



Sustainable Landscaping in California: How to Conserve Resources and Beautify your Home Landscape

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While being a good steward of our environment has been a goal of home gardeners for many years, there is increasing emphasis on adopting ‘sustainable landscaping’ practices and principles. What exactly is sustainable landscaping? In a nutshell it involves selecting plants that are adapted to your climate and microclimate and implementing maintenance practices that reduce water waste, protect water quality, nurture soil, recycle organic matter, protect and encourage desirable wildlife, and conserve energy.

Benefits of sustainable landscaping include:

- Healthy, low maintenance landscapes
- Lower water bills (for those on metered water)
- Less water quality degradation
- Increased energy conservation due to less pumping and water treatment
- Extended life of water resources infrastructure (pumping, water treatment facilities, etc.)
- Creation of wildlife habitat and/or wildlife corridors
- Reduced air pollution
- Reduced home cooling and heating costs through strategic plant placement

Following the specific recommendations discussed in this publication will help guide you through the process of developing your own sustainable landscape.

Select Plants Recommended for Your Climate and Microclimate

Choosing landscape plants that perform well in your climate and microclimate is the single most important way to prevent plant decline and loss. Making the right selection can save water, time, and other resources in the long run.

Select plants that are suggested for your specific Sunset climate zone. Sunset zones encompass smaller, more distinct climatic areas than USDA Plant Hardiness Zones which are listed on plant tags and in many gardening publications. For instance, some plants that perform well in Glendale, California (Sunset zone 20) require greater heat adaptation than plants recommended for Santa Monica, California, a city only 25 miles away in Sunset zone 24. Within San Diego County alone, there are four distinct Sunset zones taking into account coastal, inland, foothill and desert climates. Even weather in the San Francisco Bay area varies and includes multiple Sunset zones. To locate your zone consult the Sunset Western Garden book or visit <http://www.sunset.com/garden/climate-zones>.

Once you have chosen plants suitable for your Sunset zone, narrow down your choices based on which plants on your list will grow well in your microclimate. Microclimates are smaller areas within a climate zone that create unique weather patterns that can greatly influence plant performance. Examples are shady or windy areas, compact soils with poor drainage, hot spots adjacent to dark asphalt that reradiate heat, and areas adjacent to current or future construction. Ignoring microclimate effects is a common mistake many homeowners make and a major cause of plant decline. For assistance choosing specific plants that are suitable for your climate and microclimate, consult a reputable online resource such as <http://plantfinder.sunset.com> (which allows multiple criteria to be entered during a plant search), a reputable nursery, or a University of California Master Gardener volunteer serving your county.

Avoid invasive plants. Avoid choosing non-indigenous species known for their invasive potential. These plants have qualities that make them difficult to control, and they can escape into wild areas and out-compete the preferred native species. Once introduced, these plants survive and spread on their own without human assistance. This can result in substantial changes to the character, condition, form, and nature of the invaded habitat. Examples of plants that should be avoided due to their invasive habits include Scotch broom (*Cytisus scoparius*) and pampas grass (*Cortaderia selloana*). For further information on invasive plants to avoid, and attractive alternatives to invasive species go to Plant Right (www.plantright.org) This website discusses what not to plant and offers alternative non-invasive plants with similar aesthetic characteristics as substitutes.

Design and Implement a Water Efficient Landscape

There is more interest than ever in beautiful, water-efficient landscapes to conserve an important natural resource and reduce costs to homeowners using metered water. About one-third to one-half of the water used by a typical California family is directed at outdoor irrigation, averaging about 200 gallons a day. Significant savings can be realized through selecting water-efficient plants and ensuring efficient irrigation.

Many homeowners have heard the terms ‘xeriscaping’ or ‘xeriphytic landscapes’ and wonder how they relate to water-efficient landscaping. The word ‘xeriscape’ is derived from the Greek word “xeros,” meaning dry, and ‘landscape.’ Information in this publication represents ‘best management practices’ appropriate for California landscapes and includes and expands on well-known relevant xeriscape practices.

The good news is that, in most instances, you do not need to completely overhaul your entire landscape or commit to expensive fixes to save water. While native gardens are generally water-efficient and low-maintenance, there are many non-native plants that thrive in California that are just as drought efficient. Employing a diverse plant palette is also a good idea because it can result in fewer pest problems and offers a more interesting, aesthetically appealing landscape. Most of the water wasted in residential landscapes is not due to thirsty plants; it is because of inefficient and ineffective watering practices. Following the recommendations below will save you money, reduce your water bills, and beautify your landscape.

Avoid overwatering. Overwatering landscape plants is more common than underwatering. While newly planted ornamentals and garden plants require frequent light irrigations due to small, compact root systems, established plants do not need to be watered every day and do much better with deep and infrequent irrigation.

Know how much water to apply and when to apply it. Become familiar with the water needs of plants growing in your climate. The water requirement of a plant is closely linked to evapotranspiration (ET). ET is the loss of water to the atmosphere from the soil and plant surfaces (evaporation) and from the plant actively taking up water (transpiration). A plant's water requirement depends on many factors including solar radiation, air temperature, relative humidity, wind speed, type of soil, root depth, foliar density, microclimate, and stage of growth.

As the above graph shows, a plant adapted to both San Francisco, California and Riverside, California will require more water in Riverside due to its higher ET rate in the hotter, interior Southern California valley area. Adjusting the amount of water you apply to your landscapes based on seasonal changes can greatly reduce water waste and maintain the health of the plants. A common mistake is to forget to adjust your automatic timer downward going into the fall.

A straightforward approach to help you apply the right amount of water to your landscape when it is most needed is to use the 'feel test'. Get your hands dirty! Use a shovel or trowel to dig a small hole six to eight inches deep in your garden soil and 18 inches to two feet around trees,, being careful not to disturb plant roots. Soil that is wet enough but not too wet will feel like a well wrung-out sponge. Soil that falls apart easily is a little too dry and should be irrigated. If a lot of water oozes out, wait a few days before you water. Water established trees more deeply and less often than garden plants; many trees perform well with only one or two irrigations each month.

Know your soil type. Keep in mind that sandy soils hold less water than heavier soils containing clay and need to be irrigated more frequently. Sandy soils take in water and drain much faster, as well, which can lead to water and nutrient loss (and pollution) below the root zone. Clay soils, on the other hand, take in water much more slowly and are more likely to incur runoff from the soil surface, which also can result in water pollution and wasted water. An easy way to determine what type of soil you have is expand the 'feel test' described above. Soil containing clay will form a ribbon as you squeeze it between your thumb and forefinger while sandy soil will crumble and not ribbon.

Hydrozone. Place plants with similar water needs together so they can be irrigated on the same schedule, without under-watering the thirsty plants or over-watering the more conservative water users. For help in determining water needs of specific plants, refer to the resources listed in the section above titled ‘Select Plants Recommended for Your Climate and Microclimate.’

Add organic matter to your soil. Mix approximately one-third by volume of organic matter such as compost evenly into the original soil, six inches to one foot deep. Organic matter increases the water-holding capacity of sandy soils reducing the chance of water loss below the root zone and improves drainage in clay soils, reducing the chance of runoff. While organic matter makes a great soil amendment for small woody ornamentals and garden plants, it should not be used in tree planting sites because roots often prefer the higher quality amended soil and grow outward instead of downward. Eventually this restricted root system will not be able to support the maturing tree.

Mulch. Apply three inches of mulch (e.g. wood chips, straw, gravel, etc.) on the top of soil around your landscape plants. Be sure to keep mulch at least one foot away from tree trunks to avoid wet crowns subject to disease-forming pathogens. Mulch reduces soil moisture evaporation, controls weeds, reduces erosion, buffers soil temperature, prevents compaction, and – around trees – prevents bark damage from string trimmers and lawnmowers. It is important to recognize that organic mulches decompose over time and need to be supplemented regularly to remain effective. While inorganic materials do not decompose, they are often more expensive initially (rocks, pebbles, landscape fabrics, shredded tires, etc.), and provide no benefits to soil health.

Drip irrigate. Installing a drip irrigation system saves water because drip emitters apply moisture directly into the root zone of plants, minimizing evaporation of water from the soil surface between plants. Soaker hoses, drip tape, porous pipe, mini-sprinklers, and laser tubing are all examples of drip systems. They are not difficult to install; many ‘Do it yourself’ stores and irrigation supply companies offer free guidelines detailing their installation. If you do not have the time or feel competent to install the system yourself, many reasonably-priced landscapers/irrigation specialists can provide this service.

Use the ‘Lawn Watering Guide’. When irrigated correctly, warm-season lawns (e.g.: Bermudagrass, zoysiagrass) are relatively drought-resistant, requiring 20-30 percent less water than cool season species (tall fescue, Kentucky bluegrass and perennial ryegrass). It is not the type of grass that wastes the water, but inefficient irrigation systems that apply water unevenly across the lawn. The University of California Lawn Watering Guide (<http://anrcatalog.ucdavis.edu/Items/8044.aspx>) lists the number of minutes per week to water your warm- or cool-season lawn based on its seasonal water use rate and how much water your system puts out. It explains step by step how to conduct a ‘can test’ to determine the system’s output rate and evenness of application and lists tips to improve the distribution uniformity for the system. Use this guide to reduce water waste substantially and improve the health of your lawn.

Cycle water when needed. Large amounts of water are in many cases wasted through runoff in clay soils and on slopes. Cycling water applies the same amount of water needed under ordinary conditions but divides its application over two or more start times as close together as possible before soil dries out. The idea is to irrigate initially until the first signs of runoff are evident, allowing the water to soak in, and then to irrigate the same area once or twice more until the total required number of minutes (based on the UC Lawn Watering Guide) are reached.

Consider installing a ‘smart’ irrigation controller. When programmed correctly, these devices apply water based on plant water needs and may be hooked up to a weather-based network. Instead of simply relying on a timer that may be set on an arbitrary schedule, “smart” irrigation controllers rely on weather, site, or soil moisture for determining irrigation schedules. A rain sensor should be attached to your controller to shut your system off in the event of significant rainfall.

Learn to recognize plant drought symptoms. Initially, foliage may lose its luster, shrivel and droop. Turf will hold a footprint. Over time, plant growth is reduced. Stems and twigs toward the outer parts of the plant begin to defoliate and may eventually die. Eventually, the entire plant may die if water is not provided. Ideally, irrigation should be applied before plants show pronounced symptoms.

Water early in the morning. This conserves water due to less evaporation than during the heat of the day. However, it is important to occasionally check to make sure that automatic systems are in good working order if they operate earlier in the morning than members of the household are awake and able to notice malfunctions!

Collect and reuse rainwater. Use cisterns, barrels, or storage tanks to collect the water, and consider diverting your downspout into a covered barrel. Reuse the captured water to irrigate non-edibles such as hanging baskets and container plants or connect it to a drip irrigation system. Make sure that collection vessels are covered to prevent mosquito breeding and entry by animals and children. Check with your local water agency for more information and to inquire about local ordinances restricting or limiting collection and reuse of rainwater.

Repair worn and broken irrigation system components regularly. Both sprinkler and drip irrigation systems should be checked regularly for broken or inoperative components and leaks that may otherwise go undetected. Examples are clogged nozzles, worn nozzles, tilted sprinkler heads, and heads in the same zone with varying precipitation (output) rates. Also look for signs of leaky valves in your control box, such as water continually oozing around a sprinkler head. Correcting these problems often reduces water waste by at least 20 percent.

Use a broom rather than a hose to clean patios, driveways and walkways. Sweeping also provides an opportunity for exercise in addition to reducing water waste!

Consider using graywater to irrigate your landscape. The use of graywater (also spelled greywater, gray water, and grey water) to irrigate landscape plants is becoming popular throughout California and other arid states. Using graywater to irrigate landscape plants can conserve water, reduce water bills, and conserve electricity by recycling water otherwise

destined for a wastewater treatment plant. Since an estimated 30 to 50 percent of home water use produces graywater, significant savings can be realized by reusing this source of non-potable water to irrigate landscape plants. A typical household (2.6 people) produces an average of 90 gallons of graywater each day. While most graywater systems will not supply enough irrigation water to irrigate an entire traditionally landscaped yard, many can supply one-half to three-quarters of the needs of a drip-irrigated water-efficient landscape with limited or no turf.

In California, graywater is defined as “untreated wastewater that has not been contaminated by any toilet discharge, has not been affected by infectious, contaminated, or unhealthy bodily wastes, and does not present a threat from contamination by unhealthful processing, manufacturing, or operating wastes. Graywater includes, but is not limited to, wastewater from bathtubs, showers, bathroom washbasins, clothes washing machines, and laundry tubs, but does not include wastewater from kitchen sinks or dishwashers.”

A permit is no longer required for the installation of the following single or two-family residential graywater irrigation systems if other conditions under section 1603A1.1 of the Department of Housing and Community Development (HCD) are met:

- a simple clothes washing graywater system as long as it does not require cutting of the existing plumbing piping.

- a single fixture system that collects graywater from one plumbing fixture. All other systems require a construction permit prior to erection, retrofitting, construction and installation as stated in the actual code.

The full text of these standards can be viewed on the following website:

http://www.hcd.ca.gov/codes/shl/Preface_ET_Emergency_Graywater.pdf.. (Because these regulations may change at any time, always check with the HCD and local enforcement agencies in your county and city before developing plans for or installing a graywater system).

Laundry to landscape graywater systems are relatively simple and inexpensive to install. Simply attach the hose exiting the clothes washing machine to a valve that separates graywater from water destined for the sewer. The graywater is diverted through a one-inch main irrigation line with one-half inch tubing outlets placed throughout the landscape, terminating in a valve box in a mulch basin. The washing machine pump distributes water directly to the landscape with no filter. Keep in mind that salt and boron-free liquid laundry detergents should be used if the graywater is used for irrigating the landscape. Also avoid chlorine bleach.

Mulch basins receive and distribute graywater to plant root zones and need to be sized correctly to prevent surface ponding. Basin size depends mainly on soil texture. For example, graywater percolates quickly through sandy soils, requiring minimal mulch. In slower percolating clay loam soils, a larger mulch basin is required around the valve box to prevent graywater ponding. Large wood chip mulch is more durable and longer lasting than smaller wood chip mulches or shredded fiber.

Graywater should only be applied to non-edible ornamental plants, never directly to edible plant parts or root crops. . It is also important to avoid splashing graywater on edible plants neighboring ornamentals. Do not apply graywater through sprinkler systems since droplets containing harmful microbes can become suspended in the air and breathed in.

It is important to note that because of the recent less restrictive uses regarding graywater reuse, research pertaining to the long-term impacts and risks of graywater use on plant health, human health, plant health, soil chemistry, and ground and surface water quality is very limited. Potential risks include those related to human health, potential risk to plant health, and potential risks to soil chemistry and water quality.

Due to these potential risks, always take the following precautions:

- Carefully label all valves and pipes associated with your graywater system and prevent backflow
- Do not store graywater more than 24 hours
- Wear gloves and do not come into direct contact with graywater
- Do not let graywater pool or run off of the soil surface, potentially contaminating surface water or come into contact with well water
- Do not irrigate edibles with groundwater or allow it to splash on neighboring edible plants
- Do not sprinkler-irrigate turfgrass or groundcover areas with graywater since potentially harmful microorganisms can remain on the surface
- Do not use graywater contaminated with human waste, infectious disease organisms, grease, paint residue, gasoline, solvents, or other chemicals found in household and industrial products
- Keep the graywater system simple and avoid systems requiring heavy upkeep and maintenance. Contact a professional with experience designing and installing graywater systems if you lack the specific knowledge or time to undertake the project yourself.

Protect Water Quality

Degradation of inland and coastal waterways is of great concern in California. Runoff water carrying suspended solids, pet wastes, pesticides, and fertilizers pollute waterways and occur in high enough levels to impair water quality and harm aquatic life. Anytime you apply a fungicide, insecticide, herbicide, or even many types of fertilizers, water quality is at risk. Always prioritize other 'best management practices' described in this publication and other UC ANR publications (anrcatalog.ucdavis.edu) and UC Integrated Pest Management (UC IPM) publications (www.ipm.ucdavis.edu) to avoid using a chemical in a way that may contribute to water pollution.

Fertilizers are frequently applied to urban landscapes to improve plant growth, performance, aesthetics, and function. Water pollution can occur when certain elements enter waterways from soil runoff and groundwater leaching due to higher than recommended application rates and applications made prior to or during heavy rain. Overuse and misapplication of nitrogen (N) and phosphorus (P) are particularly problematic and can readily lead to water quality degradation and harm to aquatic life. Grass clippings and fertilizers should be kept off of impervious surfaces, for example driveways and sidewalks, due to the risk of runoff and potential pollution of waterways.

Pesticides are sometimes applied to urban landscapes to control weeds, diseases, insects, and other pests. Overuse and/or misuse of pesticides and improper disposal and storage can negatively impact public health; reduce or eliminate populations and diversity of beneficial insects; result in pollination problems and honeybee losses; impact the health and reproduction of birds and other wildlife; and, contribute to water and air pollution.

Specific fertilizer and pest management practices that favor environmental protection follow.

Avoid Over-fertilizing

You may be fertilizing your landscape too much. Landscape plants generally don't need regular fertilization. While all plants require nutrients, applying more than is necessary contributes to the potential for polluted runoff, and leads to flushes of new growth which require more water.

There are nine essential elements required for plant growth that is referred to as macronutrients. They are: nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, carbon, hydrogen, and oxygen. The last three are readily available in air and water. Eight other essential elements required in small amounts by plants (micronutrients) are iron, manganese, zinc, boron, molybdenum, copper, chlorine, and nickel.

Nutrient deficiencies are uncommon in established landscape plantings other than palms and turf. In fact, applying high rates of nitrogen-containing fertilizer may stimulate excessive, undesirable growth. Soils lacking adequate organic matter are very susceptible to nutrient deficiencies.

The decision to augment the inherent fertility of a landscape soil should be based on how healthy the plants look and perform as well as the results of soil and/or tissue tests performed by a reputable laboratory. Fertilizer applications are sometimes beneficial for recently planted non-native landscape plantings, particularly those growing in sandy soil. While common symptoms of nutrient deficiencies include smaller than normal yellowish leaves and stunted shoot growth, similar symptoms are the result of other factors, including root or crown diseases resulting from over-watering, insect damage, or environmental problems. Correctly identifying the cause of the symptoms before routinely applying nutrients is crucial to maintain plant health and to prevent surface and groundwater pollution from unnecessary fertilizer applications.

Be aware that a high soil pH may create a situation where soil nutrients are tied up in the soil and unavailable to the plant. A good example of this is iron deficiency, which is a relatively common

nutrient deficiency in high pH soils. Reducing the pH to a more neutral condition will remedy this situation.

Although nitrogen deficiencies are relatively uncommon in most established landscapes and overuse can lead to nitrate pollution in ground and surface waters, a discussion of quickly available (fast-release) and slowly available (slow-release) forms is important. This distinction refers to how fast the applied nutrients are available to the plant, and the length of time they remain available. Both quickly and slowly available sources of nitrogen fertilizer may be applied separately but are typically packaged together in one product for convenience, along with phosphorus and potassium.

Slowly available nitrogen products cost more than quickly available products, but do not require as frequent applications to provide an even supply of nitrogen, and are less likely to lead to water pollution. They have a lower burn potential and are recommended for sandy soils that are highly leachable. They are also easier to use when grasscycling (leaving cut grass clippings on the lawn as you mow), since flushes of rapid growth are easier to avoid.

Longer-chained urea formaldehyde products such as Nitroform and Hydroform, and natural organic products such as bone meal and activated sewage sludge are examples of slowly available nitrogen products that are dependent on high temperatures and bacterial activity for release, while polymer-coated sulfur-coated urea (SCU) and isobutylidene diurea (IBDU) are less temperature dependent. Coated urea products slowly discharge urea through cracks in the coating. The urea enters the soil solution over a two or three month period.

Sources of nitrogen that are quickly available include inorganic salts such as ammonium sulfate, ammonium nitrate, and potassium nitrate, and organic forms such as urea and methylal urea. They are all highly water-soluble. In California, ammonium sulfate is often the preferred quick-release fertilizer for general-use due to its acidifying effect on our high pH soils. It is important to remember that while fast-release fertilizers result in a more immediate response than slow-release forms of nitrogen, greater skill is needed in their application to ensure even distribution and prevent problems resulting from over-application such as surface and groundwater pollution.

Limit the Use of Pesticides

Pest control measures should always be selected and applied in a manner that minimizes water pollution. Pesticides applied in the garden can move off target by drifting in the air or washing off into storm drains or creeks.

- Do not apply pesticides just prior to rainfall or during windy conditions.

- Avoid applying pesticides to hard surfaces such as sidewalks or driveways, where they can easily be washed off.

- Check pesticide labels for warnings regarding use near bodies of water such as streams, rivers, and lakes.
- Never dispose of pesticides in storm drains, sinks, or toilets.
- Under no circumstances should pest control equipment be cleaned in a location where rinse water could flow into gutters, storm drains, or open waterways.
- Never apply more than the rate listed on a pesticide label.
- Be aware that some pesticides are more easily carried in surface runoff than others and therefore have a greater potential to move off site during irrigation or storms. The leaching and runoff risks of specific pesticides can be obtained from the UC IPM Web site WaterTox database (<http://www.ipm.ucdavis.edu/TOX/aboutwatertox.html>).

Practice Integrated Pest Management

There are many ways to manage pests other than by using pesticides. Most pest problems in urban landscapes can be prevented or reduced to acceptable levels through proper plant selection and use of recommended cultural practices. Integrated Pest Management (IPM) minimizes damage from insects, diseases, weeds, nematodes and other potentially harmful organisms through largely preventive measures. IPM is an important component of sustainable landscaping. It reduces waterway pollution, protects populations of beneficial soil microbes, encourages desirable wildlife, and conserves energy required for pesticide manufacturing.

Important IPM practices include providing optimum growth conditions for plants by matching plants to their preferred climates and microclimates; selecting disease resistant varieties; providing well drained, healthy soil; providing the right amount of water and nutrients; eliminating habitat or conditions that favor pests, and, many others. Low to moderate levels of many pests often can be tolerated. Also many insect and pathogen pests are controlled by naturally-occurring biological control agents or suppressive soils in gardens and landscapes that are managed sustainably.

An underlying principle of IPM stresses pesticide use only as a last resort. Pest control measures should always be selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment. If a pesticide is necessary, choose a product that will create the least environmental disruption, limit hazards to human health, and maintain the integrity of the ecosystem by targeting only the pest. For example, a broadly toxic insecticide may also kill natural enemies, pollinators or wildlife. The negative impact on the environment and human/animal health of some pesticide products may be significant. Likewise,

applying a pesticide before the problem is accurately identified is also an environmentally unsound practice, as is applying a pesticide on a plant to control a short-lived problem that will self-correct during a change in season or weather pattern or be controlled by natural enemies.

IPM programs combine a variety of management options to maximize effectiveness.

- **Biological control** relies on *natural enemies* (e.g.: predators, parasites, natural enemies) to control insect and mite pests. Another example is soil microorganisms in healthy soils that reduce soil borne plant pathogens.
- **Cultural controls** (or good gardening practices) prevent and reduce pest problems by promoting a favorable environment for the plant and an unfavorable habitat for the pest. Examples include providing a well-drained soil, and irrigating established plants deeply and infrequently to prevent disease-causing organisms that thrive under wet conditions. Another example is installing drip irrigation to eliminate soil surface moisture that favors weeds, snails, slugs, and other pests.
- **Mechanical and physical controls** kill a pest directly or make the environment unsuitable for it. Examples include using traps for rodent control, removing an insect from a plant with one's hands, hand-weeding and using mulches for weed control, and establishing barriers such as screens to exclude birds and insects.
- **Pesticides** can be part of IPM programs as well. Use pesticides only if nonchemical methods are ineffective. Choose products that have the least negative impact on beneficial insects, pollinators, and other non-target organisms.

Before any control measure is selected, correct identification of the problem is essential. Some problems require no control other than waiting it out, while others require a more active response. Many problems thought to be due to pests are actually the result of an environmental or physical stress, such as an unusually hot or cold season, too little or too much moisture, root damage due to construction, compacted soils with poor aeration, or mineral or pesticide phytotoxicity. In fact, most problems leading to unhealthy plants are due to soil and water management issues rather than pests. Following the recommended practices on page ___ under Water Management will prevent many of these conditions.

Of the pest problems that do occur in home landscapes, many are due to diseases, insects, and weeds. An overview of each follows:

Plant Diseases. Plant diseases disrupt normal, healthy plant growth, and when severe enough, can kill plants. Plant diseases occur when a plant pathogenic microorganism (e.g., a fungus, virus, or bacterium) interacts with a host (susceptible plant) under environmental conditions that favor disease development. For an infectious disease to develop, a series of events that are depicted in the disease triangle (see below) must occur: inoculation; penetration; establishment

of infection (which includes invasion of host plant tissues, growth, and reproduction of the pathogen); dissemination of the pathogen; and survival of the pathogen (overwintering or over-summering in the absence of the host).

Selecting plants that are resistant to a prevalent disease-causing organism in your area is a key IPM practice. Examples include native plants with broad disease resistance and newer varieties of introduced species with good disease resistance, such as many of the newer crape myrtle cultivars that are resistant to powdery mildew.

You can prevent or effectively manage most diseases by implementing appropriate cultural management methods. Choose plants based on your climate and microclimate; select healthy plants that are not root-bound or appear to be diseased; plant container plants at the same depth in the landscape as they were in the pot; keep roots of newly transplanted trees, shrubs and groundcovers evenly moist until established; cut back on frequency of irrigation but water more deeply once roots mature; provide adequate nutrition but avoid over fertilization; and, follow recommended pruning practices. Sanitizing pruning tools between cuts in rubbing alcohol, Lysol or a 1:9 bleach: water solution can prevent the spread of disease when pruning affected plants. To avoid corrosion of tools from bleach, lubricate them after sanitizing.

It is important to conclusively identify a causal agent for a disease before deciding on a treatment. Many abiotic (nonliving) disorders, such as drought stress, air pollution damage, and damage due to soil compaction and poor aeration in the root zone, mimic disease symptoms. Improper identification may result in an inappropriate treatment. You will not only fail to solve your problem, but waste money and may unintentionally worsen the situation.

(add pictures comparing disease and abiotic problems)

Arthropods. There are many insects, mites and spiders in our landscapes. Many are beneficial rather than harmful. Removing or killing beneficial insects will result in outbreaks of insect pests. It is critical that you properly identify the insect and related damage before deciding on a control measure. In a few cases, there may be natural predators that you can introduce to your landscape if high enough populations are not found naturally.

Beneficial insects include pollinators such as honeybees and other native bees; insect predators such as ladybugs, soldier beetles, wasps, lacewing larvae, and predaceous mites; parasites such as braconid and chalcid wasps and tachinidflies. Predator and parasite species play a vital role in maintaining insect pests at tolerable levels. If these beneficial species are killed off by pesticides, a large pest problem can occur later in the season. In addition, misuse and overuse of pesticides can kill pollinators. Reduction in pollinator populations will have a significant negative impact on the production of many types of fruits. Refer to the UC ANR Natural Enemies Gallery for additional information <http://www.ipm.ucdavis.edu/PMG/NE/>.

Following recommended cultural practices such as applying the correct amount of water and fertilizer and avoiding soil compaction and construction close to trees will go a long way to preventing significant insect or mite damage. In many cases, a plant weakened from an environmental stress or disease may be more susceptible to other stressors, such as spider mites,

than a healthy plant. Conversely, too much nitrogen can cause excessive vigor, which can then invite insects that prefer vigorous plants, such as certain psyllids, leafhoppers, and aphids.

Implement sound sanitation measures to significantly reduce insect problems. Woodpiles can attract termites, carpenter ants and even rats. Store wood up off the ground and away from outer walls. Trim vegetation that touches the house. Remove debris, rocks, and bricks where pests such as sow bugs, millipedes, snails and slugs hide. Also remove diseased plants, tree trimmings and fallen fruit and leaves, since they can all harbor pests. Handpicking, trapping and knocking pests off with a forceful spray of water are also good ways to reduce some insect problems in gardens.

Regularly check plant parts for signs of insect and/or mite feeding or tunneling: foliage (holes, skeletonized leaves; browning); trunk (holes, cankers, oozing sap, and dieback); roots (wilting, stunted growth, cut off or chewed appearance). Then identify the pest related to the damage you see: chewed foliage (beetles, caterpillars, grasshoppers); chlorotic, yellow foliage (aphids, mites, thrips, mites etc.); trunk holes (borers); and, root damage (grubs).

Before resorting to a chemical pesticide, try insecticidal soap or another non-toxic product if handpicking, spraying the pest with a forceful spray of water through a hose, and recommended cultural management practices previously discussed are not effective.

There are a number of low toxicity insecticides that are appropriate for use in sustainable landscapes. Preferably choose one of the following products if an insecticide spray seems necessary. Insecticidal oils (including mineral and plant-based oils like neem) control aphids, whiteflies, mealybugs, scale insects, lacebugs, psyllids, thrips and spider mites. Microbial insecticides, which are derived from microorganisms that cause disease only in specific insects, include *Bacillus thuringiensis* products for caterpillars and fungus gnats, and codling moth granulosis virus. Spinosad is a microbial-based insecticide that controls caterpillars, spotted wing Drosophila, leafminers and thrips—but it also can harm some beneficial insects. Be aware that these products are relatively short-lived and may need to be applied several times if populations are high. Always read and follow the label to get the best results.

Weeds. A weed can be defined as a plant growing in the wrong place. Thus weeds may include pesky plants that most of us consider weeds, such as dandelions and nutsedge, but also squash and tomato seedlings germinating in our compost pile or turfgrass growing in our planting beds. Brushy weeds such as blackberries or poison oak can be the most difficult to manage.

Like other pests, weeds can best be controlled through prevention. An excellent example is adding a three to four-inch layer of organic mulch on top of a clean, weed-free soil surface. This prevents weed seeds from germinating in the first place. Weed control fabric topped with an organic mulch also works well.

Drip irrigation is another tried and true way to reduce the number of weeds germinating between plants by keeping the soil dry. Other preventive weed control measures include maintaining a

dense cover of groundcover or lawn to prevent germination; making sure any soil amendments or composts are weed-free; and patching cracks in driveways and walkways.

It is very important to prevent weeds that do survive from producing seed. Many weed species produce literally hundreds of seeds. Weeds are easiest to pull when they are small and growing in moist soil. Make sure you hand pull or dig out the roots of annuals before they set seed. If perennial weeds are a problem and you can't dig up the entire root system, deprive them of energy by cutting the plant off at ground level and cover the area with three to four inches of mulch. If they re-sprout, cut them back to the ground right away to deprive the plant of energy before leaves develop. You will eventually win the battle!

Hand-pulling weeds or using cultivation tools is a key method of weed control. Use a shovel or hoe to turn the soil and remove weeds. If you dig deep and turn the soil over, weed seeds may surface from this method, so do not plant until you have had a chance to remove a second crop of weeds. Specialized tools like dandelion tines are useful and keep seeds from surfacing. Solarize soil by placing a two mil piece of clear plastic over a moistened, clean soil surface and securing the edges for six weeks to two months during the hottest time of the year. This will kill most weed seeds in the top few inches of soil.

Low toxicity, organic herbicides such as those containing clove oil (Burn Out II) or soap (Concern Fast Acting Weed Killer) are available. However, these products kill only the top portion of the weed, and the roots or crowns of perennials or older plants will likely re-sprout. Older weeds will likely require repeated applications.

CAUTION: When spraying any type of pesticide, follow label directions carefully. Avoid applications during windy weather and protect landscape plants from coming into contact with the chemical. Keep pets and people out of the area until the product has dried.

The best methods for managing pests vary from species to species. See the UC IPM home and garden web site at www.ipm.ucdavis.edu for environmentally sound pest management practices for hundreds of garden and landscape pests.

Nurture the Soil

A basic understanding of your landscape soil and how to nurture it are important aspects of successful sustainable landscaping. Because soil conditions are largely below the surface, it is easy to overlook the importance of how soil texture and structure relate to water and nutrient management, and how activities such as construction and heavy foot traffic may negatively impact plant health. All too often, adverse effects from these situations do not result in above ground plant decline until they are too late to remedy.

The waterholding and nutrient-storage capacity of a soil are largely determined by its texture (particle size representing the sand, silt, and clay content) as well as its structure, which is how the textures remain held together (aggregate). Fine textured-soils contain relatively high percentages of silt and clay hold more water and nutrients than coarser-textured soils with higher percentages of sand. Generally, the higher the sand content of a soil, the more freely (draining?)

and better aerated it is. Heavier soils with greater clay content drain more slowly and are more prone to poor aeration and minimal downward root penetration. Aggregation is an important and beneficial process that occurs when groups of soil particles bind more strongly to each other than to adjacent particles. Pore space between the aggregates is important for water retention and for air and water exchange. Aggregation is poor in very sandy soils void of organic matter and clay. Soil aggregation can be enhanced by adding compost (discussed later in this publication) deeply and homogeneously into garden soil. Tilling a soil too often can destroy aggregation and should be avoided.

Maintaining a uniform soil profile void of layers (horizons) of varying textures is a key component of healthy sustainable landscapes. Layered soils result in poor infiltration and downward movement of water because soil will not move into a deeper horizon until the upper horizon reaches water-holding capacity. Layered soils can result in shallowly rooted plants; they are particularly problematic for trees which require deep homogeneous soils for adequate anchorage and stability.

Construction activities should be kept several feet from tree trunks to maintain healthy trees that are not prone to failure as they mature. Tree roots can easily be injured and destroyed by soil compaction. Tiny root hairs absorb water and nutrients while larger roots anchor the tree and store mineral elements and carbohydrates. Tree roots grow horizontally two to three times the diameter of the dripline and most live in the top 18 inches of soil, making them particularly susceptible to soil compaction.

Compost is an excellent soil conditioner that, when applied properly, reduces loss of soil water from evaporation, buffers soil pH, and adds valuable organic matter to landscape soils. Rather than providing large quantities of nutrients, its value lies in increasing the drainage of clay-based soils and the water holding capacity of sand-based soils. This topic is covered in more depth below.

Greencycle – Recycle Organic Matter

You do not need to throw away most green waste such as lawn clippings, prunings, or dead garden and landscape plants. Reuse them instead in your landscape for healthier plants and a cleaner environment. Californians generate over 43 million tons of municipal solid waste each year or 6.4 pounds per person per day. Recycling this valuable resource improves soil health and diverts thousands of tons of greenwaste from overflowing landfills each year.

There are several environmentally-friendly options for using greenwaste that result in a healthier landscape and garden. These methods may be used singly or in combination to achieve your ‘zero accumulation’ goal. “Zero accumulation’ means that you reuse all the greenwaste that you generate. Options for reusing greenwaste (greencycling) include: composting, mulching, grasscycling, incorporating, soil amending, and making your own potting soil. The greencycling system that is best for you largely depends on the kinds of greenwaste you produce, equipment you own, and your specific home horticulture needs for the end products.

Mulch. Most landscape plants benefit from applying mulch. Organic mulches can be composted or fresh greenwaste materials spread on top of the soil around landscape and garden plants. Some are large in size such as wood chips made by chipping tree branches and trunks; local tree trimming services often offer this material for free. This type of mulch is useful on garden walkways, as well as around plants. A three to four inch layer of mulch can reduce soil evaporation and runoff, aid in weed and erosion control, buffer soil temperatures, reduce compaction from foot traffic and construction, and result in a more attractive planting. Due to settling over time, you may have to replenish the mulch occasionally when less than two inches is left. Since wood chip mulches do not decrease much in size and decompose slowly, they do not need to be replenished often, and adding a two to four inch layer holds up well over time in most cases. Coarsely shredded wood mulches are often preferred for erosion control since they weave together and do not wash away readily. Adding a leafmulch to a vegetable or flower garden using deciduous tree leaves in the fall is a great way to maintain higher soil temperatures into the winter. Remember to remove the mulch early in spring so the soil can warm up quickly if you live in an area with cool springs. While most trees and shrub leaves make great mulch, plant parts from some, such as black walnut, acacia, eucalyptus, camphor, and oak, and black walnut often contain large amounts of harmful chemicals that may damage plants. While research indicates that mulches made from these species do not harm plants, it is always best to compost them first to play it safe!

Grasscycle. Grasscycling is the easiest way to recycle lawn clippings. Clippings are simply left on the lawn to decompose, rather than being bagged. Besides diverting organic matter from landfills, grasscycling supplies valuable organic material and nutrients to the soil. Studies indicated that grass clippings contain about four percent nitrogen, one-half percent phosphorus, and two percent potassium. Grasscycling reduces mowing time, buffers soil temperature, reduces evaporation, and aids in erosion control. Contrary to popular belief, grasscycling does not contribute to thatch (a partially decomposed layer of turfgrass stems, shoots and roots that accumulate at the soil surface). Grass clippings are composed mostly of water and decompose rapidly when left on the lawn. However, it is necessary to mow at least weekly when grasscycling to avoid a build-up of excess clippings on your lawn. There are many makes and models of dedicated mulching mowers on the market. Conventional bagging lawnmowers are good choices if you prefer to compost your lawn clippings instead of grasscycling. Grass clippings are also a valuable source of nitrogen for your compost pile.

Maintaining your lawn at or slightly below the recommended mowing height is important when grasscycling. In general, mow often enough so that you never reduce the leaf height by more than one-third during any given mowing. Mow common bermudagrass lawns when blades reach two inches long (tall?), and tall fescue lawns when blades reach four inches tall. Cutting your lawn at the right height is one of the most important elements of successful grasscycling and maintaining a healthy lawn.

Incorporate. Bury organic matter such as dead plants, grass clippings and tree and shrub prunings, along with small amounts of kitchen waste such as fruit and vegetable peels, to improve soil texture and perhaps add nutrients over time. Find a vacant patch of ground, remove a shovelful of soil at least six inches deep, deposit your organic matter, and replace the soil. Most

waste will decompose within one month. Avoid adding oils, meat, and dairy products because they will not break down readily.

Compost. Compost your landscape tree and shrub prunings, grass clippings, and fading flowers and vegetable garden remnants to add valuable organic matter to your garden, improve growth and decrease the amount of organic matter otherwise destined for landfills.

Soil is a valuable yet limited resource that can be improved, conserved, and increased through the proper use of compost. Compost improves soil tilth and structure; improves the water holding capacity of sandy soils; improves drainage in heavy soils; improves soil nutrient holding capacity; prevents or decrease erosion; improves soil aeration; decreases the need for chemical fertilizers; remediates chemically damaged soils; replenishes nutrients required for plant growth; increases the activity and diversity of soil microorganisms; reduces the incidence or severity of certain soil-borne diseases; and, filters storm water runoff.

Mix several inches of compost into your vegetable and flower gardens before you plant, or use it as a potting soil as is. Avoid planting trees in compost because this will encourage a small root zone confined to the composted area and likely unable to support a maturing tree.

Building Your Own Compost Pile

Step 1: Find a convenient location near a source of water in a partly sunny location.

Step 2: Collect enough 'browns' (leaves, tree trimmings under one inch) and 'greens' (grass clippings, old flowers and vegetables) to make a pile at least 1 cubic yard in volume (3' x 3' x 3'). Chop or shred coarse materials so they will break down faster.

(Avoid adding meat scraps, fatty material and bones, chips or sawdust from treated wood, large pieces of wood which decompose slowly and large volumes of ash from wood burning stoves which can significantly increase pH.)

Step 3: Mix the materials regularly and add moisture as needed. Squeeze a handful of the mixed material to check its moisture level. If you can barely squeeze out water (similar to a wrung out sponge), the moisture level is about right. The pile should be slightly moist rather than soggy or dry. If the pile is too dry, add water, and check the moisture again. If it is too wet, mix in some drier material.

Step 4: Continue adding 'browns' and 'greens' and mix the pile regularly

For a more thorough discussion on the topic, download 'Compost in a Hurry';
<http://anrcatalog.ucdavis.edu/pdf/8037.pdf>

Protect and Encourage Appropriate Wildlife

For hundreds of thousands of years, plants, animals, and other living organisms have interacted with one another and the environment. As a result, species adapt and change over time, shaping an ecosystem supporting a wide variety of life forms. It is estimated that 6,000 acres of open space are lost each day in the U.S, resulting in a significant reduction of wildlife habitat. In addition to losses due to urban sprawl and development, misuse of pesticides, invasive plant species, climate change, and other stresses have further reduced natural habitats for wildlife.

Ensuring a balanced ecosystem that supports a wide array of plant and animal species should be a primary goal of your sustainable landscape. Butterflies, birds, pollinators, beneficial insects, and other wildlife will be attracted to your landscape if you provide their basic requirements.

The Four Basic Wildlife Needs: Food, Water, Cover and Space

Food. Food supplies energy and nutrients. Wildlife species native to your area have largely evolved with plants that are also native to your area. An excellent way to provide food for wildlife is to restore native plant communities in your landscape. Never feed any wildlife species human scraps, trash, or pet food. These types of foods are unhealthy for most wildlife. In addition, some species of mammals such as raccoons, skunks, bears, and deer can become dependent upon humans as a source of food. Many lose their natural fear of humans and potentially dangerous encounters can occur.

Each wildlife species has its own nutritional needs, which change seasonally and across their life cycles. A diversity of fruits and berries; grains and seeds; nuts and acorns; browse plants which include twigs and buds; forage plants (grasses and legumes); and aquatic plants is recommended to attract a wide diversity of wildlife. Insects and other invertebrates that are attracted to flowers, shrubs and trees are also a food source for wildlife.

Providing food in fall and winter is especially important in colder California climates. Wildlife species that are inactive or hibernate in the late fall and winter need to increase their caloric intake in the late summer and early fall in order to survive. Migratory species need a steady source of food over a wide geographic area. Monarch butterflies rely on late blooming plants such as aster and goldenrod to provide the nectar they need to make their journey south.

Maintaining a steady supply of predators that feed on unwanted insects and other pests plays an important role in your wildlife habitat. When predators are present, ecosystems tend to be more diverse, more resilient, and healthier. Predators maintain an ecosystem balance by keeping populations of their prey in check. Spiders are common garden predators that catch and eat more insects respectively than all other insectivorous animals combined. Other predators include the Ladybird beetle, salamanders, and owls.

Although the best way to provide food for wildlife is to preserve and restore local plant communities, supplemental feeders are recommended when this is impractical. Birds can be safely fed with feeders. Studies have shown that many birds rely on natural food sources first and use feeders only to supplement their diet as needed. They don't become dependent on feeders or

delay seasonal migration or starve if you stop feeding them. Since the type of seed placed in the feeder can determine what species of birds you attract, select seeds appropriate for your habitat. While black-oil sunflower will be eaten by almost any bird species, safflower is less appealing to squirrels and to exotic birds such as English or house sparrows.

Water. All wildlife species need water for drinking and many need it for bathing, as well. There are many ways you can provide water in a backyard habitat, and should be determined by the type of wildlife you want to attract. Options range from water gardens to simple birdbaths or puddles. If you have a water habitat on your property, preserve it. Be sure to change water regularly to prevent mosquito breeding.

Cover. Many wildlife species rely on cover, or shelter, to provide protection from the elements and predators. Some predators rely on cover as camouflage. Cover is also used for feeding, resting, nesting and rearing young. Cover comes in many different types and can be both living (e.g.: trees, shrubs, grasses and flowering plants) or nonliving (e.g. rock piles, brush piles, rock walls, cavities in trees and birdhouses).

Space. Space is a critical component for wildlife. All wildlife species need places to bear and raise their young. Space is also used for courtship and mating, nest building, digging dens and burrows, egg laying or live birth, and to provide areas for exercise and even play. You can increase the vertical diversity of your landscaping by adding more layers of vegetation between the ground and the top of the trees, varying heights and growth habits in arrangements that are appealing to you. This will meet the spatial needs of a wide array of wildlife that feed, nest and find shelter at varying elevations.

Additional Ways to Encourage Appropriate Wildlife to your Sustainable Landscape

1. Limit the size of your lawn. Grass offers very little food or cover for most wildlife.
2. Provide snags and brush piles. As trees become diseased or die, consider leaving them either standing or lying
3. Plant native vegetation whenever possible. Natives provide better food / cover, and require less care and maintenance.
4. Plant a wide variety of flowering plants with varying bloom periods to ensure pollination. Make sure to include species that produce berries or seeds that provide food for wildlife.
5. Provide bird/bat houses and bird feeders. Adding different types of feeders and houses helps increase wildlife diversity.
6. Remove invasive exotic plants. Invasive plants aggressively take over natural habitats and can out-compete native vegetation.
7. Manage pets. Cats and dogs can drastically impact wildlife. Cats are excellent hunters and kill millions of birds and mammals each year.
8. Reduce pesticide use. Implement integrated pest management strategies discussed in this publication and found at <http://www.ipm.ucdavis.edu/>
9. Expand the size of your habitat. The required habitat for many wildlife species is much larger than what you could provide within your yard. Consider partnering with your neighbors to create larger wildlife habitats.

Conserve Energy

Important goals of energy efficient landscapes are to use less energy in gardening practices and to choose plants wisely to reduce inside energy use while maintaining the functionality of the outdoor landscape. Incorporating recommended sustainable landscaping principles and practices that modify your outdoor environment can also positively impact your indoor environment, reducing energy and utility costs. Properly placed vegetation, use of energy conserving landscape maintenance measures, can significantly reduce energy use while keeping your home warm in the winter and cool in the summer. Use of energy efficient lighting and gardening equipment can also increase the energy-efficient nature of your home and landscape and at the same time can increase its real estate and aesthetic value.

An obvious starting point is tool selection. Consider dusting off your hand tools and retiring power tools. If you maintain a lawn, consider using a reel mower or an electric mower to save gas. Other obvious changes you can readily make are to think and buy locally, propagate your own plants and share them with your neighbors, use local or recycled building materials, and grasscycle and compost your lawn and landscape trimmings.

You can significantly reduce indoor energy use by strategically planting trees. In hot inland regions of California, well placed trees can provide shade to cool roofs, walls, and windows. Trees can reduce surrounding air temperatures as much as 9°F. About 40 percent of the unwanted heat that builds up in your house enters through windows. Block sunlight before it enters windows. Because the summer sun is so high, almost twice as much solar energy enters through the east and west windows as the south windows. This is especially true if there is a roof overhang on the south side of your house.

Deciduous trees (trees that lose their leaves each winter) offer one of the best opportunities to cut home cooling costs. Planting them on the northeast-to-southeast and northwest-to-southwest sides of your house provides excellent protection from the summer sun by shading the roof, walls and windows. Deciduous trees permit winter sunlight to warm the house. This is why it is best not to plant deciduous trees on the south side of your house if you live in a cool climate. In the winter, even bare branches of mature deciduous trees can reduce the amount of sun reaching your home.

When choosing a shade tree to plant, consider its ultimate height, growth rate, branch spread and shape. These factors influence the tree's cooling benefits. For western exposures, wide-spreading trees are best. Tree species that never grow tall won't provide much shade. In general, try to shade as much of the roof and walls of your home as possible. Resist the urge to cover a small portion of your home with dense shade if instead a larger area could be covered with less dense shade. This will ensure optimum summer cooling. If you're concerned about preserving your view, keep the sun's path in mind and plant one or two smaller trees slightly to the side of the window.

Well-placed landscape plantings also reduce the impact of 'heat islands.' Air temperatures under shade trees can be 20-25°F cooler than air temperatures above blacktop. Strategically planting

turf and groundcovers next to driveways, streets, and sidewalks can significantly reduce the temperature of surrounding areas as well. Temperatures just a few inches above turf and groundcovers can be up to 20°F cooler than above black asphalt and 12°F degrees cooler than above lighter colored concrete surfaces.

Landscape plants with low crowns provide excellent windbreaks by blocking wind close to the ground. Dense plantings of evergreen shrubs and small trees on the north and northwest side of your home can serve this purpose. To reduce wind chill, vertical windbreaks with approximately 50percent density positioned at a 90° angle to the direction of the wind are preferred over a dense, solid wall, which can result in turbulence.

Energy efficient lighting for residential landscapes has gained popularity in recent years. Light emitting diodes (LED) are both energy efficient and cost effective in the long run. For these reasons, they have quickly gained popularity in residential as well as commercial landscapes. While the initial cost of LED lamps is higher than other lighting options, their lifespan is much longer (around 200,000 hours). LED lighting is versatile and is also available in solar-powered units, though they are less effective during the winter.

Summary

Selecting suitable landscape plants for your climate and microclimate and following ‘best management practices’ that are water-efficient, protect ground and surface water quality, nurture the soil, recycle organic matter, protect and encourage appropriate wildlife, and are energy efficient can greatly enhance the beauty of your landscape and protect the environment for future generations. In addition to recommendations in this publication, UC ANR has a wide array of information that covers many of these topics in extensive detail: <http://anrcatalog.ucdavis.edu/> and <http://www.ipm.ucdavis.edu> are a great place to start. Many publications are free and instantly downloadable while others carry a nominal charge.