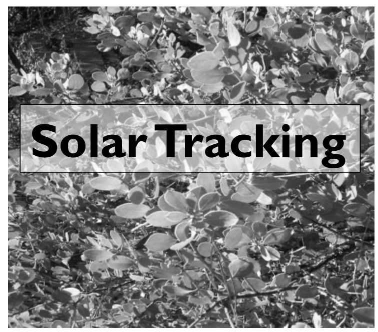
VERY LOW & LOW ET plants require <10% - 30% of water needed for ETo.

MEDIUM (Moderate) ET plants require 40% - 60% of water needed for ETo.

HIGH ET plants require 70% - 90% of water needed for ETo.

1. Normal year values and zones are derived from the ***California Irrigation Management Information System (CIMIS) Reference Evapotranspiration Map***, 1999.
2. Please note; these values are not adjusted for irrigation efficiency.

SoCal Native Plants Have Adapted to Available Resources



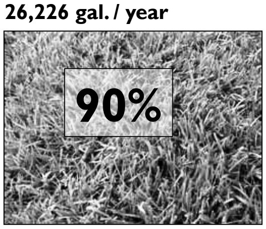
Plant Water Requirements Determine Landscape Water Requirement:

How Much Annual Water Is Required For a Front Yard of 1,000 Square Feet If ETo = 47"?

1. **How Big?** 1,000 SF
2. **Where Are We?** ETo = 47"
3. **What's There?** PF

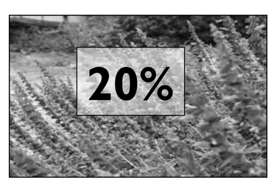
1,000 SF x 47" x 0.90 x 0.62 =

26,226 gal. / year



1,000 SF x 47" x 0.50 x 0.62 = 14,570 gal. / year

?



LWR = SF x PWR

SHARE EMAIL PRINT SITE MAP Enter Search Terms

WUCOLS IV
Water Use Classification of Landscape Species

Plant Search Database

3769 results. (Search Again)

WUCOLS List for all Regions

Type	Botanical Name	Common Name	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
S N	Justicia californica (Beloperone californica)	chuparosa	Very Low	Inappropriate	Very Low	Low	Low	Very Low
S	Justicia candicans (ovata)	red justicia	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
S	Justicia carnea	Brazilian plume flower	Moderate	High	High	High	Inappropriate	Unknown
S	Justicia fulvicoma	mountain laurel	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
S	Justicia leonardii	justicia (leonardii)	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
P	Kniphofia spp. and cvs.	poker plant	Low	Low	Moderate	Moderate	Moderate	Moderate
P	Kniphofia triangularis	red hot poker	Unknown	Unknown	Moderate	Moderate	Unknown	Unknown
P	Kniphofia uvaria hybrids and cvs.	red hot poker	Low	Low	Low	Low	Moderate	Moderate
G	Koeleria glauca	blue hair grass	Moderate	Unknown	Moderate	Moderate	Unknown	Unknown
T	Koelreuteria bipinnata	Chinese flame tree	Moderate	Moderate	Moderate	Moderate	Inappropriate	Moderate
T	Koelreuteria elegans	Chinese flame tree	Moderate	Moderate	Moderate	Moderate	Inappropriate	Moderate
T	Koelreuteria paniculata	golden rain tree	Moderate	Moderate	Low	Low	Moderate	Moderate
S	Kolkwitzia amabilis	beauty bush	Low	Moderate	Moderate	Moderate	Moderate	Inappropriate
T	Laurus "Saratoga"	Saratoga laurel	Low	Low	Low	Low	Moderate	Moderate
T	Laurus nobilis	sweet bay	Low	Low	Low	Low	Moderate	Moderate
S	Lavandula spp. & cvs.	lavender	Low	Low	Low	Low	Moderate	Inappropriate

PLANT FACTOR WORKSHEET- Exercise #2

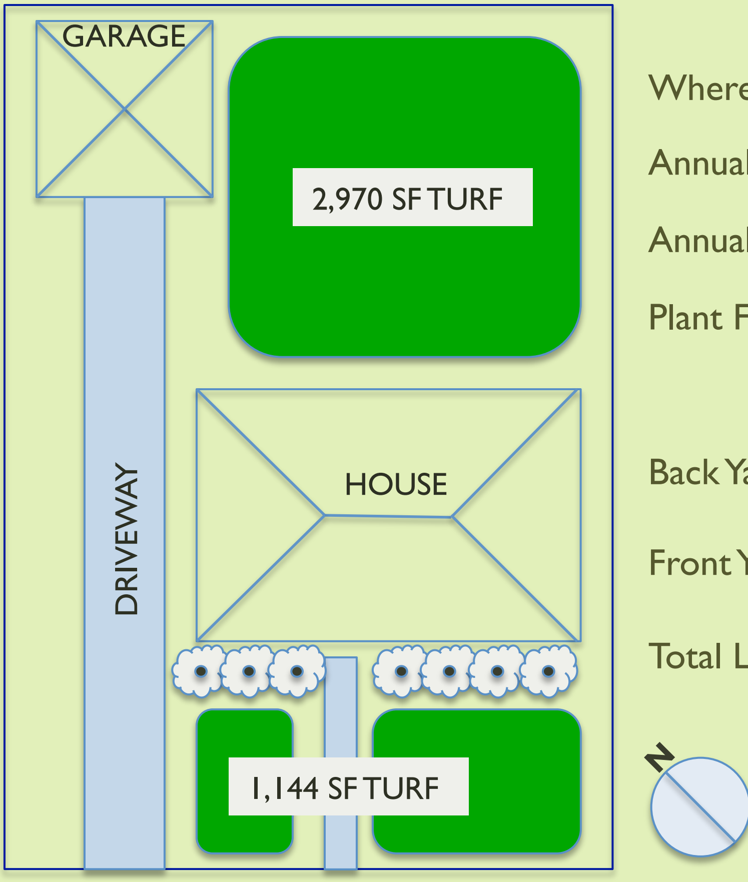
Using the WUCOLS IV 2014 reference information attached to this worksheet, determine the Plant Factor and Plant Water Requirement by region for the three plants listed below:

Santa Monica	Annual ETo=		Borrego Springs	Annual ETo=	

Picture	Botanical Name	Common Name	Santa Monica WUCOLS Water Need	% PF (Kc)	Santa Monica PWR	Borrego Springs WUCOLS Water Need	%PF (Kc)	Borrego Springs PWR
	Justicia carnea	Brazilian plume flower						
	Kniphofia uvaria	Red hot poker						
	Laurus nobilis	Sweet bay						

If Plant Factor is listed as unknown (?) then use data from growers of the plant

Exercise #3
Annual Water Requirement for TURF-Centric Landscape



Where are we? = California

Annual ETo for Region = 50"

Annual Rainfall for Region = <12"

Plant Factor–Cool Season Turf (PF) = 1.0

Back Yard Turf SF: ____________

Front Yard Turf SF: ____________

Total Landscape Area (TLA): ____________

Annual Water Requirement in Inches = TLA x Eto x Plant Factor

Annual Water Requirement in Gallons = TLA x Eto x Plant Factor x 0.62

Plant Factor Inches per SF:
(ETo x PF) ____________________________

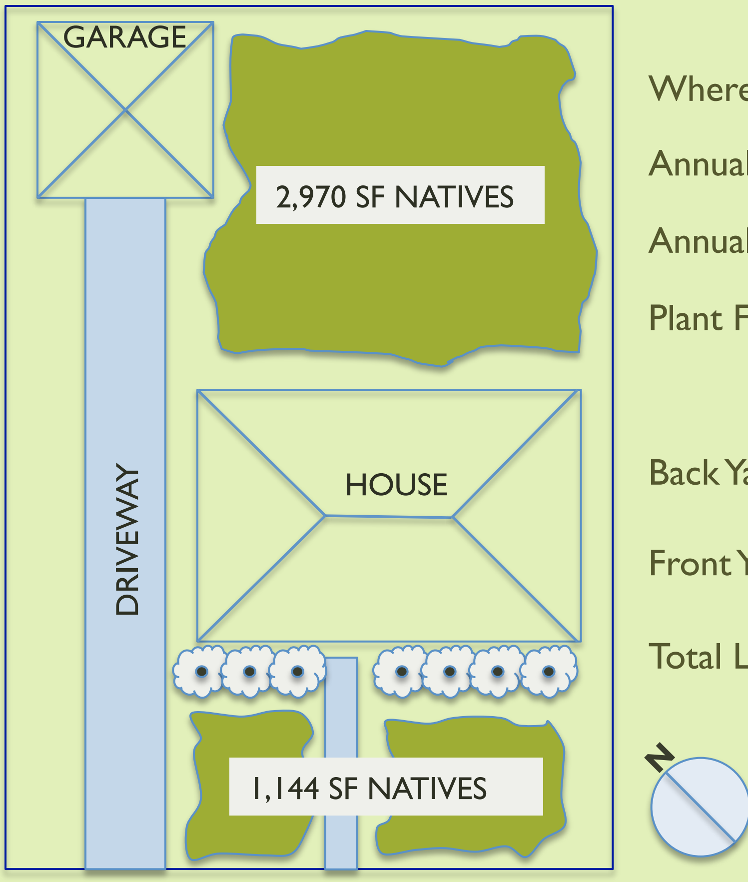
Plant Factor Gallons per SF:
(ETo x PF x 0.62) ____________________________

Total Gallons Per Year:
(TLA x ETo x PF x 0.62) ____________________________

What does this number mean? ____________________________________

____

Exercise #4
Annual Water Requirement for NATIVE -Centric Landscape



Where are we? = California

Annual ETo for Region = 50"

Annual Rainfall for Region = <12"

Plant Factor–Cool Season Turf (PF) = 0.20

Back Yard Turf SF: ____________

Front Yard Turf SF: ____________

Total Landscape Area (TLA): ____________

Annual Water Requirement in Inches = TLA x Eto x Plant Factor

Annual Water Requirement in Gallons = TLA x Eto x Plant Factor x 0.62

Plant Factor Inches per SF:
(ETo x PF) ______________________________

Plant Factor Gallons per SF:
(ETo x PF x 0.62) ______________________________

Total Gallons Per Year:
(TLA x ETo x PF x 0.62) ______________________________

What does this number mean? ______________________________________

____

Irrigation Efficiency and Landscape Water Requirements

The difference between your Total Local Annual Rainfall
and the Landscape Water Requirement of your garden
must be made up with
supplemental water.

Irrigation in Watershed Wise Design?

The efficiency of the irrigation equipment contributes to the amount of water required by the landscape.

No irrigation equipment is 100% efficient.

Irrigation efficiency is another ETo Adjustment Factor we can use to describe **What's There?** in our landscape water requirement calculations.

Irrigation Efficiency vs. Distribution Uniformity

Distribution Uniformity (DU) measures how evenly water soaks into the ground during an irrigation event.

Irrigation Efficiency (IE) is the ratio of irrigation water which is beneficially used to the amount of irrigation water applied.

1. Must be good DU before there can be good IE
2. Good DU is no guarantee of good IE
3. We use DU and IE interchangeably in this workshop

Examples:

Spray irrigation has great head to head coverage (DU), but 30% is lost with runoff, so IE is low.

Drip irrigation distributes the water evenly over a grid pattern (good DU), but the precipitation rate exceeds intake rate and there is runoff (poor IE).

Southern California Lawn Requires About 50"/Yr.

Most People Apply 2x PWR on Their Lawn

Why do you suppose this is?

What Is Distribution Uniformity And How Do We Determine It?

The Distribution Uniformity (indicated in most literature as DU) is a measure of the uniformity of the Application of irrigation water over a defined area, and expressed as a decimal. DU is a percentage of the 100% perfect irrigation system.

An Irrigation Audit is required to determine the DU of an irrigation system in a particular area (or zone). Irrigation Audits are most commonly performed on spray and rotor irrigation systems, though the process also is applicable to drip irrigation.

During the Irrigation Audit, measurements are taken in catch-cans that have been spread out uniformly throughout the zone. These measurements are evaluated through a simple mathematical process. The measurements are organized in a sequence from the highest individual measurement to the lowest individual measurement. Then the total measurements are divided into 4 sample groups.

The **LOWER QUARTER** measurements are those falling into the lowest 25% of the sample group. This is the "DRIEST QUARTER" of the samples. The **LOWER QUARTER DISTRIBUTION UNIFORMITY** (**DU_{LQ}**) is the average of the lowest 25% of measurements to the overall average measurement.

DU_{LQ} = [Average of the Lowest 25% of measurements Volume ÷ Average of the Total measurements Volume]

The **LOWER HALF** measurements are those falling into the lowest 50% of the sample group, or the "DRIEST HALF" of the samples. The **LOWER HALF DISTRIBUTION UNIFORMITY** (DU_{LH}) is the average of the lowest 50% of measurements to the overall average measurement.

DU_{LH} = [Average of the Lowest 50% of measurements Volume ÷ Average of the Total measurements Volume]

The Irrigation Association provides the following table as a reference for target uniformity range for spray and rotor sprinklers. Target Uniformity is dependent on the configuration of the area being irrigated. There are expectations for free-form and curvilinear shaped areas as compared to large areas that will accommodate regular and consistent spacing of sprinklers.[1]

Minimum Operational Uniformity Type of Zone	Type of Uniformity	Target Uniformity*
Spray	Lower Quarter DU	0.55 – 0.65
Rotor	Lower Quarter DU	0.65 – 0.75

[1] Irrigation Association 2010 *Turf and Landscape Irrigation Best Management Practices.* Prepared by the Water Management Committee of the Irrigation Association. Falls Church, VA.

Irrigation-Related Considerations For Determining "What's There?"

Application Rate, which also is known as **Precipitation Rate (PR),** is the rate at which a sprinkler system APPLIES irrigation water over time, and is presented in units of Inches/Hour.

The PR for a system, or portion of a system (zone or hydrozone), that uses sprinklers with differing arcs (e.g. half-circle, quarter circle, etc.), flow rates (Gallons Per Minute (GPM) or Gallons Per Hour (GPH)), and spacing is calculated with a variety of formulae.

There are two viable methods for calculating Application Rate (PR) of a spray or rotor system.

1) Determine PR from a determination of the Zone Flow Rate (GPM) from the observation of the water meter:

    Application Rate (Inches/Hr.) =
    [(96.25* x Zone Flow Rate GPM) ÷ Sq. Ft. of Irrigated Area]

    *Constant converting GPM to Inches Per Hour

2) Determine PR from milliliter observations of your audit and the size of your catch-cans:

    Application Rate Observed (Inches/Hr.) =
    [(3.66* x Total Average Volume) ÷ (Test Run Time in Minutes x Catch Can Throat Area Inches Squared*)]

    *Constant converting millileters to minutes

Remember Area of a Circle = 3.14 x Radius^2

Determining GPM Using A Residential Water Meter. The meter is read at the START of the observation and at the END of the observation. The difference between END and START is the Total Cubic Feet per zone. Total Cubic Feet must be converted to gallons by multiplying by 7.48 Gallons/Cu.Ft. The result is Total Gallons Per Zone.

Total Gallons Per Zone is divided by Test Run Time in Minutes to determine Zone Gallons Per Minute.

Other relevant information gathered at the time of the audit should include:

Slope	Root Zone of the Plants
Soil Type	Microclimate Information
Plant Condition	Broken or Missing Heads, Pipes, etc.
Clogged Nozzles	Pressure Too High
Arc Misalignment	Low Head Drainage
Leaking Seals/Fittings	Spray Deflected or Blocked
Sunken or Tilted Heads	Uneven Spacing
Valve Malfunction	Heads Not Turning/Heads Malfunction

What Effect Has Irrigation Efficiency on ETpf?

A THOUGHT EXPERIMENT:

If irrigation is only 50% efficient, how much more water do you have to put on the landscape to be equal to irrigation at 100% efficiency?

ETo Adjustment Factor = Plant Factor ÷ Irrigation Efficiency (DU)

Drip Irrigation = 90% DU

Plant Factor is DIVIDED BY Irrigation Efficiency (DU) to adjust the landscape for the extra water that will be required by the less than 100% efficient irrigation equipment.

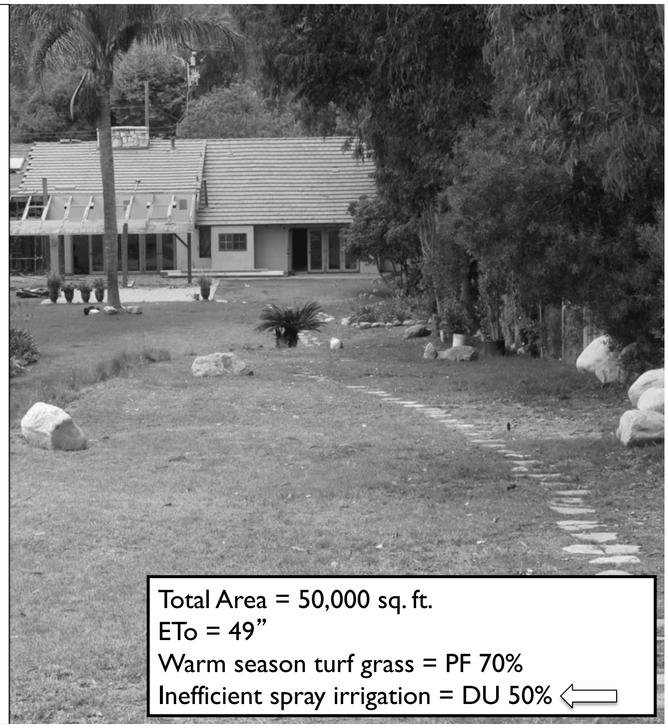
A landscape using drip irrigation with 90% DU requires 111% of the water a 100% DU landscape would require.

100% ÷ 90% = 111%

WHAT'S THERE?

PF = 70%
DU or IE = 50%

The landscape with DU = 50% needs 200% of the irrigation water to equal a landscape with 100% DU.

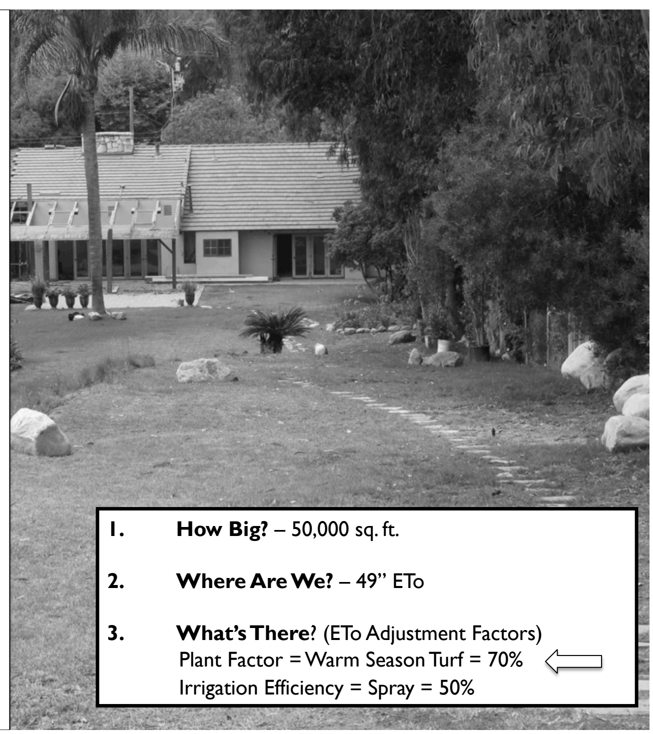


What Is the Water Need Considering Just Plant Factor?

50,000 sq. ft. x 49" x 70% x 0.62 =

Annual gallons needed for this landscape using only PF as ETo Adjustment Factor

= 1,063,300 gal. per year

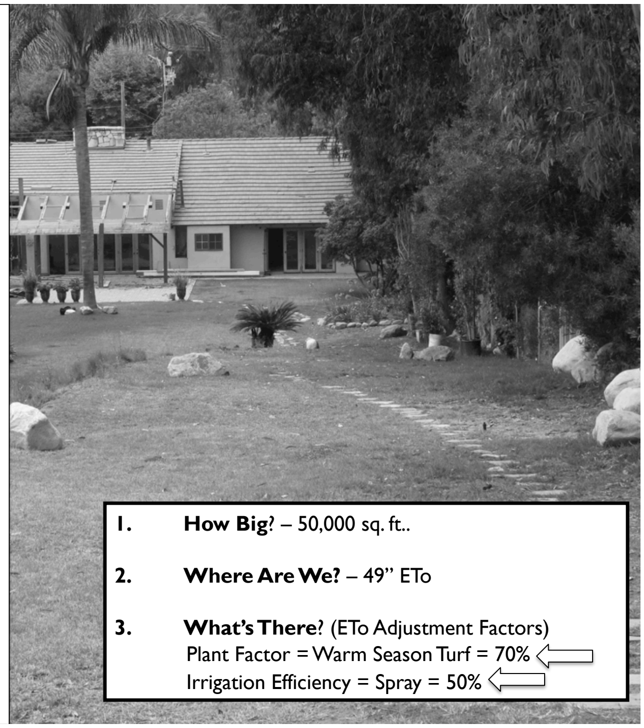


Adjust ETo with Both PF and DU Together

50,000 sq. ft. x 49” x 70% ÷ 50% x 0.62 =

Annual gallons needed for this landscape also including DU as ETo Adjustment Factor

= 2,126,600 gal. per year

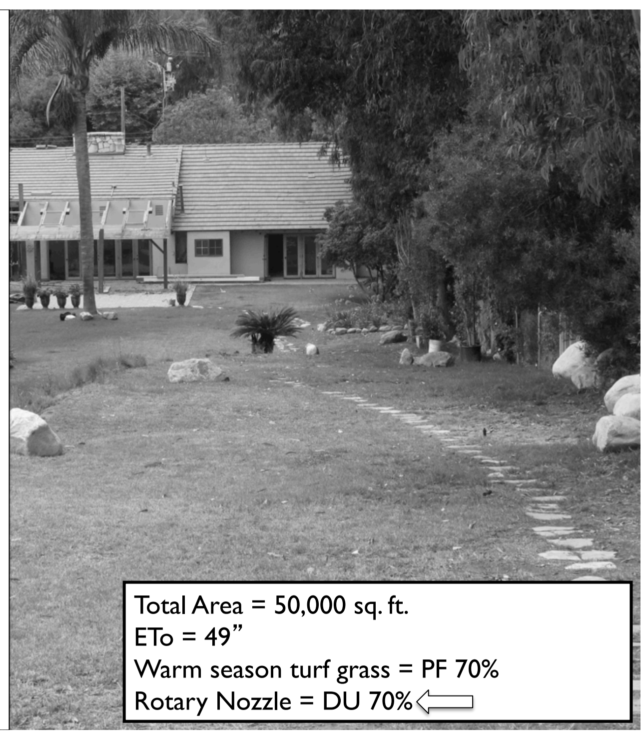


What Happens If We Just Change Irrigation to a More Efficient Type?

50,000 sq. ft. x 49” x 70% ÷ 70% x 0.62 =

Annual gallons needed for this landscape if we make the irrigation more efficient

= 1,519,000 gal. per year

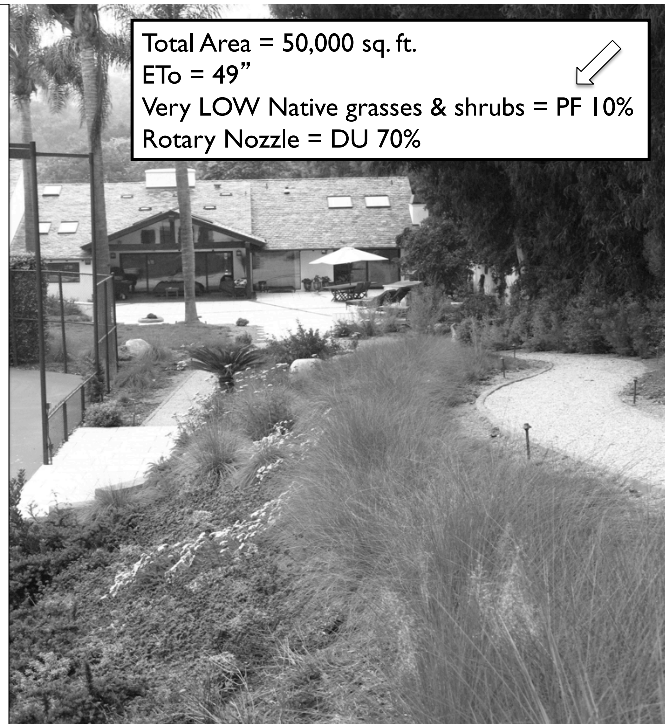


NOW, WHAT'S THERE?

PF = 10%
IE or DU = 70%

The new landscape with DU=70% only needs 143% of the irrigation water to equal a landscape with 100% DU.

And the new plant palette requires a lot less water.



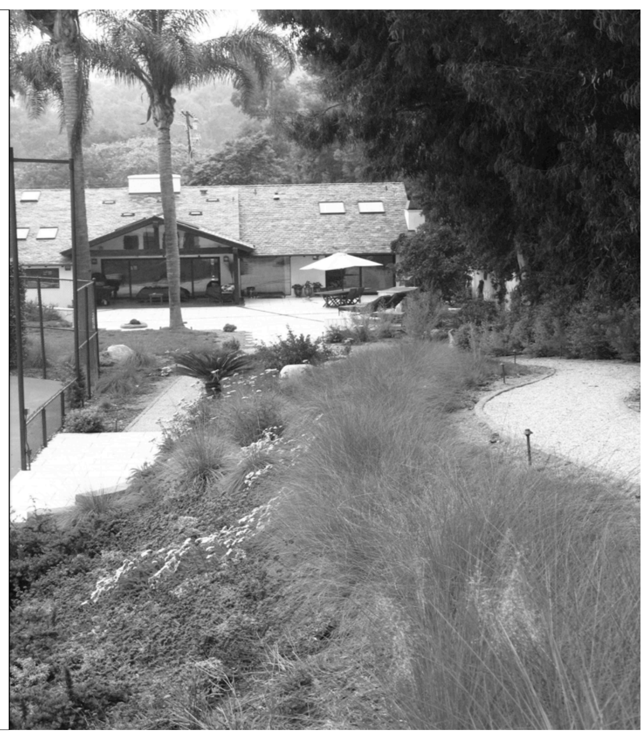
What is the Total Annual Water Need of the New Native Landscape?

50,000 sq. ft. x 49" x 10% ÷ 70% x 0.62 =

Annual gallons required for this landscape

= 217,000 gal. per year

Better design saves almost 2 million gallons per year.



What If Irrigation Water Were Restricted?

If irrigation water were restricted, we would have to design landscapes to fit within the allocation of water.

If penalties in the form of higher water rates or service disconnections were imposed:

① We would have to WATER BUDGET.

② We would have to show that our DESIGNED WATER PLAN was less than the WATER BUDGET.

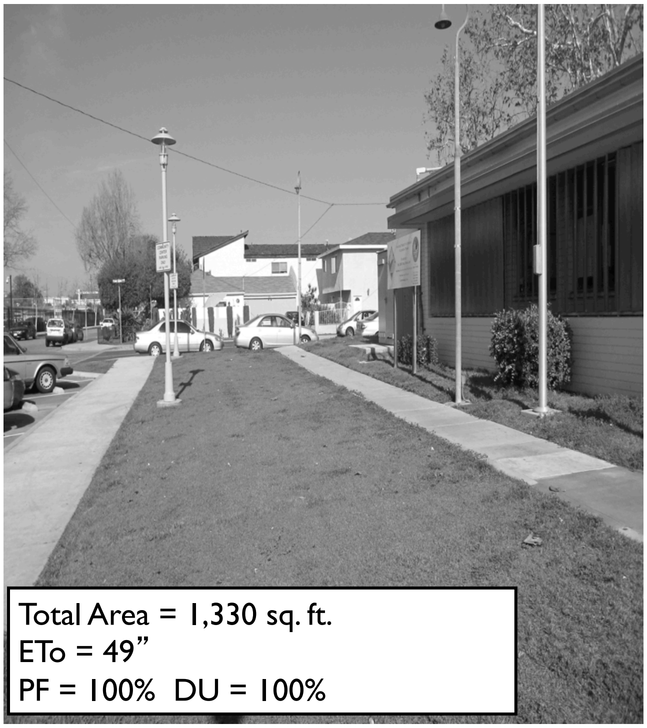
③ Through meters, audits and site visits, we would have to prove that the ACTUAL WATER USE at the landscape was equal to or less than the DESIGNED WATER PLAN.

Let's Tighten Our Belts With A Water Budget

Water Budget – Assume we are allowed to use only a portion of the water the 100% ETo Landscape would need.

If our 100% ETo Landscape requires Z gallons of water per year to remain healthy, then how much water would we be allowed if our Water Budget were only 80% Z?

What is a 50% Water Budget?



How Much Water Does This Garden Require at 100% of ETo?

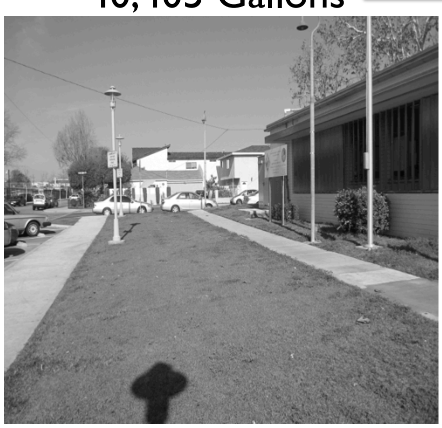
1,330 sq. ft. x 49” x 100% ÷ 100% x 0.62 =

Annual gallons needed for this landscape @ 100% of ETo

= 40,405 gal. per year

Our Designed Landscape Must Stay Within Budget
Maximum Applied Water Allowed (MAWA)

40,405 Gallons ⟶ 20,203 Gallons



100% ETo Landscape (No Budget)

Water Budget Landscape
50% of ETo Landscape (MAWA)

Do you think this garden is DESIGNED to use less than or more than the 50% ETo Water Budget?

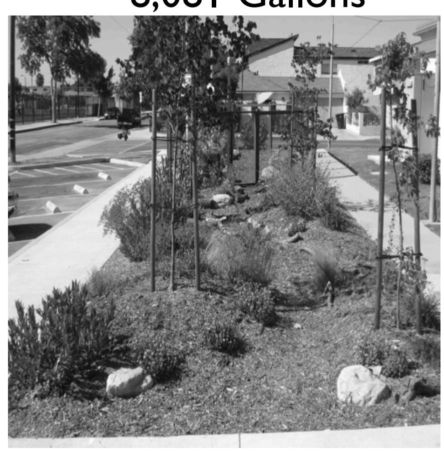
How do we prove that this garden ACTUALLY uses less than or more than the Water Budget?

Our Designed Landscape Must Stay Within The Budget

20,203 Gallons

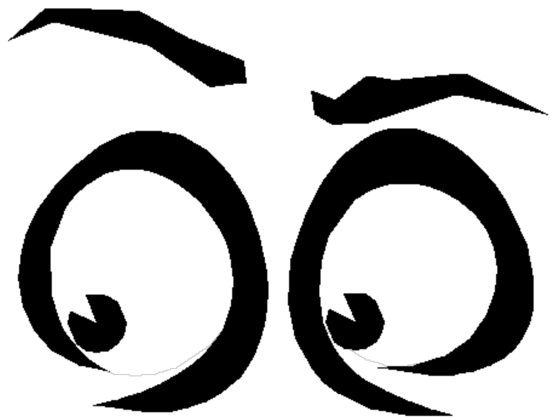
Water Budget Landscape
50% ETo Landscape

8,081 Gallons



Designed Native Landscape
20% ETo Landscape

Now That We've Trained Our Eyes…



Let's train ourselves to design within budget!

What Is the Role of Rainwater in
Watershed Wise Design?

Doesn't rainwater effectively reduce the MAWA?

How much rain/precipitation do we expect?

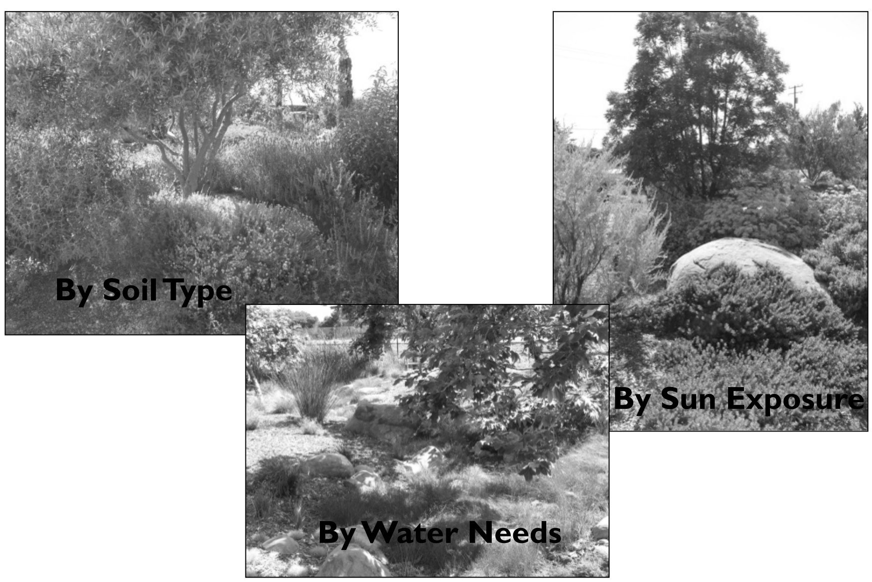
When do we expect the precipitation, and does that change our assumptions?

The Water Use of Your Landscape Depends on Hydrozones

Hydrozones, or groupings of plants by water needs, are used to calculate the amount of water required by a portion of the landscape. Hydrozones take into account which plants are selected and the efficiency of irrigation used in each area of the landscape. A hydrozone calculation should be done for EVERY area of the landscape that uses water, including pools and water features.

The Designed Water Plan of your landscape is the sum of all Hydrozone Water Use. This is **your ETWU**, or Estimated Total Water Used.

Nature Groups by Natural Hydrozone Communities



Select Plants That Are Friends and Group Them Together

Group your plants into communities according to their similar characteristics.

1. Similar exposure SUN or SHADE
2. ET (water requirements)
3. Root depth
4. Soil Type
5. Hardiness and Temperature adaptation
6. Size (All trees together, all shrubs separate)

When irrigated with different irrigation valves, these groups of hydrozoned plants are also called VALVE ZONES.

What If Your Hydrozone Is a “Mixed” Zone?

The best design groups plants of similar water requirements together into their communities.

When some plants require more water than others in a particular Hydrozone:

Plant Factor of the ENTIRE ZONE =
Plant Factor of the HIGHEST WATER USE PLANT in the zone

What If Your Hydrozone Is a Water Feature?

Use the HIGHEST Plant Factor of 100% to describe the evaporation from a water feature or pool.

Irrigation Efficiency is not applicable.

The ET Adjustment Factor* for a water feature or pool is 100%.

*** Hydrozone ETo Adjustment Factor = (Hydrozone ET Plant Factor ÷ Hydrozone Irrigation Efficiency)**

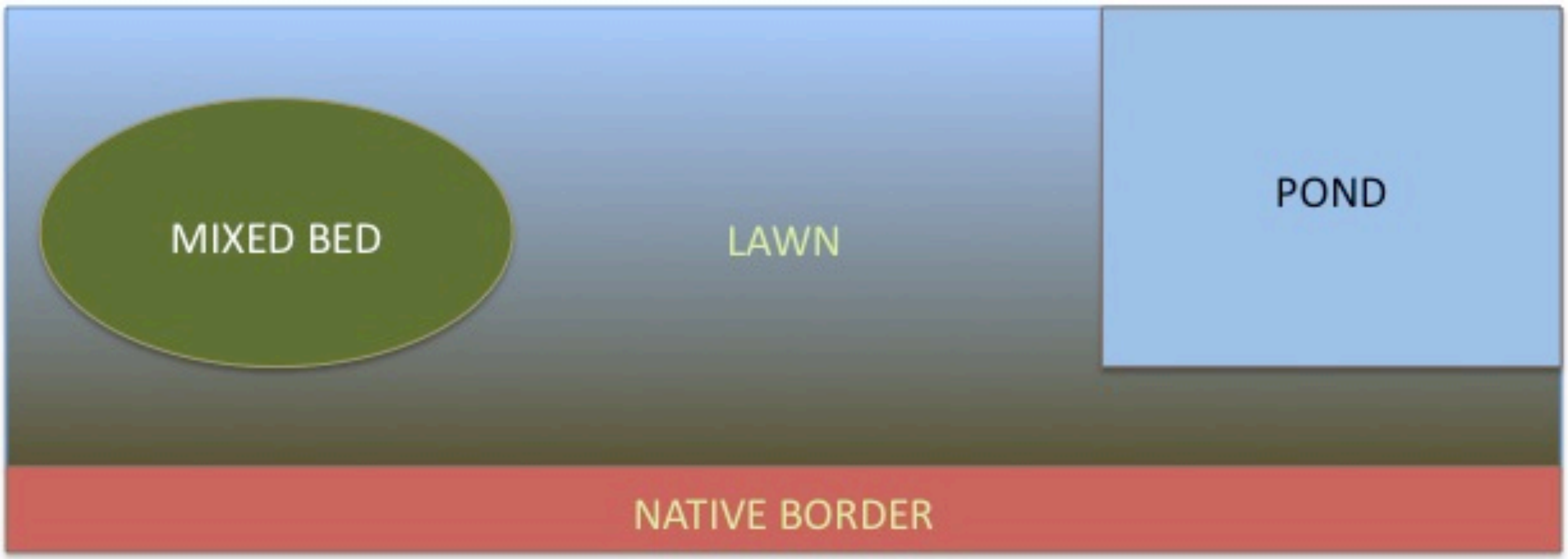
The G3 Protocols and Process

The Green Gardens Group has developed a set of protocols that are applicable to **ALL landscape projects** (new, rehabilitated, and retrofit), regardless of size or land use. They focus on both the effective implementation and the communication of Watershed Wise strategies:

① Determine how much water the existing landscape requires.
② Determine a Water Budget (MAWA) based on 50% of ETo.[1]
③ Design the new landscape using watershed wise principles and plant factor design.
④ Calculate the Designed Water Plan (ETWU).[2]
⑤ Conduct a site assessment and irrigation audit to ensure implementation.

[1]MAWA = Maximum Applied Water Allowed = Water Budget
[2]ETWU = Estimated Total Water Used = Designed Water Plan

Annual Designed Landscape Water Requirement



This Inland Landscape (Annual ETo = 60”) has the following characteristics:

- 5,000 Sq. Ft. of Cool Season Lawn irrigated with classic spray @ 55% IE
- 2,000 Sq. Ft. of Mixed Bed of Low & Medium Plants irrigated by on-line drip irrigation @ 90% IE
- 1,000 Sq. Ft. of Native Plant Border (Low) irrigated by online drip irrigation with 90% IE
- 2,000 Sq. Ft. Pool evaporates at 100% of ETo

Calculate Annual Designed Landscape Water Requirement

Hydrozone Description	Sq. Ft.	x ETo	x Plant Factor	÷ Irrigation Efficiency	x .62	= Gallons
				TOTAL GALLONS	=	

Annual Inland Landscape Designed Water Requirement =

Exercise #5
Calculating Annual Designed Landscape Water Requirement

What is the Total Landscape Area (Sum of all the Hydrozones)?

What is the ETo for this project?

What would be the Annual Landscape Water Requirement of this property assuming the entire Total Landscape Area is covered in Lawn that is Cool Season Turf with a Plant Factor (Kc) of 100% and Irrigation Efficiency of 55%?

If the Annual Water Budget (MAWA) for this property is set at 60% of ETo, What is the Water Budget in gallons for this property? (THINK! This is tricky!)

What are the Hydrozones of the property?

What are the Hydrozone Water Requirements? (Use chart on next page)

What is the Designed Water Plan or Designed Landscape Water Requirement (EYWU) for this property? (Use chart on next page)

How does the Water Budget (MAWA) compare to the Designed Water Plan (ETWU)?

Calculate Annual Designed Landscape Water Requirement

Hydrozone Description	Sq. Ft.	x ETo	x Plant Factor	÷ Irrigation Efficiency	x .62	= Gallons
Lawn	5,000	60”	.80	.55	.62	270,545
Mixed Bed	2,000	60”	.50	.90	.62	41,333
Native Plant Border	1,000	60”	.20	.90	.62	8,267
Pond	2,000	60”	1.0	N/A	.62	74,400
				TOTAL GALLONS	=	394,545

Annual Inland Landscape Designed Water Requirement =

Some Ideas For Minimizing Designed Water Plan (ETWU)

① Install the most efficient irrigation system you can for your situation.

② Hydrozone effectively and thoughtfully – more zones are better than fewer.

③ Plan hydrozones that do not require any supplemental water or irrigation. Select plants with little to no water requirements at maturity or after establishment. Keep them on a separate irrigation valve.

④ Specify dry-adapted natives or climate-appropriate plants.

⑤ Build Living Soil to act like a sponge, holding water when it's scarce and releasing water when it's plentiful.

⑥ Utilize captured rainwater or reclaimed gray water.

IRRIGATION AUDIT & SITE EVALUATION

Purpose:

1. Complete an irrigation audit of spray irrigation to determine how much water currently is applied to the site.
2. Conduct the field work necessary to complete this part of an evaluation.
3. Calculate the distribution uniformity of the system.

Preparation:

- ✓ Catch cans, flags and other necessary equipment to conduct the audit.
- ✓ Irrigation audit sheets for the field and for calculations.
- ✓ Access to the irrigation controller, valves, and meter.
- ✓ Irrigation system should be in optimal working condition prior to test.

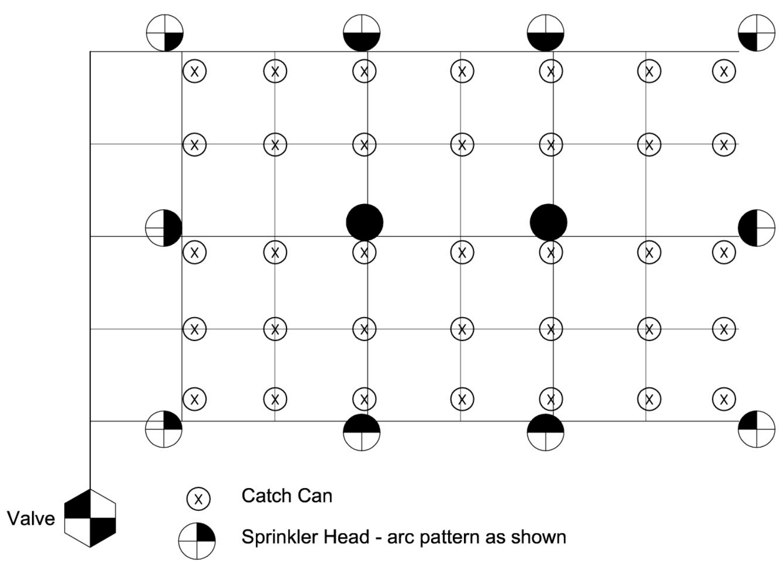
Field Work

1. Using an anemometer, determine if the wind speed is more or less than 5 MPH, as it is not accurate to conduct the test in winds exceeding this level. Record information.
2. Using a soil probe, determine root depth of turf. Record information.
3. Conduct hand test for soil type. Record information.
4. Using a penetrometer, determine compaction level.
5. Identify irrigation water source and backflow prevention.
6. Turn on sprinklers to identify placement – place flags at sprinkler heads.
7. Measure pressure at beginning of zone and end of zone – either with pressure tee if pop-up sprinkler heads or with pitot tube if rotors. Record information.
8. Adjust any egregious issues with sprinklers or fix any major broken elements.
9. Measure site and draw a site map indicating the location of the heads and any other major landscape elements (trees or large shrubs in the lawn area).
10. Note observations about the irrigated area: slope, condition of turf, type of turf, moss or hardscape issues. Note microclimates and other site conditions. Indicate North.
11. Identify downspouts and terrain of the site.
12. Measure the size of the roof areas that are draining into each downspout (or to one particular downspout selected for discussion).
13. Lay out catch cans in a grid covering the entire irrigated area – best to place one line of grid 2’ from sprinkler heads and one in the middle between heads as a starting grid. (see diagram)
14. Mark the location of the sample cans on your drawing and assign them numbers.
15. Utilize 16+ catch cans, in a number always divisible by 4. If, for some reason, too many cans are utilized and the number is not divisible by 4, then

throw away the results from the highest cans exceeding a number divisible by 4. For example, 23 cans are used, throw out the 3 highest numbers to arrive at a test with 20 samples.

16. Read meter at beginning of test.
17. Turn on irrigation zone and allow to run for 10 – 15 minutes or a min. of 20 ml or ¼".
18. Read meter at end of test. Record both start and end meter readings.
19. Working from one end of the grid to the other record the amount of water in each of the catch cans.
20. Mark the corresponding amount of water in the can with the sample number on the drawing so that any low or high numbers might be correlated with actual turf quality.
21. Calculate the DU_{LQ} and DU_{LH} per *"What is Distribution Uniformity and How Do We Determine It?"*.
22. Complete the Site Evaluation form from workbook.
23. Make sure to also include the following information:
    a. Location / date / time of test
    b. Sprinkler make, model and nozzle size
    c. Test run time

Catch Can Layout



Spacing:
- Along edge, place 12-24" in from the edge.
- For fixed spray - near a head (within 2-3 feet) and half-way between heads.
- For rotors placed less than 40' on center, near a head and every one third of the distance between heads.
- For rotors greater than 40' on center, near a head and every one fourth the distance between heads.

Exercise #6
Calculate Precipitation Rate and Lower-Quarter Distribution Uniformity From Observed Data

DATA:
Wind speed = 3.5 MPH
Irrigation run time = 10 minutes
Meter reading at Start = 66956 Gal. Meter reading at End = 67540 Gal.
Irrigated area Square Footage (SF) = 8,250 sq. ft.
Observed water volume in milliliters from catch cans:

CAN #	ML OBSERVED	CAN #	ML OBSERVED
1	55	9	30
2	50	10	35
3	45	11	30
4	37	12	25
5	55	13	10
6	4	14	8
7	25	15	55
8	10	16	4
TOTAL	281 ml	TOTAL	197 ml

QUESTIONS:
What is the Average Total ML Observed?

Total ml In Sample	÷ Number of Samples	Avg. Total

What is the Flow Rate or Gallons Per Minute (GPM)? [(Meter read End – Meter read Start) ÷ Run Time]

What is the Application Rate we have observed (Inches/Hr.)? [(96.25 x GPM) ÷ SF Irrigated Area]

Arrange the results in ascending order of magnitude in this chart:

DATA #	ML OBSERVED
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
TOTAL	

What is the Average of the Lower Quarter? (hint: #1-4)

Total ml In Lower Qtr.	÷ Number of Samples	Avg. Lower Quarter

What is the Average of the Lower Half? (hint: #1-8)

Total ml In Lower Half	÷ Number of Samples	Avg. Lower Half

What is the Distribution Uniformity of the Lower Quarter if DU_{LQ} = (Average of Lower Quarter ÷ Average of Total)?

What is the Distribution Uniformity of the Lower Half if DU_{LH} = (Average of Lower Half ÷ Average of Total)?

In order to correctly evaluate our irrigation system, what other information should we gather when we are on site?

____________________ ____________________

____________________ ____________________

____________________ ____________________

IRRIGATION AUDIT & SITE EVALUATION

Purpose:

1. Complete an irrigation audit of spray irrigation to determine how much water currently is applied to the site.
2. Conduct the field work necessary to complete this part of an evaluation.
3. Calculate the distribution uniformity of the system.

Preparation:

- Catch cans, flags and other necessary equipment to conduct the audit.
- Irrigation audit sheets for the field and for calculations.
- Access to the irrigation controller, valves, and meter.

Activity Cue: Field Work/

1. Participants are divided into two groups.
2. Using an anemometer, determine if the wind speed is more or less than 5 MPH, as it is not accurate to conduct the test in winds exceeding this level.
3. Using a soil probe, determine root depth of turf.
4. Conduct hand test for soil type.
5. Using a penetrometer, determine whether or not the site is compacted.
6. Identify irrigation water source and backflow prevention.
7. Turn on sprinklers to identify placement – place flags at sprinkler heads.
8. Measure pressure at beginning of zone and end of zone – either with pressure tee if pop-up sprinkler heads or with pitot tube if rotors.
9. Adjust any egregious issues with sprinklers or fix any major broken elements.
10. Alternatively, G3 provides the pre-fabricated spray irrigation system 60' x 60'.
11. Measure site and draw a site map indicating the location of the heads and any other major landscape elements (trees or large shrubs in the lawn area).
12. Note observations about the irrigated area: slope, condition of turf, type of turf, moss or hardscape issues. Note microclimates and other site conditions. Indicate North.
13. Identify downspouts and terrain of the site.
14. Measure the size of the roof areas that are draining into each downspout (or to one particular downspout selected for discussion).
15. Lay out catch cans in a grid covering the entire irrigated area – best to place one line of grid 2' from sprinkler heads and one in the middle between heads as a starting grid.
16. Mark the location of the sample cans on your drawing and assign them numbers.
17. Offset each row of the grid, triangulating the cans.

Continued

IRRIGATION AUDIT & SITE EVALUATION

18. Utilize 16+ catch cans, in a number always divisible by 4. If, for some reason, too many cans are utilized and the number is not divisible by 4, then throw away the results from the highest cans exceeding a number divisible by 4. For example, 23 cans are used, throw out the 3 highest numbers to arrive at a test with 20 samples.
19. Position person at the water meter to read meter for length of test. Read meter at beginning of test.
20. Turn on irrigation zone and allow to run for 10 – 15 minutes (15 minutes only if using G3 pre-made irrigation grid).
21. Read meter at end of test. Record both start and end meter readings.
22. Working from one end of the grid to the other, using a team of 2 people, (one to call out the amounts in the cups and one to record the results) record the amount of water in each of the catch cans.
23. Mark the corresponding amount of water in the can with the sample number on the drawing so that any low or high numbers might be correlated with actual turf quality.
24. Calculating the DULQ and DULH is completed back in the classroom.
25. Complete the Site Evaluation form from workbook.

Time: 40 minutes to complete the audit and site evaluation, 30 minutes for calculations, 10 minutes for Q&A.

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MINI WATERSHED SITE EVALUATION: DATA COLLECTION

1) General Site Description

a) What is the name of the watershed in which this site resides?

b) What is the annual ETo of this area? (Name your source.)

c) What is average annual rainfall? (Name your source.)

d) Is this a Residential, Commercial, or Public site?

e) Does property slope? Describe how and where it is sloping.

f) Is there visible erosion or other damage? (Hypothesize why damage may have occurred.)

g) Other observations relevant to the description of the site:

h) Prepare a Site Plan and calculate square footage of the site.

On graph paper, prepare a Site Plan for the site and trace off 2-3 copies.

1. Area Description __________________ Sun Orientation _______ Sq. Ft.________

2. Area Description __________________ Sun Orientation _______ Sq. Ft.________

3. Area Description __________________ Sun Orientation _______ Sq. Ft.________

2) Downspouts/Drainage- Indicate downspouts and gutters on your site map.

G3, the Green Gardens Group: Watershed Site Assessment HOW
Page 2

a) To where do they drain?
   i) Are the downspouts directly connected to the curb? (Look for a hole.)
   ii) Indicate which downspouts are accessible in the garden area.
   iii) Indicate areas of pooling or erosion.
   iv) Describe the roof material.

b) Can you guess the dimensions of the roof space draining into each downspout?
   i) Calculate the square footage of roof space draining into each downspout.

Roof Area Downspout 1___________ Roof Type ______ Sq. Ft._______

Roof Area Downspout 2____________ Roof Type ______ Sq. Ft._______

Roof Area Downspout 3____________ Roof Type ______ Sq. Ft._______

<u>3) Plants/Soil Conditions/Habitat</u>- Indicate locations of trees, large shrubs and other noteworthy plants on the site plan.

a) Describe plants on site. Overall, do the plants look healthy? Why or why not?

   i) Is this plant material climate-appropriate? Indicate which of the 4 plant adaptations lead you to this conclusion. Name other adaptations, if known.

G3, the Green Gardens Group: Watershed Site Assessment HOW
Page 3

b) If regular lawn is 100% water use, climate appropriate are 50% and natives are 20% water use, what are these plants on average? **This % is called the PLANT FACTOR – Indicate a Plant Factor Percentage for each area.**

1. Area Description ________________ Plant Factor% ______ Sq. Ft._______

2. Area Description ________________ Plant Factor% ______ Sq. Ft._______

3. Area Description ________________ Plant Factor% ______ Sq. Ft._______

c) Do you see weeds? What kind?

   i) Do you see fungus/mushrooms? Where?

d) Does the property have mulch? How deep is it? Describe it's consistency.

   i) Pick up mulch and smell it – Does the mulch / earth beneath smell good?
   ii) Do you observe worms or other creatures in the soil? Describe them.

e) Do you observe birds, butterflies, and insects? Describe them.

f) Conduct a **Percolation Test**. Dig a 12" x 12" hole and fill it with water twice.
   i) Indicate how long it took for the water to drain from the hole completely both times.

g) Conduct a hand test for soil type. What type of soil is in the garden?

h) Using a **Penetrometer**, check the PSI of each area and mark on the chart. Multiple readings may be required in each area, depending upon soil type and and compaction. Where is it compacted?

---

4) <u>Irrigation/Electrical</u> – Indicate the approximate location on your site map.

______Water meter _____Hose bibs. ______Electrical outlets.

_____Irrigation controller ______Irrigation valves ______Backflow preventer

_____Irrigation heads. **Put flags in the ground at irrigation heads.**

a) Do you observe overspray on to hardscape when irrigation is running?
   i) How quickly? Which hardscape?

b) Do you observe misting?

c) Do you observe broken or damaged heads or other aspects of irrigation? Mark on your site plan and describe below so repairs may be made.

d) What is the Static Pressure at the Hose Bib?

5) **Determining Actual Water Use**

Number of Spray heads of each type in each Zone:

______ 1/4 circle ________ 1/2 circle ________ Full circle ______ Side strip

______ Bubbler ________ Impact Spray ________ ¾ circle ________ Drip emitters

Fill in chart below: Range based on Static Pressure PSI: Low 15 PSI, High 60 PSI

Nozzle Pattern	# Heads or Emitters	Pressure at Hose Bib	Est. Gallons per minute (GPM)	Total GPM/GPH
1/4			**.39 - .59**	
1/2			**.78 – 1.18**	
Full			**1.56 – 2.36**	
Side (4'x30')			**.89 – 1.21**	
3/4			**1.17 – 1.77**	
Bubblers/Impacts			**2.00 – 5.00**	
Drip Emitters			**.5 – 2 GPH**	
TOTALS				

6) **Conduct An Irrigation Audit (See Audit Sheet)**

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IRRIGATION AUDIT DATA

Location Address	**Date and Time of Audit**
Zone/Station Number(s)	**Controller Notes**
Irrigated Area Square Footage	**Catch-Can Description**
Plant Material Description	**Irrigation Type**
	Spray **Multi-Stream Trajectory** **Rotating Nozzle** **Rotor** **Drip (note GPM of emitters)**

Reference Sketch Test Area:	**Catch-Can Layout Test Area:**

Zone	Run Time (min.)	Meter Initial (gal.)	Meter Final (gal.)	No.of Heads/Description
1				Full Half Quarter Variable Emitters

Observed Data:

CAN #	ML OBSERVED	DATA REF #	REORDERED LOW TO HIGH
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	
9		9	
10		10	
11		11	
12		12	
13		13	
14		14	
15		15	
16		16	
17		17	
18		18	
19		19	
20		20	
21		21	
22		22	
23		23	
24		24	
		TOTAL	

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IRRIGATION AUDIT REPORT

TEST RESULTS	ZONE 1
Run Time	
Irrigation Type	
No. of Heads and Nozzle Pattern	
Flow Rate (Calculated GPM) **START Meter Reading** **END Meter Reading**	
Application Rate (Calculated In./Hr.)	
DU_{LQ}	
DU_{LH}	
Soil Core Notes and Root Zone Depth	
Additional Comments **Wind Speed At Time of Test**	

Remediate Your Soil

Introducing:

- Soil Food Web, Living Soil & the Soil Party!
- Soil / Plant / Water Relationships
- Sense of 'Place'
- Plant Available Water
- Determining Distribution Uniformity

This Is The Soil Food Web

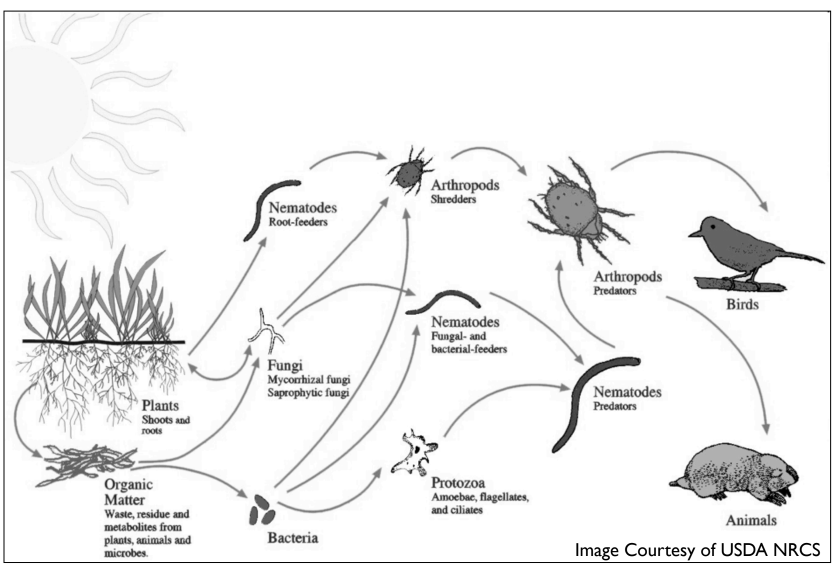


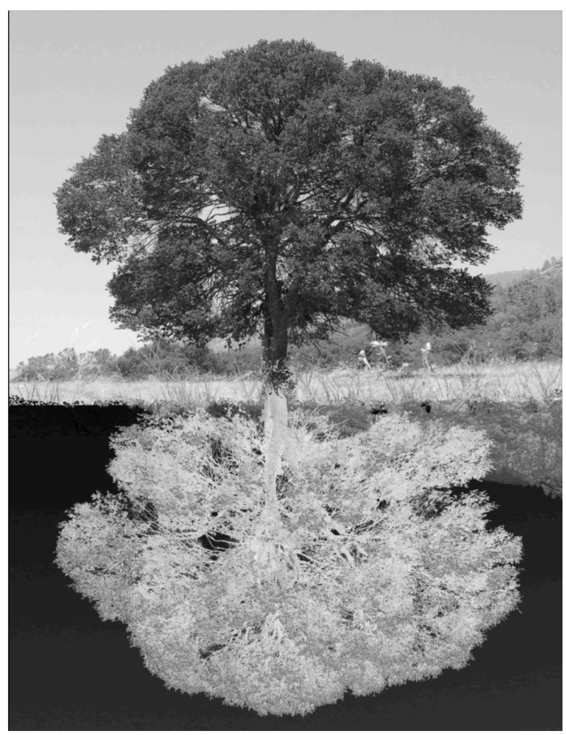
Image Courtesy of USDA NRCS

Take a Moment : Imagine Your Favorite Plant

80% of what's going on is below ground in the roots.

Not 80% of the root mass, but 80% of the plant's energy.

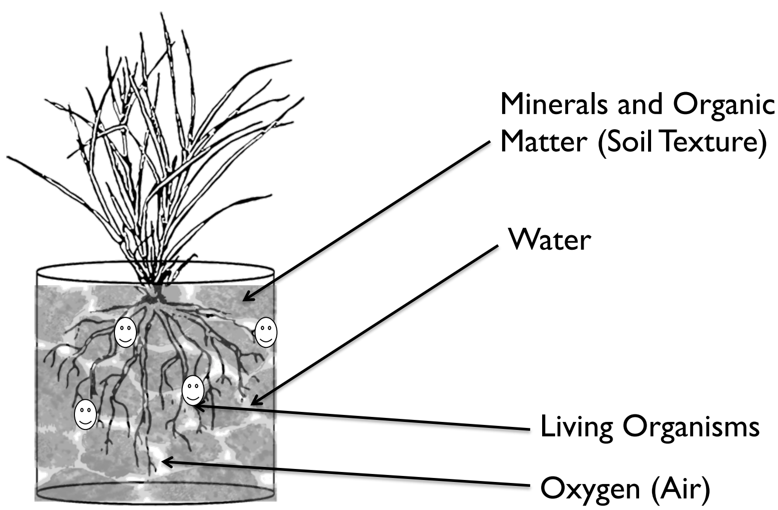
Photosynthesis and reproduction encompass only 20% of the plant's total energy.



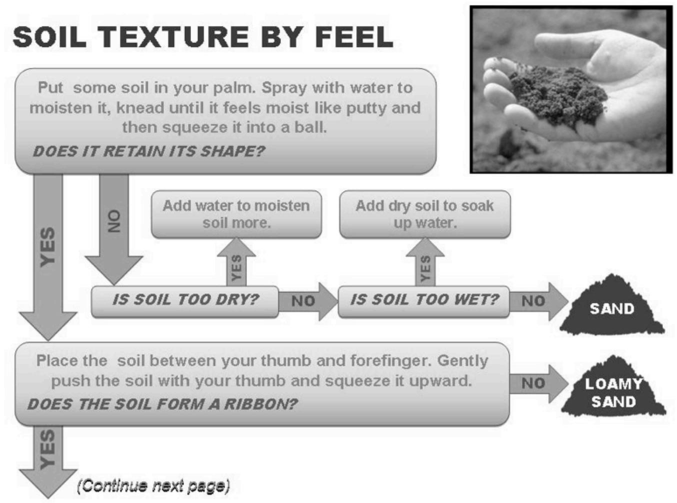
Oxygen + Water + Life
Are the Essential Components of Living Soil

The Balance of OWL
Guarantees Landscape Success

Oxygen + Water + Life
Are the Essential Components of Living Soil



Soil Texture (Type) Is Not the Whole Story

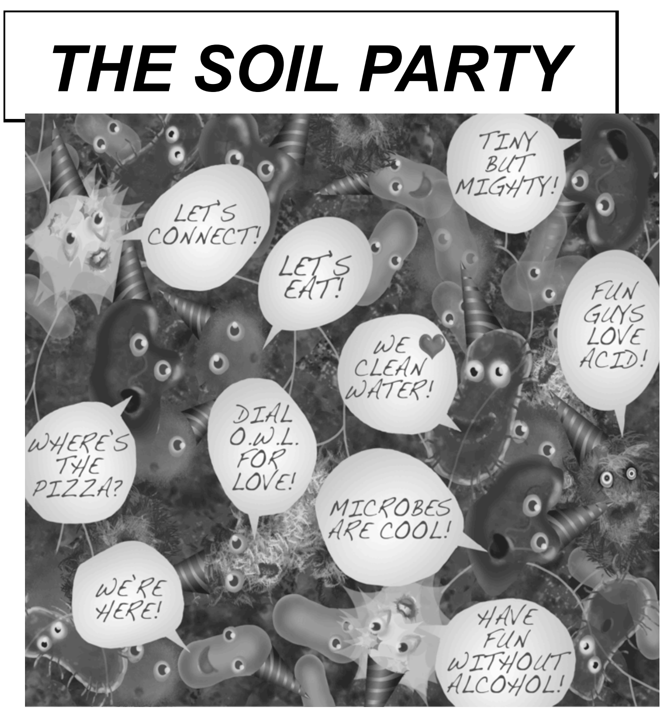


Living Soil Is NOT DIRT!

Living soil, the basis of all life, is filled with abundant microbial and fungal organisms that work together to feed the plants. This is done by gathering water and creating nutrients when the plants ask for them.

Compacted soil quickly becomes dirt with no oxygen, water, or life to support plants.

Compaction Occurs Regardless of Soil Texture

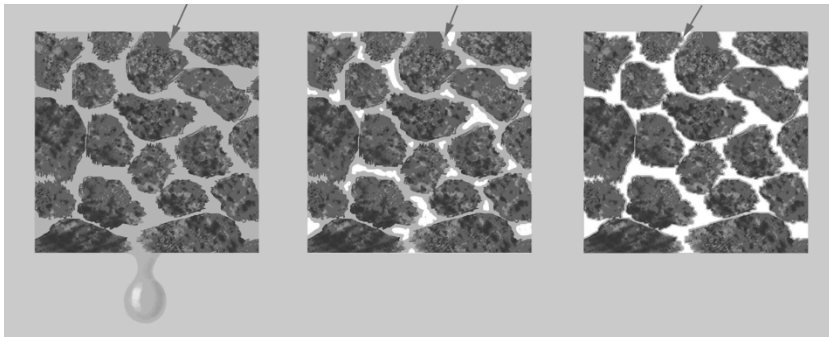


Healthy Soil Is ALIVE!

A teaspoon of good garden soil contains billions of microbes that were only recently discovered.

The microbes sequester carbon, making the soil a sponge, and also cycle nutrients so plants can thrive.

The Purpose of Irrigation Is to Maintain OWL

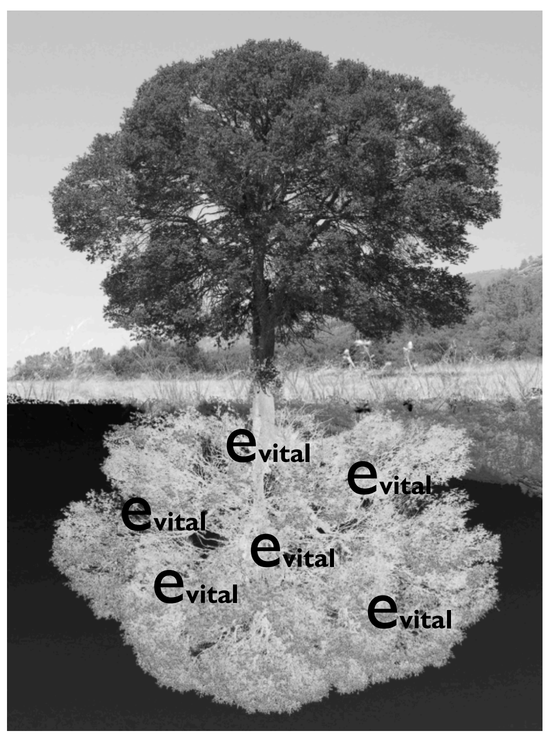


No Oxygen Too Much Water Anaerobic Life	Balanced Oxygen Balanced Water Aerobic Life	Plenty of Oxygen No Water No Life

Plants Send Out "Invitations" to the Soil Party

Invitations are in the form of "exudates" – liquid carbon sugars, carbohydrates and proteins exuded by plant roots.

These exudates are similar to fingernail growth or skin sloughing in humans. They become the food used by the plant to attract the specific biology needed at the specific time and in the specific quantities to perform particular functions.



SOIL PARTY

Purpose:
1.Group people by similar characters in the Soil Party: Bacteria, Protozoa, Nematodes, Herbage, and Fungi
2.Explain the sequence of biology that supports plant life on earth and introduce the concept of "Living Soil."

Preparation:
•Each nametag has a picture of one character from the Soil Party on the back side.
•A poster or handouts indicating the affiliation of each character is created and printed out for the event.

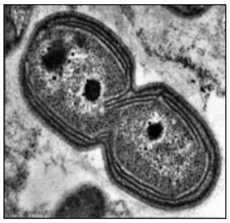
Activity Cue: Plants are interactive with the soil and they send out invitations to the Soil Party.

1.Participants seek out other members of their affiliation and form 5 groups in the landscape.
2.Each group is told it's shout out:
   a. Bacteria – We're here!
   b. Protozoa – We're hungry!
   c. Nematodes – Where's the pizza?
   d. Herbage – Here's the pizza!
   e. Fun Guys – Let's party!
3.Each group is instructed to agree upon a little dance or movement that would accompany their shout out. The team is given a clue about their character in order to inform their movement. Eg. "Bacteria have no feet, so they can't swim around"– 1 minute of discussion.
4.Party commences and each group is encouraged to both shout out and dance when their affiliation is called and explained.
5.Groups return to their seats, but remain standing until the Party is complete.

Time: 10 minutes to seek affiliation, form groups and determine movement. 10 minutes to complete the Soil Party.


You're invited to a Soil Party!!
Nematodes
Bacteria
Herbage
Protozoa
Fungi

spacebook



Good Bacteria has:
38,000,000,000 friends
1 photo
0 notes
1,000,000 wall posts
1 group

Check out My Soil Party Profile

Hi Everyone!!!!

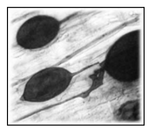
I always arrive first at a soil party, and I always have a good time!

I like to munch on dirt and convert it to nutrients which I store in my body until I'm eaten by something bigger. Getting eaten isn't fun, but oh well . . . That's LIFE!

Keep some water around, or I'll just go to sleep.

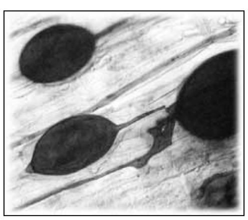
I have no feet, so I need a "taxi" like a bird or bug to get me to the party if I'm not sleeping there already.

See who else has invited you to the Soil Party:



Mr. Bacteria-eating Fungi
1,000 Protozoa
500 Nematodes
200 Macroarthropods

spacebook



Protozoa has:
1,000 friends
1 photo
0 notes
500,000 wall posts
1 group

Check out My Soil Party Profile

Hi gang,

I'm following around the bacteria, because they're my favorite food.

When I eat bacteria, I release the nutrients in their bodies in a form that is available for other partygoers and plants.

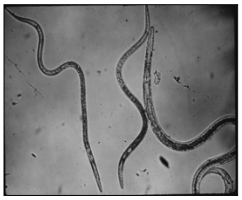
See my flagella? I can swim in small amounts of water!

I am seeking the company of some really friendly nematodes.

See who else has invited you to the Soil Party:

Mr. Protozoa-eating Fungi
38,000,000 Bacteria
500 Nematodes
200 Macroarthropods

spacebook



Nematode has:
200 friends
1 photo
0 notes
1,000 wall posts
1 group

Check out My Soil Party Profile

Hello there fun-guys,

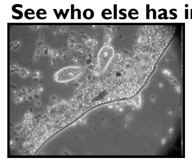
I'm just hanging out with my protozoa buddies, eating bacteria, releasing nutrients…you know, the same old thing.

Don't tell anyone, but sometimes I eat protozoa too.

People tell me I look like a worm, but I'm not.

I'm trying to avoid my cousins, the root-eating nematodes, because I hear there's a nematode-eating fungi vigilante group out to eliminate them.

See who else has invited you to the Soil Party:



Mr. Mycorrhizal Fungi
38,000,000 Bacteria
1,000 Protozoa (pictured)
200 Macroarthropods

spacebook

Weeds has:
1,000,000 friends
1 photo
0 notes
1,000,000 wall posts
1 group

Check out My Soil Party Profile

Hi there soil microbes,

I'm crashing this party, but I'm bringing the PIZZA!

Your soil must be poor (dirt + bacteria + protozoa + nematodes) and the biodiversity low, because once this party starts to rock, the soil will be too healthy for me to survive.

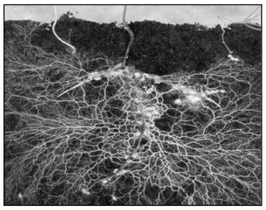
When I die, my body feeds the soil party, and fun guys can start arriving.

If you want me to stay home – add compost or other organic material to your soil.

See who else has invited you to the Soil Party:

Mr. Mycorrhizal Fungi
1,000,000 Weeds
38,000,000 Bacteria
200 Macroarthropods

spacebook



Fungi has:
300 miles of friends
1 photo
0 notes
1,000,000 wall posts
1 group

Check out My Soil Party Profile

Howdy Gang,

I'm going to rock this house party into a block party.

My fungi stretches for miles and miles connecting plants in the community and sharing resources like water, nutrients, and hormones. I sequester carbon and store water.

If you connect with me, you can out-compete weeds and "outsider" plants that don't belong here.

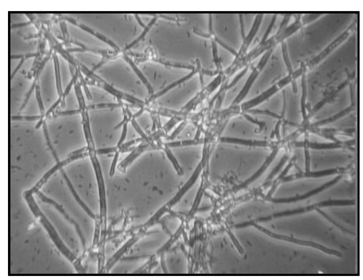
See who else has invited you to the Soil Party:

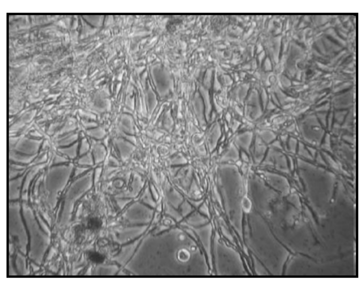
Healthy Plants
38,000,000 Bacteria
1,000 Protozoa
200 Macroarthropods

Mycorrhizal Fungi Build a Plant "Internet"

Small fungal hyphae: from tiny beginnings

Large fungal hyphae: grow into great complexes





Fungal hyphae activated in actively aerated compost tea after only 30 hours

spacebook

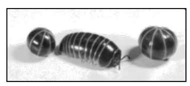
Macroarthropod has:
38,000,000 friends
1 photo
0 notes
1,000,000 wall posts
1 group

Check out My Soil Party Profile

Hello All,

If you can see me, then you know your soil is healthy. Anything that passes through my body is turned into nutritious food for good bacteria, fungi, and all the other soil partygoers.

See who else has invited you to the Soil Party:



Vertebrates/Invertebrates
38,000,000 Bacteria
1,000 Protozoa
Mr. Fungi
Healthy Plants

Good Soil Biology Builds a Plant Defense Shield

Leaf It Where It Falls to Keep the Immune System Healthy

Pesticides, Fungicides and Herbicides Are a Buzz-Kill

Kill the microbes, and you destroy the nutrient-makers. Then you are required to "add" nutrients with fertilizers and kill weeds with herbicides.

Kill the "taxis," and guests can't arrive. Then you are required to continue applying pesticides.

Replace NPK With OWL

Time-release fertilizer? Don't try to feed the plants – you don't know what they want.

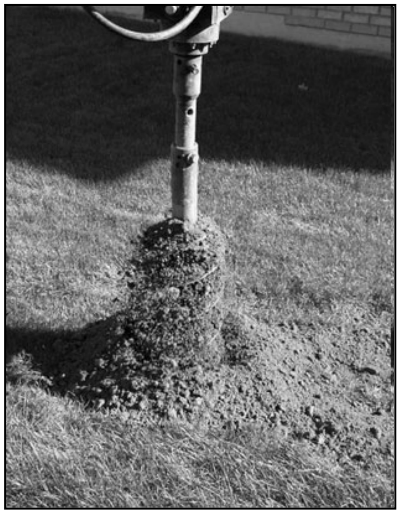
Does this look healthy to YOU?

OWL makes sufficient NPK for your plants without any added nutrients.

Compaction? Take Action! Landscape Renovations

First, you must get Oxygen into the soil.
Go as gently as possible!

Compaction? Take Action! Existing Landscapes



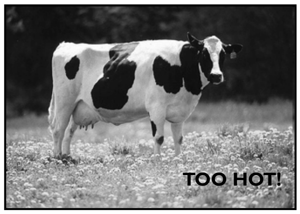
Auger at regular intervals

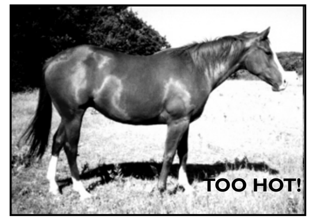
Add worm castings or compost tea down the holes (remember the Pizza!)

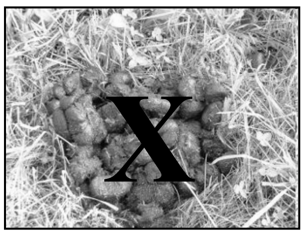
As Always: Compaction? Take Action!

Keep your turf aerated and
de-thatched at least annually

How Do You Add Nutrients to the Soil?







Just like knowing your food source, know the source of the animal waste and make sure it's healthy.

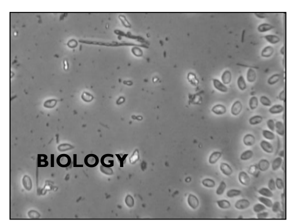
If it's not fully composted . . . It's just POOP.

If it smells it doesn't get through the garden gate.

By Feeding the Soil Microbes, Not the Plants

+

+

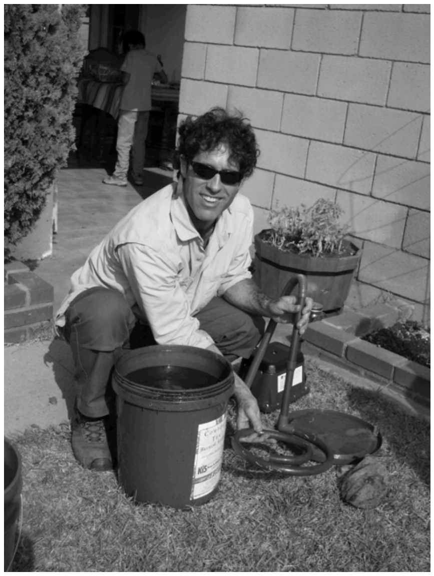


Organic Matter should look and smell good enough to eat!

COMPOST

MULCH

Brew Nutritious Actively Aerated Compost Tea

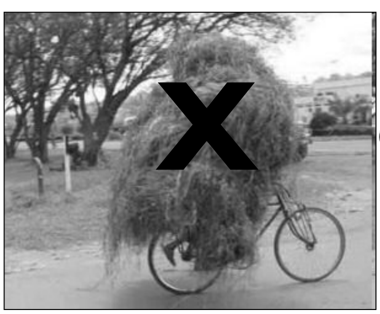


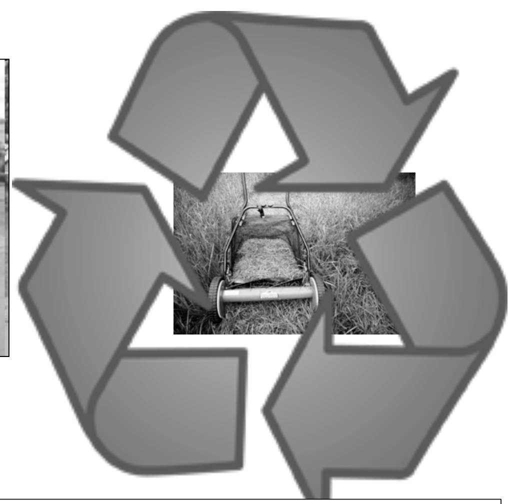
Actively Aerated Compost Tea (AACT) is inexpensive to brew and is an excellent “taxi” for all the good biology.

One 5 gallon bucket of tea can be diluted with water to make 15 gallons – enough to cover up to 1,000 sq. ft. of garden space.

You need a strong air pump to get the microbes suspended in solution. Be careful, a bubbler from a fish tank won’t do the trick.

Reduce Waste By Grasscycling





Recycle your grass clippings back on to your turf,

as mulch for your planter areas, or into a compost pile.

Case Study

North Bay Office Park

Becoming part of the solution by committing to preserve the beauty that surrounds us and to heal our planet for future generations

Results Achieved:

- 50,000 ft^2 sheet mulching project w/ soil food web strategies
- 1 Acre Native Wildflower field to enhance biodiversity
- Water consumption reduced by **52%**
- Watering cost reduced by **$39,000**
- **50,000 ft^2** of turf replaced with native plants
- Sterile soil is now teaming with microbes and nutrients

Project Site Details:

- Commercial Office Park
- Larkspur, CA
- 3.5 acres of landscape
- Age of site: 26 yr

Customer Goals:

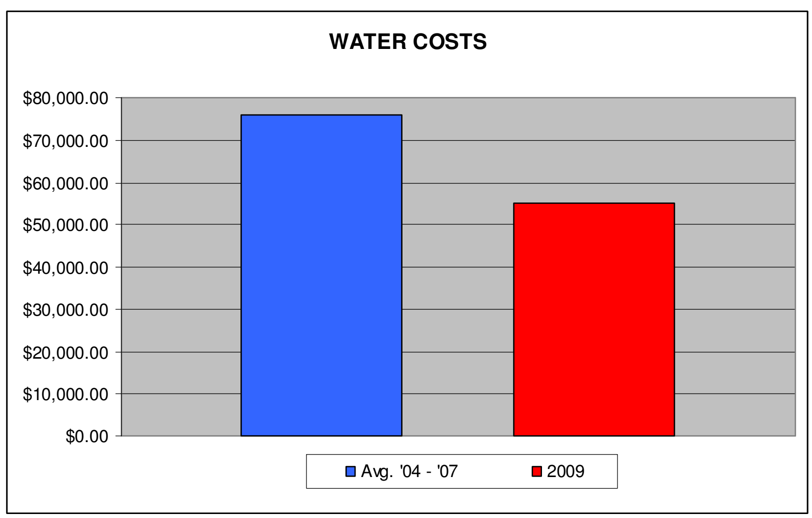
- Create a beautiful and sustainable landscape
- Achieve water savings
- Zero waste construction

Challenges Faced by Customer:

- Average annual water costs = $ 76,000
- Rate increase just in 2009 = 7.5%

Solutions:

- Tennant education in sustainability
- Site water budget developed
- 1 ET Water smart controllers installed
- 3 -5 year Return on Investment (ROI) study completed
- Zero waste construction methods
- 2 applications of compost tea



cagwin & dorward
landscape contractors

References for this case study and others like it are available upon request

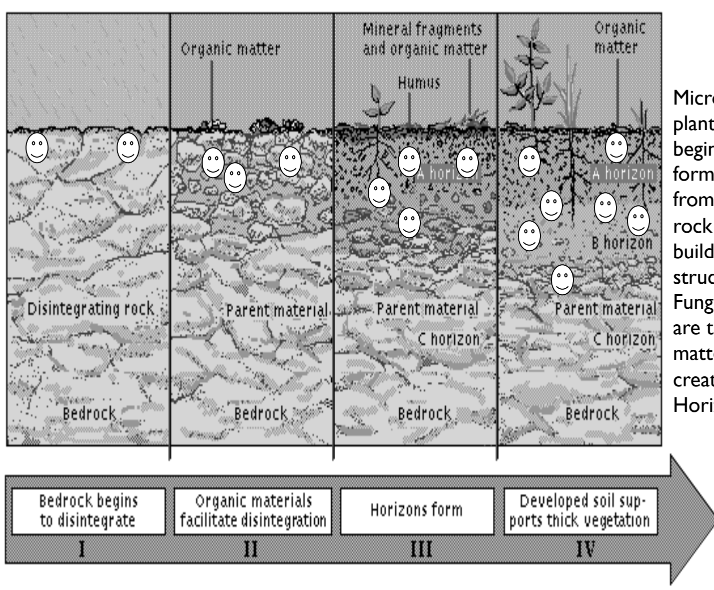
Soil Has A "Sense of Place"

Beneficial organisms necessary for Living Soil have evolved with the life cycles of plants and animals, living on rainfall in the acidic or alkaline soils of specific areas.

These microorganisms cycle nutrients and sequester carbon brought to the soil by the plants through photosynthesis.

The carbon sequestered by microorganisms far outweighs carbon sequestered by biomass above ground, especially in arid climates.

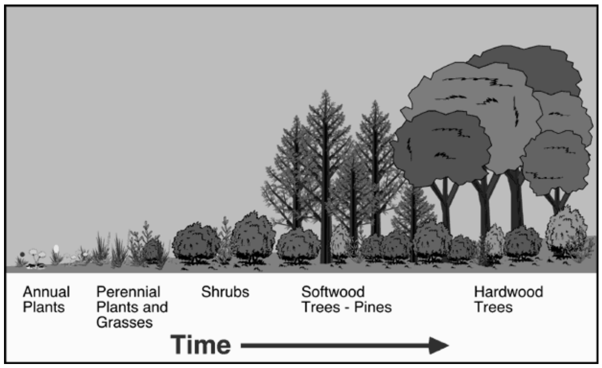
Soil Begins As Parent Rock Degraded By Rain and Microbes



Microorganisms and plants like lichen begin the soil formation process from these bits of rock and begin to build the soil structure.
Fungi and bacteria are the great organic matter decomposers creating the "A Horizon."

Bacterial to Fungal Is a Natural Succession of Plants

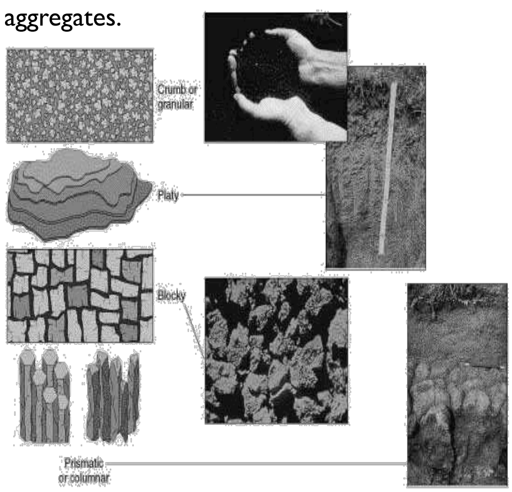
There is a natural succession in soils from bacterial to a more fungal biomass until finally, in old growth forests, the soil is almost completely fungally dominated. Understanding this natural succession allows you to determine the kind of soil microbes that will best support the landscape you desire.



Bacterial Mixed Fungal

Good **Soil** **Structure** is CREATED Through BioChemistry

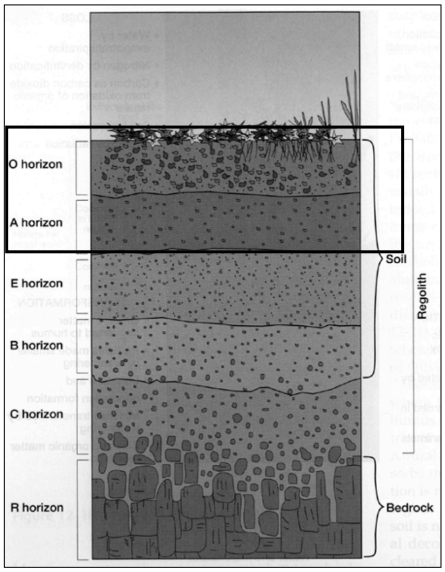
Particles of soil are glued together (by glomalin) in clumps to form Soil Structure, "the shape of aggregated soil particles" called Micro-aggregates.



Oxygen+Water+Life

Life (bacteria) slime glues together micro-aggregate particles and (fungi) weaves them into larger structures called Macro-aggregates.

Where Does the Biology Live?



<u>“O” - “A”: Topsoil</u>

Living Soil is mostly here with decaying organic material and rock, huge microbial activity, and plant roots. The interface of plant root with soil is called the RHIZOSPHERE.

<u>“B”: Subsoil</u>

Nutrients and minerals are leached into Subsoil from the Topsoil by water.

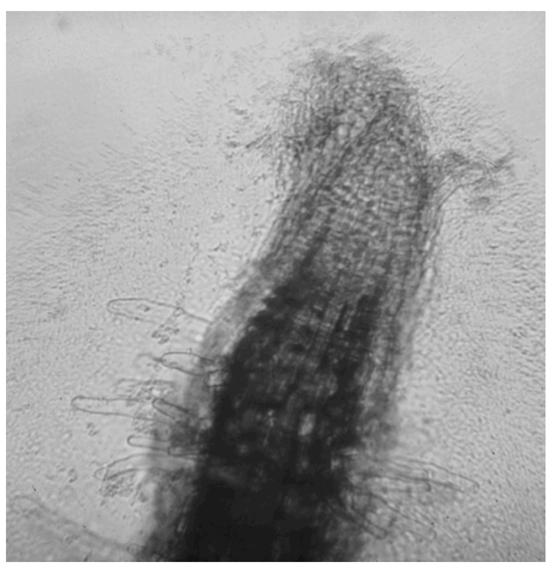
<u>“C”: Non organic subsoil</u>

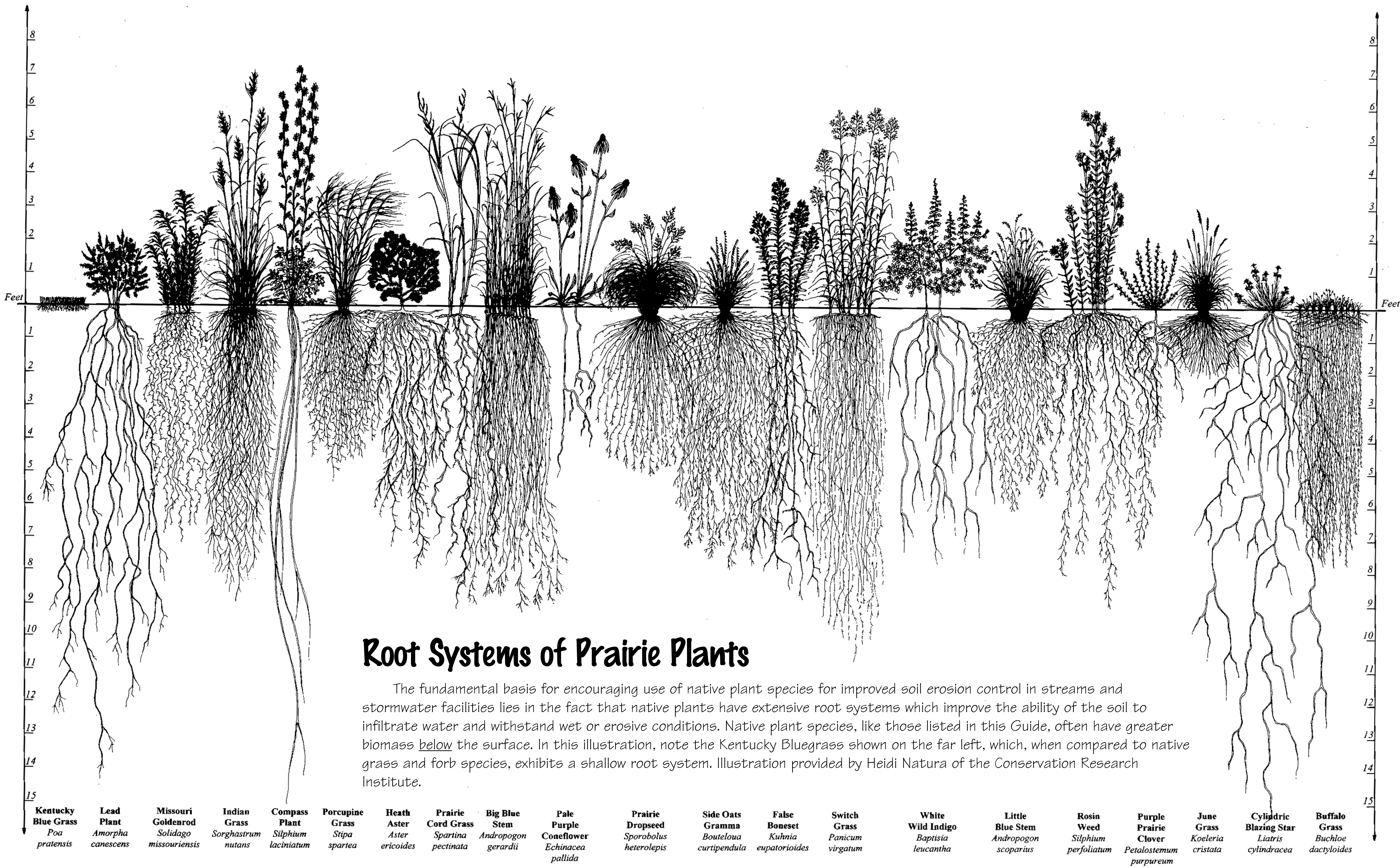
Unweathered stone, parent rock and trace mineral remains from Topsoil.

Where Does the Biology Live?

The RHIZOSPHERE area around the root of the plant is the most active area for biological activity.

This is where the SOIL PARTY is taking place!



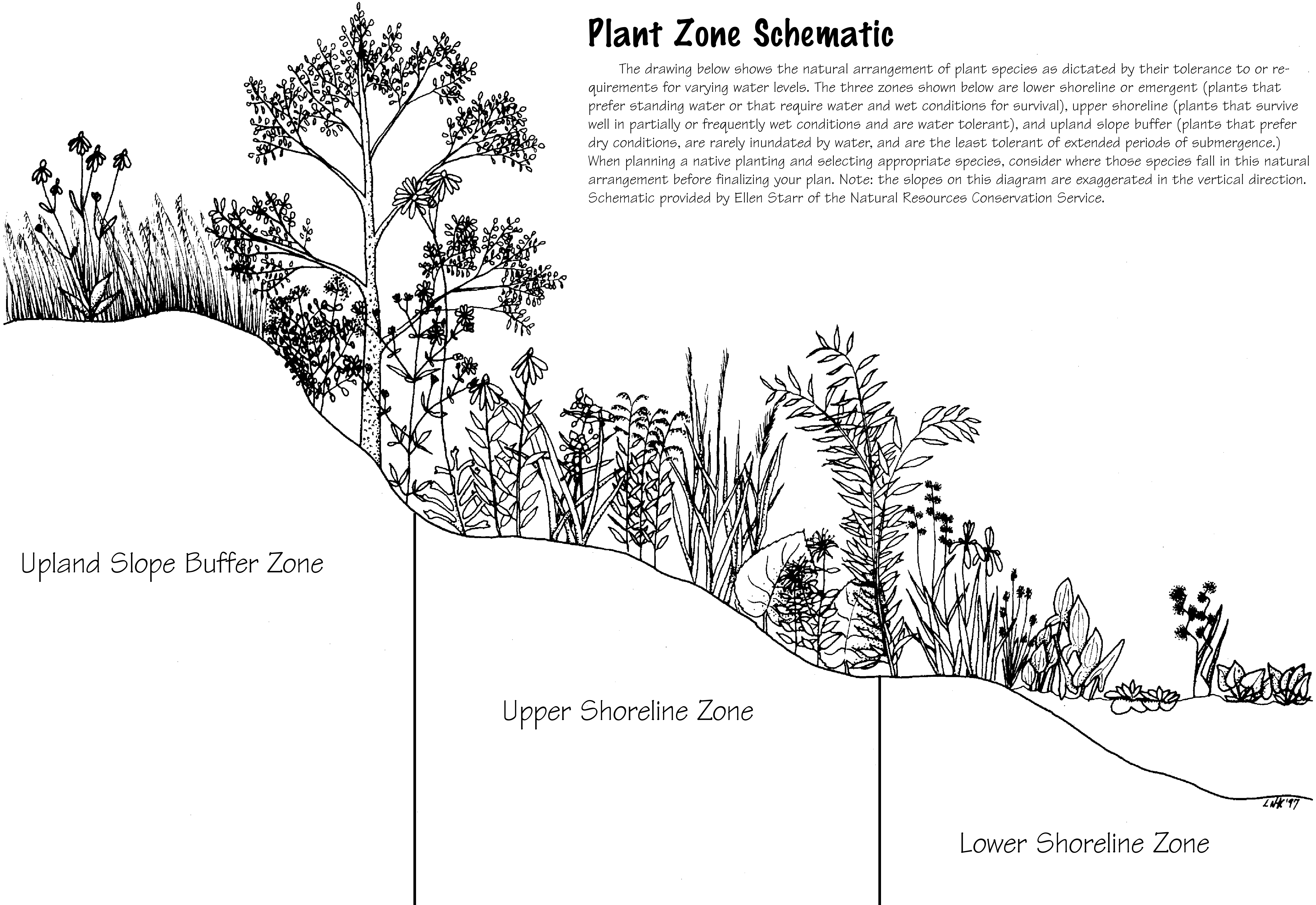


Root Systems of Prairie Plants

The fundamental basis for encouraging use of native plant species for improved soil erosion control in streams and stormwater facilities lies in the fact that native plants have extensive root systems which improve the ability of the soil to infiltrate water and withstand wet or erosive conditions. Native plant species, like those listed in this Guide, often have greater biomass <u>below</u> the surface. In this illustration, note the Kentucky Bluegrass shown on the far left, which, when compared to native grass and forb species, exhibits a shallow root system. Illustration provided by Heidi Natura of the Conservation Research Institute.

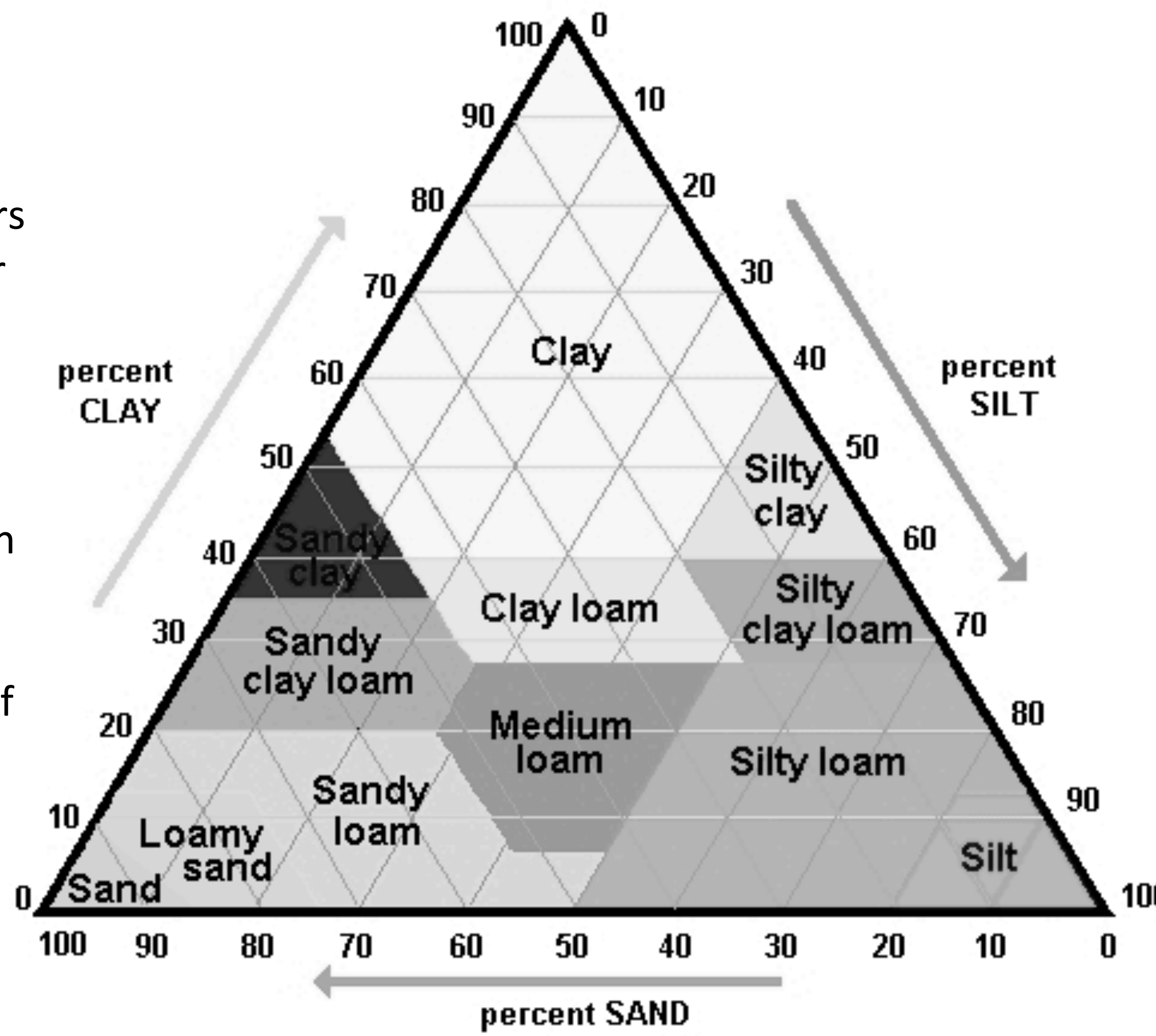
Plant Zone Schematic

The drawing below shows the natural arrangement of plant species as dictated by their tolerance to or requirements for varying water levels. The three zones shown below are lower shoreline or emergent (plants that prefer standing water or that require water and wet conditions for survival), upper shoreline (plants that survive well in partially or frequently wet conditions and are water tolerant), and upland slope buffer (plants that prefer dry conditions, are rarely inundated by water, and are the least tolerant of extended periods of submergence.) When planning a native planting and selecting appropriate species, consider where those species fall in this natural arrangement before finalizing your plan. Note: the slopes on this diagram are exaggerated in the vertical direction. Schematic provided by Ellen Starr of the Natural Resources Conservation Service.



Determine Soil Type Using Jar Test

1. Use 1 Qt. Size Glass Container
2. Add 1 Cup Soil
3. Add 3 Cups Distilled Water
4. Shake Until All Solids are Suspended in Water
5. Sit on Shelf and Wait 24 hours
6. If Cloudy, Then Wait Another 24 hours
7. After 48 hours Layers Should Appear: Sand on Bottom, Silt in Middle, Clay on Top
8. Measure Layers in Proportion To Each Other
9. Use Chart to Determine Soil Type Based on Proportions of Sand, Silt, Clay in Layers

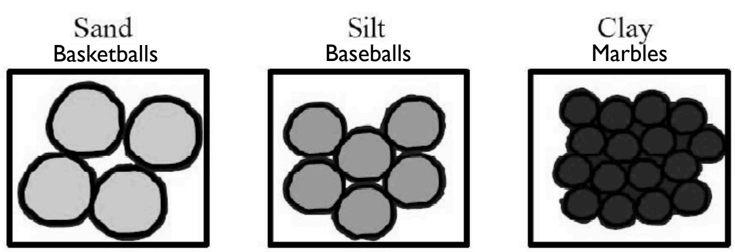


How Much Water Is in Soil?

First use soil hand test to determine the soil type.

Soil Type Matters for Water Holding Capacity

Soil Particle Size Classification



Type of Mineral Particle	Size Range
Sand	2.0 - 0.06 millimeters
Silt	0.06 - 0.002 millimeters
Clay	less than 0.002 millimeters

A Plant's Ability to Extract Water Differs with Soil Type

Sand
Iced Coffee

Clay
Coffee Frappuccino

Imagine: the plant's leaves pull water for evapotranspiration, while the roots act like a straw trying to bring the liquid up through a glass filled with ice of varying sizes and densities.

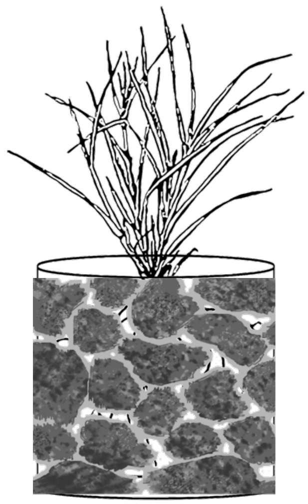
A Plant's Ability to Extract Water Differs With Soil Type

Sand
Iced Coffee

Clay
Coffee Frappuccino

① Iced Coffee goes fast, water is not held in sand.
② Coffee Frappuccino is difficult to suck up quickly because it all sticks together, like water in clay soil.

How Much Soil Water is Available to Plants?



Depends upon soil type and Available Water Holding Capacity (AWHC).

Depends upon Root Depth (turf, groundcover, shrub, tree).

Depends upon plant type and Plant Water Requirement (PWR).

Depends upon other microclimate factors, including water source and salinity.

Available Water Holding Capacity (AWHC) Differs with Soil Texture

Soil Texture	Available Moisture Range (Inches/Foot of Soil)	Available Moisture Avg. (Inches/ Foot of Soil)
Very Coarse to Coarse (Sands and Loamy Sands)	0.50 – 1.25	.90
Moderately Coarse Textured (Coarse Sandy Loam, Sandy Loam, Fine Sandy Loam)	1.25 – 1.75	1.50
Medium Textured (Silt, Silt Loam, Sandy Clay Loam, Clay Loam, Silty Clay Loam)	1.50 – 2.30	1.90
Fine and Very Fine Textured (Silty Clay, Sandy Clay, Clay)	1.60 – 2.50	2.10
Organic Soils (Peats and Mucks)	2.00 – 3.00	2.50

AWHC expressed as inches/foot of soil must be converted to inches/inches by ÷ 12

2.50"/ft. ÷ 12 = 0.21"/inch of soil

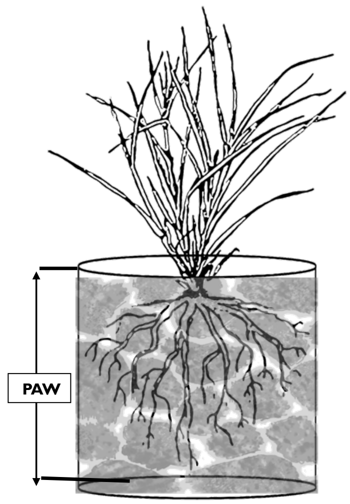
AWHC is expressed as inches of water per foot of soil or inch of soil depth.

Available Water Holding Capacity (AWHC) By Soil Texture

Soil Texture	Available Moisture Range (Inches/Foot)	Available Moisture Avg. (Inches/ Foot)
Very Coarse to Coarse (Sands and Loamy Sands)	0.50 – 1.25	.90
Moderately Coarse Textured (Coarse Sandy Loam, Sandy Loam, Fine Sandy Loam)	1.25 – 1.75	1.50
Medium Textured (Silt, Silt Loam, Sandy Clay Loam, Clay Loam, Silty Clay Loam)	1.50 – 2.30	1.90
Fine and Very Fine Textured (Silty Clay, Sandy Clay, Clay)	1.60 – 2.50	2.10
Organic Soils (Peats and Mucks)	2.00 – 3.00	2.50

AWHC expressed as inches/foot must be converted to inches/inches by ÷ 12

How Much Soil Water is Available to Our Plants?



Plant Available Water (PAW) is:

Available Water Holding
Capacity of Soil
(from the chart)
x
Plant Root Depth in Inches

How Do We Determine Root Depth?

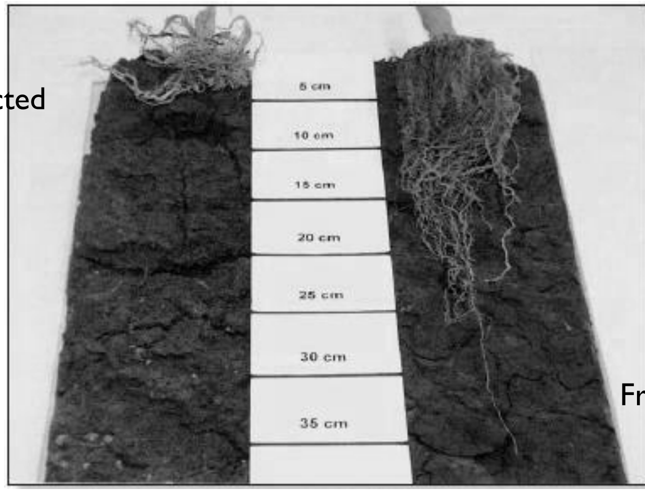
Use your soil probe.

Read nursery trade information.

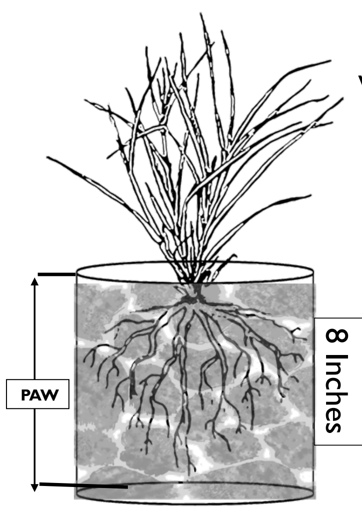
Recollect your experience with the plant from other projects.

How established is the garden or the plant?

Compaction Affects Plant Root Growth



Calculate the Plant Available Water (PAW)



What is the Plant Available Water if the soil is Silt Loam and the Root Depth is 8"?

Plant Available Water =
Available Water Holding Capacity of Soil
x Plant Root Depth in Inches

Loam AWHC = 1.90" per foot of soil
Loam AWHC = 1.90"/ft. ÷ 12"/ft. =
Loam AWHC = 0.158" per Inch of soil

0.158" AWHC x 8" root depth = 1.27" PAW
The **Plant Available Water** in 8" of loamy soil is **1.27"**

Exercise #7
Calculate Plant Available Water (PAW) For This Landscape Scenario

DATA:
Plant = Koelreuteria paniculata
Landscape Maturity = Planted 1 year ago
Root Depth = 24″
Soil Type = Sandy Loam

QUESTIONS:

What form does this plant take in the garden? How will you determine this?

How do you determine the Root Depth of the plant if it were not provided?

What is the Soil Available Water Holding Capacity (AWHC)?

Using the Root Depth above to complete this question, what is the Plant Available Water (PAW)?