Soil

Exploring the relationship between biodiversity and soil management

Vetted by Riverside County Office of Education-STEM

Why Is This Important?

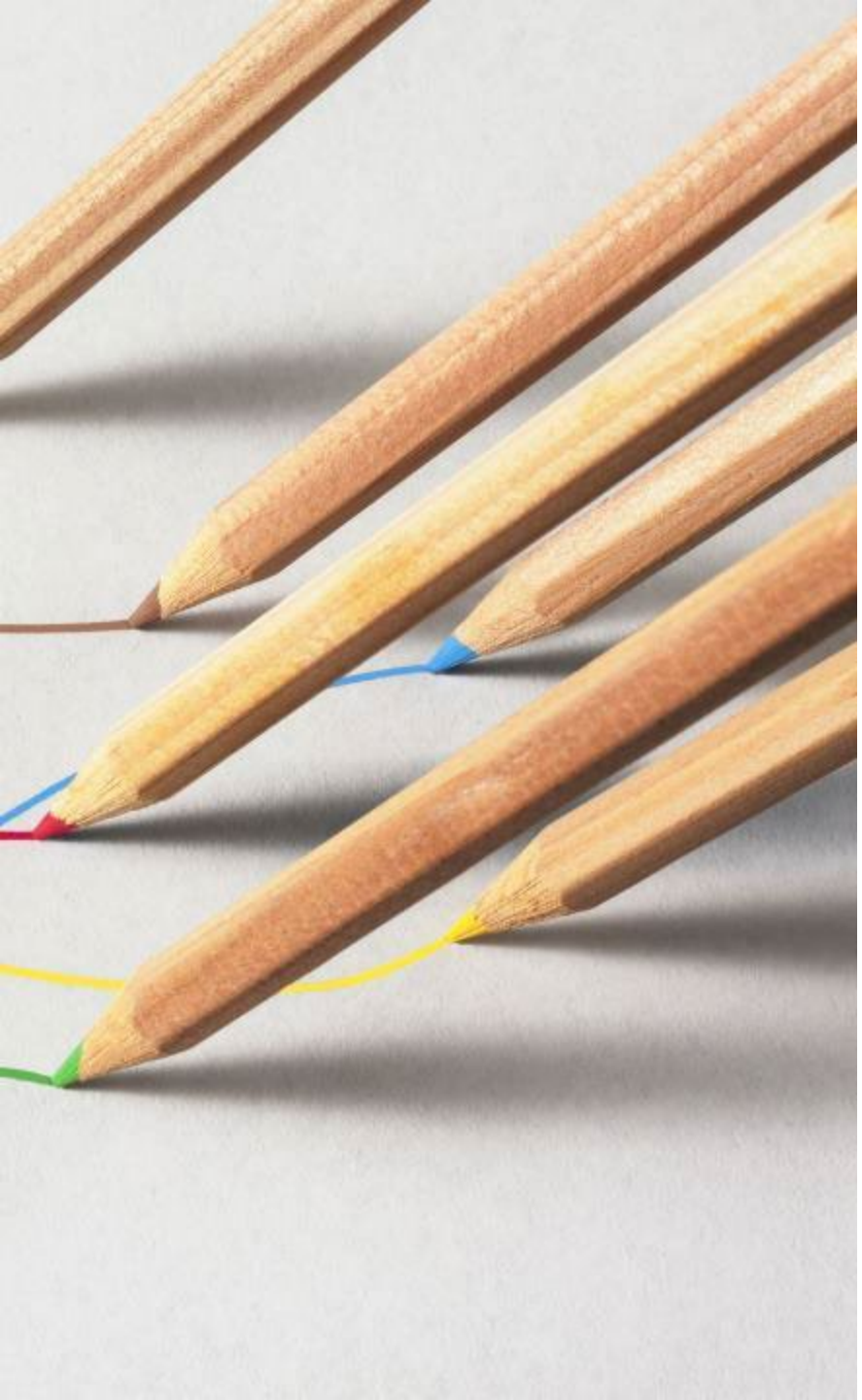
- Soil is the upper layer of the earth that may be plowed and in which plants grow. Depending on location, soil can be a few inches to more than 100 feet deep.
- Soil is a complex, dynamic natural material in which physical, chemical and biological reactions are constantly occurring.
- Soils harbor a substantial fraction of the world's biodiversity, contributing to many crucial ecosystem functions.

Learning Goals

Students will learn:

- The relationship between biodiversity in soil and the characteristics of healthy soil;
- How to evaluate the quality of soil and;
- Sustainable soil management practices.

Anchor Phenomena: Soil



Develop a Model To Describe the Phenomena

Draw a diagram demonstrating the phenomena of soil including both observable and unobservable details.

- Label all important parts of the diagram.
- Use arrows to show how all parts interact.
- Write an explanation describing soil.

Lesson One: Soil is a Living System

Healthy soil is a *living* system that includes:

45% Inorganic material: Mineral particles

25% Air

25% Water

5% Organic matter: ***Living organisms*** including roots, worms, microbes, and ***decomposing/decomposed organisms***

Biodiversity is defined as all the different kinds of life you will find in one area.

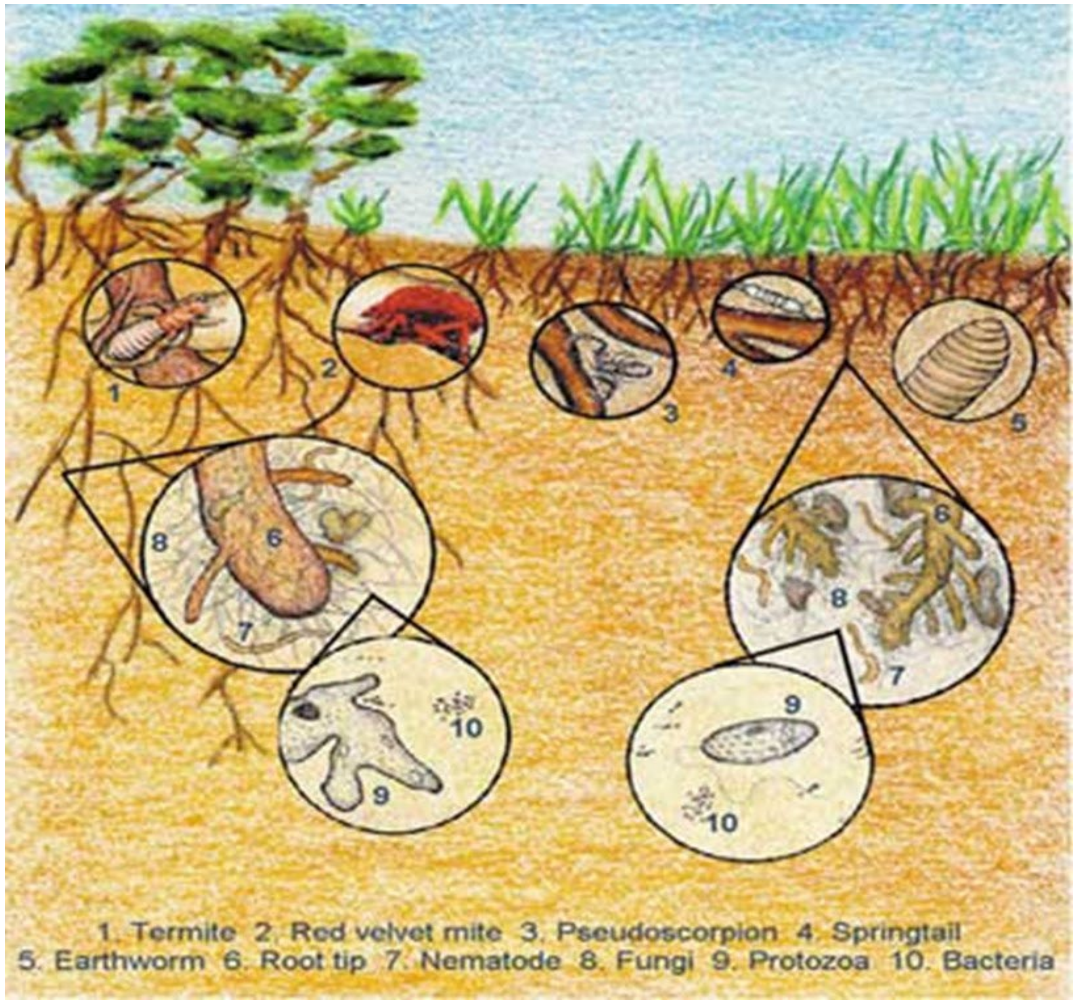
The **organic matter** – both living and decaying organisms- indicates the biodiversity of soil.

These Organisms Are the Foundation of an Interdependent Ecosystem: The Soil Food Web

The Soil Food Web *Continued*

The soil food web represents one fourth of all the world's biodiversity!

- Depending on the health of the soil, the soil food web will contain and support many different plants, animals, arthropods, earthworms and microorganisms.



A Closer Look at Microorganisms

- **Bacteria** are very important in the soil. Some are decomposers, others provide nutrients and others interact with nitrogen in the soil. *There may be as many as 5 billion in a teaspoon of soil.*
- **Protozoa** recycle nutrients by feeding on bacteria. *There are up to 5 million per teaspoon of soil.*
- **Fungi** bind soil together, decompose organic material, and may have symbiotic relationships with plants. *There may be as much as 20,000 km of fungi networks in a cubic meter of soil.*
- **Nematodes** Recycle nutrients by feeding on fungi, bacteria, plant roots, amoeba, and other nematodes. There are many different species, some attack crops, others are beneficial. *There may be many as 5,000 per teaspoon of soil.*

A Closer Look at Burrowing Creatures

- **Arachnides, mollusks, beetles, and ants** burrow and tunnel, loosening and turning over soil which mobilizes nutrients. Their excretions help to bind the soil. They break down organic matter and move it into the soil.

- **Larger species such as mice, rabbits, moles and gophers** turn over soil and loosen it for other organisms.

- **Earthworms** decompose smaller organisms when eating soil and their excretions bind the soil. Earthworms are considered an indicator species for soil health.

Video: Soil is Alive!

Check For Understanding

- What are the basic components of soil?
- What does biodiversity mean?
- Describe how soil is a living system.
- How are decaying organisms important to the soil food web?
- Select a soil organism and describe how it affects soil.

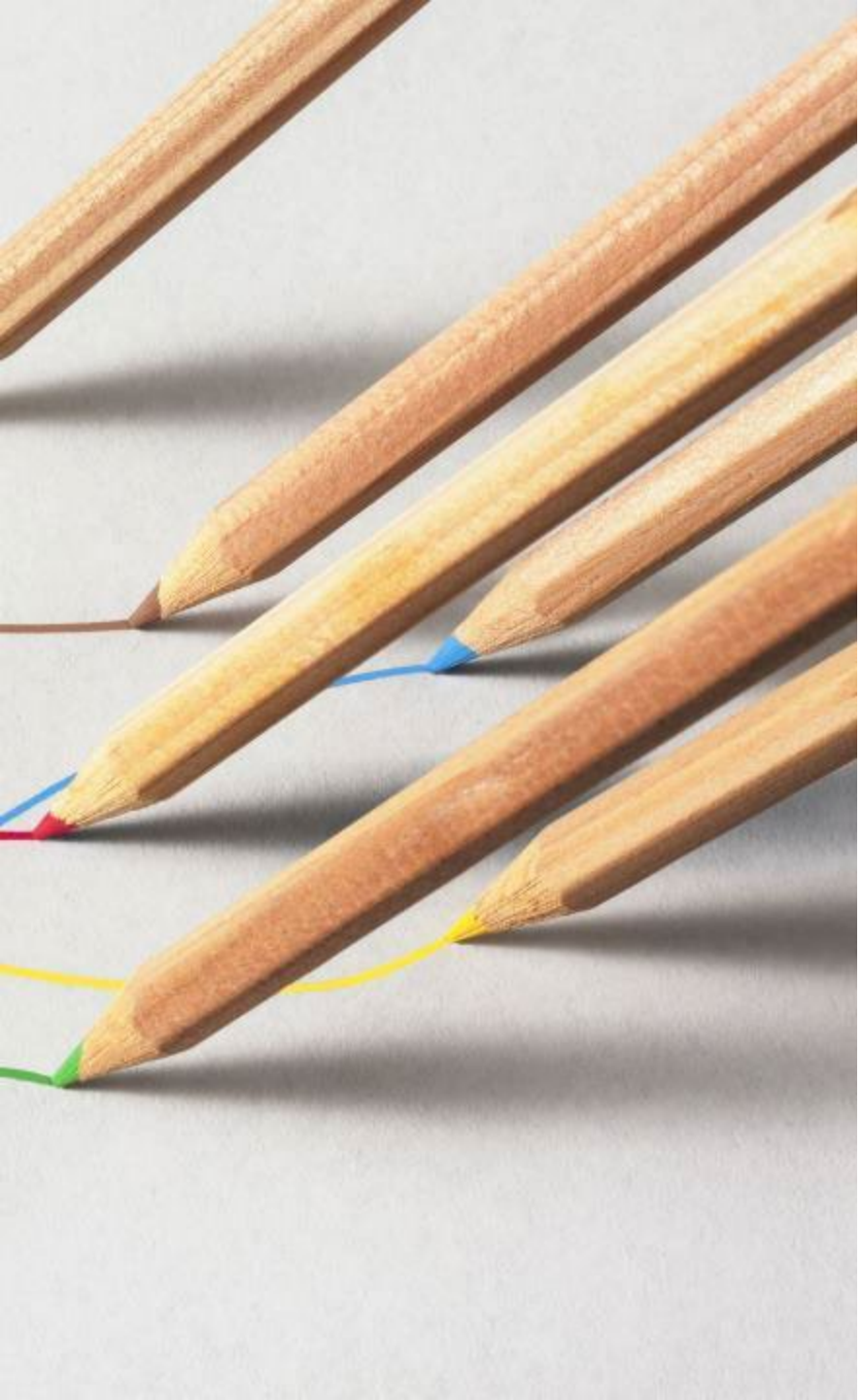
Phenomena in the Garden:

Explore the biodiversity of your soil by conducting a soil survey

1. Collect hand shovel-deep soil samples from several different locations on campus such as a garden bed, lawn area, a well-worn dirt path or playground field, and around trees.
2. Place each soil sample into a plastic bag and label the bag with the location from where the sample was taken.
3. Spread out one soil sample at a time on white butcher paper. Carefully sort through the soil and look for signs of **plant and animal life**. Use a magnifying glass to help find smaller creatures.
4. Record your observations on the Soil Survey Chart.
5. At the completion of your survey, return the soil and its organisms to your garden.

Soil Survey Chart

Location of Soil Sample	Name or Describe Each Living & Decaying Organism	Quantity Observed in Sample	Possible Effect on Soil



Develop a Model To Describe the Phenomena

Revise or draw a new model of soil to reflect what you have learned about this phenomena.

- Label all important parts of the diagram.
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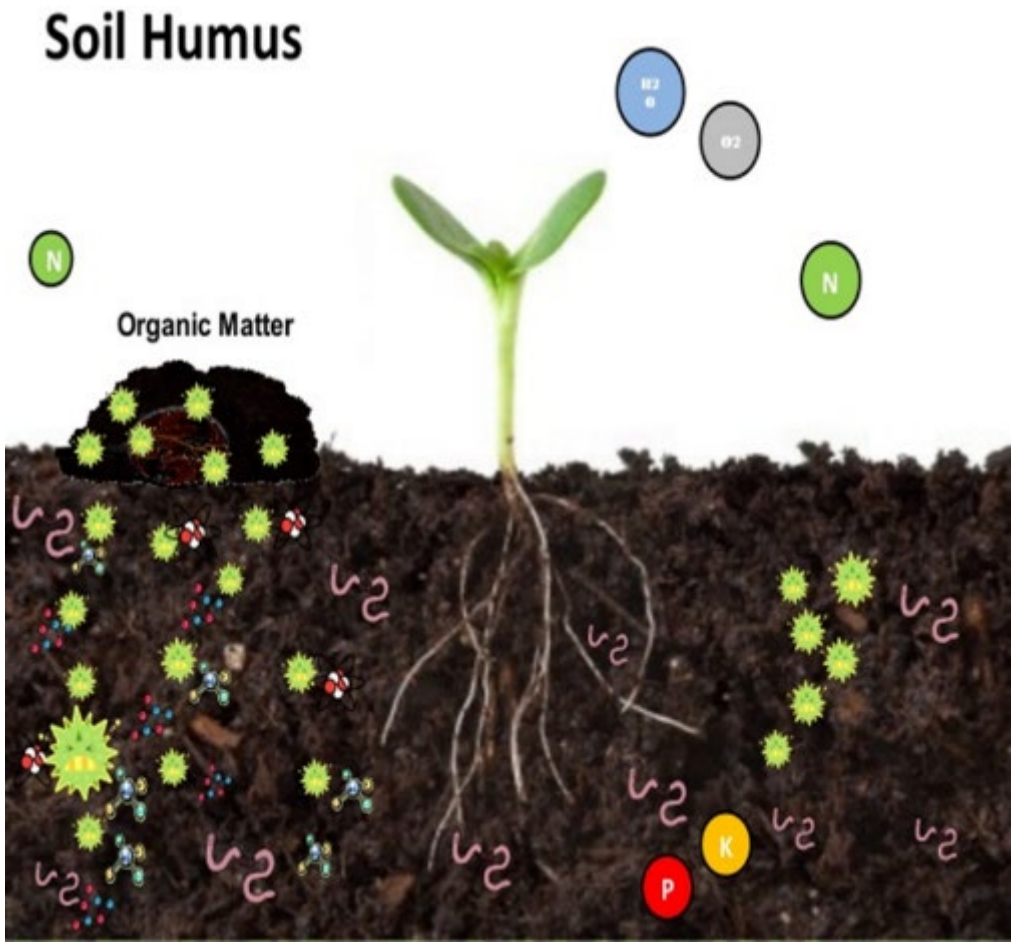
Lesson Two: Biodiversity and Soil Health

Organisms Help Maintain Healthy Soil

- Living soil organisms *decompose plant and animal materials*, slowly producing rich growing soil called **humus** which is highly resistant to further breakdown.
- Soil organisms *produce glues and filaments that bind tiny mineral particles* and humus together into soil crumbs.
- In addition, worms and other burrowing creatures *continuously open pathways for roots, air and water*.

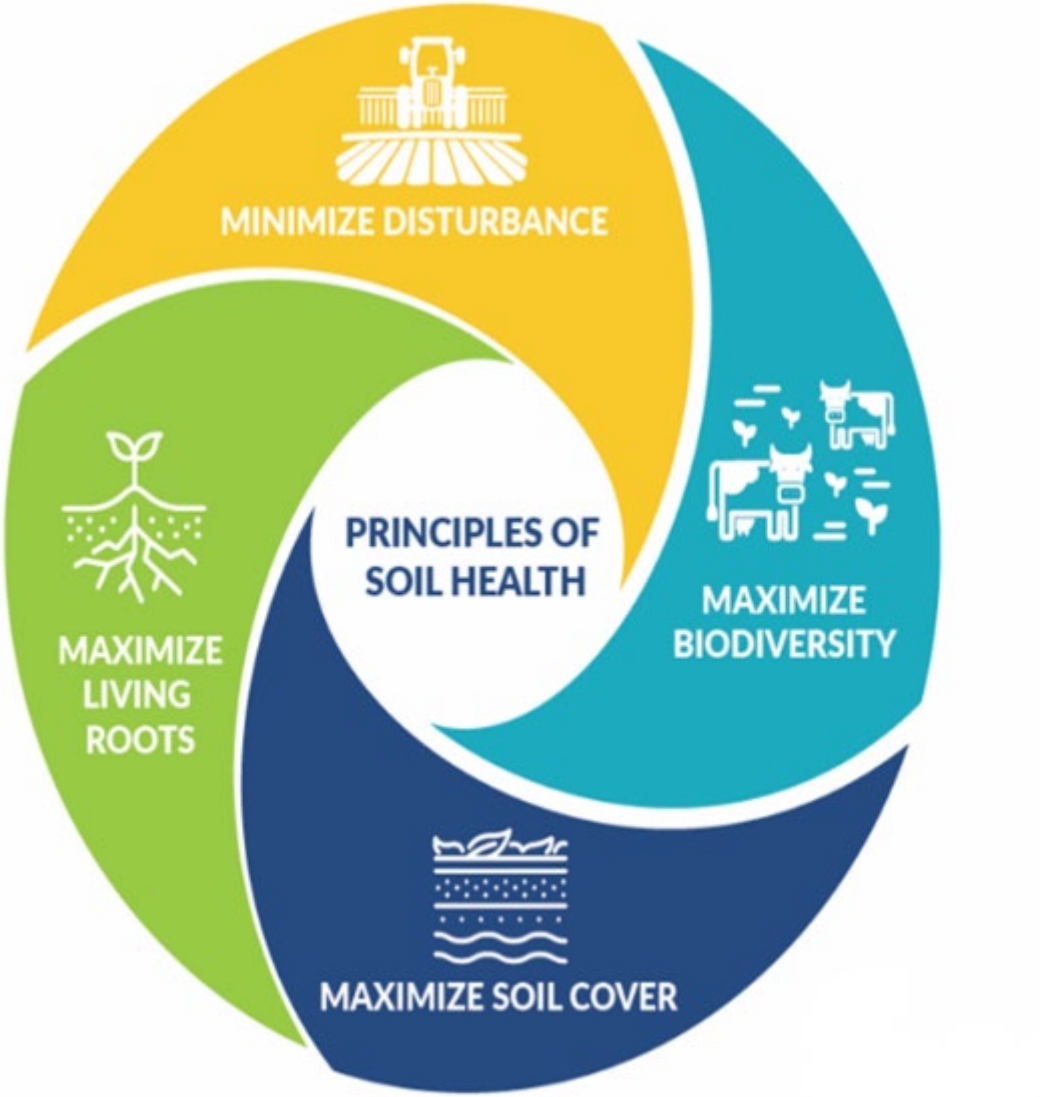


Video: Scientific Demonstration of Soil Health

- Most soil organisms are found in the **topsoil**, from 0 -10 cm, where the maximum amount of **carbon**, a main food supply, is found.
- **Excessive disturbance of topsoil destroys soil organisms** which results in less biodiversity in the soil food web and poor soil health.
- **Soil Scientist Ray Archuletta** demonstrates how disturbing the soil can affect soil health.

Keep Soil Organisms Alive!

- Keep these organisms alive and they will maintain your garden's soil structure, providing healthy soil that supports the soil food web.
- How do we do this? ***Follow the four principles of soil health.***



Minimize Disturbance

- Soil disturbance such as tillage can kill the organisms living in the topsoil.
- Decrease or eliminate the tilling of soil and you will increase the overall organic matter in the soil

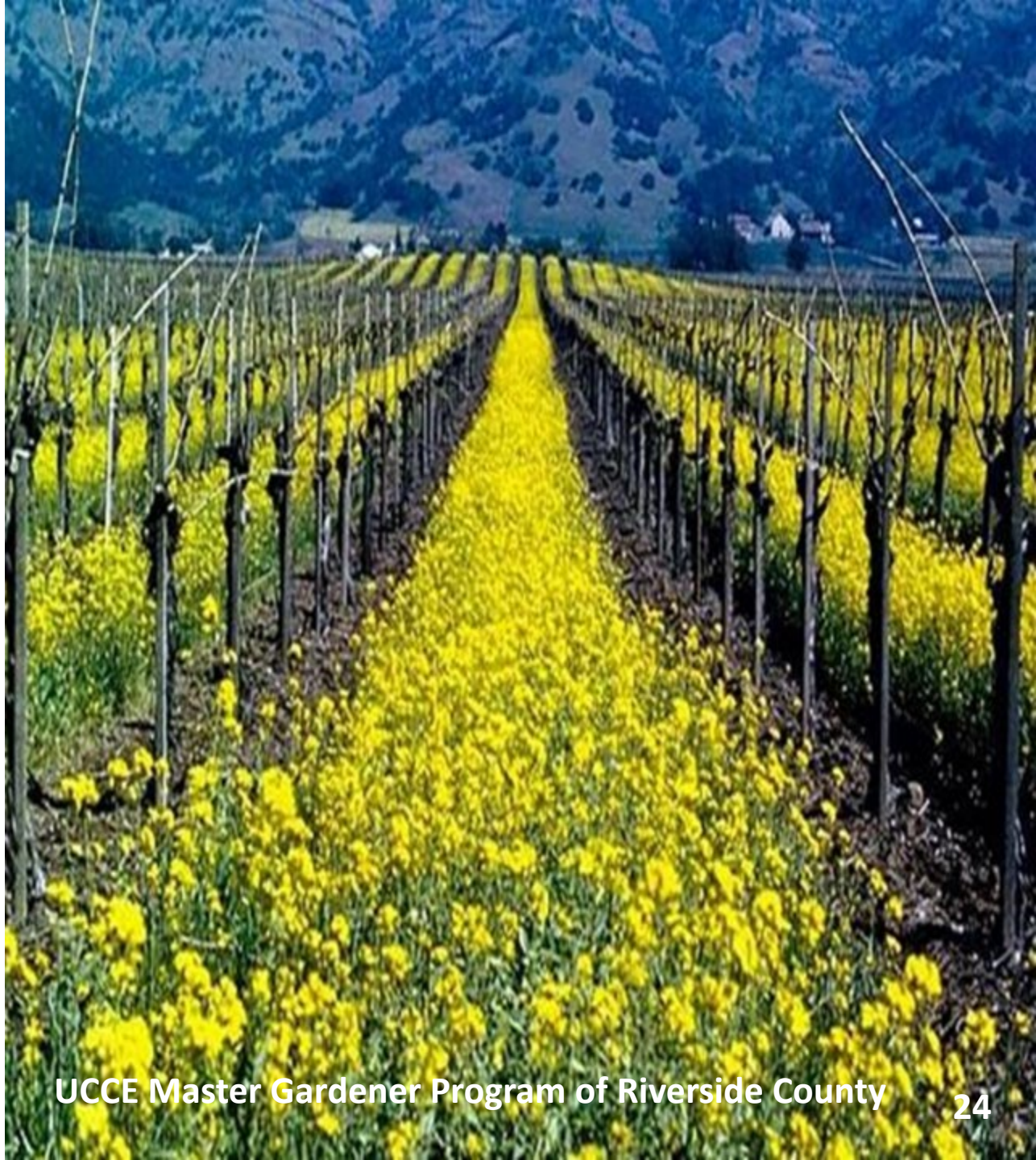
Maximize Biodiversity

- Increasing the variety of **plant species** in your garden will also increase the diversity of life living in the soil.

Maximize Living Roots

- Keep living roots growing throughout the year. Living roots provide the easiest source of food for soil microbes. This will feed the foundation species of the food web as much as possible during a growing season.

➢ Grow long-season crops
➢ Grow a cover crop following a short-season crop
➢ Practice the growing methods of interplanting and succession planting.

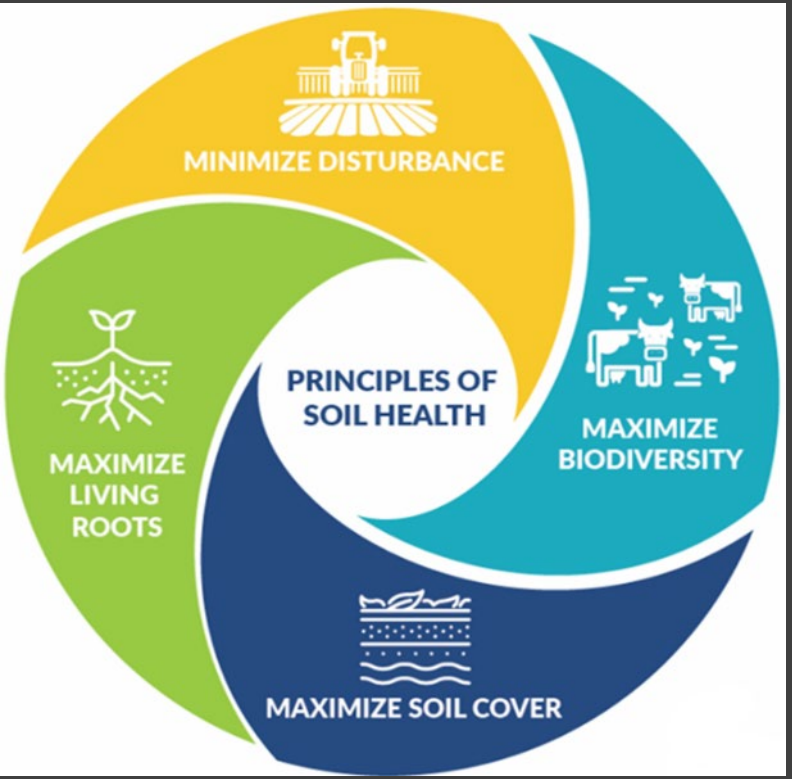


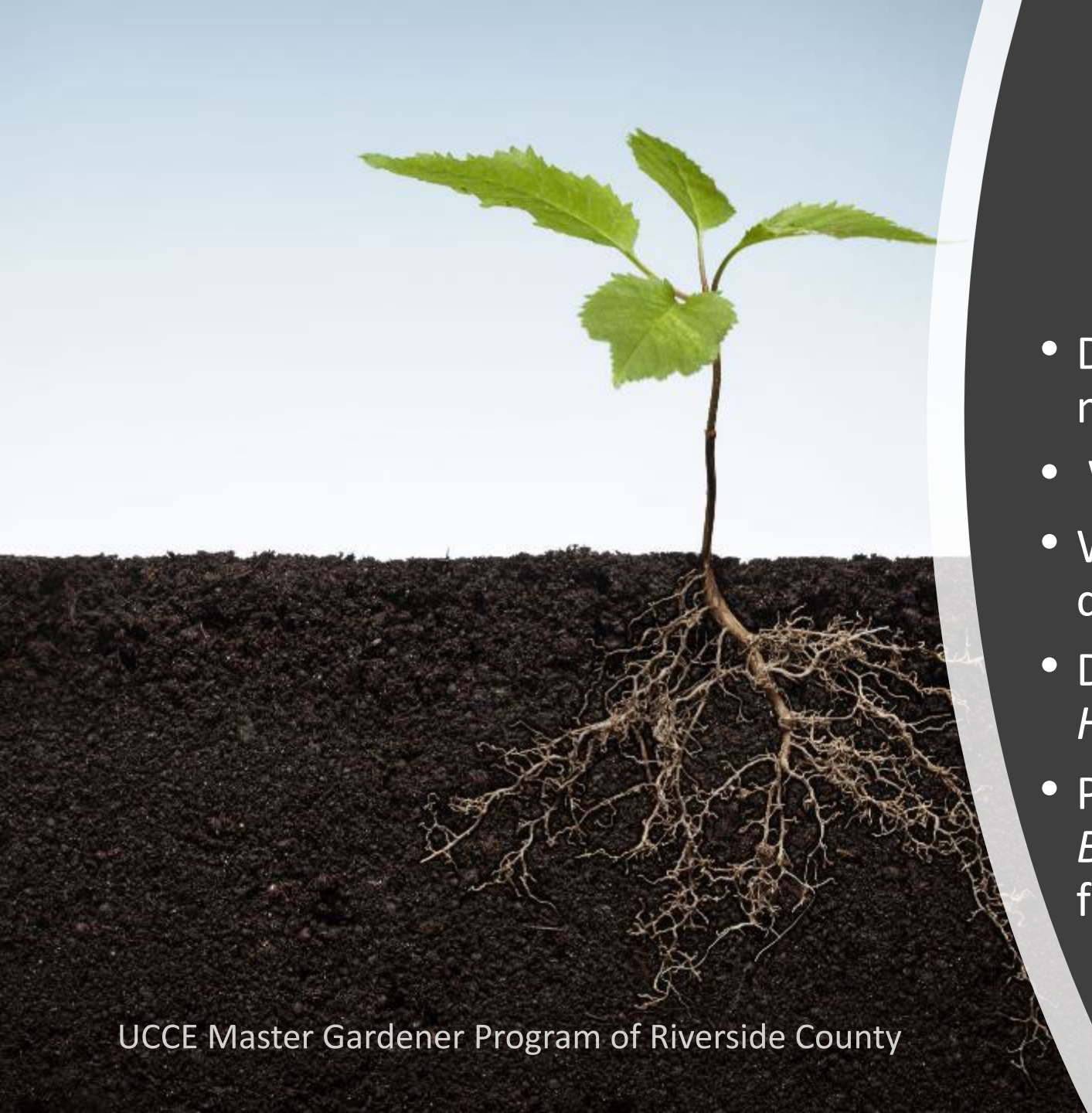
Maximize Soil Cover

- No bare soil! Mulch and compost will supply/recycle soil microbes and nutrients to feed the soil organisms.

Video: The Living Soil Beneath Our Feet

As you watch this video: Identify how nature follows the Four Principles of Soil Health





UCCE Master Gardener Program of Riverside County

Check For Understanding

- Describe one way soil organisms help maintain healthy soil.
- Where do most soil organisms live?
- What can happen to soil that has been disturbed?
- Describe one of the *Four Principles of Soil Health*.
- Provide an example from the *Living Soil Beneath Our Feet* video of how nature follows these principles.

Phenomena in the Garden:

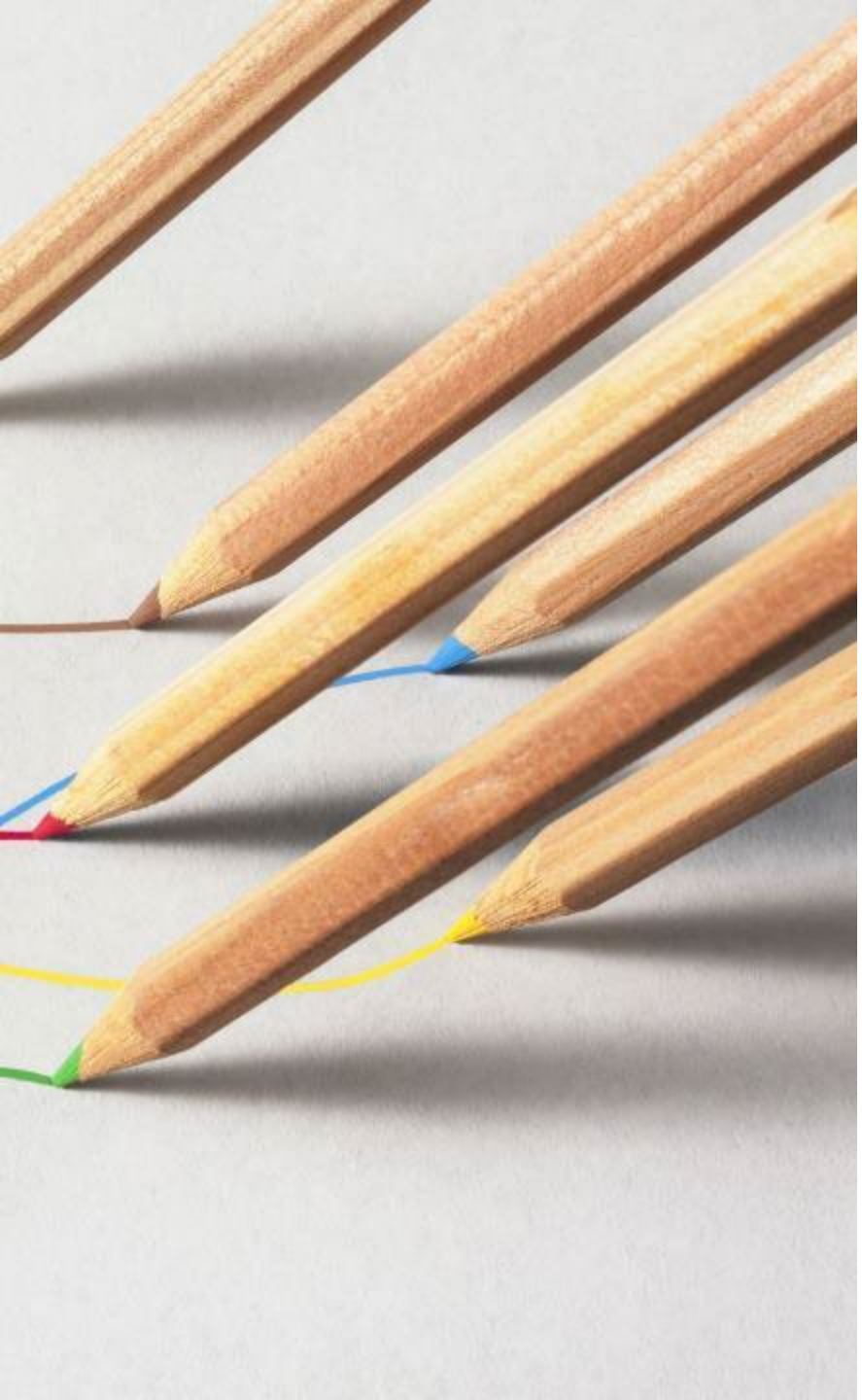
Does your school or home garden practice the Four Principles of Soil Health?

- Use the survey chart on the next slide to guide your garden observation.
- Record examples you observe of the Four Principles.
- Evaluate your data.
- Develop soil health recommendations for your garden based on this data.

Principles of Soil Health Garden Observation Data

Location Observed:

Minimize Soil Disturbance	**Maximize Plant Biodiversity**	**Maximize Living Plant Roots**	**Maximize Soil Cover**
Provide brief examples	Provide brief examples	Provide brief examples	Provide brief examples



Develop a Model To Describe the Phenomena

Revise or draw a new model of soil to reflect what you have learned about this phenomena.

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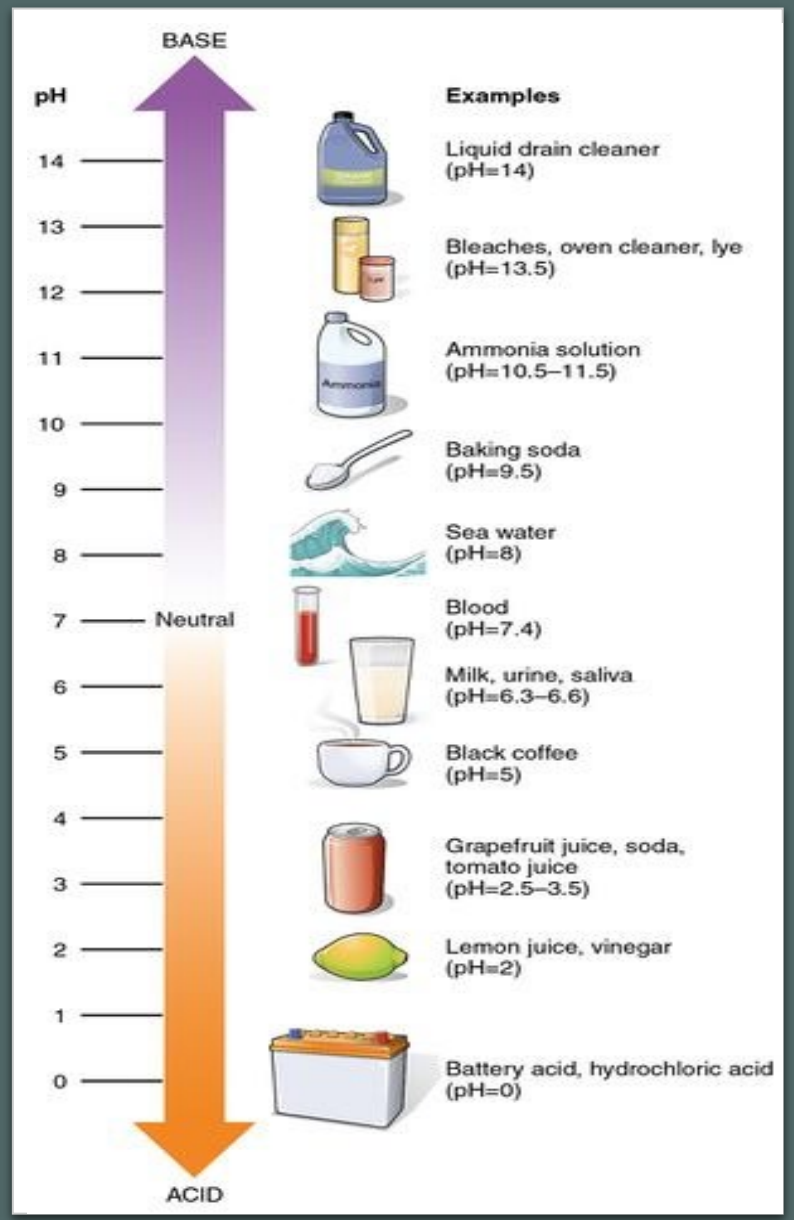
Lesson Three: Understanding Your Soil's pH

Where chemistry and biology meet to support soil health



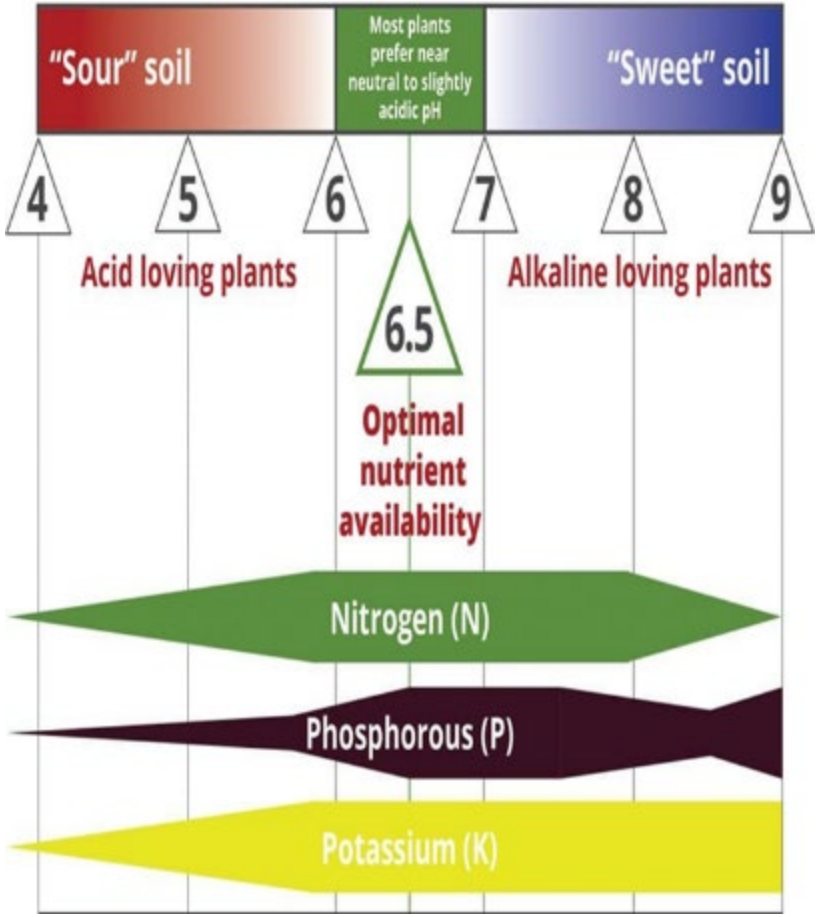
What is pH?

pH (potential of hydrogen) is a notation used to express where a substance falls on an acidity scale of 0-14.

- More acidic solutions have lower pH. Some substances, like lemon juice, are acids. **Acids** have a *sour* taste.
- More alkaline solutions, have higher pH. Substances, like aspirin, are alkaline which are also called bases. **Alkalines** have a *bitter* taste.
- Substances that are neither acidic or alkaline (base) are said to be **neutral**.

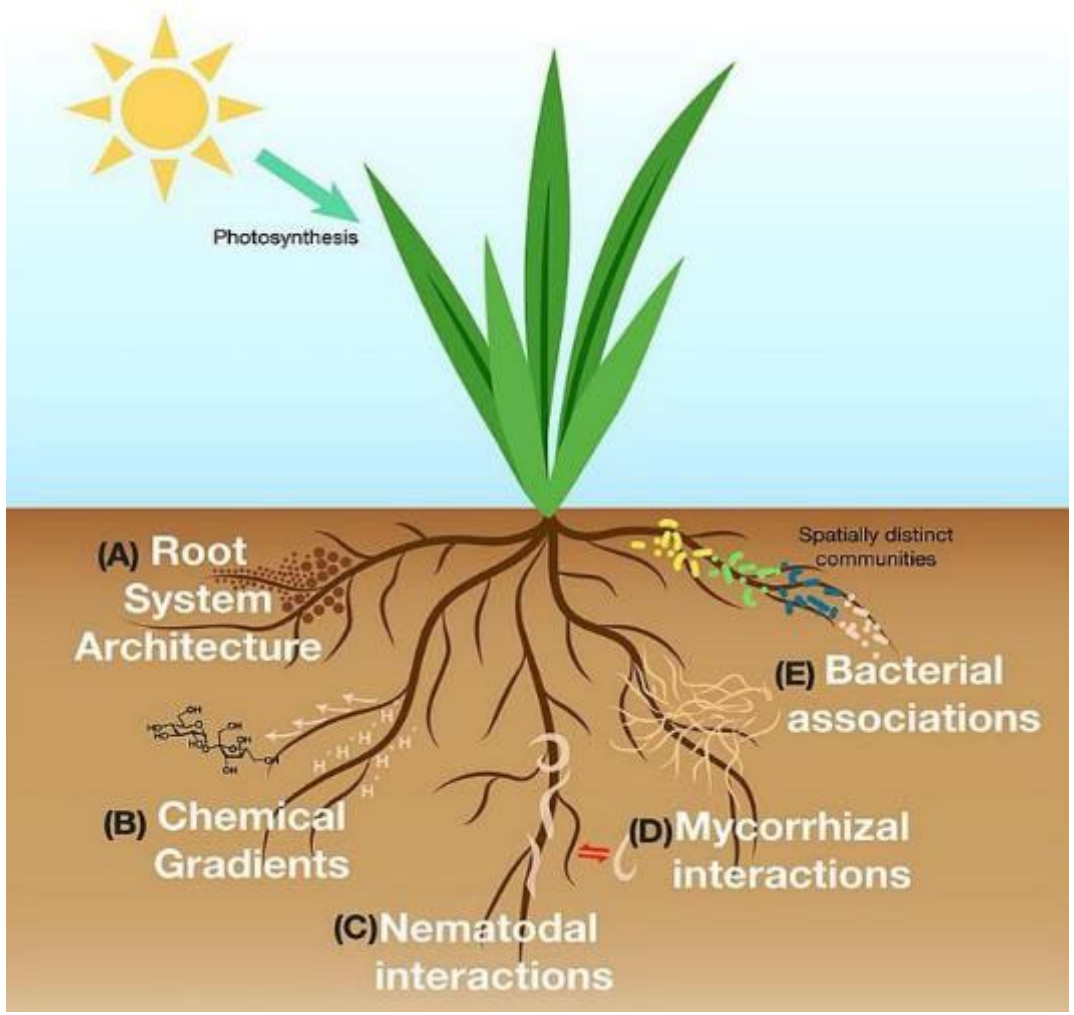
Why Is Knowing a Soil's pH Important?

- Soil pH is the measure of the acidity (sourness) or alkalinity (sweetness) of a soil.
- Soil pH has a critical influence on a soil's biology, chemistry and physical processes.
- This means it has a direct impact on the health of plants and other soil organisms.
- **Generally, the pH range 5.5–6.5 is optimal for plants and most soil organisms.**



Soil pH *Continued*

- In the optimal 5.5-6.5 pH range plants grow well and produce more root **exudates** (fluids) as a carbon.
- This carbon is an important source for survival and multiplication of microorganisms.



How Do You Measure a Soil's pH?

- A **pH indicator** is a chemical compound added in small amounts to a solution so the pH (acidity or basicity) of the solution can be seen.
- The pH indicator is a chemical detector for hydronium ions (H_3O^+) or hydrogen ions (H^+). The indicator causes the color of the solution to change or the meter arrow to move depending on the pH level in the soil sample.

Weeds may also serve as soil pH indicators!

- Some weeds, such as sorrels, docks, dandelions, and Queen-Anne's- lace, grow in poor, **acidic soils.**
- Other weeds, such as mustards and thistles, are often found in very **alkaline soils.**

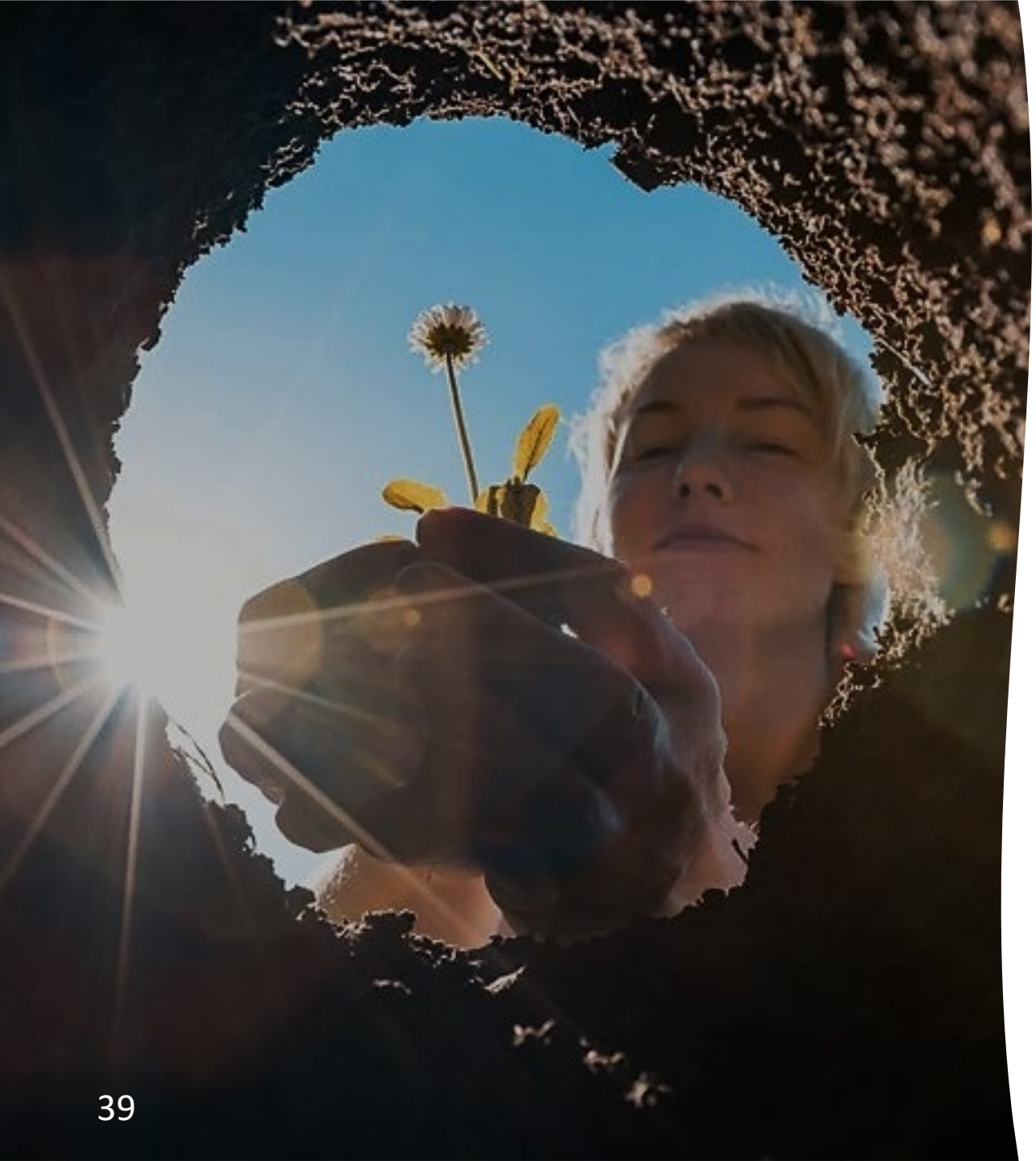
If you have these weeds growing in your garden, change the soil pH, and many of these weeds may leave on their own!

How do you change the pH of the soil?

You can add natural substances to the soil to make it less or more acidic.

- Add lime or wood ash to acidic soils to make the soil **less** acidic.
- Add sulfur or peat moss to alkaline soils to make the soil **more** acidic.
- The PDF Adjusting Soil pH in the Garden provides guidance on how to appropriately apply these materials to your soil.

Video: Demonstrating pH Testing



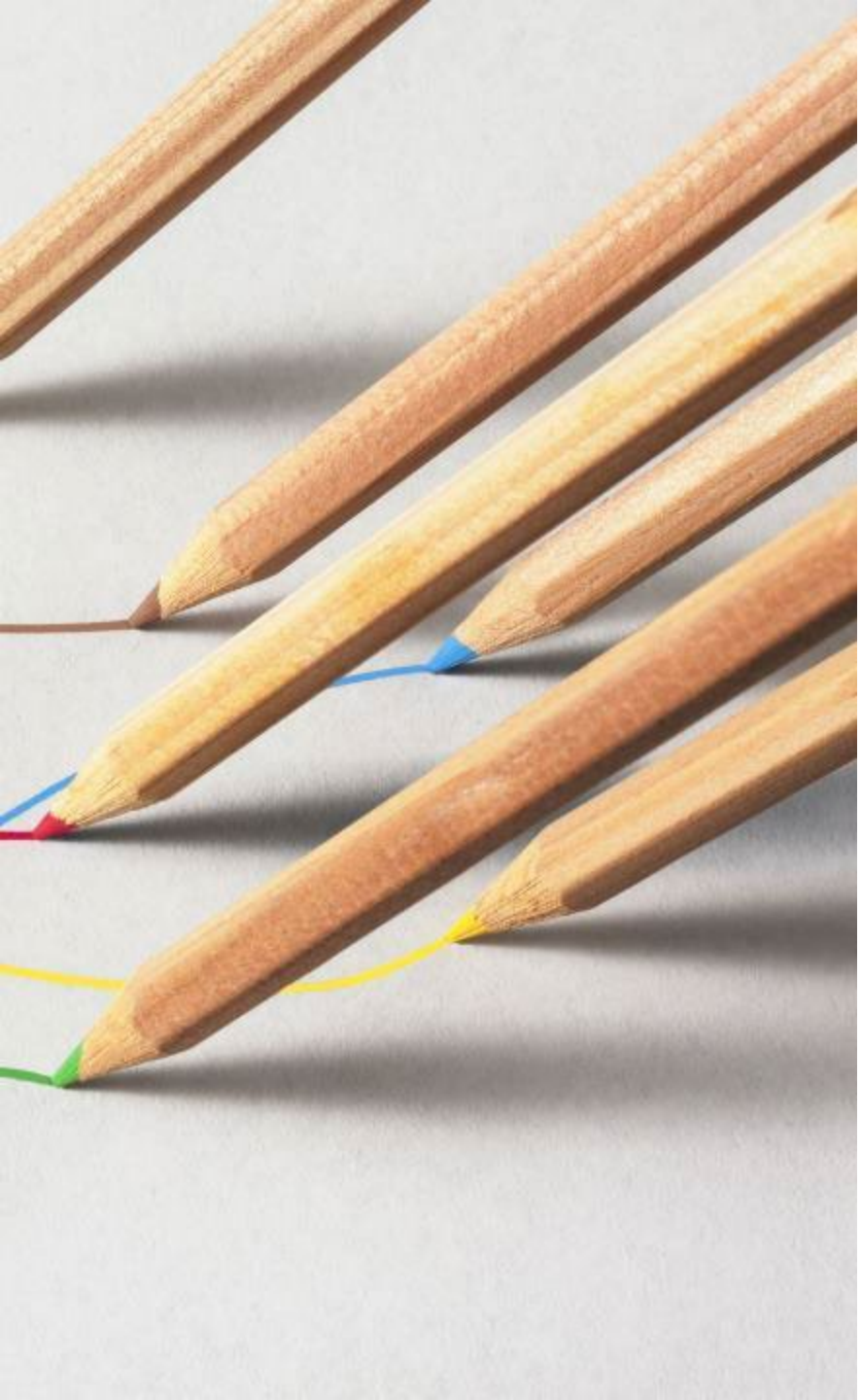
Check for Understanding

- What is pH?
- What is the optimal pH range for plants?
- Why is it important to know a soil's pH?
- What scientific tools can you use to measure soil pH?
- How can you improve a soil's pH?

Phenomena in the Garden: *What is your garden's pH?*

Identify the pH level of the soil in each of your garden beds.

- Use a pH meter or a kit using dyes to measure the pH in each planting bed.
- For accurate results, be sure to use **distilled water** when testing the soil. Faucet and drinking water contain minerals that could affect the accuracy of the soil pH results.
- Is the soil in the optimal range for plants and soil organisms?
- If not, what actions will you take to improve the soil's pH?



Create a Final Model To Describe the Phenomena

Draw a new model of soil to reflect what you have learned about this phenomena.

- Label all important parts of the diagram.
- Use arrows to show how all parts interact.
- Write an explanation describing soil.

Extend Your Thinking: *Vermiculture*

Follow nature's example of using decomposers to recycle nutrients from decaying or dead organic matter to enrich your garden's soil health.

Vermiculture is a process that uses worms to recycle food scraps and other organic material into a valuable soil amendment called vermicompost or worm composting.

- **Watch this video:** Kids Should See This!
- **Read these directions:** Worm Composting

Next Generation Science Standards

MS LS2.A: Interdependent Relationships in Ecosystems

Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1)

MS LS2.B: Cycle of Matter and Energy Transfer in Ecosystems

Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)

Next Generation Science Standards

MS LS2.C: Ecosystem Dynamics, Functioning, and Resilience

Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4) ▪ Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)

Next Generation Science Standards

Science and Engineering Practices

- Develop a model to describe phenomena. (MS-LS2-3)
- Analyze and interpret data to provide evidence for phenomena. (MS-LS2-1)

Crosscutting Concepts

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1)
- Energy and Matter -The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3)
- Stability and Change- Small changes in one part of a system might cause large changes in another part. (MS-LS2-4),(MS-LS2-5)

Career Technical Pathway Standards: Agriculture and Natural Resources

- G7.1 Plan how to effectively manage and conserve soil through conventional, minimum, conservation, and no-tillage irrigation and through drainage and tillage practices.
- G6.2 Analyze soil properties necessary for successful plant production, including pH, electrical conductivity (EC), and essential nutrients.
- G6.3 Explain soil biology and diagram the cycles in nature as related to the soil food chain.

Resources

- California Master Gardener Handbook, Second Edition 2015
- Healthy Soils-Basic; and Healthy Soil and Soil Basics; UCANR
- Healthy Soils and Carbon Farming: Soil Biology June 20, 2012; Rural Solutions SA
- Humus; Soil Ecology Wiki; buffalo.edu
- Natural Resources Service; USDA
- Soil Food Webs PowerPoint; Amanda Hodson, PhD; UC Davis
- Sustainable Gardening Practices; Contra Costa County UC Master Gardeners
- Sustainability at the US Botanic Garden; US Botanic Garden
- The Real Dirt Blog; Butte County UC Master Gardeners
- What is Healthy Soil?; Marin County UC Master Gardeners

Resources

- Lessons and Activities; Soil Science of America
- Wikipedia
- Images: Buffalo.edu; Creative Commons; EIP-Agri; kiddle.com; Stock Images; USDA
- Videos: Buz Kloot; California Academy of Sciences; Grow Organics; Sci Show Kids; TKSST

Master Gardeners

The University of California Cooperative Extension (UCCE) Master Gardener Program (MGP) is an educational program designed to teach and effectively extend information to address home gardening and non-commercial horticulture needs in California.

UCCE is the outreach arm of UC's division of Agriculture and Natural Resources (ANR). Master Gardener volunteers (MG volunteers) promote the application of basic environmentally appropriate horticultural practices through UCCE-organized educational programs that transfer research-based knowledge and information.

University of California
Agriculture and Natural Resources
UCCE Master Gardener Program

Gardening Questions?

- Email or Call the UCCE Master Gardeners of Riverside County
- Email Helpline
  - anrmgriverside@ucanr.edu
- Riverside Master Gardeners Website

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