Chapter Two

Garden Basics: Your Eyes are the Best Tools in the Garden

Gardening success takes more than simply admiring your view. Taking a good look at your plants helps you recognize potential problems on leaves, flowers, stems, shoots, bark or the entire plant. (If the whole plant is failing, it might be a root issue.) This chapter helps you diagnose problems, and recognize knowledge, or the lack of it, behind a salesperson's advice.

Leaves. Do leaves drop off, curl up, or droop? Are they off-color—maybe yellow or brown—or are the outer edges pale or brown? If they have holes, note their size and shape. If spots, note colors and patterns. And which leaves are affected? New or old, high or low, or on just one side of the plant?

Flowers. Do the buds drop off or fail to open? Are blossoms undersized, spotted, sticky, ragged, or misshapen? Do you see holes, fuzz, powder, cocoons, yellow stuff, or anything else that doesn't look normal?

Shoots, stems, or trunk. Do you see holes or slits, abnormal peeling, wilting, or lumps, bumps, or growths? Is slime or sticky stuff oozing from a hole? Fuzzy or powdery stuff? Blackened areas or dark rings near the soil?

Roots. Are plants undersized or just don't grow? Do they fall over or pull out easily? Dig down to examine roots. Do you see knots or growths? Are roots slimy; do they smell rotten?

A loupe is an integral part of scouting for small pests or signs of pests. Buy a few extra and share them with children and adults. A close look at nature really stirs curiosity and may increases understanding. Pest control is a team effort.

Name That Plant

Here's why it's worth your time to learn your plants' Latin (scientific) names and family connections. Start with a few of your favorites. Impress your friends and neighbors.

- Common names vary from region to region
- Most diseases and many insect pests are species-specific, meaning they only affect one or a few plant species within the same plant family. Knowing a plant's scientific name and family helps you pinpoint the problem.

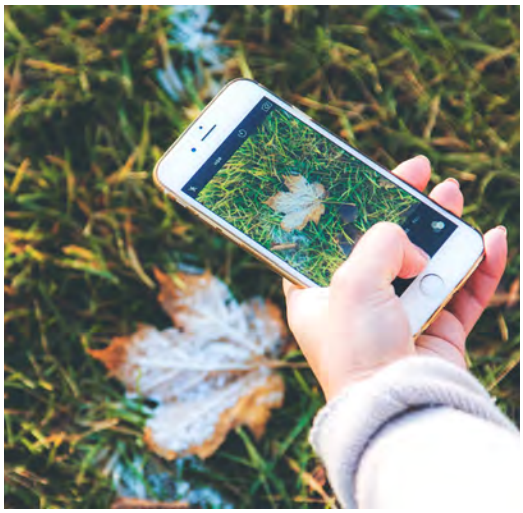
Loupe-de-loupe

We try to provide detailed descriptions to help you, a master gardener, or garden center pro make the correct identification. Examples: 'Pinkish gray with brown head and spots on every segment' or 'bright orange pustules on leaf undersides'. That's a lot of detail without magnification.

Consider buying a loupe, the kind of inexpensive, hand-held magnifier used by IPM scouts and field biologists. Digital microscopes aren't that pricey now, and provide educational fun for adults and kids.

Help!

Contact your local Cooperative Extension or a reputable nursery or landscape firm for help in identifying your plant and possible pest. Careful packaging, and quick turnaround is the best way to get a sample to those who may help you. Describe the setting, symptoms and history of the plant or site. Send along digital photos as well.



- Each species and cultivar has its own characteristics—growth rate, size and shape, the look of the leaves or buds, how long it takes to produce flowers or fruit. (In some species yellow leaves could indicate drought or a nutrient deficiency, but in others it's their normal color. Bumps or nodules on the roots of some plants are normal—they're nitrogen-fixing plants; but on other plants, nodules could mean trouble.) The Latin and cultivar name helps you discover what is normal for that specific plant.
- Every diagnosis, whether from a book or a professional, starts with a plant's Latin name.
- What you do about a problem (and when you do it) varies by the species. Leaves dropping from some trees in July might be fairly routine. For others it's a sign of serious stress. You can treat one type of scale insect with horticultural oil during one timeframe, but another scale requires different timing.

While it's true that disease and insect pests also travel by common, and often confusing, names, you don't usually need to know the Latin name until you have a diagnosis. Then, knowing its proper name helps you choose the right tactics for dealing with it.

Identifying Plants

Other gardeners might be able to help you name the plants in your yard. Good records help—save plant tags when you buy plants; put tags on trees and shrubs. Make a sketched map of your garden, and pencil in names. Buy or borrow field or garden guides to identify plants. Professionals use "key guides" for identification. Don't be intimidated if you're inexperienced. They're definitive. With today's digital images, a few detailed photos on your phone or other mobile device can help you get assistance in identification.

Be a Good Detective

Good detectives ask good questions, observe the whole scene, and consider its history. Do the same when you're figuring out why your plant appears unhealthy or what led to its demise. Events that happened a year ago might have caused today's problem.

Culture. In the world of gardening, culture isn't about a night at the opera, but about meeting a plant's needs. If your blue spruce requires excellent drainage but is planted in clay soil prompting standing water, look no further. If your white pine is near the road, salt thrown by snowplows probably caused those brown needles that face traffic. If the tea rose you bought in southeastern Pennsylvania isn't thriving in your Tug Hill garden … you get

Defining Sun and Shade

Full Sun: 6+ Hours

Part Sun: at least 4-6

Part Shade: 3-6 hours of sun may be tolerated but avoid afternoon sun. All day dappled works too.

Full Shade: most will tolerate 2-3 hours of sun early in the day.

the idea. A plant's site or cultural requirements means its best location, soil, and care.

History. Has your plant been transplanted, pruned, or fertilized? What about weather patterns? Drought or endless rain, humidity or high winds, early or late freezes, extreme heat or rapid temperature changes—all affect how plants and pests grow and change. Planting a lawn, building a garage, putting in a walkway, or cutting down a nearby tree alter the site.

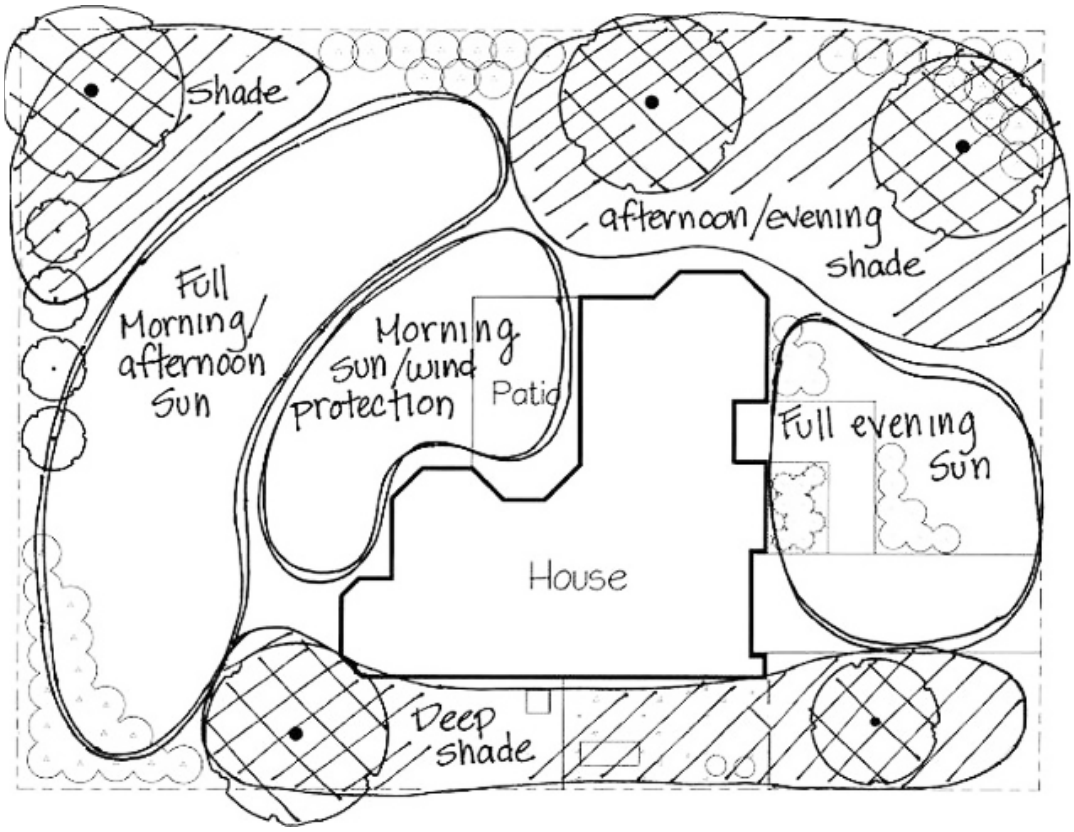
So before you get busy identifying diseases or insects (biotic organisms), consider your plant's history and growing conditions. This resource guide tells you what cultural (abiotic) conditions to watch for.

Your Site. Bad things happen when good plants are in the wrong place. They look terrible, don't grow, attract pests and diseases, or die. It's easy to blame a late-appearing insect or recent disease when a plant does poorly, but plant decline might be related to being planted without regard to its needs (even many years prior) or subsequent lack of care. Trees and shrubs usually take longer to decline than your perennials do, mostly because they have larger root and vascular systems and can store more food. The site could be wrong because it drains slowly, or too well; air circulation is poor or a hilltop setting exposes them to ceaseless wind; plants get too much or little sun, shade, warmth, or cold—each plant having, of course, its preferences. And sometimes nature lets them down. Unusual droughts, floods, severe winters, and scorching summers can take their toll.

Plants that prefer shade can tolerate sun with some extra care and additional moisture, but will rarely thrive. You might notice the flip side. Plants that prefer sun will become spindly and fail when, years later, a sunny yard becomes shady. Photo: mwms1916, c2.staticflickr.com/6/5322/9186166429_6f29a9c141_b.jpg, CCBY-NC-ND 2.0

Map your garden

Note sun and shade, as well as areas where soil tends to be wet or dry. Start small with gardening until you know how much time you need to invest to keep your plants healthy and your schedule flexible.



A garden map. Illustration: Gail Hansen, UF/IFAS, gardeningsolutions.ifas.ufl.edu/design/ ten-planning-tips-for-design.html.

Hardiness Zones		
ZONE	RANGE °F	RANGE °F
1	Below -50	below -30°F
2	-50° to -40	-35° to -30
3	-40° to -30	-35° to -20
4	-30° to -20	-20° to -10
5	-20° to -10	-10° to -5
6	-10° to 0	-5° to 5° F
7	0° to 10	5° to 10
8	10° to 20°F	10° to 20°F
9	20° to 30°F	20° to 30°F

Heat Zone Averages	
ZONES	AVERAGE
1	less than one day over 86°
2	1-7 days over 86°
3	7-14 days over 86°
4	14-30 days over 86°
5	30-45 days over 86°
6	45-60 days over 86°
… and up	

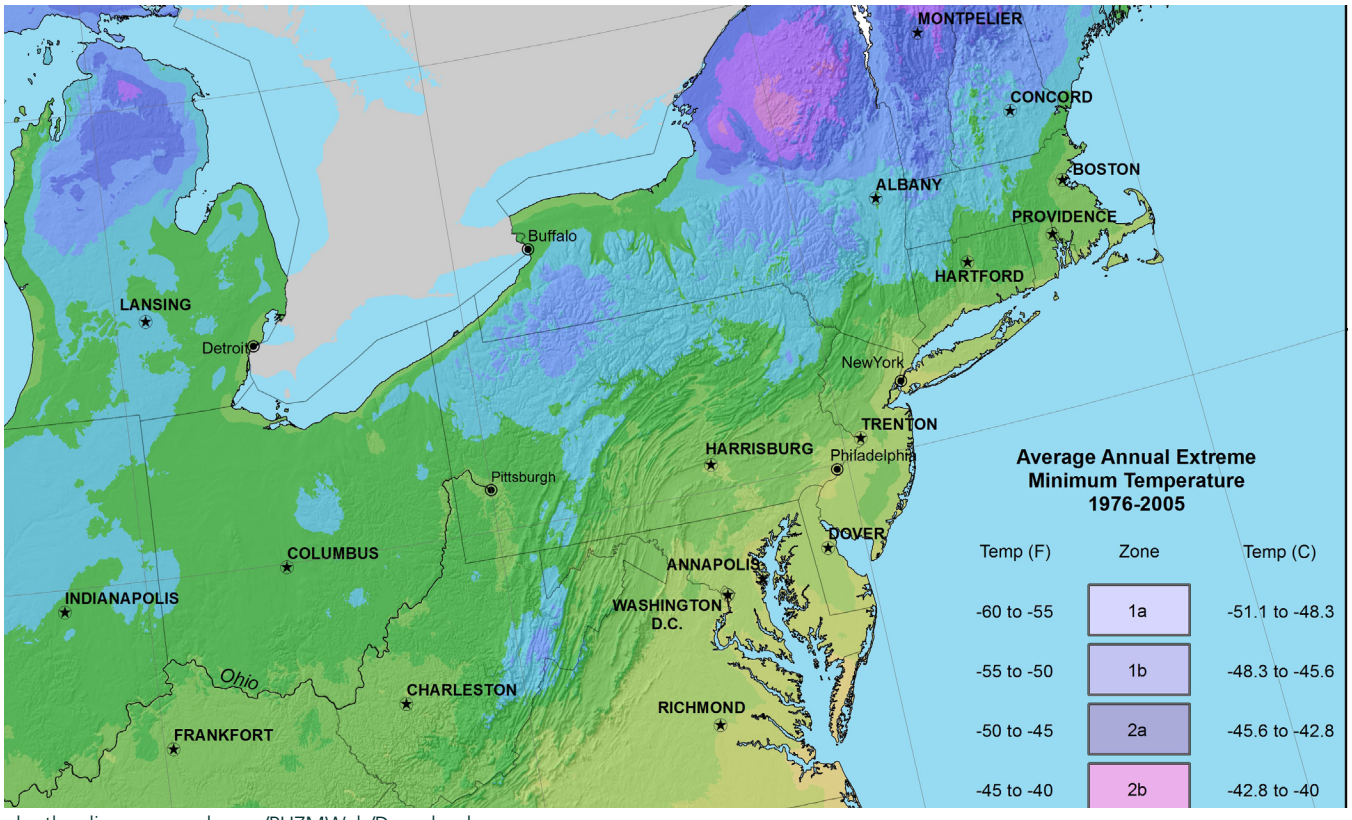
The American Horticultural Society also publishes a Heat Zone Map showing the average number of days a particular area has temperatures of 86 or above. The northeast is primarily in zones 3, 4 and 5.

Getting to Know Your Property

Taking the time to learn about your site and what your plants need will reduce future problems. Stroll around your property, jot down your observations, questions, and how weather changes week-to-week, season-to-season, year-to-year. Note the following:

- Areas of sun and shade; six plus hours of sun is usually the minimum
- Soil moisture. Does the ground stay soggy after a rain or dry quickly?
- Air circulation. Do trees or trellised vines inhibit the breeze?
- Frost protection. Cold air tends to pool in low-lying sites while sites near buildings tend to be more protected

Consider the site at all times of year, even if you're growing only veggies or annual flowers. Let's move on to factors influencing your site and the health of its plants:



planthardiness.ars.usda.gov/PHZMWeb/Downloads.aspx

Orientation and Exposure; Heat and Cold

Does your garden face east, west, north, or south? Does it get direct wind? Is it sheltered by a building or other plants? Orientation and exposure create microclimates that increase or decrease the likelihood of success. Some plants can survive a harsh winter if they're in a sheltered spot.

The Meaning of Zones

Plant tags or reference books show you a "Z" or "Zone" range of numbers. What do those numbers mean?

The hardiness zone indicates whether the plant can survive where you live, and refers to the lowest average annual minimum temperature in the area. Learn what zone you're in.

Higher numbers signify warmer areas, (Zone 9 is found in Florida), while lower numbers are given to colder areas. Northern Maine is Zone 3. Hardiness zones are important—but far from perfect science. Sometimes zone ranges are based on scientific trials. But sometimes they're experts' best guesses based on personal experience and anecdotal information. Still, pay attention. Don't count on a plant listed as "hardy to zone 6" to survive in zone 5.

Another confusing thing about zones: there are two different systems or hardiness zone maps used by experts and books. The first was developed by the United States Department of Agriculture (USDA) and the second by the Arnold Arboretum of Harvard University. They differ slightly, so check your plant tag to be sure which one it's referring to. Both maps show the Northeast states to mostly be between Zones 3 and 6.

And since too much heat is sometimes a plant killer, the American Horticultural Society has also published a heat zone map. Most of the northeast falls in Zones 4 and 5.

Sunlight and Shade

How many hours of direct sunlight reach your yard and garden daily throughout the growing season? Morning and afternoon light affect plants differently. Direct, afternoon sun is hotter than morning sun and too harsh for some plants. Note the source of shade and its quality. Dappled shade, like sunlight filtered through tree leaves, is different from the solid shade cast by a building. Remember that in ten years, your sunny garden might be shaded by that new tree.

Heat Stroke!

Wilting on a hot day, bleached leaves that turn brown and shrivel—those are classic signs of too much heat. Even when you pick the right site, a sudden streak of unseasonably hot weather can put your plants in a tailspin. These plants need temporary shade. Keep a stash of crates, big plastic pots, stakes, shade cloth, or even old sheets on hand. Use them to put together protection as needed, based on the weather forecast.

Disease? Insect damage? Human carelessness? No, this is sunscald on a thin-barked evergreen. Once the damage is done, insects and disease have easy access. Photo: Susan K. Hagle, USDA Forest Service, Bugwood.org, www.insectimages.org/browse/detail.cfm?imgnum=1241756&

Plant Survival is a Complex Thing

These all matter where hardiness is concerned:

- Your microclimate: Do you garden in a protected courtyard? Is your home on a wind-chilled hilltop?
- How hot and humid are your summers?
- How much snow falls and remains on the ground in winter?
- How long does it stay really cold?
- What's your total rainfall?
- Does extreme cold strike in mid-winter—or in spring? Bud and stem damage is more likely in spring.

Our Abiotic World

You know what cultural means in your landscape. It's about care, about thinking ahead. But other abiotic factors, those things that aren't alive, and are sometimes beyond our influence, also matter:

Actual soil chemistry—how it alters plant nutrition.

Environmental—the wind that flattened your corn; scorching days or endless rain.

Mechanical—the weed whacker that scoured the bark off the beautybush.

Site issues—the big fence that went up on the south side of your berry patch.

Allelopathy—the toxins in some plant roots that keep other plants away and are the plant world's form of chemical warfare. It can work for you or against you.

Good Neighbors?

Existing plants in your garden can tell you about your site, and may have an impact on the plants you add. If rhododendrons are thriving several years after planting, your soil is acidic (or it's been routinely treated). If the moisture-loving ligularia, a perennial, looks great, you have a damp site. If the sugar maples are healthy, you probably have decent drainage and little salt accumulation from winter.

Tree roots can reach great distances, competing for nutrients and moisture. Because black walnuts are allelopathic, a substance in their roots keeps some plants, notoriously tomatoes, from growing nearby. Experiment carefully with a few plants to see what can handle the site. Some trees block sunlight when they mature. And some plants are alternate hosts of diseases or insects that could damage newcomers.

The Clues—Signs and Symptoms

Symptoms describe what's happening: wilting, browning, spots, holes, no fruit, plant doesn't grow. Wilting, for example, could mean not enough water, borers in the stems, or a bacterial disease such as bacterial wilt of cucumbers and other cucurbits. And stippled, finely dotted leaves could speak of leaf-sucking insects or ozone pollution, while water-soaked spots on leaves usually point to disease.

A lady beetle larva feeds on the sticky honeydew marking an aphid infestation on this rhododendron. Next up is sooty mold. Photo: OSU Master Gardeners, c1.staticflickr.com/7/6148/5975235475_e5a15011c1_b.jpg, CC BY-NC-ND 2.0

Signs are evidence that may explain what is causing your problem. Signs of cultural or abiotic problems could be salt residue on a nearby sidewalk or even something as commonplace yet critical as pools of standing water where you haven't seen water stand before. Signs of insect activity are eggs, larva or nymphs, pupal cases (cocoons), adults, and their droppings (frass) or excretions (honeydew). Don't assume it's a pest. It might be a beneficial. And sooty mold or other fungi that grow on honeydew, typical on magnolias, catalpas, and linden trees, could be a sign of aphids, scale, or other pests.

True signs of disease usually take a specialist with a microscope to diagnose. Fuzzy stuff is most often the mold or fruiting bodies of a fungal disease. Still, for a solid diagnosis, diagnosticians need to examine the tissue using a good dissecting microscope, isolate it on the right culture media in petri plates, or test for the actual pathogen such as a fungus, bacterium, nematode, or virus.

Signs and Symptoms of Cultural Problems

Most problems happen when plants are in the wrong place or get the wrong care, whether it's nature or you that's not meeting their needs. Some clues to cultural problems speak for themselves—the drooping leaves of a drought-stressed plant. Sometimes the clues are the diseases or insects that come after.

For example, a plant getting too much nitrogen fertilizer puts out the new lush growth aphids love. This can lead to aphid infestation and damage of new growth. So the original problem might simply have been cultural, as in too much fertilizer, but now you have a pest problem too. Of course, aphids sometimes attack unfertilized plants as well.

Move It

If a perennial plant is not doing well, you can try another spot. Move it in the late fall or early spring for the best chance of success. Some plants don't transplant well, but if they are failing in one spot, it might be worth the try. Water transplants well until roots have had a chance to recover, and then baby it for a few months.

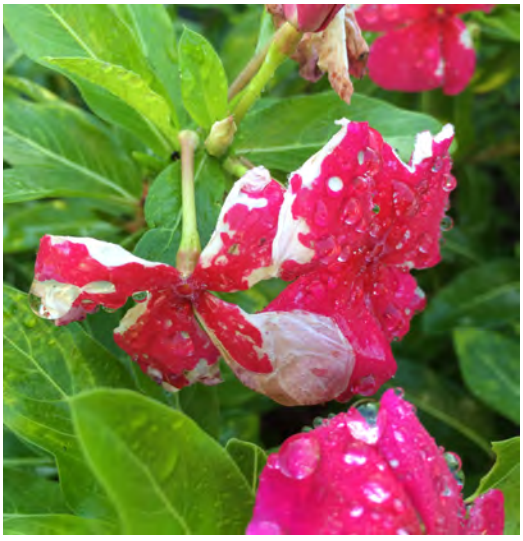
Nutrient Deficiencies in Plants

Nutrient	Symptom	Fertilize with
Calcium deficiency (Ca) (Macronutrient)	New leaves at top of plant or ends of stems are distorted. Note: May cause blossom end rot.	Calcium, Gypsum. NOTE: excess calcium may inhibit other nutrients.
Nitrogen deficiency (N) (Macronutrient)	Lower and inside leaves become yellowed (Chlorotic).	Ammonium, Urea, Nitrates. Aged manures are an option. NOTE: More is not better.
Phosphorus deficiency (P) (Macronutrient)	Older leaves turn dark green or purplish. Leaf tips may appear burnt.	Phosphate, Bone or Greensand.
Magnesium deficiency (Mg) (Macronutrient)	Older leaves yellow at edges and between the veins; leaf veins appear darker green.	Dependent on soil chemistry. Soil lacking calcium allows Mg to leach away. Epsom Salts is an option.
Potassium deficiency (K) (Macronutrient)	Older leaves appear scorched and misshapen. Yellowing (chlorosis) between the leaf veins is more pronounced at the center than at the edges.	Potassium or Potash.
Sulfur deficiency (S) (Macronutrient)	Newest leaves are yellow.	Sulfate.
Copper (Cu) (Micronutrient)	Plant seems small and leaves become a darker green.	Copper, Cupric, Cuprous.
Iron (Fe) (Micronutrient)	Yellowing between veins of newer leaves, and highly related to soil acidity.	Chelated Iron or Iron Chelate.
Manganese (Mn) (Micronutrient)	Yellowing between veins on young leaves (similar to iron deficiency, but leaves are often malformed)	Manganese or Manganous.
Molybdenum (Mo) (Micronutrient)	Yellowing of older leaves near base of plant. The remainder may appear light green.	Molybdate or Molybdic.
Zinc (Zn) (Micronutrient)	Newest leaves are smaller, misshapen and yellow between the veins.	Zinc.

Nitrogen deficiency (here in cucumber) can be easy to recognize. Photo: Gerald Holmes, Polytechnic State University at San Luis Obispo, Bugwood.org, (CC BY-NC 3.0 US)

Watch That Whacker

Landscapers casually talk about 'weed-whacker syndrome': a complex of symptoms including cracked bark, an open wound, rot and insects getting in, and branches dying back because the sap flow is blocked. Make sure your trimmer's line or blades do not touch the bark of trees and shrubs.



With all the variety in leaves and petals, it's not always easy to notice virus or fungal diseases on plants. This Madagascar Periwinkle has botrytis fungal disease. Photo: Scot Nelson, c1.staticflickr.com/9/8581/15585887974_abeef60d63_b.jpg, CC BY 2.0

These symptoms of plant distress could tell you that something's wrong with the site or care:

Leaves turn pale, purplish, yellow, or the wrong shade of green: Nutrient deficiency or toxicity. Too little or too much water.

Badly deformed growth; bleached or washed-out looking leaves or needles: Might mean chemical damage.

Flecks, specks, or stippled: Ozone or other air pollutants. Splashed chemicals.

Plants or leaves too small or grow too slowly: Too much or too little light, water, heat, cold, or nutrients.

Stems too thin, tall, or weak: Too much or too little light, water, heat, or cold.

Fruit or flowers too small, too few, or none at all: Too little light, water, heat, cold, or nutrients. Excessive nutrients. Wrong soil. Needs pruning or thinning. Too few bees or other pollinators around. Or maybe the plant is just too young.

Buds or blossoms drop: Abrupt temperature changes. Transplant shock. Too much or too little water at a certain time. Nutrient deficiencies.

Leaves wilt, droop, or drop too soon: Too little water; too much heat. Direct injury to vascular system, preventing sap and nutrient flow up or down stems.

General failure to thrive: usually a combination of cultural factors, sometimes followed by disease or insect attack. Often called decline. Sugar maple decline, for example, hits trees with sub-par nutrition and heavy insect attacks that strip their leaves. But trees with poor nutrition and no defoliation—or good nutrition and defoliation—stay healthy. Well-nourished areas of 50 years ago might be sub-par today, perhaps due to acid rain. Other examples include oak decline and red pine decline.

Symptoms of Plant Diseases

If you suspect a disease, review your plant's site and cultural requirements. "Wrong Place" syndrome is often the precursor of disease.

Dwarfing: Root infection caused by soil-borne fungi; stunted plants due to viral or phytoplasmic infections.

Galls: Knobby growths caused by fungi or bacteria form on roots, leaves, stems, or crown. (Many galls are caused by insects, or nematodes.)

Leaf damage: Spots, round or blotchy; yellow, purplish, black, mottled or mosaic; some spots are clear. (If spots are angular, outlined by leaf veins, you might have foliar nematodes.) Abnormally patterned leaves. Leaves twist, curl, wilt, yellow, brown, or drop too soon.

Stem or shoot damage: Plant wilts; leaves turn yellow or brown. Dark brown streaks in stem when you cut across it. All indicate a vascular system blocked by mycelium (or by byproducts of fungal microorganisms). Galls, wounds, or lesions. Shriveled, wilted, or dead shoots. Inner tissue or bark discolored.

Root damage: Darkened, stunted, slimy, or smelly roots. (Some roots are normally dark.) Growths or galls. Stunted plant. Yellowing or brown leaves (roots can't support good growth).

Injured blossoms or fruit: Drop prematurely; spotted, twisted, distorted, or discolored.

Pepper plant leaf showing signs and symptoms of bacterial leaf spot *(Xanthomonas vesicatoria)*. Photo: Howard F. Schwartz, Colorado State Univ., Bugwood.org

Signs and Symptoms of Insect, Mite, and Slug Pests

Signs, remember, include actual critters—insects, slugs, or mites, whatever stage of their life cycle they're in, or things they leave behind, like frass, cocoons, or discarded skins. Symptoms are damage, direct or indirect—including holes, tunnels, and stippling.

Holes, notches, or tunnels inside leaves or under bark; entirely eaten buds, stems, leaves, or flowers—all indicate chewing insects, mostly beetles, caterpillars, or grasshoppers.

Pale or brown spots; stippled leaves; distorted leaves, buds, fruit, or flowers. These could indicate spider mites or sucking insects like true bugs.

Frass: looks like sawdust, dried pellets, or fresh pesto, depending on what the insect has been eating. If the insect bores into wood (including the frame of your house), you'll see the sawdust. If it's eating green leaves—presto, you've got pesto. Gypsy moth larvae produce distinctive dried pellets. Keep in mind that larvae, nymphs, and adults might all leave frass.

Honeydew: looks and feels like corn syrup and attracts other insects (famously ants) because it's sweet. Aphids and similar bugs excrete lots of honeydew because they suck up such huge amounts of sap, compared to their size.

Galls: Some insects secrete chemicals as they lay their eggs, causing knobs, bumps, or other growths on twigs, leaves, or stems; the growths surround and protect the eggs. Sometime just the insects' presence is irritation enough that the plant forms galls. Some galls don't matter. Others can disfigure or damage plants, sometimes even killing them. (Diseases can cause some galls—and for some galls, like burls on trees, the cause is unknown.)

Scorched-looking leaves: Some insects inject toxins into plants when they feed. This causes leaf scorch, hopper burn, and similar problems.


Roseslug feeding damage. What can you do? The first step is always the same. Scout (take the time to really look at your plants), then learn what pests are attracted to that plant, and learn their life cycle. Then you'll know the best management strategy. Photo: Brian Kunkel, University of Delaware, Bugwood.org (CC BY 3.0 US)


Spider Mite damage on soybean. Watch for stippling marks (tiny, pale spots), and webbing. Photo: Mike Stanyard, Cornell University CCE

Columbine leafminer, *Phytomyza aquilegivora,* damage on columbine. Photo: Lisa Ames, University of Georgia, Bugwood.org.

Asian longhorned beetle frass is a sure sign this borer is destroying trees from the inside. Photo: Kenneth R. Law, USDA APHIS PPQ, #5392759 Bugwood.org

Aster Leafhopper *(Macrosteles quadrilineatus),* which can vector the disease aster yellows. Photo: Robert Webster / xpda.com / CC-BY-SA-4.0.

Egg-laying scars: Some insects make slits or holes in leaves, stems, twigs, bark, or fruit, then lay their eggs within. Sometimes these scars cause malformed fruit, broken stems, or damaged foliage. Entomologists call them oviposition scars.

Webbing: Some webs are major construction projects covering entire branches. Others are fine and delicate, easily missed, just a few strands of silk under a leaf or where leaf meets stalk or twig. Still others pull a leaf together, rolling it up into a neat, little, well-protected home for whatever's inside.

Is an Insect Really the Problem?

Check these off as you form your diagnosis:

- For flowers, review the Latin name of your plant and its needs, so you understand its common concerns.
- Note the signs and symptoms. Could a hailstorm or disease have caused those holes or wilting foliage?
- Is your plant in the right site and getting the water, nutrients, sun, or shade it needs?
- Diagnosis in hand, look at our IPM solutions. How serious and long lasting is the problem? Many problems pass quickly on their own. How important is the plant? Is it valuable enough to warrant the use of pesticide? If you use a pesticide, always read and follow the instructions on the label.

Water Right

Water in early morning. Aim the watering can at the base of plants. Use drip irrigation. Retire the sprinkler. (Sure, during a long stretch of dry weather and low humidity, sprinkling the garden in the morning won't hurt. But lots of water evaporates before it even gets to the ground.) You want plants as dry as possible when darkness falls. They'll be less disease-prone. Water deeply rather than often to encourage deep roots that hold up better to drought. And work in the garden only when plants are dry—you're less likely to spread disease around, and less likely to compress the soil.

When Insects Cause Disease

Some insects transmit pathogens as they feed, vectoring disease. If your asters or cosmos get aster yellows, leafhoppers were the likely culprit.

Diagnosing Problems by Plant Parts	
What the Problem Looks Like	**Causes and Diagnosis of the Problem**
Entire Plant	
Seeds don't sprout or seedlings die (damping off).	Fungi prevents seed germination or causes a killing rot at the soil surface.
One side or entire plant wilts with no apparent wound or broken spot. Roots may rot.	Bacterial or fungal wilt diseases such as *Pythium, Phytophthora, Rhizoctonia*, or *Verticillium*.
Wilting or color change—following recent work in the garden or yard, or where salt was spread the winter before.	Herbicide damage. Salt drift or buildup during winter. Too much fertilizer.
General failure to thrive (depending on the species)—and a black walnut tree is nearby.	Walnut wilt caused by juglone, a chemical released by black walnut roots; stunts or kills some plants.
Plant falls over, stems split or break easily, or roots are ripped from soil.	Wind, hail, or heavy rains. Frost-heaving of recent transplants.
Plant falls over; dense white mycelium shows on soil.	Crown or stem rot (sclerotium), root rot.
Unusually tall or long branches for that species; very weak stem tissue.	Soil too wet. Rapid change from dry to wet soil in hot or wet weather. Too much nitrogen. Not enough sun.
Whole plant stunted; mottled leaves.	Mosaic viruses.
Flowers	
Buds don't form; buds or blossoms drop; small flowers.	Damage during transplanting, weeding or pruning. Wind damage. Planting too late in season. Not enough light. Too cold or hot. Drought or too much rain. Ice or frost damage. Too much nitrogen.
Distorted buds don't open. Silvery tones, abnormal color.	Thrips.
Twisted, curled flowers don't look right.	Herbicide drift.
Fuzzy gray growth covers buds or flowers.	Gray mold (*Botrytis*) provoked by crowded, damp settings.
Plant looks way different in year 2, 3, or 4 than it did in year one.	Seedlings of cultivars that self-sow easily (among columbine and phlox, for instance) often revert to how the parent or species looks. In roses (and others grown from bud grafts), see if shoots have sprouted from below the bud graft.
Various sized spots on petals.	Fungal or bacterial leaf spots, some viruses (INSV, TSWV, etc.).
Stems, shoots	
Plant stem has an opening or hole somewhere above the soil level (usually near the plant base). Plant wilts from that point. Insect frass (droppings) usually visible.	Borers (larvae of some butterflies, moths, flies, and beetles).
Dark or tan areas on stem near soil line, plant wilts.	Fungal diseases including *Rhizoctonia*, Southern blight, and other root and stem diseases.
Elongated, often pale stems, stretching toward light. Bend easily.	Not enough sunlight, too much shade.
Leaves	
Leaf tips and edges wilt, sometimes leaves brown slightly. Newer leaves wilt first.	Drought or heat stress (looks different in each species), or too much water, which can look like drought stress.
Leaf edges and tips brown, especially new leaves in spring near where salt has been used.	Leaf scorch from too much salt applied the previous winter (or contact with chlorides from swimming pools).
Leaves, leaf tips, and stems show brown, burnt looking tips and margins.	Acidic soil (below 6.5 pH) means inadequate nutrition. Also frost on early emerging bulbs or sudden temperature changes, such as a hot spell.

Diagnosing Problems by Plant Parts	
What the Problem Looks Like	**Causes and Diagnosis of the Problem**
Entire leaf or spaces between veins yellow (chlorosis) or become discolored.	Nutrient deficiency. Soil may be incorrect pH for species, or may lack certain necessary nutrients. Not enough water.
Older leaves yellow, brown, and drop gradually as the plant ages.	Could be normal for that plant. May need more nitrogen.
Leaves develop irregular, discolored spots. Entire leaf dies.	Four-lined plant bug. Herbicide burn. Some fungal diseases.
Dead spots on leaves.	Fertilizer or salt burn. Some pathogens.
Foliage fades, wilts, yellows; you see insect droppings (frass), stickiness, eggs or larvae—or predators.	Pest insects such as aphids, borers, mealybugs, scale, spider mites, whiteflies.
Irregular holes in leaves, notches, or missing leaves.	Chewing insects including caterpillars, Japanese beetles, sawflies, slugs, weevils.
Leaves curl, become distorted; you see small insects, especially on new growth.	Aphids.
Leaves, are distorted, twist, cup, and grow very irregular shapes. Leaves are thin or show random, off-colored spots. Often found on new growth, or along leaf veins.	Viruses. Herbicide damage.
Leaves show stippling.	Spider mites make tiny ***chlorotic*** spots on leaves; each spot is a feeding site where one or more cells were damaged. Worse in dry spells.
Leaves show a series or patches of beige or colorless perfect circles.	Four-lined plant bug (greenish yellow with black stripes. Nymphs are red) found on undersides of leaves. Lacebugs and other plant bugs cause similar patterns.
White or yellow blotches on leaves.	Harlequin bugs (red and black, shield-shaped).
Leaves show symmetrical spots that sometimes cross veins. Small dark specks could show near centers of some spots. Spots are dry.	Fungal leaf spot.
Leaves show dark, water-soaked, irregular or angular spots that might not cross veins. Some bacterial leaf spots show yellow tissue, halos, or borders around edges of dead or dying spots.	Bacterial leaf spot.
Leaves look bronze or yellowish and wilt, especially in the heat. Could have ring-shaped or wedge-shaped spots limited by larger leaf veins.	Foliar nematodes.
Leaves have water-soaked spots or mushy areas and turn black.	Damage from frost or freezing. Bacterial leaf spot diseases.
Leaves show orange-yellow or orange-red raised spots or bumps.	Rust fungi.
Speckled upper leaf surfaces, perhaps with silvery undersides. Speckles not uniformly distributed.	Air pollution.
Leaves are mottled, green and yellow. Growth may be stunted.	Various viruses and phytoplasmas (such as aster yellows) spread by leafhoppers.
Leaves marred by pale, irregular, wavy lines (that are actually tunnels between the top and bottom of the leaf).	Leafminer larvae feeding between leaf surfaces form the tunnels.
Leaves are blistered, especially on the lower part of the plant.	Edema (also oedema), caused by water imbalance in plant when it takes up more water than it can transpire. Contributing factors include high humidity, overwatering, warm days with cool nights, and low light.

Getting Help

If you're still unsure what the problem is (or your plant's name) once you've read our chapters, check with your county's Cooperative Extension office. Most Master Gardener groups now accept digital photographs for a start. Garden centers, landscapers, and garden clubs are other options, but remember that some 'summer employees' may not know more than you.

Or get in touch with a diagnostic laboratory at your state's land grant college, or an agricultural college. Be sure to ask about their fees. If you send them a portion of your diseased plant or an insect sample, prepare it carefully and tell the full story: Where you found it. When you noted the damage. What plants showed disease or damage. What plant parts are damaged: leaves, roots, flowers. Is the damage getting worse? What products you used recently on or near the plant? Any new projects inside or out: painting the house, putting up a garage. If you're a good detective, the lab can probably help you. A photo of the plant in its surroundings can be very useful.

What the lab needs for diseased plants:

- **Dry samples:** Put fresh leaves, roots, or flowers between layers of dry paper towels. Include parts representing a range of symptoms as well as healthy pieces. Label with name of plant. Hand-deliver or put in a sturdy box. (Samples in envelopes or flimsy boxes can get badly crushed.) Ship via one- or two-day delivery so the sample has little time to deteriorate.
- **Fresh samples (branches):** Protect cut ends; wrap them in damp paper towels. Enclose in plastic bag. Put small air holes in the bag. If in doubt, contact the lab to ask how best to submit the sample.
- **Include a detailed note** describing the problem.
- **Provide your contact info.** Plant problems aren't always straightforward—even for diagnosticians. For the best diagnosis, it's important they be able to call you.

What the lab needs for insects and other critters:

- **Hard-bodied insects** (beetles or moths, for example): Place in a small container and freeze for a few days to kill them. Put paper towel inside to absorb moisture.
- **Soft-bodied insects** (aphids, scale, or larvae, for example): Put in a small, unbreakable, leak-proof container with a tiny amount of hand sanitizer gel, or rubbing alcohol. Place container in a sealable plastic bag—and seal before shipping. You must confirm the contents of your package to the post office.

It's What They Do, Not Who They Are

Leafminers are the larvae of flies … or beetles … or moths … or sawflies. And yes, these barely visible larvae really tunnel right through the insides of leaves, eating as they go. Note their looping, wandering, translucent tunnels. Not many predators can reach them there. While they rarely pose serious problems in the flowerbed, you don't want them in your beet greens, and some are bad news for trees.

Likewise, borers are larvae that bore into rose stems (for example) or even your ear of corn, but as adults they could be flies, beetles, or moths. Where they create similar problems, you'll probably need similar solutions.

Powdery mildew, *Podosphaera fuliginea,* on watermelon. Photo: David B. Langston, University of Georgia, Bugwood.org.

Striped Cucumber Beetle feeding damage on melon. Photo: Whitney Cranshaw, Colorado State University, Bugwood.org, CC BY 3.0 US

Buy from garden centers or nurseries with good reputations. Photo: Shutterstock.

- **Try to send five samples.** Use a crushproof container for shipping.
- **Include a note** describing the problem and details of the site.

Finding the Experts

Buy from garden centers or nurseries with good reputations. If you're a newbie, how do you know? Try some questions to gauge their expertise. (But in fairness to staff, be realistic and reasonable. If they're running around on a sunny Memorial Day Saturday, the best of them won't have time for great answers. And the summer college kids aren't there to diagnose your rhododendron's spots.)

Here are examples:

"What should I do for my heavy clay soil?" Best answers: Add compost and other organic matter; poor answers would be adding sand—an out-of-date idea—or renting a tiller, unless you have hardpan in your gardening area.

"Where are your salvias, and which ones are best for a border?" Trained plant people know that salvias can be annual or perennial. The conversation should move to whether you have full sun and what height you're looking for.

"I'm looking for disease-resistant tomatoes … or roses…" If the answer is "um" or "they're all great," you don't have an expert. Meaningful answers refer to plant tags (F1, V, N, TMV, etc., on tomatoes or, for roses, "resistant to black spot," etc).

"What do you recommend for a foundation planting?" If they just show you a bunch of shrubs, that's not so good. A knowledgeable salesperson will ask you questions about the site, sunlight, air flow, which way the house faces, or where the windows are—and even bring up related issues, like how not to provide shelter near your house for mice.

"What kinds of mulches and compost do you carry? How do I use them?" Responsible sellers should know the difference for sure—the mulch goes on top of the soil, while compost is generally mixed in. They'll recommend how thick a layer to put down, what kinds to choose depending on what you hope to plant, and remind you not to heap it around tree trunks.

And call your county's Cooperative Extension office; their master gardeners are there to help and can tell you if your town has a garden club. Many good resources can be found online, but take note what area of the country they are working in. Or network with neighborhood gardeners to hear their recommendations—both on where to buy healthy plants and what's best for your microclimate.

Look-alike Diseases

You'll find that different diseases sometimes cause similar symptoms—depending on the time of year, weather conditions, and whether they infect trunks or stems; leaves, buds, flowers, or fruit; or roots or crowns. But just to confuse you, one disease can cause a range of symptoms, depending on the time of year and what part is infected. If you're not confident in your diagnosis and think you have a baddie on your hands, seek diagnostic help. Don't worry about feeling overwhelmed. Experts have to double-check as well.

Prevention and Solutions

Now it's time to look at the pest management options we'll detail in the chapters that follow.

Prevention Techniques. The best offense is a good defense. Learn five main ways to prevent problems:

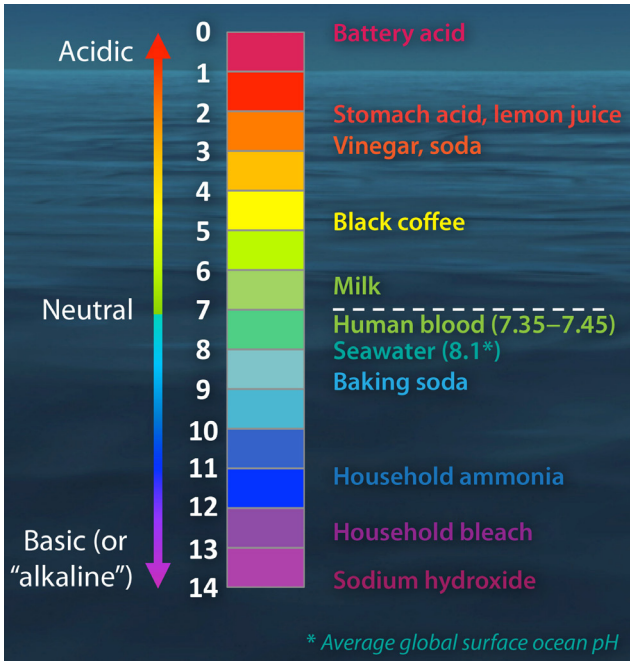
- Your Soil is the Groundwork
- Keep it Clean and Safe
- Be Choosy
- Timing is Everything
- Call On the Good Guys

Your Soil Is the Groundwork

Plant to match your soil. Plant health—and disease!—starts with the soil. Before you plant a new area, look at soil texture and test for pH. Putting rhododendrons, potatoes, or blueberries in alkaline or high-pH soil is sure to disappoint. Likewise, plants needing a rich, moist soil, favored by ample organic matter, often fail in sandy soil.

Soil Texture. Is your soil cloddy with clay or so sandy it runs through your fingers? Sand, clay, and silt are the three sizes soil particles come in. Silt is the smallest, clay is in the middle, and sand is the largest.

Loam soil—that's what gardeners lust after—is a good combination of sand, clay and silt. Why does it matter? Good soil has room for air and water, and the chemistry that allows nutrients to bond to soil for slow release to 'invisible' root hairs. Good soil texture helps your plants stay healthy.



The pH scale, with examples of common solutions and their pH values. Photo: National Oceanic and Atmospheric Administration, US Dept of Commerce.

Your Healthy Soil

You can't grow healthy plants without healthy soil. Healthy soil teems with living things—macroorganisms (you can see them) and microorganisms (you can't). These form the soil food web, a complex community of living things: bacteria, fungi, protozoa, nematodes, earthworms and arthropods are all part of the web.

In most forests and meadows the web is well tended. Leaves, branches, grass, and dead insects fall to the ground and decompose; soil organisms complete the process. But in our gardens, we're part of the system, and we take things out. So we need to give back: compost, cover crops, mulch.

Mycorrhizae are a group of fungi that help roots take up nutrients. Knowledge in this field is growing rapidly: which mycorrhizae and other microorganisms are helpful when, and how to supply them. What we know for sure is that taking care of living organisms in the soil is the first step to growing healthy plants.

What is pH?

Every substance on earth is acidic (think vinegar), alkaline (think baking soda), or neutral (right in the middle). The scale for pH runs from 0 to 7 for acids; from 7 to 14 for alkaline substances. Some plants—blueberries, potatoes, and azaleas, for example—crave an acid, low-pH soil, and planting them in high-pH soil is sure to disappoint. Yet other plants want an alkaline soil. But most like it neutral or just a bit acidic. Of course, many factors influence plant health. A plant given the right site and nourishing soil can compensate for a less-than-ideal pH.

How do you know how your soil rates? You can buy a test kit at the garden center. If you're getting a full-fledged soil nutrient analysis from a lab, a pH test will be part of the mix. A range of 6.0 – 7.5 is considered "acceptable" for most crops and garden plants, though it's too high for acid-loving plants. (Reminder: high pH doesn't mean high acid—just the opposite.)

The Soil Texture Triangle

So … how to determine particle size? An easy way is to take a scoop (a garden trowel is good) of soil and put it into a clear plastic or glass jar. Add about the same amount of water, put on the lid, and shake it up.

When it settles, you'll see the layers: sand, heaviest, at the bottom; silt, lightest, at the top. Then just eye-ball it: Or use the soil texture triangle to determine what kind of soil you have.

For instance, if your soil is about 20 % clay, find 20 on the clay side of the triangle. Same for silt (let's say 40%) and sand (40%). Following the direction of the arrows from each side, find out where the three lines converge. In this scenario, they met in the section marked loam. Congratulations! Great soil!

Sandy soil drains quickly which means it does not store nutrients well. Silty soil holds on to nutrients well, but because it drains poorly, roots can get waterlogged or drown. They need air, too. So, loam—the ultimate mix—is good garden soil.

Another quick method of soil sampling is the squeeze test. Take a handful of soil, add water until it becomes a nice mud cake. Squeeze it in your hand. Does it stick together or fall apart? You want it to stick together rather than crumble (crumbling indicates a lot of sand).But if it's so sticky it feels slippery and doesn't fall apart into a couple pieces, you probably have predominantly clay soil instead.

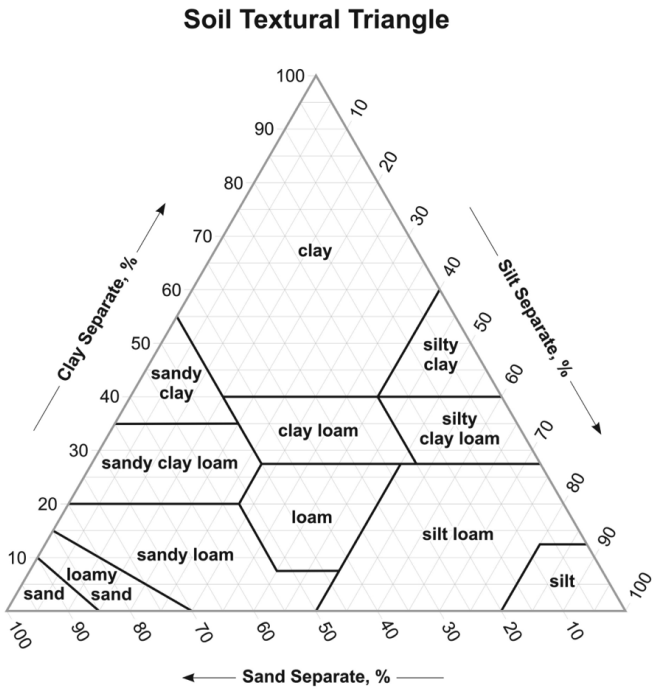
Steps to Better Soil

Check the drainage. Dig a hole, fill it with water, and let it drain out once. Then fill it again and check the clock. If it takes more than a couple of hours to drain, it's best to avoid plants that dislike 'wet feet'.

Test your soil's pH and nutrient levels. You can buy a pH test kit or call your Cooperative Extension office or a landscape professional. For a nutrient test, though, you'll need to send a sample to a lab—Cooperative Extension can tell you how. What if your soil flunks its test? Amend it! You can enrich soil to increase fertility, or adjust pH. Lime and wood ashes raise pH, while sulfur lowers it. Follow the directions on the bag, and don't use hydrated lime. It takes about a year for lime or sulfur to take effect. If your soil is low in calcium or magnesium, adding lime makes these nutrients more available.

Get weeds under control before you plant. Weeds are tough to get rid of after-the-fact. Cover the area with black plastic or cultivate it several times. Or plant the whole plot in a buckwheat-rye routine for a season. Try to identify the weeds so you know what you'll be up against—some can be controlled but some will fight endlessly for square-footage.

Add organic matter. Compost, leaf mold, aged manure enriches the soil. Especially important for dry or sandy sites. Or plant a cover crop in late summer or early fall. This will help nourish the soil when you turn it under next spring. You can also plant buckwheat in summer. Growing a crop of marigolds, Sudangrass, or oilseed rape for a year or two before planting fruit helps knock back harmful nematodes. Be sure to plant solid blocks of these plants—not just a few—and turn them under afterward.



USDA textural triangle showing the percentages of clay, silt, and sand in the 12 basic texture classes. Photo: USDA, www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054253#soil_structure

DIY Soil Drainage Perk Test for Your Yard

Almost every garden instruction guide refers to the importance of "well-draining soil." If water drains (percolates) away from plant roots too quickly, the plants will parch even if they're getting regular water. And if water doesn't drain, many plants will drown and rot from the roots up. A percolation test—or perk test—is a great way to measure drainage in your lawn or garden soil. Here's how to conduct an easy, DIY soil perk test in your yard.

Step 1: Dig Hole … dig a hole at least 12" in diameter by 12" deep, with straight sides. If you're testing your entire property, dig several holes scattered around your yard, since drainage can vary.

Step 2: Fill Hole with Water … fill the hole with water, and let it sit overnight. This saturates the soil and helps give a more accurate test reading.

Step 3: Refill Hole with Water … refill hole with water the next day.

Step 4: Measure Drainage Every Hour … measure the water level by laying a stick, pipe, or other straight edge across the top of the hole, then use a tape measure or yardstick to determine the water level. Continue to measure the water level every hour until the hole is empty, noting the number of inches the water level drops per hour.

The ideal soil drainage is around 2" per hour, with readings between 1"- 3", which is generally ok for plants that have average drainage needs. If the rate is less than 1" per hour, your drainage is too slow and you'll need to improve drainage or choose plants tolerant of wet soil. If drainage is more than 4" per hour, it's too fast.

Drainage problems can be addressed by: (1) incorporate compost and/or organic matter into the soil OR as a top dressing (it helps heavy clay soil drain and coarse sandy soils to hold moisture); (2) choose plants suited to your soil drainage; (3) build raised beds for better control over the soil texture.

Instructions and photos by: Amy Dismukes, Horticulture Extension Agent; adismuke@utk.edu or adismuk1@tnstate.edu; williamson.tennessee.edu

Raised beds are popular options in small gardens and provide many benefits. Photo: UCANR, ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=13130

Compost piles vary from 'relaxed' and open to the use of composting bins. Both work. Open piles tend to dry out faster and attract animals. Photo above: myrtle_avenue_brooklyn, c2.staticflickr.com/4/3050/2946851505_b1e7de37b3_b.jpg, CC BY 2.0. Photo below: kirybabe, c2.staticflickr.com/4/3222/2774798500_75ea448aa5_b.jpg, CC BY 2.0

Make Your Own Compost

They call it black gold—an alchemy of ordinariness, of kitchen scraps and the like. This decomposing heap of organic matter, once decayed into humus, helps improve soil structure, retain soil moisture in sites that drain too quickly while buffering the effect of soggy soil, and maintain the soil's microbial life. Good microbes help plants stay healthy, so always add a scoop of soil! Those microorganisms are needed to heat up the action. Make compost from kitchen scraps (no meat; no pet poop either), the leaves you rake up in fall, shredded newspaper, and the remains of healthy crops after the harvest. You can add well-rotted manure as well. Fluff it all up now and then—a pitchfork works best—to incorporate items on the edge and some air into the center.

But beware! If you inadvertently toss in infested plants, the inoculum might keep going. These include the fungal disease Phytophthora that survives for years in soil, and the bacterial diseases Septoria and Alternaria.

We encourage you to compost. It reduces trash going to the landfill and it returns nutrients to your garden soil. But don't make composting so difficult that you'll want to quit. Find what works for you. Make it easy on yourself or you'll lose interest. Generally, any mixture of vegetable or fruit scraps, leaves and, most importantly, time, does the trick.

A top-notch compost pile balances greens and browns as well as wets and dries. Lawn clippings, veggie scraps, and fresh leaves are both 'greens and wets'—rich with nitrogen and moist enough that you probably don't need to add water. 'Browns and dries' are fallen, dried leaves, shredded paper, sawdust and such—all carbon-rich. Though manure sure looks brown (and can dry out), it's nitrogen-rich, so think of it as a green.

Avoid seedy weeds, cuttings of invasive plants and disease or insect-infested plants and food scraps like dairy and fats that will draw pests. In fact, experts even disagree on the possible risk of late blight spreading from potato peelings. Choose your battles!

Layer these ingredients like lasagna. Too much of one or the other means the compost takes longer to cook. And cook it should—heating up hot enough to kill insect eggs and many plant pathogens. Lean to the cautious side, and never assume you'll attain the heat to completely eliminate such problems.

Make Your Own

Grass clippings, leaves, fruit and vegetable scraps, coffee grounds, tea bags/leaves, weeds (without roots; only if they haven't gone to seed!), shredded paper and junk mail, peat moss, pine needes. Incorporate soil organisms by adding the occasional shovelful of your garden soil. Keep it moist, not wet.

From the Ground Up

Match your plants to your site. Smart homeowners know that plants aren't furniture. You can't stick a pretty plant just anywhere. Analyze your setting before you decide. If you have high winds, don't plant tulips or a magnolia tree where there's no shelter. If you have a low, wet spot, plant black cohosh *(Cimicifuga racemosa)* or even watercress—but not a blue spruce. Choose drought-tolerant (xeriscape) plants if they'll be far from a source of water, and place those that like shade and wet feet under the drip line on the north side of your house. Some plants even prefer low-nutrient soils.

Consider ultimate plant size. Many problems, and lots of aching backs, have their origin when, for example, that 20-foot tall, 10-foot wide shrub got planted just two feet from the porch steps—back when it was only a foot tall! Sure, plants in the wrong site might survive. But they'll be stressed plants, prone to insect infestations and diseases.

Layout and design. What impact will your family and pets have on your yard and garden? Choose a design that keeps plants away from heavy traffic or damage from salt. Group plants with similar needs, be they for water, light, soil, or pest prevention. Think ahead to how veggies, herbs, trees, shrubs, flowers, and groundcovers will complement each other. Avoid monoculture (planting large areas of only one species). Pests can find them more easily. Biodiversity—mixing many living things together—also reduces pests by inviting natural enemies, such as birds and the beneficial insects that eat pests.

Fence out trouble. Learn the leaping, digging, squirming-through-holes, and chewing capabilities of the wildlife around you before you install a fence so you'll know how high or deep to place it. (Also check zoning codes.)

Keep in mind that deer, for example, establish travel and browsing patterns early in the season. By summer it's harder to block them from their habitual dining spots. Try to anticipate problems, whether from deer, rabbits, woodchucks, or voles, and put up those fences or barriers first. Think about fencing out pets, too, so they don't use your garden as a litter box.

And consider the expense. If fencing is too much trouble, try to design plantings less attractive to wildlife. Cooperative Extension offices, land grant colleges, or garden centers offer area-specific list of deer-resistant (or deer-prone) plants. That said, deer will eat almost anything in harsh winters or when over-population exhausts their favored foods.

Repellents. Commercial chemical repellents smell or taste bad (think rotten eggs). Research shows that odor-based products usually outperform taste-based products. Nothing is 100 percent

Fence Them Out

Sturdy fencing can deter rabbits, dogs, fox, and woodchucks. Its practical for small home gardens, but not for a large acreage.

Groundhogs are good climbers, so fences must be electric, woven, or made of welded wire, and extend at least 3 to 4 feet tall with a 45 degree angle at the top to discourage groundhogs from climbing over.

The fence should also be buried 12 to 14 inches underground to prevent groundhogs from digging under. The fence material can either bent at a 90 degree angle to the outside (away from the protected area) and extend for 6 inches or a separate piece of fencing material can be buried perpendicular to the fence and extended away from the garden 30 inches.

In some cases, electric wire alone, placed 4 to 5 inches above the ground, has been effective.

Whitetail deer are browsers, preferring a varied plant diet of grasses, woody stems, seeds and leaves. They can kill young trees by damaging bark and the underlying cambium layer. Deer and small rodents like mice and chipmunks are important parts of tick life cycle as well. Photo: Bill Spruce, c1.staticflickr.com/5/4136/4758356342_e41e71a01e_b.jpg, CC BY NC-SA-2.0

Deer Resistant?

Sometimes. But deer will try to eat most plants if they are hungry enough and the population is large.

Woodchuck or groundhog? Either way this fleshy rodent enjoys a menu of your property's finest. Photo: woolcarderbee, c2.staticflickr.com/4/3793/11362352853_3b8eb6bbcf_b.jpg, (CC BY-NC-SA 2.0)

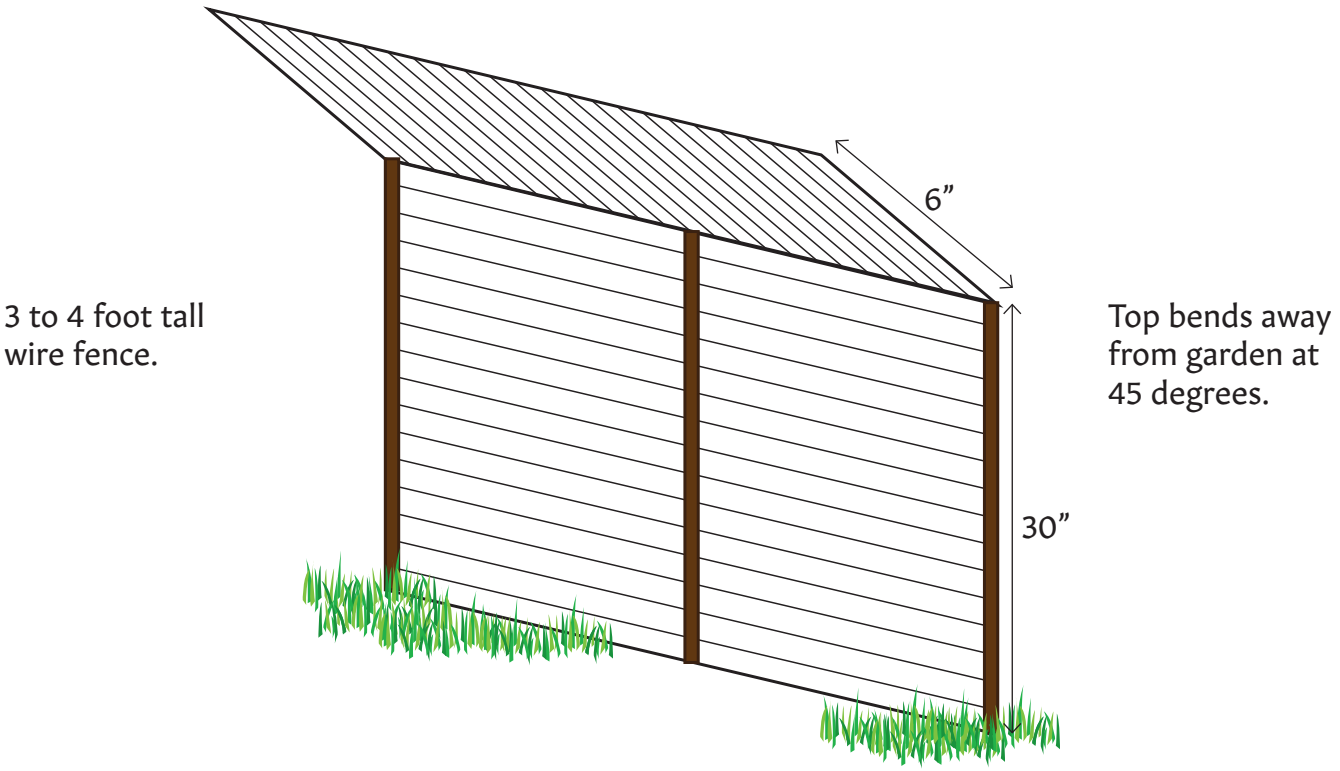
effective, but they can help. Registrations can change from year to year—for example, a product like Deer-Off may be legal in one state but not another. Use at the first sign of trouble so deer don't establish a feeding pattern. Check the forecast: apply when no rain is likely in the next 24 hours and temps will stay between 40° – 80°F. If deer pressure is heavy, reapply every five weeks.

Man the barricades. Cutworms girdle seedling stems at the soil level. Collars—made from tuna cans, paper cups, or cardboard toilet paper rolls—block them. Cabbage maggots tunnel into roots and stems. A 4" x 4" piece of cardboard, tarpaper, or carpet will deter the adult flies from laying eggs.

Floating row covers, made of lightweight spun-fabric agrifleece, come in a range of weights and sizes that allow light and rain through. While some hold in heat and others provide shade, all prevent insects from flying, crawling, eating, colonizing, or laying eggs on your crops. But take note: row covers don't prevent munching from insects that are already in the soil! Scout often!

Bird nets, deer nets, wire screens, chicken wire, and gutter guard: Use them to keep birds off your berries, rabbits out of the rutabagas, or crows out of the corn. Barriers keep down weeds, too. You'll learn more in later chapters.

Confuse them. Garlic, onions, herbs, and many other companion plants, provide a multitude of scents, sometimes making it harder for pests to find the plants they prefer.



Serious fencing for serious pests. Redrawn from: NC Cooperative Extension Resources, content.ces.ncsu.edu/extension-gardener-handbook/20-wildlife

Keep it Clean and Safe

Keeping the landscape tidy discourages pests. In wet weather or after watering, don't brush up against one plant and then another; disease spores hitchhike on drops of moisture on your clothes. Keep tools, gloves, and pots clean to prevent disease. Use rubbing alcohol at equal parts with water, or one part bleach to nine parts water (a 10% solution) to disinfect tools between cuts as you remove diseased stems, leaves, and flowers.

Routine fall cleanup. Cut, rake, and compost frost-killed stems and leaves to help keep minor diseases—leaf spots, say—from building up. Plus it destroys overwintering sites for insect pests. The downside: natural enemies hide in leaf litter and old stems, too. In flowerbeds, focus your cleanup work on plants with signs of disease, or leaf miners tunneling through leaves, or those ravaged by insects. (As we go, we'll tell you which pests overwinter in leaf litter.) Try to leave other plants standing (Sedum 'Autumn Joy,' for example, stays attractive most of the winter) or create small piles of disease-free cut stems here and there to shelter the good guys. Common sense says if you've had a particular insect or disease pest, remove plant residue; if you've had no problems, leave some plant residue for the beneficial insects.

Buying soil. If you buy topsoil or compost, choose carefully! It could contain weed seeds, diseases, or undetectable stages of insect pests. Test it in a small area before using it widely. And think about having it analyzed for nutrients—does it have too few? Too many? Call your county's Cooperative Extension office to learn where to send it and how to package it. Buy sterile potting mix for houseplants.

Soil solarization. This might help if your soil harbors known weed seeds, or pest nematodes or insects. There is a risk that valuable microorganisms and beneficial insects or nematodes could also be killed. While a good option in certain areas, the amount of consistent Northeast U.S. heat and sun over a four-to-six week period reduces the chance of a completely effective treatment, but it's helpful.

Mulching. Mulching is worthwhile because it holds in soil moisture and reduces erosion. It also helps keep down weeds and, if you use organic materials, will slowly help improve your soil. Hardwood or bark, shredded or chipped, are best because they break down slowly. Other organic mulches include leaves (ideally shredded—run through a leaf pile with your lawnmower; try to be sure branches and stones aren't mixed in), sawdust, cocoa bean shells, peat moss, pine needles, and buckwheat hulls. Put down cardboard—flattened boxes—or several thicknesses of newspaper and cover with two or three inches of mulch to block

Till Away Your Troubles

We till our vegetable gardens to discourage weeds from germinating and to expose pests to predators. (Birds are happy to pick off those insects for you!) Here's how to do it right:

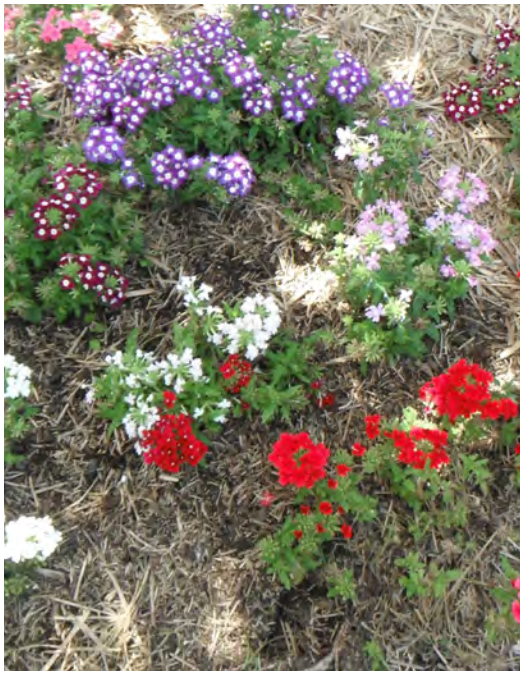
- In fall, clean up crop debris and nearby weeds.
- Leave soil bare for a few days to expose pests to predators, as well as drying sun and wind.
- Cultivate soil lightly (one pass) 6 – 8 inches deep.
- Wait 2 – 3 weeks and rake again lightly.
- Wait another 3 – 4 days. The birds are cleaning the soil for you.
- Plant a cover crop, mulch deeply, or put black plastic over the garden.

For spring and main-season crops:

- Till 2 – 3 inches deep—one pass!—two weeks before your crop goes in.
- Leave the soil exposed for birds.
- Just before planting, till again, one pass, 2 inches deep.

You can overdo a good thing. Over-tilling damages soil structure or brings weeds to the surface. And noxious perennial weeds like Canada thistle just laugh—you've cut their roots into tiny pieces, helping them spread hither and yon.

Late-season sunflowers. Photo: InAweofGod'sCreation, farm2.staticflickr.com/1951/31080193068_7e2cb4336d_o.jpg, CC BY 2.0



Well-muched flower bed. Photo: RubyGoes, farm4.staticflickr.com/3948/15715526852_3b3f12efbf_o.jpg, CC BY 2.0.

River birch resists the bronze birch borer. Photo: Googoo85, upload.wikimedia.org/wikipedia/commons/5/5a/River_Birch_Middle.JPG, CC BY-SA 3.0

weeds even better. Consider the pH or nutrient load of some mulches before applying. Some will alter the pH or create a flush of fast leaf growth due to excess nitrogen.

Most mulches need to be refreshed or replaced and won't prevent all weeds: many blow in as seeds and sprout on top of the mulch. Most importantly, use the right depth to slow down erosion and weeds but not so much that water runs off. Don't heap mulch around tree trunks, where it contributes to insect and disease problems.

Gravel and plastic sheeting are options, too. All mulches have their pros and cons. Do your homework. For example, peat moss affects soil pH, and can block rain if it dries out. And don't use so-called landscape fabric. The weeds that sprout on top are very hard to get out once their roots grow through the fabric.

Spacing and air circulation. Most fungi thrive in moist, still air. So thin, pinch, or prune to let the breeze blow through, according to your plants' recommended forms and spacing. Need more good reasons to space them out? Crowded plants compete for nutrients, water, sunlight, and even for room enough for their roots to grow. And insect pests like crowded plants too, especially monocultures. They move easily from plant to plant, sheltered from predators but with easy access to meals. **Note:** If you have good soil, crowding can work to your advantage (few weeds) for some vegetable varieties. In some cases, vegetables and some flowering plants benefit from close planting. It also reduces weeding. Gardening is all about experimenting.

Be Choosy

Select for health. Examine plants before you buy them. Bring your loupe or magnifier. Look under leaves or the stem near the soil for insect signs (eggs, larvae, or sticky honeydew, for example) or disease symptoms. If you can, without damaging plants, inspect roots for disease or other problems (girdling roots, aka 'root-bound' plants are often evident early in pot-grown trees, for instance) Buy from reputable suppliers.

Select for resistance. Seek out plants labeled to be resistant. They could be species known to resist serious pests in your area. (Example: river birch resists the bronze birch borer.) Or they might be cultivars or hybrids developed to resist diseases. (Example: tomatoes labeled "V" or "F" or "N" resist Verticillium or Fusarium wilt or nematodes.) You'll learn more about resistance as we go along, including commonly used codes for disease-resistant varieties.

If you see signs of diseased roots while you're putting in transplants or dividing stock, stop right there, and don't plant them.

Be Extra Choosy, Don't Choose Invasives!

Ask thoughtful questions at the garden center: How quickly (read: aggressively) does this plant spread? How does it mainly spread—by seed or by root? Is it, or a close relative of, a known invasive?

Think twice about planting old-time favorites: burning bush, barberry, Norway maple, butterfly bush and privet, which are now invading forests throughout the Northeast.

Plants aren't the only invasives of concern. Be aware of the following invasive pathogens and insects in the Northeast. If you see what might be symptoms or signs, act.

Amur honeysuckle, (*Lonicera maackii)*	Japanese barberry, (*Berberis thunbergii)*
Autumn olive, (*Elaeagnus angustifolia)*	Japanese honeysuckle, (*Lonicera japonica)*
Black locust, (*Robinia pseudoacacia)*	Japanese knotweed, (*Polygonium cuspidatam)*
Black swallowwort, (*Vincetoxicum nigrum)*	Japanese sedge, (*Carex morrowii)*
Pale swallowort, (*Cynanchum rossicum)*	Japanese stiltgrass, (*Microstegium vimineum)*
Border privet, (*Ligustrum obtusifolium)*	Mile a minute Vine, (*Polygonum perfoliatum)*
Buckthorn, (*Rhamnus cathartica)*	Morrow's honeysuckle, (*Lonicera morrowii)*
Burning bush, (*Euonymus alata)*	Multiflora rose, (*Rosa multiflora)*
Calamus, (*Acorus calamus)*	Norway maple, (*Acer platanoides)*
Common reed, (*Phragmites australis)*	Oriental bittersweet, (*Celastrus orbiculatus)*
Curly pondweed, (*Potamogeton crispus)*	Purple loosestrife, (*Lythrum salicaria)*
Eurasian watermilfoil, (*Myriophyllum spicatum)*	Reed canarygrass, (*Phalaris arundinacea)*
European privet, (*Ligustrum vulgare)*	Rock snot, (*Didymosphenia geminata)*
Fig buttercup, (*Ranunculus ficaria)*	Tansy ragwort, (*Senecio jacobaea)*
Garlic mustard, (*Alliaria petiolata)*	Tree of Heaven, (*Ailanthus altissima)*
Giant hogweed, (*Heracleum mantegazzianum)*	Variable-Leaf milfoil, (*Myriophyllum heterophyllum)*
Goats-rue, (*Galega officinalis)*	Water chestnut, (*Trapa natans)*
Hydrilla, (*Hydrilla verticillata)*	Wine raspberry, wineberry, (*Rubus phoenicolasius)*

Invasive Pathogens	Invasive Insects
Bacterial leaf scorch, (*Xylella fastidiosa)*	Asian long-horned beetle, (*Anoplophora glabripennis)*
Bacterial wilt, (*Ralstonia solanacearum)*	Brown marmorated stink bug, (*Halyomorpha halys)*
Daylily rust, (*Puccina hemerocalllidis)*	Emerald ash borer, (*Agrilus planipennis)*
Dogwood anthracnose, (*Discula destructiva)*	European wood wasp, (*Sirex noctilio)*
Oak wilt, (*Ceratocystis faqacearum)*	Giant woodwasp, (*Urocerus gigas)*
Plum pox virus, (*Potyvirus member)*	Golden nematode, (*Globodera rostochiensis)*
Southern bacterial wilt, (*Ralstonia solanacearum)*	Hemlock wooly adelgid, (*Adelges tsugae)*
Soybean rust, (*Phakopsora pachyrhizi)*	Light brown apple moth, (*Epiphyas postvittana)*
Sudden oak death syndrome, (*Phytophthora ramorum)*	Nun moth, (*Lymantria monacha)*
	Pine shoot beetle, (*Tomicus piniperda)*
	Siberian moth, (*Dendrolimus superans)*
	Swede midge, (*Contarinia nasturtii)*
	Viburnum leaf beetle, (*Pyrrhalta viburni)*
	Winter moth, (*Operophtera brumata)*

Timing is Everything

Right time, wrong time. Planting, thinning, pruning, fertilizing, watering, tilling, dealing with pests—there's a wrong time for everything! A right time, too. Plant carrots in mid-June to avoid the carrot maggots awaiting them in the soil in May. Most grub treatments work best if applied in late summer when grubs are thin-skinned and close to the surface, rather than early in spring. Horticultural oils control many scales or mites only if used at the right time for each pest on each plant.

Be sure to rotate heavy feeders, like tomatoes, with nitrogen-fixing vegetables like peas or beans. Photo: NYSIPM Staff.

Spread the risk. Don't plant the whole crop or flowerbed at once. If your growing season allows, stagger plantings every couple of weeks. Or start some seeds inside for early planting, then plant the rest after the soil warms up. You're bound to slip by pests some of the time.

Do-si-do your veggies, (rotate your crops). Don't put the same vegetables, or even annual flowers, in the same spot year after year. Some pests, especially diseases, build up in the soil or thrive on last year's roots or stems. Rotate out those plants—and their relatives, if they're subject to the same pests. Rotation helps to conserve or rebuild nutrients. Corn and tomatoes, for example, are nutrient hogs, so follow those crops with nitrogen-fixing plants like peas or beans.

GDDs can help. Growing Degree Days tell you when to start scouting for insect pests. Here's the idea behind GDDs:

Insects don't proceed through life according to dates on the calendar: hatch now, pupate now, lay eggs now. But they are predictable.

Once spring blows in, most insects rev their engines whenever the thermometer goes above a threshold temperature—usually 50°F. If the temperature drops, they shut back down till the next warm spell. So the way to predict when an insect will get troublesome is to track how much warmth above 50°F accumulates, day by day.

Say honeylocust plant bugs show up in April one year but May another. How do you know when best to do battle? Consult a Growing Degree Day (GDD) chart. It might say "Honeylocust plant bug: Horticultural oil: 58 – 246 GDDs." This means the spray works during that development window after your running total hits 58 but before it hits 246 GDDs. If your running total is less than 58, wait. If it exceeds 246, you're out of luck. Another example: "Mealybugs: Horticultural oil: 7 – 91 GDDs." So pay attention early on.

Where do you get Growing Degree Reports? Try the Network for Environment and Weather Applications at newa.cornell.edu. Most county Cooperative Extension offices can tell you how to do this.

Call on the Good Guys

You've done everything you can to prevent problems. But you've got one more source of help. Beneficial insects and natural helpers straddle the boundary between the prevention techniques you just learned and the intervention techniques that follow.

Help Them Help You

Insects, mites, nematodes. Birds and toads, frogs and snakes. Fungi, even. All can be natural helpers.

Some destroy pests. Rove beetles, for example, destroy Japanese beetle grubs. Tiny wasps parasitize tomato hornworm caterpillars.

Others handle problems after they've begun. Lady beetles show up as aphids peak. Birds swoop in to dine on inchworms.

Rose-breasted Grosbeaks will eat Colorado Potato Beetles. Photo: Matt Stratmoen, c2.staticflickr.com/8/7288/8737206434_1a0b4007c4_b.jpg, CC BY-NC-ND 2.0

Plan Your Garden and Yard with Garden Helpers in Mind

Diversity rules. Naturalized landscapes or gardens with plenty of herbs and flowers encourage natural predators.

Water for all. Provide birds, insects, and frogs with birdbaths, shallow pans of water at soil level, or moving or dripping water. Replace water weekly, before it becomes stagnant or if you see wrigglers—larval mosquitoes.

Year-round housing. Permanent hedgerows, bio-strips (rows of perennials and groundcovers among the veggies), meadows, perennial gardens, and groundcovers provide shelter where beneficial insects and others can overwinter, breed, and seek safety. Birdhouses and nesting trees attract birds. Some birds, such as the hawks and owls that eat mice, use dead trees for roosts.

Adult syrphid fly on a flower.. Photo: Whitney Cranshaw, Colorado State University, Bugwood.org

Never enough nectar. Both pollinators and predatory insects eat nectar. Provide a variety of flowers from early spring through fall.

Don't destroy all pests. If you kill off the aphids, the lady beetles have no call to stay around. In a truly natural system there's no such thing as pests—they're just somebody's lunch. Allow a tolerable level of problem pests to feed their natural enemies without letting them destroy the plants you want. This is where threshold comes in to play. You will never have a pest free property, but a nice balance of pests and their predators is a sustainable goal.

Meet special needs. Provide a mix of wide-open, flat flowers (such as asters or daisies) and tiny florets full of nectar (herbs such as dill or parsley). Birds will be glad to snag your pests if you grow seed, berry, and nut-bearing plants. Toads and frogs need cool, moist places, and snakes love warm rocks. So know your friends and meet their needs.

Lady beetle larva among the aphids. Photo: Ken Wise, NYSIPM

Welcome, Visitors: Placing a small piece of wood or a rock in a birdbath encourages beneficial insects and birds to light. Birds prefer fresh to stagnant water, so give it a shot from the hose. This also reduces the chance of stagnant water—a mosquito breeding ground. Photo: NYS IPM Staff

Farmers don't waste crops or cash by ignoring pest problems. Scouting is pure IPM. Photo: NYSIPM Flickr Photo Gallery

If you buy them, have a plan. Tempted to buy lady beetles, lacewings, praying mantids, parasitoid wasps, spined soldier beetles, and other beneficial insects? Ask your supplier how to keep them around long enough to become established; they might explain on their website. Some beneficials are overrated—probably best not to spend money on praying mantids, for example. Often it's easier just to provide good conditions and give resident natural enemies a boost, since they're already there and inclined to like your offer.

Give them time. A little patience often lets natural enemies catch up with pests. For example, it could be a week before lady beetles find your aphids. By then, they've done some damage, but plants recover well once the predators arrive.

If you use pesticides, read the label and understand that sprays can kill natural enemies. Even natural or organic pesticides can damage predators, and cause health problems for your family and pets. Professional IPM practitioners sometimes combine selective pesticide applications with beneficial insects. But they time it carefully.

Taking Action: Intervention Techniques

When diseases or insects threaten your plants, it's time to act. Intervention can be as simple as flicking bugs into soapy water or as involved as planting a trap crop. What you do will depend upon the importance of your plant or crop (a personal value judgment), the size of the problem, and what works best. Here's the scoop, with details to follow in each chapter.

Crossing the Threshold. Farmers use thresholds, and you can too. A threshold signals a change. When you cross a threshold something is different. In gardening or farming, crossing the threshold of tolerance means it might be time to do something about pests.

Farmers scout their fields for disease and insect pests, using scientific sampling techniques that reliably predict whether or not a pest will reduce yields more than the money it would cost to deal with it. For you, it's probably a little more subjective. Consider these things to arrive at your threshold of tolerance: How important are these plants to you? Can you live with some damage? Is the solution more trouble than it's worth? Keep notes in your garden journal to help you decide if you're over threshold.

Get Rid of Them

Rogueing. Removing and destroying badly diseased or damaged plants is critical. Prune diseased leaves, stems, or branches; dig out diseased roots. Then do them in. Bag them and throw away, compost them properly at high temperatures, or put them in a dead-end compost heap you'll never use on the garden. Burying deep in soil may work. You really have to understand the pest before you decide. Want to burn them? Check local laws first.

Sticky traps. Greenhouse growers use these to monitor for whiteflies and aphids. They also attract leafminer flies. Most traps are yellow or blue and the size of an index card, with a twist tie so you can hang them from a stake or wire. You can use them in the garden to scout for a pest problem—to help assess the size of an infestation. Though they might catch enough pests to control a problem, don't assume they will. Also—sticky traps can't tell the difference between friend and foe.

Lures. Similar to sticky traps, lures can help you scout and assess pest populations; some capture pests. For example, sticky-coated red balls that look like apples catch apple maggot flies. (Sometimes they're accompanied by yellow cards that simulate flower color.) Some lures use insect sex pheromones, the chemical signals insects use to communicate with each other. Examples are codling moths, gypsy moths, and more.

The art and science of handpicking. Squeamish? Handpicking insects doesn't have to involve direct contact. Scout first—then at dawn or dusk (especially when it's cool and pests are sluggish, and especially if you've got lots of pests), spread newspapers or an old sheet beneath a tree, shrub, or flower, then shake it, rap on its branches, or tap its stems. (For smaller plants, use a paper plate, or a light-colored, upside-down frisbee.) Look to be sure you're getting mainly pests and few beneficials. Gather up the sheet and dump the bugs into a bucket of soapy water. The soap gets inside their airways, shutting down respiration. It's as if it smothers them. You can use this bucket-of-soapy-water trick for big bruisers like Japanese beetles that a regular soap spray won't work on. Or you could even take a shop vacuum cleaner to them, but be sure to plug the hose with an old sock when done, so they won't crawl back out.

For nipping small infestations 'in the bud', nothing beats hand-picking for ease and simplicity. Wear gloves or drop pests into a can of soapy water if you don't want to smush them.

Hose them off. Your garden hose can do double-duty as a bug-blaster. Test how hard a blast different plants can take; some are more delicate than others. Hit aphids, spider mites, and other pests with a hard stream of water several days in a row. To those tiny, soft-bodied pests it's like being slammed with a load of

Alternaria solani, Early Blight on Tomato, is a killer. Remove and destroy as soon as you see signs of it and you may prevent its spread. Photo: Gerald Holmes, California Polytechnic, Bugwood.org, CC BY-NC 3.0 US

Handpicking pests is the ultimate pesticide-free treatment. Make sure you're removing pests and not their predators. Wear gloves if you'd like. Smush or drop into soapy water. Photo: Kathleen Moore, content.ces.ncsu.edu/extension-gardener-handbook, CC BY 2.0

Thinking Ahead

Sometimes you need to spray or dust before you see disease symptoms or while larvae are so tiny you hardly notice them. Got blight? Fungicides work only preventively. Got borers? Insecticides don't work once the borers are inside the stem. That's why scouting and keeping good records are so important.

Alfalfa, a good trap crop. Photo: Huerta Agroecológica Comunitaria "Cantarranas", c2.staticflickr.com/8/7432/8730792701_7d4d12c1f2_b.jpg, CC BY-NC-ND 2.0

bricks. If a big storm blows in, the pounding rain could pinch-hit for your hose. You might need to repeat a week or two later.

Trap crops. Every critter has its favorite food, and some plants are just irresistible. Take advantage of that weakness! Early radishes, for example, capture cabbage root maggots, saving your broccoli, while flea beetles attacking your chard could be lured away by mustard greens. Once pests have covered the trap plant, quickly pull and stuff the whole thing into a trash bag, seal it—and away they go. Best done in early morning, as pests tend to move more slowly when it's cool. We suggest specific trap crops for certain veggies in the Vegetable Chapter.

Not every trap crop need be destroyed with the pest. Flick slow-moving caterpillars into soapy water. And some you wouldn't destroy anyway. Mulberry trees on one side of the property keep birds happy and far from the blueberries. An alfalfa patch far from the garden (with a wide open space between) can keep woodchucks contented and less inclined to hike into your vegetable plot.

Trap crops work in combination with beneficial predators. Lady beetles, for example, are attracted to the aphids on your trap crop. But they stay in the neighborhood to protect other plants from other pests.

Beer trap for slugs. Photo: Tony Cyphert, c1.staticflickr.com/7/6127/5956372667_51b7a18507_b.jpg, CC BY-NC-ND 2.0

Pitfall and other traps. Steep-sided cans or yogurt cups help trap black vine weevils: use it to scout for their presence. Boards, cabbage leaves or hollowed-out citrus rinds provide shelter for slugs during the day: drop or scrape them into a bucket of soapy water. Wireworms love potatoes—to trap them, skewer some chunks and bury them at the soil line. You'll find more details and suggestions in coming chapters.

The beer trap. Slugs are among the top pest questions at many Cooperative Extension offices and garden centers. And if you've heard of slugs, you've probably heard of beer traps. Basically, you sink cups such as yogurt containers, old coffee mugs, or the like a few inches into the soil, then routinely fill with beer or water and yeast. Works best if placed reasonably close together. Let the lip of the cup protrude 1 inch above the soil level to prevent valuable ground beetles from drowning.

Pesticides

The last resort. Pesticides are products that kill pests, whether those pests are diseases, insects, or weeds. Even insecticidal soap or horticultural oil, benign as they are, can kill beneficials (and soap sprays can damage certain plants) and should be used only if other methods fail. Botanical or natural pesticides are still pesticides. They often break down quickly, but some are more toxic or affect a broader range of organisms than other, synthetic pesticides. Choose carefully and always read and follow the pesticide label.

Before you act. Identify the problem and think it through. Is that sluggy looking thing you zapped really the larva of a beneficial predator? If you kill all the spiders, what will catch the flies? Tough questions to answer, but leading to one last IPM option … do nothing.

What about home remedies? Occasionally we mention a traditional home remedy—or warn you against one. Home remedies are not endorsements by any Northeastern land grant university. Nor are they recommendations for use, either express or implied. Neither Cornell University nor its employees or agents is responsible for injury or damage to person or property from the use of any home remedy. For more information, see pmep.cce.cornell.edu/pesticide-policies/home-remedies.html.

Since home remedies aren't registered or exempted pesticides, commercial applicators are prohibited from commercially applying them.

Read the Label – Understand the Signal Word Warnings

Caution: Very low toxicity (Category IV)

Caution: Low toxicity (Category III)

Warning: Moderate toxicity (Category II)

Danger: High toxicity (Category I)

How are Signal Words Chosen?

Before the EPA can determine the appropriate signal word for a pesticide product, the manufacturer performs research on laboratory animals to determine the toxicity of the formulation. Required studies include oral exposure (eating the product), inhalation exposure (breathing in the product), dermal exposure (spreading the product on the skin) and exposures to the skin and eyes to check for irritation. The study that shows the highest toxicity is used to determine the signal word.

For example, if a product demonstrated low toxicity when eaten, moderate toxicity when inhaled, and high toxicity when applied to skin, the EPA would assign the signal word DANGER, based on the most sensitive route of entry (skin in this example).

Growing your own fruits and vegetables means never wondering how much pesticide is on your produce. Photo: Andi Graf from Pixabay, cdn.pixabay.com/photo/2014/06/05/19/39/thanksgiving-362911_960_720.jpg

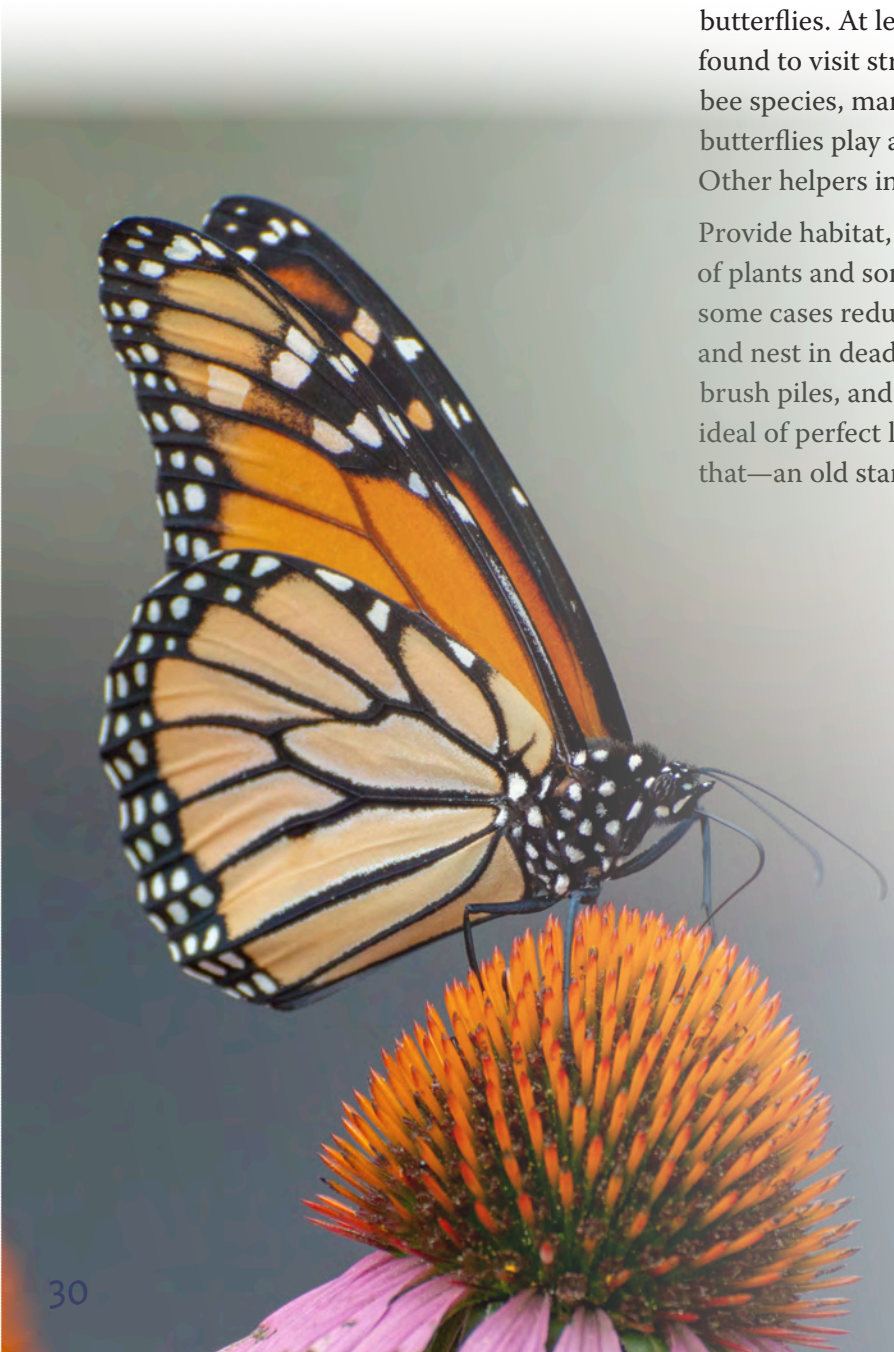
Focus on Pollinators

Healthy, well-chosen flowering plants in your yard do more than just satisfy the eye. They contribute to the ecosystem and our food sources by encouraging pollinators of many kinds. Our list is not all-inclusive; we encourage you to choose what works best in your area. Natives are always preferred but you need not limit yourself. Choose annuals and perennial flowers, and herbs as well as flowering shrubs and trees.

To further support pollinators, choose plants that are easy-care and bloom at different times during the season. Reduce the use of pesticides, prune and deadhead flowers, and consider adding a non-stagnant water source. One more suggestion … let your dandelions and other turf weeds grow. Dandelions are an important food source for bees in the spring.

Pollinators are more than just honeybees and monarch butterflies. At least fifteen species of wild bees have been found to visit strawberry flowers. Besides the hundreds of wild bee species, many other insects including beetles, wasps and butterflies play a part in pollination as they look for pollen. Other helpers include ants, bats, flies, moths and birds!

Provide habitat, not just plants and water. This means a variety of plants and some undisturbed areas. Diversity is key and in some cases reduces pest problems. Most native bees are solitary and nest in dead wood and soft soil. Where possible, allow some brush piles, and keep weathered wood around. The old standard ideal of perfect lawns and perfectly manicured gardens are just that—an old standard.



Monarch butterfly on purple coneflower. Native plants attract native insects and birds. Photo: Carolyn Lehrke, c1.staticflickr.com/1/925/41626158130_613e83a320_b.jpg, CC BY-NC-ND 2.0

Better Habitat for Bees

Excerpted from: *Protecting and Enhancing Pollinators in Urban Landscapes for the US North Central Region.* Authors: David Smitley, Michigan State University Department of Entomology; Diane Brown, Rebecca Finneran and Erwin Elsner, Michigan State University Extension; Joy N. Landis, Michigan State University IPM; Paula M. Shrewsbury, University of Maryland Department of Entomology; and Daniel A. Herms, The Ohio State University Department of Entomology.

Honey bee on zinnia. Photo: Olin from Pixabay.

Annuals Attractive to Bees

In general, herbs and garden perennials are good for bees while annual bedding plants are not as attractive to them. Annual flowers like petunias are readily available at the garden center, but most have been bred for showy flowers or vigorous growth and do not produce enough pollen and nectar to be good food plants for bees or butterflies. Below are some annuals that may be more difficult to find, but are good food plants for pollinators. Please note that some of these, like garden heliotrope, lantana and pentas, are considered annuals in northern states but are perennials in more southern states.

Annuals Attractive to Bees

Common name	Genus species (scientific name)
Ageratum	*Ageratum houstonianum*
Anise-scented sage	*Salvia guaranitica*
Aster	*Callistephus chinensis*
Black-eyed susan or gloriosa daisy	*Rudbeckia hirta*
Blue salvia (mealycup sage)	*Salvia farinacea*
Borage or starflower	*Borago officinalis*
Calendula	*Calendula officinalis*
Clary sage	*Salvia sclarea* (biennial)
Common lantana	*Lantana camara*
Common sunflower	*Helianthus annuus*
Cornflower	*Centaurea cyanus*
Cosmos	*Cosmos bipinnatus*
Dahlia (open types)	*Dahlia* cv.
Garden heliotrope	*Heliotrope arborescens*
Mignonette	*Resedaodorata*
Pentas	*Pentas* spp.
Pineapple sage	*Salvia elegans*
Popcorn plant	*Cassia didymobotrya*
Snapdragon	*Antirrhinum majus*
Spider flower	*Cleome* spp.
Sweet William (biennial in southern parts of north central region)	*Dianthus barbatus*
Sweet alyssum	*Lobularia maritime*
Tithonia	*Tithonia rotundifolia*
Vervain	*Verbena bonariensis*
Zinnia	*Zinnia elegans*

Herbaceous Perennials Attractive to Bees

Researchers have identified that perennial flowers tend to be far more attractive to bees than annuals. Many different types of perennials are good for bees, from showy flowers to herbs. Herb gardens are an excellent resource for bees because they flower over a long period of time, and herbs grow fairly large and produce lots of flowers. The perennials and herbs listed below can be purchased from nurseries and garden centers in the North Central United States.

Because species and cultivars vary in cold-hardiness, be sure to check the acceptable hardiness zones listed on the plant label and match it to the USDA Plant Hardiness Zone where you live. Some of the plants listed below are also available as seeds in commercial "wildflower" mixes. If you are looking for native wildflower seed, a good source of information is the Xerces Society, which gives a list of plants and a supplier for each region.

Herbaceous Perennials Attractive to Bees	
Common name	**Genus species (scientific name)**
Anise hyssop	*Agastache foeniculum*
Aromatic aster	*Symphyotrichum oblongifolium*
Aster	*Symphyotrichum novae-angliae* – 'Purple Dome'
Astilbe, false spirea	*Astilbe* spp.
Basil, sweet basil (annual)	*Ocimum basilicum*
Bee balm	*Monarda* spp.
Bellflower	*Campanula* spp.
Betony	*Stachys monieri*
Bigleaf ligularia	*Ligularia dentate*
Black-eyed Susan, coneflower	*Rudbeckia* spp.
Blanket flower	*Gaillardia*
Blazing star	*Liatris spicata*
Butterfly bush	*Buddleja* or *Buddleia* spp.
Butterfly weed	*Asclepias tuberosa*
Calamint	*Calamintha nepeta*
Carolina lupine	*Thermopsis villosa*
Catmint	*Nepeta* spp.
Chrysanthemum (open types)	*Chrysanthemum*
Chocolate flower	*Berlandiera lyrata*
Clematis	*Clematis* spp.
Common poppy, red poppy	*Papaver rhoeas*
Common yarrow	*Achillea millefolium*
Coral bells	*Heuchera* spp.
Cornflower	*Centaurea* spp.
Crown vetch (ground cover)	*Securigera (= Coronilla) varia*
Cut-leaf mallow	*Malva alcea*
(various names)	Eryngium spp.
Fennel	*Foeniculum vulgare*
Foxglove or beardtongues	*Penstemon* spp.

Herbaceous Perennials Attractive to Bees	
Common name	**Genus species (scientific name)**
Garden speedwell	*Veronica longifolia*
Globe thistle	*Echinops ritro*
Hardy geranium, blue cranesbill	*Geranium ibericum* x *(Geranium himalayense)*
Hosta	*Hosta* spp.
Hyssop (naturalized in North America)	*Hyssopus officinalis*
Inula, Himalayan elecampane	*Inula royleana*
Japanese anemone	*Anemone hupehensis* 'Robutissima'
Large-leaved aster	*Eurybia macrophylla*
Lavender	*Lavandula*
Lemon balm	*Melissa officinalis*
Leucanthemella	*Leucanthemella serotine*
Lupine	*Lupinus* spp.
Mints	*Mentha* spp.
Narrow-leaved foxtail lily	*Eremurus stenophyllus*
New England aster	*Symphyotrichum novae-angliae*
Ornamental onion, garlic, chives, leek, scallion	*Allium* spp., including *Allium 'millenium'* and *'christophii'*
Oregano	*Origanum vulgare*
Pachysandra	*Pachysandra terminalis*
Parasol whitetop	*Doellingeria umbellate*
Pentas	*Pentas* spp.
Peony	*Paeonia* spp.
Pincushion flower	*Scabiosa caucasica*
Purple burkheya	*Berkheya purpurea*
Purple coneflower	*Echinacea purpurea*
Rosemary	*Rosmarinus officinalis*
Russian sage	*Perovskia atriplicifolia*
Salvia	*Salvia* 'Victoria Blue', *Salvia nemorosa* 'Black and Blue', others
Sea holly	*Eryngium maritimum*
Sedum	*Sedum* spp.
Sedum, stonecrop	*Hylotelephium spectabile* and *telephium* and cvs.
Snakeroot	*Cimicifuga famose*
Sneezeweed	*Helenium*
Stiff-leaved aster	*Ionactus linariifolius*
Stokes aster	*Stokesia laevis*
Sunflower	*Helianthus*
Swamp milkweed	*Asclepias incarnata*
Sweet alyssum	*Lobularia maritima*
Thyme	*Thymus* spp.
White wood aster	*Eurybia divarcata*

Shrubs Attractive to Bees

Flowering shrubs can be an excellent food source for bees because they tend to grow larger than herbaceous perennials, and therefore produce a larger number of flowers. Some species, like *Rosa rugosa,* bloom all summer.

Shrubs Attractive to Bees	
Common name	**Genus species (scientific name)**
Black chokeberry	*Aronia melanocarpa*
Bottlebrush buckeye	*Aesculus parviflora*
Buttonbush	*Cephalanthus occidentalis*
Common witch-hazel	*Hamamelis virginiana*
Cotoneaster	*Cotoneaster*
Dwarf fothergilla	*Fothergilla gardenia*
Eastern ninebark	*Physocarpos opulifolius*
Elderberry	*Sambucus* spp.
Holly: American, box-leaved, Merserve hybrid, winterberry	*Ilex* spp.
Mockorange	*Philadelphus coronarius*
Potentilla (bush cinquefoil)	*Potentilla fruiticosa*
Privet	*Ligustrum vulgare*
Raspberry, blackberries	*Rubus* spp.
Silky, gray, redosier dogwoods	*Cornus* spp.
Spicebush	*Lindera benzoin*
Spirea	*Spiraea* spp.
Sumacs	*Rhus* spp.
Summersweet, sweet pepperbush	*Clethra alnifolia*
Viburnums	*Viburnum* spp.
Wild prairie rose	*Rosa arkansana*

(Mach and Potter 2016)

Buttonbush, *Cephalanthus occidentalis,* from East Texas. Photo: i_am_jim, upload.wikimedia.org/wikipedia/commons/5/56/Buttonbush_--_Cephalanthus_occidentalis.jpg, CC BY-SA 4.0.

Trees Attractive to Bees

Flowering trees are critical to providing an ample food source for bees because of their large size and thousands of flowers. A blooming linden or black locust produces so much pollen and nectar that it dwarfs the amount provided by most garden flowers in comparison. However, most trees only bloom for two to three weeks, so a succession of trees that bloom from early spring through summer is very helpful to bees. Trees in the North Central United States that are frequently mentioned as good food plants for bees are listed in the following table.

Trees Attractive to Bees

Common name	Genus species (scientific name)	Bloom
Eastern redbud	*Cercis canadensis*	April
Red maple	*Acer rubrum*	April
Alternate-leaved, pagoda or green osier dogwood	*Cornus alternifolia*	May
Black tupelo, blackgum	*Nyssa sylvatica*	May
Cherry, peach, plum, almond	*Prunus* spp. (many)	May
Crabapple, apple	*Malus* spp. (many)	May
Hawthorn	*Crataegus* spp. (many)	May
Serviceberry	*Amelanchier* spp.	May
Willow	*Salix* spp.	May
Black locust	*Robinia pseudoacacia*	Late May-early June
Catalpa	*Catalpa speciosa*	June
Linden, basswood	*Tilia* spp.	June
Tulip-tree	*Liriodendron tulipifera*	June
Amur maackia	*Maackia amurensis*	July-August
Bee-bee tree	*Tetradium (Evodia) daniellii*	July-August
Japanese sophora, Japanese pagoda	*Sophora japonica*	July-September
Seven sons tree	*Heptacodium miconioides*	August-September

Source: Lovell 1926, Pellet 1947, Oertel 1980, Tew 2006, Mader et al. 2011, Mach and Potter 2016

Apple blossoms. Photo: NYSIPM Staff.

Wind-Pollinated Trees Attractive to Bees

Wind-pollinated trees do not produce nectar, but bees may take advantage of them as an abundant source of pollen. Pines, spruces and nearly all gymnosperms are not usually visited by bees unless it is to gather sap used for propolis, a sticky substance used to fill crevices and seal hives. However, several genera of wind-pollinated angiosperms are routinely visited by bees to collect pollen. The most frequently visited wind-pollinated trees are listed below. Red maple and willow are listed in both tables because they are wind-pollinated trees that are also considered important pollen or nectar sources for bees. Pollen from the wind-pollinated trees may be collected by bees because of a favorable nutritional value, the large amount of pollen produced, or because it is available at times when other food sources are scarce.

Wind-Pollinated Trees Attractive to Bees

Common name	Genus species (scientific name)	Attractiveness to bees[1]
Ash	*Fraxinus* spp.	Somewhat attractive
Birch	*Betula* spp.	Somewhat attractive
Elm	*Ulmus* spp.	Very attractive
Hickory	*Carya* spp.	Somewhat attractive
Oak	*Quercus* spp.	Very attractive
Poplar	*Populus* spp.	Very attractive
Maple	*Acer* spp.	Highly attractive
Willow	*Salix* spp.	Highly attractive

Source: Kraemer and Favi. 2005, MacIvor et al. 2014, Oertel 1980

[1]Level of attractiveness in this table is rated by number of reports of bees using pollen, level of bee activity, diversity of bee species observed and amount of pollen found in hives or nests.

Young oak leaves (Quercus robur) and male flowers in the setting sun, Brastad, Lysekil Municipality, Sweden. Photo: W.carter, upload.wikimedia.org/wikipedia/commons/b/bb/New_oak_leaves_with_male_flowers_1.jpg, CC0 1.0

Wildflowers Attractive to Bees

Wildflower mixes often contain seed of several of the attractive perennials listed above. A good source for native wildflower seed is the Xerces Society, which gives a list of plants and a supplier for each region. Another list of native plants and wildflowers available from nurseries and seed companies is maintained by the American Horticultural Society, and is organized by state. MSU Extension publication E2973, "Attracting Beneficial Insects with Native Flowering Plants," provides photos and bloom time for many of the native flowers listed below. This publication is available for purchase at the MSU Extension Bookstore. Wildflowers described in E2973 are marked with an asterisk (*) in the following table.

Obedient Plant *(Physostegia virginiana),* is a low maintenance, showy native and a favorite of pollinators and beneficial insects. Photo: Kingsbrae Garden, c1.staticflickr.com/5/4115/4934731104_a9b477419b_b.jpg, CC BY-NC-SA 2.0

Wildflowers Attractive to Bees	
Common name	**Genus species (scientific name)**
American vervain, blue vervain	*Verbena hastata**
Aromatic aster	*Symphyotrichum oblongifolium**
Canadian milkvetch	*Astragalus canadensis**
Clover	*Melilotus* spp.
Clover	*Trifolium* spp.
Coneflower	*Ratibida columnifera**
Culver's root	*Veronicastrum virginicum**
Cup plant	*Silphium perfoliatum**
Golden alexanders	*Zizia aurea**
Goldenrod	*Oligoneuron* spp.
Goldenrod	*Solidago speciosa*
Great blue lobelia	*Lobelia siphilitica*
Horsemint, spotted beebalm	*Monarda punctata**
Joe-Pye weed	*Eupatorium fistulosum**
Late figwort	*Scrophularia marilandica**
Meadowsweet (shrub)	*Spirea alba**
Missouri ironweed	*Vernonia missurica**
Mountain mints	*Pycanthemum* spp.*
Native milkweeds	*Asclepias* spp.*
Naturalized asters	*Aster* spp.
Nodding wild onion	*Allium cernuum**
Obedient plant, false dragonhead	*Physostegia virginiana**
Pale Indian plantain	*Cacalia atriplicifolia**
Penstemon, hairy beardtongue	*Penstemon hirsutus**
Prairie blazing star	*Liatris pycnostachya*
Rattlesnake master, eryngo	*Eryngium* spp.

*Wildflowers known to attract beneficial insects and described in MSUE publication E2973.

Riddell's goldenrod	*Solidago riddellii**
Rough blazing star	*Liatris aspera*
Rough oxeye, false sunflower	*Heliopsis helianthoides*
Showy milkweed	*Asclepias speciosa*
Smooth aster	*Aster laevis**
Thimbleweed herbaceous perennial	*Anemone cylindrica**
White wild indigo, false indigo	*Baptisia alba*
Wild quinine, American feverfew	*Parthenium integrifolium*
Yellow coneflower	*Ratibida pinnata**
Yellow giant hyssop	*Agastache nepetoides**
Chickweed	*Stellaria media*
Clover	*Trifolium* spp.
Dandelion	*Taraxacum officiniale*
Knapweed (feral)	*Centaurea montana*
Smartweed	*Polygonum* sp.

*Wildflowers known to attract beneficial insects and described in MSUE publication E2973.

Onward—to Solving Problems

You've opened the toolbox and looked at the tools. You know the premise of IPM thinking. The following chapters provide detailed guidelines to help you diagnose, prevent, lessen, and solve pest problems. And while coping with problems isn't always easy, we hope you find satisfaction in choosing solutions based on an intelligent, science-based and nature-based approach.

Garden tools. Photo: Thomas Hawk, farm1.staticflickr.com/196/509296254_826621a732_b.jpg, CC BY-NC 2.0