

Class 1

An Overview of Bay-Friendly Gardening and Building Healthy Soil

Bay-Friendly Gardening: From Your Backyard to the Bay

In the San Francisco Bay Area, what you do in your garden – from applying fertilizer to planting a lawn – affects the larger local environment. When water runs off your property and into the storm drain rather than seeping down into healthy, living soil, it carries sediment, automobile pollutants, and toxic garden chemicals directly into the Bay.

When plant trimmings, weeds, and grass clippings are hauled away from the garden, even for municipal or commercial composting, the soil is essentially stripped of the minerals and nutrients it gave up to the plants during months, or even years, of vegetative growth.



Overwatering causes runoff into waterways and the Bay

Bay-Friendly Gardening is both a philosophy and a practice of gardening that is mindful of the *watershed* (the area of land that water flows across or through on its way to a creek, river, bay, or ocean), the *waste shed* (the area of land that garbage travels across on its way from its source to the landfill), and the *food shed* (the area of land that food travels across on its way from the field to the table).

Bay-Friendly Gardening considers the larger local environment: how water moves from the garden to the Bay, how waste moves from the garden to the landfill, and where food originates, how it is grown, and how far it travels. Bay-Friendly Gardeners restore health and life to the environment by re-using plant materials on site through various methods of nutrient recycling, capturing and preserving water in the garden, and supporting (and sometimes participating in) local food production.

“Thinking globally and acting locally” is an idea that’s been around awhile. Bay-Friendly Gardening is a way to take action in our immediate environment while considering the impact of our actions in a larger context.

For example, our ever-increasing reliance on trucking and hauling, and the fossil fuels to run them, takes a harsh toll on the environment. Large quantities of fuel are required to remove waste from our yards and to bring in soil amendments and fertilizers, and even to bring food in to our neighborhoods from far-away places.

Returning plant debris to the soil, as mulch or compost, in our home gardens, instead of hauling it away, is critical to protecting our watershed, conserving landfill space, and restoring nutrition to the food we grow and eat. The continuous recycling of organic matter is the way nature does it, and we have only to imitate that wisdom.

The 7 Benefits of Bay-Friendly Gardening

Bay-Friendly Gardening reduces pollution to the Bay and to the local landfills by preventing waste in the first place, building healthy soil, and reducing water runoff. The seven benefits of Bay-Friendly Gardening are to: Contribute to a Healthy Community, Reduces Waste in the Garden, Builds Healthy Soil, Conserves Water, Saves Energy, Protects Local Watersheds and the Bay, and Create Wildlife Habitat.



1. CONTRIBUTE TO A HEALTHY COMMUNITY

Bay-Friendly Gardening recognizes the fact that we need to employ sustainable practices

to maintain the health of ourselves, our families, pets, and local flora and fauna. Producing year-round edibles, reducing the use of toxics, and using our garden spaces as a model for neighbors, friends, and family are some ways we can contribute to a healthy community.



2. REDUCES WASTE IN THE GARDEN

Reducing waste starts with not generating waste in the first place. Selecting the right plants for the right place, as well as watering, pruning, and fertilizing judiciously are important ways to reduce organic waste, while minimizing harmful impacts on the environment. Grasscycling, composting, pruning selectively and properly, and using plant trimmings as mulch improves soils, creates healthier gardens, and keeps materials out of local landfills.

Knowing more about the plants we choose before buying and planting them allows us to select plants that can grow to their natural size in our gardens and to give them enough space to fully mature. Hedge shearing, as an example, is a senseless, endless cycle of activity that essentially confines a plant in too small a

space – with the result being a never-ending stream of plant debris going to the landfill.

Salvaged materials can be used creatively in the Bay-Friendly Garden. Finding and using them takes time and ingenuity, but in the long run, salvaged materials can save money and add interesting elements to the garden design. Recycled-content materials, such as plastic or composite lumber, make very durable decks or raised garden beds that do not rot, crack, or splinter.



3. BUILDS HEALTHY SOIL

The foundation, really, of Bay-Friendly Gardening is the proper care of our garden soils and the soil inhabitants. It is based on the principle of feeding the soil, not the plant, in order to encourage a thriving community of microorganisms, worms, and other beneficial creatures. Soil that is teeming with life stores and cycles nutrients, protects plants from pests, improves water infiltration and storage, and filters out urban pollutants. Composting, mulching, and grasscycling are essential practices for building healthy soil.



4. CONSERVES WATER

California's climate includes long, dry summers and unpredictable and sporadic winter rains. Water is a precious and often scarce resource in this arid part of the world.

With current population growth projections, it is estimated that by year 2020, the state will face annual water shortages, even during years of regular rainfall. Yet, many home gardeners choose plants that require more water than our local climate provides. Water-greedy lawns are a staple of the American home and are deeply ingrained in our national psyche.

Irrigation of home gardens accounts for more than one-fourth of all urban water use. Shockingly, much of this water is used in excess or at the wrong time of the year or day: residential properties are regularly over-watered by 30 to 40%.

Bay-Friendly Gardening is water-wise gardening. But, it is much more than simply controlling irrigation. It also means increasing the water holding capacity of the soil, planting appropriately for the site and the climate, minimizing the lawn, grouping plants according to water need, and collecting and recycling rain water.



5. SAVES ENERGY

The need to conserve energy is as important to Bay-Friendly Gardening as is the need to conserve water. Both are increasing concerns in California, as energy shortfalls and droughts continue to occur throughout the seasons.

Conventional gardening practices require the excessive consumption of fossil fuels – for transportation, hauling, and to run power equipment. Nationally, 40 million lawnmowers consume 200 million gallons of gasoline per year, representing a huge investment of energy for this one gardening task.

Bay-Friendly Gardeners conserve energy by planting trees appropriately, shading paved areas and air conditioners, designing outdoor lighting carefully, using hand-powered tools and equipment whenever possible, and supporting local suppliers of garden products to reduce trucking costs.

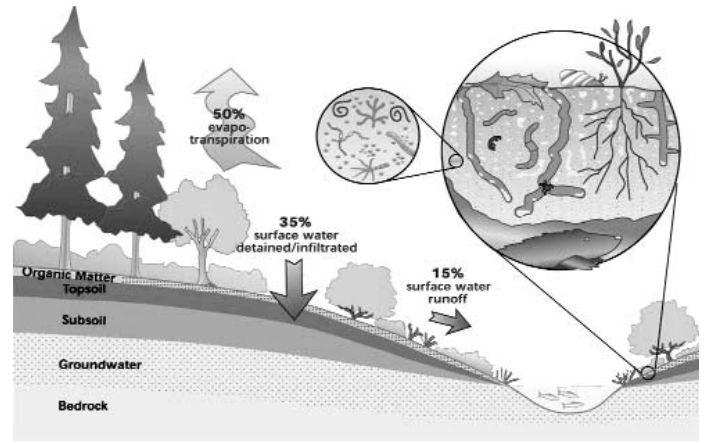


6. PROTECTS LOCAL WATERSHEDS AND THE BAY

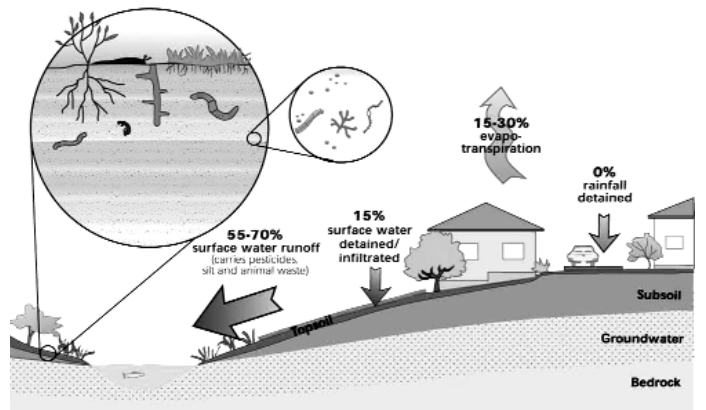
Bay-Friendly Gardening helps to protect the local watershed from pollution by increasing the soil's ability to hold and absorb water (through proper care of the soil), thereby increasing water infiltration in the garden, reducing runoff, and utilizing the soil's remarkable ability to remove contaminants from water before it enters the underground and above-ground water drainage systems.

In an undisturbed landscape, only 15% of rainwater leaves the system through surface water runoff. More than 30% moves into the soil where living, biologically diverse organisms break down and filter out pollutants before it reaches groundwater or our local waterways. As land is developed into residential or commercial landscapes, roads, and parking lots, major changes occur. More water runs off the surfaces – as much as 70% – without moving through soil. The soil supports less microbial life and is less able to filter harmful chemicals out of the little water that infiltrates and moves through soil.

Flash floods and erosion follow this development, and pollutant loads to the Bay increase. Bay-Friendly



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In a disturbed landscape, more water runs off the surface – as much as 70% of all rain and irrigation water runs into our waterways without moving through soil.

Gardening reverses this damage by building up the first line of defense, the soil.

Bay-Friendly Gardening practices – building healthy soil, creating a biologically diverse environment, and using **integrated pest management** (using beneficial insects and environmentally-friendly gardening practices to minimize the use of pesticides) – also reduce, or eliminate altogether, the need for toxic chemicals, benefiting water quality and the overall health of the watershed.

In addition to water quality protection, Bay-Friendly Gardening helps to protect our air from pollution by reducing fossil fuel consumption, recycling plant debris on site, minimizing the use of toxic pesticides and herbicides, and planting trees which remove carbon dioxide from the air and absorb air pollutants.



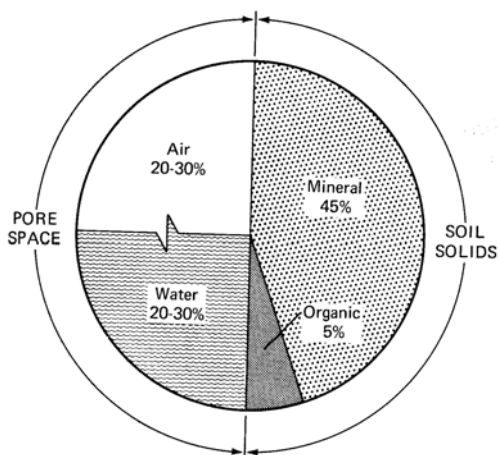
7. CREATE WILDLIFE HABITAT

Plant and animal diversity is one of the many factors that make the San Francisco Bay Area unique and beautiful. Biological diversity is crucial to the health and resilience of any *ecosystem*. More than 1,500 local plant species bloom throughout the year, supporting hundreds of native pollinators, beneficial insects, and other organisms that can reduce the need for pesticides in the home garden.

As the population of the Bay Area continues to grow, development increases, with a negative impact on wildlife habitat. This loss of *native habitat* threatens the *biodiversity* on which life itself depends. The Bay-Friendly Gardener can play an important role in restoring ecological diversity by creating landscapes that provide food, water, shelter, and nesting sites for birds, butterflies, beneficial insects, and other local wildlife.

Start from the Ground Up

We will see later on that good planning and design, tied to the basic principles, is central to Bay-Friendly Gardening, whether you're starting from scratch or filling in an existing garden. Yet, no matter how or where you jump in to make your garden more Bay-



Minerals: Non-Living Components

Friendly, everything always begins and ends with the soil.

Bay-Friendly Gardeners, first and foremost, build soils that are teeming with life. Living soil decomposes and digests spent plant material quickly, recycling important plant nutrients in the process. Soils softened and fluffed with organic matter absorb and retain much of the rain water, as well as filtering out pollutants, before the water reaches the groundwater or washes into the storm drain.

Healthy, alive soil creates healthier plants by giving them the full vitality, nutrition, and biotic potential held in the dark, damp depths. By treating the soil as a living system, Bay-Friendly Gardeners mimic nature and understand the wisdom and efficiency of keeping nutrients cycling continuously on site.

So then, what exactly is soil?

What is Soil?

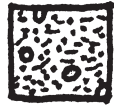
Soil is a complex ecosystem. It is composed of living and non-living materials – minerals, organic matter, water and air that are intimately mixed and subject to sometimes great fluctuations. Though the soil comprises a very thin layer on the Earth's surface – in fact, if the Earth were a tomato, the soil layer would be as thick as the tomato skin – it provides plants with the support, nutrients, water, and air necessary for all life.

For millions of years, wind, rain, ice, intense heat, gravity and chemicals have carved away at the Earth's crust. As water in and around rocks freezes and thaws, the rocks are broken down into smaller and smaller particles. As rivers and streams rush downhill, they carry away these bits and pieces of the Earth's rocky surface. During the Ice Age, heavy glaciers crushed rocks and other materials such as shells into fine particles, carried them thousands of miles, and then deposited them as the glaciers melted.

The particles of rock resulting from this weathering vary in size and kind. They range in size from large, coarse *sand* particles to *silt* to fine *clay* particles. The relative proportions of clay, silt, and sand determine soil texture. Soil texture has a critical influence on water and nutrient retention and movement through



Sandy Soil



Clay Soil



Silty Soil



Loam

the soil, as well as the circulation of air through the soil.

SAND: These are the largest, coarsest soil particles, .05 to 2 mm diameter. The pore spaces between sand particles are large, allowing water and nutrients to drain through very quickly. Soils with a high proportion of sand feel gritty and crumble easily.

CLAY: Clay particles are extremely fine and cling together, <.002 mm

diameter. Because of the very small pore spaces, water moves through very slowly. Because of the many small particles, there is a great deal of surface area to which nutrients can adhere. Soils with a high proportion of clay – like most East Bay soils – feel heavy and slippery, will compact into a tight ball when wet, and are hard and nearly impenetrable when dry.

SILT: Silt particles are in between the sizes of sand and clay particles, .002 to .05 mm diameter. Their other properties also lie somewhere between the previous two. Silty soils tend to be productive and friable. Silt feels silky, like talcum powder.

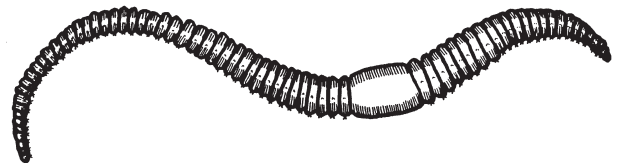
Soil Organic Matter

Organic matter is the fraction of the soil that originates from living organisms. It is a combination of living organisms and the non-living plant and animal residues in various stages of decay. Soil organic matter is not a static component but is constantly being both broken down and replenished. Although this portion of the soil is small (3 to 5 % by weight in average topsoil and only .5 to 2% in California soils), its influence on soil properties and plant growth is extremely important. The benefits that organic matter brings to a soil include:

- increased biological activity
- improved structure
- increased porosity
- improved water holding capacity
- nutrient source
- retention of nutrients

A healthy soil with a fair amount of organic matter is in fact teeming with life of all kinds. In just one teaspoon of healthy soil, billions of microscopic organisms exist. The predominant living organisms are the bacteria and fungi. Also included are soil-dwelling mammals and reptiles, earthworms, insects, mites, and nematodes. Some of these organisms are pests that damage the plants in our yards and gardens. But to a larger extent, the activity of soil-dwellers is positive, as it creates channels in the soil for air and water, helps form aggregates, adds nutrients, suppresses disease, or mixes layers of soil.

The living organisms also are the prime force in the cycle of decay that replenishes soil's natural fertility. When the remains of plants and animals have been completely decomposed in the soil, they form a dark, crumbly, and spongy-textured material called **humus**. It typically brings the benefits described above, as it provides the nutrients used by plants, helps retain soil moisture, and provides good aeration, drainage, and a loose, crumbly structure for plants to grow in. The replenishment and maintenance of soil organic matter by recycling organic wastes is thus considered key to sustainable gardening.



Earthworms: The True Tillers of the Soil

Organic matter without the soil organisms that feed on it would be simply lifeless, dead plant debris. **Soil organisms** bring life and vitality to what is dead and decaying through the process of decomposition. Earthworms are perhaps one of the most important, and often overlooked, of the visible soil organisms. In ancient times, Cleopatra decreed them sacred, to be revered and protected. Aristotle called them “the guts of the soil,” and Charles Darwin considered them an animal of greater value than the horse, more powerful than the African elephant, and more important to humanity than even the cow. These are pretty noble words for a creature most of us hardly notice except on sidewalks after a hard rain!

Earthworms are the true tillers of the soil, digging tunnels, carrying leaves down into their burrows, and mixing and sifting the earth. They produce more compost of the highest grade, in a shorter time, with less effort, than any other method. Darwin, a student of worms, determined that they produce between 8 and 18 tons of rich **worm castings** per acre per year. These figures have since been confirmed by contemporary scientists. This worm manure does wonders for the soil... for free!

After years of research and study, Darwin concluded that all the vegetable mold of England passed through, “and will again pass many times through the intestinal canals of worms. “It may be doubted,” he wrote, “whether there are many other animals which have played so important a part in the history of the world as have these lowly organized creatures.”

In the garden or farm, healthy populations of earthworms can improve a soil’s porosity and water infiltration rates, increase levels of soil humus, decompose plant and animal residues, and greatly improve a soil’s overall health.

We are more intimately connected to this continuous process of nutrient cycling than most of us know: the soil is the ultimate source of all our food. In fact, the word “human” comes from the Latin humus, which means earth. Literally, the humble person is “close to the earth.” Gardening restores a sense of humility to our humanity, reminding us to be mindful of the soil-dwelling creatures that gave us life, that sustain us, and that will ultimately reclaim us.

But, if we are no longer an agriculturally-based civilization (as was the case in Cleopatra’s time), then what is the current role of the earthworm in our lives? We still have to eat and our food comes from somewhere. Wherever food is grown, in the home garden, the local family farm, or continents away, earthworms are processing the soil, moving it and making nutrients available, improving soil structure, and mixing organic matter into the soil. Earthworms are essential to good agriculture and healthy soil in the home garden.

This is particularly important when we consider conventional gardening and agricultural practices.

Earthworms are discouraged if not killed outright by many pesticides and most synthetic fertilizers. Nearly all commercial nitrogenous fertilizers quickly wipe them out by creating highly acidic soil. Conventional farmers and home gardeners then have to attempt to fulfill the role of that which it has replaced -- an impossible task -- and are caught in an endless cycle of poisoning soil life, and then feeding plant life with synthetic nutrients because nutrients are no longer available in the soil.

Conversely, the more organic material earthworms receive, the faster they proliferate. The fundamental principle in both sustainable gardening and sustainable agriculture is to feed the soil, not the plants. Healthy, nutrient-rich soil creates healthy, nutrient-rich plants. And this requires the earthworm.

Earthworms are among the oldest of land-dwelling animals. There are thousands of species of them. They come in a variety of colors. In Australia, there is an earthworm ten-foot long; the most common European and American garden variety is less than 6 inches in length.

Earthworms fall into one of three basic categories – endogeic, epigeic, and, anecic – defined by where they live, what they look like, and the unique role they play in the ecosystem.

Endogeic earthworms are the workhorses of California garden and farm soils. They generally live and eat within the deeper, horizontal layers of the soil. They are commonly found around the root balls of plants where they are feeding on the decaying portions of root systems and on the fungi, bacteria, and nematodes that live there.

Epigeic earthworms live close to the surface where organic matter is abundant. The red worm commonly used for worm composting is of this type.

Anecic earthworms are typified by the nightcrawler. These are large, muscular species that burrow deeply and vertically in the soil. Their burrows become their permanent residence for an entire lifespan of one to ten years. Nightcrawlers are so named because of their habit of coming to the surface at night to feed on dead

and decaying plant matter, which they pull down into their burrows. They are capable of transforming an entire season of falling leaves into humus in a matter of months.

To encourage earthworms in the home garden, keep a layer of organic matter on the soil year-round, and use gardening methods that are environmentally- and earthworm-friendly. Our goal as Bay-Friendly Gardeners is to get everything to pass through the gut of a worm...at least once.

Water and Air

Though some plants can actually be grown without soil, air and water are essential to their survival. Water and air occupy soil pore spaces. Plant roots absorb the water and pass it on to leaves and stems, where it serves as a coolant and as an essential part of all plant cells.

Water also carries dissolved mineral nutrients that plants need for growth and development. Adequate moisture is also critical to the decomposers, as the microorganisms in the soil are aquatic, meaning they live in water. They live in the “pools” that to our perspective seem to be “just a dampness.” However, if soil doesn’t drain well, and water occupies all the soil pore spaces, plants suffocate because their roots cannot get the air they need. It also produces an environment in which anaerobic microbes thrive.

A Good Balance

An ideal soil for growing most plants is one with a balance of different-sized particles (sand, silt, and clay) and a high proportion of organic matter. A *loam* is an example of such a soil.

Not all soils are so ideal. A soil with too much sand can drain water too quickly and be low in organic material and nutrients. A soil with an abundance of clay, as with much of the soil in Alameda County, will tend to cling together in a solid mass, with individual particles indistinguishable. Clay soil can be very fertile; however, problems with soils high in clay can include: slow warming in the spring, poor drainage (resulting in water-filled pores and lack of air for plant roots in the wet season, and a hard, impermeable crust in the

dry season, preventing water from reaching the root zone of plants), and a structure too heavy for seedling emergence and root penetration. Adding organic matter, such as compost, can offset many of the problems associated with either soil type extreme, from sand to clay.

Soil Testing

Soil-testing is not essential to Bay-Friendly Gardening. Bay-Friendly Gardening practices will add nutrients, improve soil drainage, and make up somewhat for poor texture and structure. However, for those that want to know more about their garden soils, there are a number of ways to test soil, or to have it tested. Which test to use is determined by what you want to know: Soil pH? Soil texture? Soil drainage? Chemical and physical analyses?

Professional labs can provide a written report about your soil on such things as soil pH, organic matter content, cation exchange capacity, and levels of nitrogen, sulfur, phosphorus, potassium, magnesium, and calcium. They can also test for micronutrients such as zinc, manganese, copper, and boron. The tests provide estimates of the amounts of these elements that are available to plants. Paying for a professional lab test, however, is not essential in many cases, and there are a number of simple tests you can do at home.

REASONS FOR A PROFESSIONAL TEST

- You are designing, or re-designing, and installing a new garden.
- You are radically changing the design or maintenance of your garden. Soil tests are important during the transition from a garden that has been maintained conventionally (and therefore dependent on heavy input of resources) to one that is maintained in a more Bay-Friendly manner.
- Plants are having consistent and serious problems.
- You live in an older home with lead-based paint on exterior walls, or you live within half a mile of a major roadway, freeway, or industrial area, and want to produce food in your home garden. It would then be important to know whether or not lead is present in the soil.

SOIL TESTING LABS

A & L Western Agricultural Labs
1311 Woodland Avenue #1
Modesto, CA 95351
(209) 529-4080
www.al-labs-west.com

Peaceful Valley Farm
(see Soil Analysis Package)
P.O. Box 2209
Grass Valley, CA 95945
(530) 272-4769
Order line: 1-888-784-1722
www.groworganic.com

Harmony Farm Supply & Nursery
(see Laboratory Services)
3244 Highway 116 North
Sebastopol, CA 95472
(707) 823-9125
www.harmonyfarm.com

Control Lab, Inc.
42 Hangar Way
Watsonville, CA 95076
(831) 724-5422

Soil and Plant Laboratory
352 Matthew Street
Santa Clara, CA 95050
(408) 727-0330
www.soilandplantlaboratory.com

Soil Foodweb Inc.
1128 NE 2nd Street, Suite 120
Corvallis, OR 97330
(541) 752-5066
www.soilfoodweb.com

ABC Organics
P.O. Box 967
Camarillo, CA 93011
(805) 675-8747
www.abconorganics.com

LEAD TESTING

Lead Poisoning Prevention Program
2000 Embarcadero, Suite 300
Oakland, CA 94606
(510) 567-8280
1-800-B-LEAD-SAFE
www.aclppp.org

SIMPLE TESTS YOU CAN DO AT HOME

The Smell Test.

To get a general sense of your soil health, take a closer look. While you're there, take a good whiff. Does your soil have a nice earthy smell? Unpleasant odors may indicate poor drainage or water-logged soils.

The Squeeze Test.

When your soil is still damp from recent watering or a rainstorm, take a loose ball of it, the size of a ping-pong ball, into your hand. Squeeze the ball of soil and then open your hand. If it falls apart, the soil is more sand. If it keeps its shape, the soil is more clay.

Then take some of the soil and rub it between your thumb and forefinger. Grittiness indicates sand. If it feels slippery, the soil is more silt. Stickiness means clay.

Again, take some soil and roll it into a log in the palm of your hand. The longer you can make the log, the more clay in the soil.

The Separation Test.

This test can give you a general idea of the proportions of sand, silt, and clay in your soil. Collect 1 cup of soil from the garden. Place the soil in a 1 pint canning jar with a lid (or a 16-ounce mayonnaise jar with lid). Measure 1 cup of water and pour just enough in the jar to cover the top of the soil.

Let the soil settle by rapping the jar gently on the counter and waiting a few minutes. Mark the soil level with a piece of tape. Add the remaining water. Put the lid on the jar and shake the jar vigorously.

Let the jar sit for 24 hours. The largest particles – sand – will settle to the bottom, the intermediate-sized particles – silt – will be in the middle, and the

smallest particles – clay – will be on top. (If there is a gap between the top of the clay level and the tape marker, it is because all the clay has not fully settled out. It can take a week for the clay to completely settle.)

Look at the soil layers in your jar. It may be hard to determine clear edges, but try to get an idea of the proportions of each. Is there more sand, or clay, or silt? Can you estimate the percentage of each?

Soil Drainage Test.

Collect a 46-ounce can and remove both ends of it (a tomato juice can is perfect). Dig a hole in your garden about 4” deep and push the can firmly into the bottom of the hole so that water will not leak out around the bottom of the can. Fill the can with water and wait an hour.

If the water level has drained by:

- **About 2”:** the drainage is fine for plants that require good drainage.
- **About 4” or more:** the drainage is fast, indicating you have soil that probably contains a good proportion of sand.
- **Less than 2”:** the drainage is slow and most common garden plants will have difficulty growing in your soil.

Soil pH Test.

Special pH meters can be used to test your soil, but litmus paper is just as accurate and much cheaper. Test two different soil samples from your garden, one from the first 6” of your soil where roots will grow and the other, from a foot deeper.

Mix each soil sample in a separate clean dish with a little distilled water. Using a fresh piece of litmus paper for each sample, press the litmus paper to the wet soil for 30 seconds. Rinse the litmus paper with distilled water. Match the color with the colors on the box to determine the soil pH.

How Does Compost Benefit Soil?

Once you know more about your garden soil, it helps to know what to do about problem soils, such as those that have poor drainage, for example, or a high percentage of clay. The addition of organic matter to the soil is a good beginning to successfully address many problems in the home garden.

Compost is one of the best soil amendments available to the home gardener, making almost any soil better for growing plants. Increasing soil organic matter by making and adding compost has many benefits.

Composting is the controlled process of returning dead and decaying plant and animal material to the soil through decomposition. There are a variety of methods for composting, which will be explored later.

Whether a compost pile is quick and hot, or slow and cool, when the decomposers have completed their work, the original ingredients of the pile have been transformed. Most of the materials that originally made up the pile (the feedstocks) are no longer recognizable in the finished compost, with the exception of some persistent woody materials.

What results is dark, loose crumbly material that resembles rich soil. The volume of the finished compost has been reduced to about 30 to 50 percent of what went into the pile, through breakdown into smaller pieces and respiration. The compost is now ready to use as an amendment, mulch, top dressing, or part of a potting mix, beginning the cycle again.

Beneficial Soil Life

An initial and primary beneficial characteristic of compost is the increased numbers, diversity, and activity of microbial populations. Compost is a healthy, living material. Its *microorganisms* and *macroorganisms* are indicators of a balanced ecology, serving to recycle nutrients. A teaspoon of compost has over one billion microorganisms. The microorganisms also help improve soil properties, such as structure, porosity, and water holding capacity.

Research has shown that the rich soil life in compost helps to control diseases and pests that might otherwise overrun a more sterile soil lacking natural population control mechanisms.

Soil Structure

In good garden soils, the individual particles of sand, clay, and silt will naturally group together into larger units called *aggregates*, giving the soil its structure. If these aggregate structures are rubbed between a finger and thumb, they break down into smaller aggregates. In between, and within, the aggregates themselves are many air channels of various sizes, like the empty spaces left in a jar of different-sized marbles.

Aggregates are formed by fungi, bacteria, worms, and humic acid in the soil. Formation begins with various soil fungi that grow on organic matter in the soil. Soil bacteria then come along to turn the fungal products into cementing materials. These cementing materials “glue” together tiny particles of soil into coarse grains or crumbs. Worm secretions also act to bind soil into stable aggregates.

The formation and stability of aggregates are essential in a healthy soil, as the structure of a soil determines its ability to drain well, store moisture, and provide for the needs of healthy plants. By encouraging the formation of aggregates, compost improves the structure of every type of soil: silt, clay, or sand. Even a casual observation of soil amended with compost

shows that it is made up of many round, irregular aggregates.

In loose, sandy soils, compost helps to bind unconsolidated particles together to retain water and nutrients that would otherwise wash right through. Added to a clay or silt soil, compost breaks up the small, tightly bound particles and forms larger aggregates. In addition, humus, a component of compost, not only improves aggregate formation, but increases the permanence and stability of the crumbs already formed.

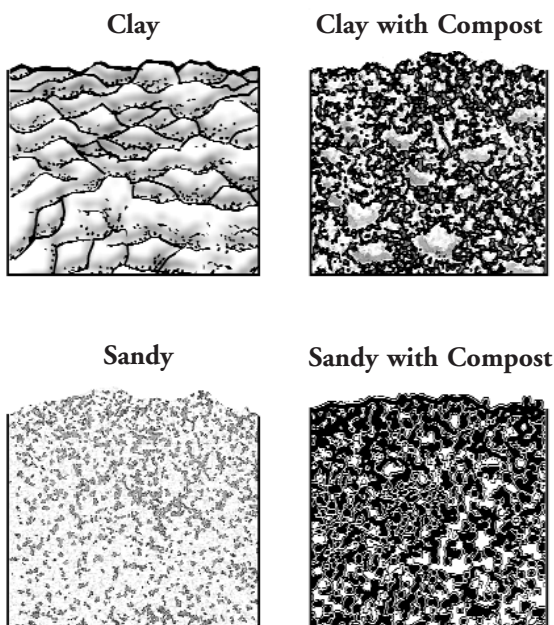
Drought Protection and Erosion Control

Soil improved with compost can hold more moisture. Indeed, the higher the organic matter content, the more moisture a soil can absorb and retain (100 pounds of humus holds 195 pounds of water!). This is especially important for sandy soils. The *water holding capacity* of soils that are amply supplied with organic matter is a potent weapon against drought damage. Water is soaked up like a sponge and stored on the soil granules. When the tiny hairs on plant roots are able to absorb all the water the plant needs from the films on these granules, they do not suffer during long, rainless periods.

Soil with ample organic matter has improved permeability, letting raindrops seep gently into it, instead of splattering and churning up soil particles. In the case of packed or crusty soil, a muddy drop of water is formed that will run over the soil surface as the first stage of erosion. A heavy rainstorm may result in considerable runoff that carries away soil. However, adding compost to soil, will improve water retention, porosity, and infiltration, which saves water and the need for soil replenishment.

Aeration

A well-structured soil with lots of small aggregates, stays loose and is easy to cultivate. The channels that aggregates create through soil allow plant roots and moisture to penetrate easily. The smaller pores within the aggregates loosely hold moisture until a plant needs it. The larger pore spaces between the aggregates allow excess water to drain out and air to circulate. Just as organic matter enables soils to hold more water



through the enhanced formation of soil aggregates, it also allows more spaces for air between soil granules. In the garden, poor structure and lack of aeration may show up as a crusting of the soil surface. Newly planted seeds suffer greatly under such conditions – lack of air and water reduces germination, while seeds that do sprout have difficulty breaking through the soil's hard surface crust.

Nutrient Content

Dark, loose compost looks like it should be rich in nutrients. Compost does, in fact, contain a variety of the basic nutrients that plants require for healthy growth. The greater the variety of materials used in making compost, the greater will be the variety of nutrients contained in it.

Of special importance are the *micronutrients* present in compost, such as iron, magnesium, copper, and zinc. They are only needed in small doses, like the lesser-known nutrients in our diet, but without them plants have difficulty extracting nutrients from other foods. Micronutrients are often absent from commercial fertilizers, so compost is an essential dietary supplement for most soil.

Compost also contains small amounts of the macronutrients that plants need in larger doses. *Macronutrients* include nitrogen, phosphorous, potassium, calcium, sulfur, and magnesium. In addition to compost, these nutrients are sometimes applied in measured amounts through fertilizers or lime. The three numbers listed on commercial fertilizer bags (such as 10-10-10), refer to the percentage of nitrogen, phosphorous, and potassium (N-P-K) available in the fertilizer.

High-nitrogen compost can supply sufficient nitrogen, but it depends on many factors, including the soil supply of nitrogen, the moisture content and biological activity of the soil, the demands of the plants, and others. The nitrogen in the compost is primarily in an organic form and, thus, it is valuable as a slow-release fertilizer.

Nutrient release is often synchronized with plant growth needs. When conditions are right for decomposition, conditions are good for plant growth.

The nitrogen and other nutrients are made available to the plants (mineralized) as the compost is further decomposed by the soil's microorganisms and macroorganisms. Nutrient release and supply can, therefore, be very complex, vary with the time of year, each area of the garden, or plot of soil, and be difficult to predict.

Nutrient Storage and Availability

To understand how compost is able to store nutrients and make them available when needed by plants requires a closer look. When viewing compost through a microscope that enlarges objects 1,000 times, individual compost particles resemble the aggregates that are observed with the unaided eye.

Like the aggregates, individual particles of compost contain many porous channels. Just as the channels in the aggregates provide space to store water, these spaces in the compost particles provide spaces to store nutrients. The very tiny compost particles provide vast, negatively-charged surfaces where individual ions of minerals and fertilizers are attracted and held. Thus, compost is not only a source of nutrients, but is a storehouse for those nutrients that might otherwise be unavailable to fine plant roots.

When mixed into soil, compost helps plants overcome soil pH levels that are either too low (acidic) or too high (alkaline), as is often the case with the soil in our East Bay gardens. Adding compost also reduces the reliance plants have on specific pH levels by supplying nutrients that are otherwise unavailable.

How Does Mulch Benefit Soil?

In nature, leaves and needles fall to the ground, creating an organic layer that protects and builds the soil. *Mulch* is any material spread evenly over the surface of the soil to enhance the growth of plants and beautify a home landscape. Many mulch materials help suppress weeds, retain moisture, and regulate soil temperatures, but only plant-based materials will also feed garden soil and plants. Mulches created from plant materials decompose, feeding beneficial organisms and improving soil structure.

Mulch Basics

1. REMOVE WEEDS AND WATER THOROUGHLY BEFORE APPLYING MULCH.

You'll get the best weed control when you weed first and then spread the mulch. And it is often easier to wet the soil before applying mulch.

2. REPLACE GRASS UNDER TREES WITH MULCH.

Mulching under trees to the drip line minimizes competition for water and nutrients from grass, and mimics the way trees grow in nature. It simplifies mowing and prevents trunk and root damage from mowers and weed eaters.

3. KEEP MULCH 6 TO 12 INCHES AWAY FROM THE BASE OF TREES AND SHRUBS.

Tree trunks are not suited to wet conditions. Placing mulch so that you can see the root flare keeps the trunk dry and reduces the risk of damage from disease and pests.

4. CHOOSE THE APPLICATION RATE THAT WILL GIVE YOU THE BEST RESULTS.

- **General Use:** Apply a layer that settles to 2 to 4 inches deep. This is the best general application rate, especially for use in planting beds.



- **Fine Mulch:** Apply no more than 2 inches. Thin layers of fine mulch (particle size of half-inch or less) are less likely to impede air and water. Fine mulches decompose more quickly and need to be replenished more often than coarse, woody mulches.
- **Coarse Mulch:** Use 4 to 6 inches or more to control weeds in open spaces. Coarse mulch is

best for weed control; it prevents annual weed seeds from germinating. Weeds that do sprout are easier to remove. For maximum weed control, replenish mulch once a year.

- **You can have too much of a good thing:** Use lesser amounts of mulch on poorly drained soils.

5. KEEP MULCH ON TOP OF THE SOIL TO PREVENT TYING UP NITROGEN.

Any woody material that is incorporated into the soil will temporarily inhibit the soil's ability to supply nitrogen to the plants. However, according to research, mulch only uses nitrogen at the soil surface, and not from the root zone. If you do not turn mulch into the soil, you'll avoid nitrogen drag.

How Much Mulch to Buy or Make

- One cubic yard covers 108 square feet, 3 inches deep.
- Six cubic yards cover 1,000 square feet, 2 inches deep.

When You Can't Make Your Own Mulch

When pruning or weeding in the home garden, you can make your own mulch quickest and easiest with the use of a heavy-duty chipper-shredder. Better yet, simply cut plant trimmings into smaller pieces with pruning shears and place them as mulch around the base of the same plants. Weeds, except for invasives, can be placed on top of the soil surface as mulch, or added to the compost pile.

The best source of greenwaste mulch is from your own garden. You can also try and arrange for truck loads of free greenwaste mulch from local tree companies listed in the phone book. Make sure to ask if the tree was healthy. Usually, they will want to deliver a truck load – ask about the number of cubic yards and be prepared to use it.

Mulch or Soil Amendment?

There is an important distinction between a *soil amendment* and a mulch. Soil amendments are dug into the soil before planting to improve the soil's biological, physical, or chemical state, in particular, the soil structure and fertility. Mulches are spread on top of the soil to help prevent weed problems, reduce water loss from the soil, and moderate soil temperatures. Mulch should not be incorporated into the soil since woody materials can tie up nitrogen needed by the plants. With an already healthy soil, mulching may be the only step needed to keep things in balance from year to year. Following is a list of organic materials that can be used either as soil amendment or mulch:

Aged manure is a significant source of nutrients. Add manure directly to the soil only after it has aged for six months. Aged manure varies in its N-P-K ratio, depending on the animal source and on how much it has been leached by rains during aging. Use dairy manure with caution because of the high salt content.

Grass clippings are a good, nitrogen-rich organic mulch for flower and vegetable beds. However, they are best left on the lawn after mowing (grasscycling), adding nitrogen and increasing the humus content of the lawn soil. Do not use grass clippings as mulch for one year after herbicides have been applied to the lawn.

Straw is an inexpensive source of organic material. It is relatively low in nutrients, but will serve as a good mulch, and can eventually boost the humus content in the soil.

Leaves are readily available in areas with deciduous trees, and easy to use. They can be chopped or shredded, or used whole. To shred leaves, run over them repeatedly with a lawn mower.

Aged sawdust is very low in nitrogen but will increase the organic matter content of the soil. Do not add sawdust directly to the soil, as it will temporarily deplete the soil's nitrogen reserves. Compost the

sawdust first with a material high in nitrogen, such as grass clippings or manure.

Wood chips and bark are often used as mulches. They are effective in keeping down annual weeds in ornamental gardens and perennial herb plantings. Like sawdust, these materials contain much more carbon than nitrogen. To ensure that plants mulched with wood chips or bark are not robbed of their nitrogen, spread 1 inch of manure or compost down before laying down these materials. Do not dig in wood chips or bark as a soil amendment.

Peat Moss has a low nitrogen content and high water-absorbing capacity. Peat moss is the remains of aquatic plants that were deposited in locations where they broke down very slowly. The pH of peat moss is acidic, ranging from 3.0 to 4.5, making it a useful amendment around acid-loving plants, such as rhododendrons, azaleas, and pine. Peat moss is a relatively expensive product and, because it is a non-renewable resource and harvesting it has negative environmental impacts, it is best to avoid using peat moss. Compost is a good renewable alternative to peat moss.

Compost used as a mulch is a "no fuss," slow-release method adding organic matter to the soil. Unfinished compost may also be used as mulch (best with lots of large woody materials) and has similar properties to sawdust, wood chips, and straw, and may deplete the nitrogen reserves in the soil if turned into the soil.

Locally available materials may include seaweed, apple pomace from a cider mill, soybean wastes from tofu-making, cheese whey, nut shells, mushroom soil, and ground corn cobs. Check to make sure these materials are free of chemical pesticides.

Inorganics, such as gravel and plastic, can also be used as mulch, but are not recommended since they do not add organic matter to the soil. In addition, plastic can become a pollutant breaking apart from UV exposure.

Sheet Mulching

Sheet mulching is a layered mulch system. It is a simple and under-utilized technique for removing lawns (except Bermuda grass), dealing with persistent weeds, building depleted soils, encouraging favorable soil microbial activity and worms, or enhancing soil structure.

Sheet mulching can be used either in establishing a new garden or tree planting, or to enrich existing plantings. In both cases, mulch is applied to bare soil or on top of cut weeds. New plantings are planted through the mulch, or a small area is left open to accommodate established plants and trees.

STEP 1: PREPARE THE SITE

Knock down or mow existing vegetation so that it lies flat. Remove only woody or bulky plant material. The organic matter left will decay and add nutrients to the soil. “Jump start” the decay of weeds and grass by adding compost or manure at the rate of about 50 pounds per 100 square feet. Soak the area with water to start the natural process of decomposition. It is much easier to soak the ground now, before the remaining layers of mulch are applied.

STEP 2: ADD A WEED BARRIER

Put down an organic weed barrier that breaks down with time. The barrier must be permeable to water and air. Use recycled cardboard boxes, sheets of newspaper, burlap bags, or old carpets of natural fiber. Two or three layers may be required to achieve an adequate thickness. Overlap the pieces of material 6 to 8 inches to completely cover the ground without any breaks, except where there are established plants you want to save. Leave a generous opening for air circulation around the root crown. Wet down the cardboard or paper barrier to keep it in place.

STEP 3: LAYER MULCH & COMPOST

The top dressing mimics the newly fallen organic matter of the forest. It must be free of weed seeds. Good materials for this layer include leaves, grass clippings, straw, chipped plant debris, or tree prunings. Well-decomposed, weed-free compost is also a good material but it should be spread directly over the weed barrier and covered with bulkier materials



Rolls of cardboard as a weed barrier



Sheet mulching site is ready for planting.

such as tree prunings, to optimize weed control. In total, the compost/mulch layer should be 3 to 5 inches deep. Many materials suitable for the top layer often have an attractive appearance, making sheet mulch a versatile and desirable practice.

STEP 4: PLANT

Punch a hold in the cardboard for 1-gallon (or bigger) plants and place them in the soil under the sheet mulch. Smaller plants can often be planted right into the mulch or compost layer. Add a small amount of compost around the root ball if compost has not been included in the top layer.

In most cases, the benefits of sheet mulching outweigh the costs. However, take care to prevent these potential problems:

- As with any mulch, do not pile materials up against the trunks or stems of plants to prevent disease.

Sheet mulch instructions adapted from Sheet Mulching: Greater Plant and Soil Health for Less Work, by C.R. Elevitch and K.M. Wilkinson, Permanent Agriculture Resources, 1998; and Sheet Mulch, by Geoff Hall, Sentient Landscaping, 2003.

- Especially during the dry season, snails and slugs will be attracted to the sheet mulch and can damage small seedlings.
- Rodents can find a cozy home in mulch and can readily debark certain trees. Protect young trees with physical guards.

How Does Grasscycling Benefit Soil?

Grasscycling means leaving the grass clippings on the lawn after mowing, so they decompose and release their nutrients slowly into the soil. The slow release makes the nutrients available to the plants when the plants need them. On most lawns, you can use substantially less fertilizer by grasscycling. In addition, because clippings add organic matter, they build soil that retains more nutrients and water, and resists erosion and disease.

It is a misconception that grasscycling causes thatch. Research has shown that thatch is primarily dead grass roots and fibrous material created at the base of the plant, not leaf blades. Thatch is most determined by grass species. Bermuda grass, for example, develops a thick layer of thatch. Excess fertilizer and irrigating only the top few inches of soil also leads to shallow roots and increases thatch problems. Soil compaction increases thatch.

You don't need any special equipment to grasscycle – simply remove the bag from your mower, and leave the clippings on the lawn. The clippings will quickly decompose and release their nutrients into the soil.

If you prefer, a mulching retrofit kit, available at retail outlets, can be used on your existing mower, and includes a mulching blade and block for the discharge chute. You can also consider switching to a push mower.

Grasscycling Basics

1. MOW OFTEN AND MOW DRY.

Grasscycling works best when the grass is dry and the clippings are short. Try to mow on days when the lawn has not been irrigated or later in the day

when the lawn dries out. Mowing no more than 1/3 the leaf blade minimizes the stress on the lawn and produces shorter clippings.

2. MAINTAIN AND ADJUST YOUR EQUIPMENT.

Keep the mower blades sharp and the mower deck clean. A clean cut limits water stress, lowers the chance of disease entry, and minimizes brown tips. A clean mower deck helps keep clippings from forming clumps.

3. LEAVE THE CLIPPINGS ON THE LAWN!

Dry clippings are evenly distributed and fall between the living blades of grass and disappear from view.

When You Just Can't Grasscycle

Sometimes, you just can't grasscycle, for example, when the grass is too wet or too long. To avoid creating waste from your lawn in this situation, compost the clippings instead. Grass clippings are a natural source of nitrogen and readily decompose, especially when you mix them with dry, carbon-rich materials, such as dried leaves. As a last resort, use your greenwaste container.

More Bay-Friendly Lawn Care Techniques

Consider minimizing or eliminating your lawn if it serves little or no useful purpose in the landscape. Instead, plant perennials, an edible landscape, native grasses, or wildlife habitat.

If you must have a lawn, make it as Bay-Friendly as possible. Grasscycling helps create lush turf without chemicals. A dense, healthy lawn out-competes most weeds.

Additional ways to build fertile soil and vigorous, deep-rooted grass that resists disease and drought damage include:

- **Mow high.**

The longer the grass blade, the deeper the root. Most lawns will develop deeper roots and crowd out weeds when mowed at a height of 2.5 to 3 in.

- **Water deeply.**
Water enough to wet the soil to a depth of 4 to 6 inches. This will encourage deeper root growth.
- **Improve established lawns with aeration and overseeding.**
Overseed to fill in thin spots and crowd out weeds.
- **Top dress with compost.**
An excellent practice is to aerate, then spread a mixture of fine finished compost into the holes made by the aerator. Apply 1/4" layer of sifted compost up to four times per year.
- **Fertilize lightly in the fall with an organic fertilizer or slow-release synthetic fertilizer.**
Natural or slow-release fertilizers, such as sulphur- or polymer-coated urea, release nutrients slowly. This lets the grass absorb nutrients efficiently.
- **Reduce the use of pesticides, soluble fertilizers, and combinations of "weed and feed" that can damage soil health.**
Overuse of pesticides and heavy fertilizers robs soil of beneficial bacteria, fungi, insects, and worms.
- **Consider planting something besides grass on steep slopes, shady areas, or near streams and lakes.**
Grass grows best in sunny areas with well-drained soil.