Watershed Management Group

YOUR GUIDE TO HEALTHY DESERT SOILS FOR PRODUCTIVE LANDSCAPES

Follow these four steps and you can build healthy soil!

(1) Plant the Water: Increase soil moisture & spark life

(2) Protect Soil: Minimize erosion & eliminate chemicals

(3) Mix in Organics: Put organics in your yard, not the landfill

(4) Plant Your Ecosystem: Promote roots, ground covers & nitrogen fixers

Building healthy soil benefits you and your community. Healthy soil is the foundation of a beautiful and productive yard. You'll have healthier trees, a vibrant vegetable garden, and more food and habitat for your favorite wildlife. In addition, you can reduce the trash that ends up in the landfill, reduce pollution to our water bodies, and mitigate flooding problems.

The specifics of this guide are geared for desert soils in arid and semi-arid environments like those found throughout the western U.S. However, the principles are relevant to soil building in all environments, wet or dry.

SOIL BASICS: Water + Carbon (Organic Materials) => Soil Life!

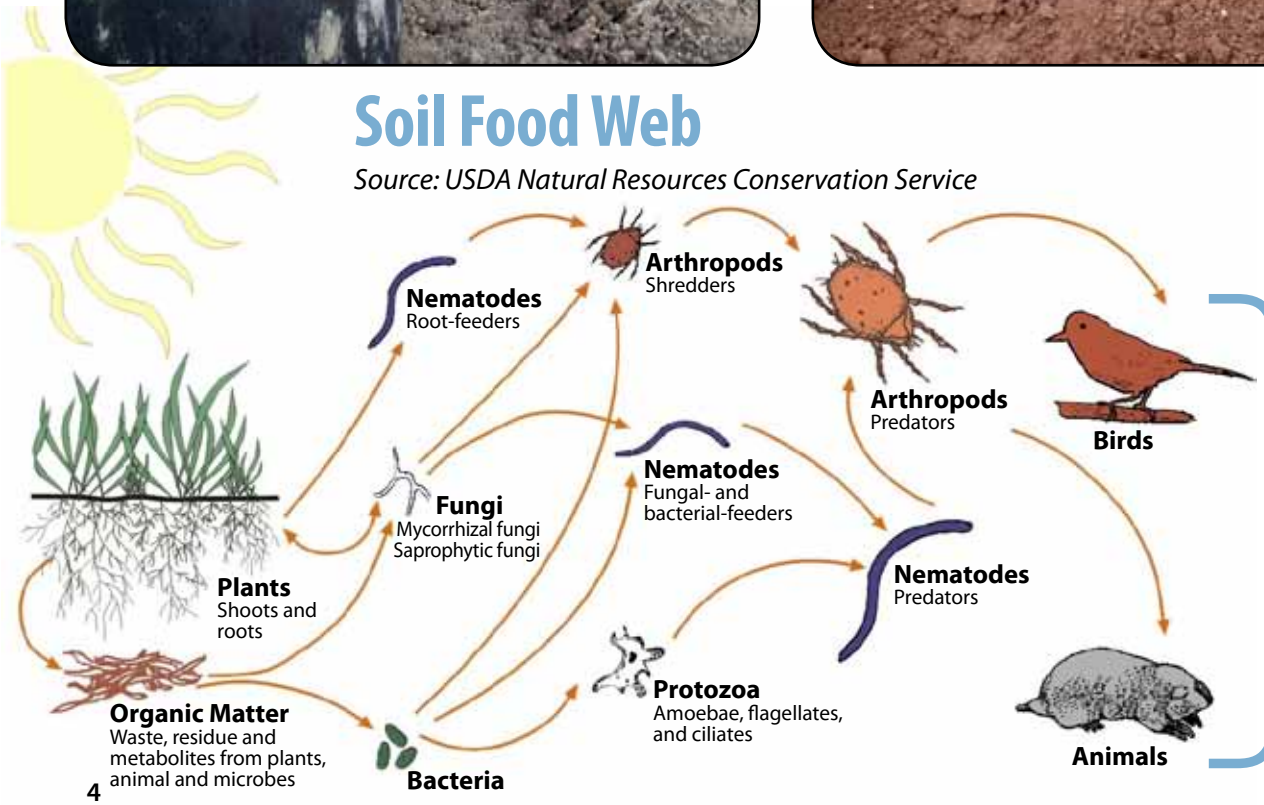
Soil is alive! It is made up of inorganic materials (sand, silt, and clay), organic materials, air, water, and critters (micro and macro organisms).

Before: Soil is compacted, with little dead or living organic material.

After: Soil is being de-compacted through increased decomposing organic material and soil life activity.

Soil Food Web

Source: USDA Natural Resources Conservation Service



Healthy soil has a complex ecosystem full of life. Did you know all these types of critters are essential for soil health?

1 PLANT THE WATER!

40-60% of residential water use is for outdoor uses, like irrigating our yards. Instead, make use of freely available waters and reduce your water footprint.

- **Direct rainwater** from your rooftop, patio, and pathways to your rain basins, allowing the soil to soak it up like a sponge. Rainwater flushes soils of accumulated salts and is free of chlorine.
- **Harvest stormwater** from the street through a curb inlet. Research shows tree growth is increased 30% by utilizing stormwater captured in organic mulch basins (Dr. Pavao-Zuckerman).
- **Divert greywater** from your laundry, shower/bath, and sinks to have a more consistent source of water for your plants.

Downspout directs rainwater to a rain basin to irrigate native plants.

Above. A laundry greywater system uses pressure produced from the machine to push water out to fruit trees.

Below. Gravity-based branched drain distributes shower/ sink water to basins.

This street-side curb inlet allows stormwater to soak into the soil and irrigate native plants within a basin.

2 PROTECT SOIL!

- Minimize practices which disturb or compact the soil. Continued disturbances inhibit soil-forming processes.
- Protect the soil surface from wind and water erosion by applying surface mulch.
- Eliminate the use of chemical fertilizers, pesticides, and herbicides. The use of these chemicals creates harmful dependencies that destroy instead of build the soil food web cycling of nutrients. Additionally the majority of these products are harmful to people, wildlife, and pets.

GOOD PRACTICES

Prune & Mulch

Stabilize slopes

Apply organic ground covers

BAD PRACTICES

Leaf Blowing

Spraying

Raking

3 MIX IN ORGANICS!

- Feed the soil from the surface with compost and mulch. Apply a surface organic mulch to protect the soil surface and reduce evaporation of soil moisture.
- When you prune your plants, chop and drop the material into your mulched basins.

Fresh tree trimmings applied to a rain basin.

After a good soaking rain the fungal organisms send up fruiting bodies - MUSHROOMS! - a good sign that decomposition is occurring!

SEE HOW MULCH TURNS INTO SOIL!

With the right moisture conditions present in a rain basin the tree trimmings quickly start to create a thin organic layer at the soil surface which helps re-build healthy soil.

See the white substance? It's fungal hyphae beginning to decompose the mulch and transport nutrients into the soil.

3 MIX IN ORGANICS!

Yard trimmings make up 13.5% of U.S. municipal solid wastes (US EPA). These are critical soil-building resources being wasted and filling landfills. Landfills are the largest source of methane production which contributes to greenhouse gas emissions.

MULCH YOUR DRIVEWAY!

Old, crumbling asphalt was removed from a driveway and replaced with organic mulch. Now the driveway allows rain to soak in and water the front yard trees rather than drain to the street.

MULCH OUR STREET-SIDE LANDSCAPES!

Organic mulch is a critical resource for restoring soil and filtering polluted runoff along street-side rain basins. Research shows that these soils attain a soil food web complexity equivalent to a mature forest soil in only 2 short years. (Dr. Pavao-Zuckerman)

MULCH YOUR YARD!

Leaves from a fruit tree decorate the soil surface and protect the tree's roots during times of extreme cold or heat.

When do you use straw vs. woody mulch?

Straw or alfalfa mulch is easily broken down by bacterial organisms. Most vegetables and annuals prefer bacterially dominated soils because the bacteria produce nitrogen in the nitrate form making it accessible to these plants.

Woody mulch (e.g. tree trimmings) laid on soil surface promotes fungi. Fungi are better adapted to breaking down tougher woody materials. Most trees, shrubs, and perennials prefer fungal dominated soils. The fungi promote nitrogen in the ammonium form making it accessible to these plants.

Here are some simple indicators of your soil health

CATEGORY	INDICATOR	IMPACT	MEANING
LIVING ORGANISMS	No soil micro-organisms	Bad	Sterile/lacking organic material
	Earthworms	Good	Soil tillers & micro nutrient processing at work
	Sow beetles & other macro arthropods	Good	Carbon shredders at work
	Fungal hyphae (Mushrooms)	Good	Stable soil with woody organic material being broken down & nutrients being redistributed for food web cycling
WATER	Surface ponding	Bad	Poor drainage and/or soil surface has sealed with fine particles and/or compacted soil
	Oils/greases/stormwater	Bad	Need soil & plant filters to treat
	Rotten smell	Bad	Anaerobic (without oxygen) conditions
	Soil greying	Bad	Anaerobic conditions - iron reduction
	Quick draining	OK	Sandy/gravelly soil - coarse materials with high porosity; depends on role of soil if this is desired or not
	Earthy smell	Good	Aerobic (with oxygen); actinomycetes (bacteria) present
SOIL CONDITION	Salt/mineral crust buildup	Bad	Irrigating with hard water
	Powdery soil	Bad	Soil structure lost - easily eroded
	Compacted	Bad	Less porosity hinders movement of air, water, and plant roots.
	Large aggregates of soil	Good	Soil has structure allowing for movement of air, water, roots, and critters.

3 MIX IN ORGANICS! Complete the

Animal Poop....

Earthworms and their castings are a highly prized garden resource. Earthworms are hard to maintain in desert soil, but by adding a regular greywater source and mulch soil stays more consistently moist promoting earthworms.

This compost pile is built right into the chicken coop. Food scraps are added during the day so chickens can eat what they want and scratch and turn the pile. They roost on a bar over the pile at night and add their nitrogen rich manure. This makes a great compost for vegetable gardens!

Food wastes make up 14.5% of U.S. municipal solid wastes (US EPA) with only 2% recovered prior to ending up in the landfill. What a waste that could be helping to grow more tasty food!

Nutrient Cycle — Integrate Humanure!

Your Poop....

You generate 13 gallons of poop each year which, if composted, could help fertilize 13% of the grain production needed to sustain you each year.[1]

A composting toilet works similarly to a kitchen composting system. The nitrogen and moisture in your poop is balanced with a carbon-based cover material that is added after each use. This cover material can be wood shavings, shredded paper, leaf litter, etc. The cover material added after each use also prevents odors and visually covers the deposited poop.

After a chamber (or batch) of the composting toilet system is filled, the chamber is left to compost for at least 4 months in warmer climates or longer in cooler climates. The composting process safely and effectively renders pathogens harmless for use in the backyard garden. Applied as a composted material to fruit trees it completes your nutrient cycle.

Top left and clockwise. The aged (>4 months of composting) humanure (composted human feces) is easily shoveled into a wheelbarrow and used to amend the soil surface around a fruit tree. The humanure smells, looks, and feels like compost!

Your Urine....

You generate 2 liters of urine each day, which if utilized, could help fertilize 70% of the grain production needed to sustain you each year. [1]

Urine is typically sterile and high in nitrogen, phosphorous, and potassium, and when diluted with water ~1:3 to 1:10 it can be easily used to add nutrients back to the soil.

From top. A urine diversion funnel directs urine below ground to infiltrate directly into the soil. Urine diversion can be placed within the barrel and as a separate male urinal. To reduce salt build-up, flush the soil with rainwater or greywater when possible.

[1]Ecosanres.org

4 PLANT YOUR ECOSYSTEM!

Create Root Mass

Select and mix plants with shallow, deep, and far reaching root structures. Native bunch grasses have dense and deeply penetrating roots which are helpful for improving infiltration and de-compacting soil. Native trees add organic material through root mass underground which also promotes movement of air and water through dense soil layers.

Encourage Ground Covers

Remember: woody mulch for most landscapes and straw/green mulch for vegetable gardens.

Fix Nitrogen and more!

Select and pair plants to fix nitrogen (legumes), host and feed wildlife (pollinators, larval food sources, berries, etc), provide shelter (multi-storied combinations of plants), accumulate leaf litter, and more...

Native trees provide a protective canopy which creates a beneficial micro-climate for understory plants. Trees and shrubs often shed leaves seasonally which creates an organic duff layer that protects the soil surface underneath.

Your actions impact your soil. Are they good or bad?

	DO YOU...	IMPACT	WHY?
SOIL SURFACE	Leave surface bare	Bad	Loss of top soil to wind & water erosion. Increased compaction of soil surface.
	Cover with landscape fabric	Bad	Prevents organic material (OM) and macro-organisms from improving soil. If using fabric to prevent weedy growth, consider using cardboard, burlap, or thick layer of organic mulch.
	Apply gravel	OK	May prevent compaction, reduce erosion, and protect from erosive forces, but does not improve soil OM. If gravel contains finer soil particles, may clog soil surface and cause ponding. Discourages beneficial critters.
	Apply straw mulch	Good	Increased OM content at soil surface. Straw provides carbon source and favors bacterial organisms. Most vegetables and annuals prefer bacterially dominated soils and access nitrogen in nitrate form. Additionally, fresh, green organic materials applied support bacteria.
	Apply woody mulch	Good	Increased OM content at soil surface. Woody mulch (e.g. tree trimmings) provides carbon source and favors fungal organisms. Most trees, shrubs, and perennials prefer fungal dominated soils and access nitrogen in the ammonium form.
	Promote Vegetation	Good	Roots assist with de-compaction of soil. Increases soil OM content, cycles nutrients, and provides habitat for organism life cycles. Use plants that build soil through root structures, leaf litter, nitrogen-fixing, etc.
SOIL DISTURBANCE	Rake soil surface; blow away leaves	Bad	Removes OM from system. Disturbs soil surface which may increase erodibility. Prevents stabilization of soil with vegetative cover.
	Frequently till or dig	Bad	Disturbs soil preventing soil structure formation which reduces presence of soil food web habitat. Increases erodibility of soil.
	Designate defined pathways for people and vehicles	Good	Concentrates soil compaction in fewer areas. If possible keep pathways permeable and use organic mulch.
SOIL AMENDMENTS	Apply herbicides	Bad	Inhibits ability for landscape to mature and stabilize vegetatively. May kill desirable plants. Adds harmful chemicals to environment.
	Use chemical fertilizer	Bad	Inhibits development of healthy soil food web by overwhelming soil with easily obtainable fertilizers and kills beneficial soil microbes. Generally chemicals should be avoided. Instead feed the soil not the plant by applying compost or mulch.
	Add sulfur, gypsum, other	Mixed	Depending on soil chemistry and production goals may or may not be helpful. Request advice from a soils expert.
	Inoculate with mycorrhizae	OK	Mycorrhizal inoculations occur naturally without the need for special products if soil conditions are set using good practices which promote soil health.
	Apply manure or compost	Good	Increases soil OM content; assists with development of healthy soil food web to stabilize cycling of nutrients. Increased OM assists with soil moisture retention and de-compaction of soil. Compost can be used to introduce, maintain, or alter soil food web by inoculating with beneficial microbes and life.
	Apply compost tea	Good	Compost tea (actively aerated) contains beneficial fungi and bacteria. In vegetable or fruit tree production more frequent applications may be desired.
WATER MANAGEMENT	Concentrate surface flows	Bad	Concentration of surface flows should be avoided as higher energy flows are erosive and less water infiltrates into soil.
	Promote gentle and spreading flow of water	Good	Promotion of shallow, spreading surface flows allows for greater infiltration potential and reduces soil erosion.
	Promote infiltration	Good	Infiltration areas should be promoted and maintained to increase soil moisture retention and storage for longer-term plant use.

Create Productive Soils with Free Resources & Cycle Your Trash!

CATEGORY	WASTE TURNED RESOURCE	RESOURCE BENEFIT	PROCESSING METHOD
Water	Rooftop Rainwater	Irrigation - mineral free	Passive or active rainwater
	Surface rainwater runoff	Irrigation of trees and shrubs	Infiltration / retention
	Greywater	Irrigation of fruit trees and shrubs	Distribution system with infiltration; not for vegetables or other plants with edible parts which contact water
Plant Materials	Leaf Litter	Fine organic material	Distributed as mulch layer / composted
	Tree or Shrub Prunings	Coarse organic material	Chipped or pruned to short lengths and distributed as mulch
	Cover crops	Green mulch	Use in vegetable gardens as a mulch layer, turned into soil, or composted
	Root mass	Fine organic material	Leave in place, no-till, grow corn, buckwheat, rye, etc
Waste Materials	Food waste	Organic material	Composted & applied as soil amendment
	Animal manures	Organic material/ fertilizer	Composted and/or applied as soil amendment
	Human manures	Organic material/ fertilizer	Composted and applied to soil amendment, not for use in most vegetable gardens
	Urine	Fertilizer (Nitrogen-Phosphorous-Potassium)	Diverted and diluted (at least 1:3) with water, applied to plant root zones; Caution: be careful with salt management and application
Other Materials	Newspaper	Carbon source. Use to balance with nitrogen. Once applied to soil allow a time lag to promote nutrient cycling by soil ecology.	Sub-surface mulch layer or shredded and composted
	Shredded Paper		Composted or cover source for composting toilet
	Sawdust		Composted or cover source for composting toilet
	Wood shavings		Composted or cover source for composting toilet
	Grain mash (brewing waste)	Food source	Chicken food/compost

Additional Resources

- Watershed Management Group, www.watershedmg.org/soil-stewards

Soil Health and Ecology

- Lowenfels, Jeff and Wayne Lewis, Teaming with Microbes
- Dr. Pavao-Zuckerman, University of Arizona's Biosphere 2 Assistant Research Professor, www.u.arizona.edu/~mzucker

Composting Toilets

- David Del Porto and Carol Steinfeld, The Composting Toilet System Book
- Drangert, J. 1998. Fighting the urine blindness to provide more sanitation options. Water SA. 24(2): 157-164.
- Ecosanres.org --> Jönsson et al., 2004. Guidelines on the Use of Urine and Faeces in Crop Production. EcoSanRes. Stockholm Environment Institute.
- Höglund, C. et al. 2002. Microbia risk assessment of source-separated urine used in agriculture. Waste Management and Research. 20: 150-161.
- Joseph Jenkins, The Humanure Handbook, http://humanurehandbook.com
- Brad Lancaster, www.harvestingrainwater.com/water-energy-carbon-nexus
- David Omick, www.omick.net
- Recode Oregon, www.recodeoregon.org/composting-toilets-in-oregon
- Rich Earth Institute, www.richearthinstitute.org
- U.S. Environmental Protection Agency. 1999. Water Efficiency Technology Fact Sheet, Composting Toilets. EPA 832-F-99-066.

Other

- U.S. Environmental Protection Agency, www.epa.gov/waste/nonhaz/municipal/msw99.htm