



# The Climate-Friendly Gardener

*A Guide to Combating Global Warming from the Ground Up*



Union of Concerned Scientists

Citizens and Scientists for Environmental Solutions





Seventy percent of American households engage in some level of gardening or lawn care every year.<sup>1</sup> Some do it for beautiful flowers, lush grass, or fresh fruits and vegetables; some for the peace and quiet or the connection to nature.

But there is another reason to grow plants in your yard: certain gardening practices can help combat global warming.

This guide will show you how. First, we explain the science linking soil, plants, and climate change; then we provide practical tips for a more climate-friendly garden, and links to resources that will help you adapt these tips to your own needs.

## The Relationship between Gardens and Climate

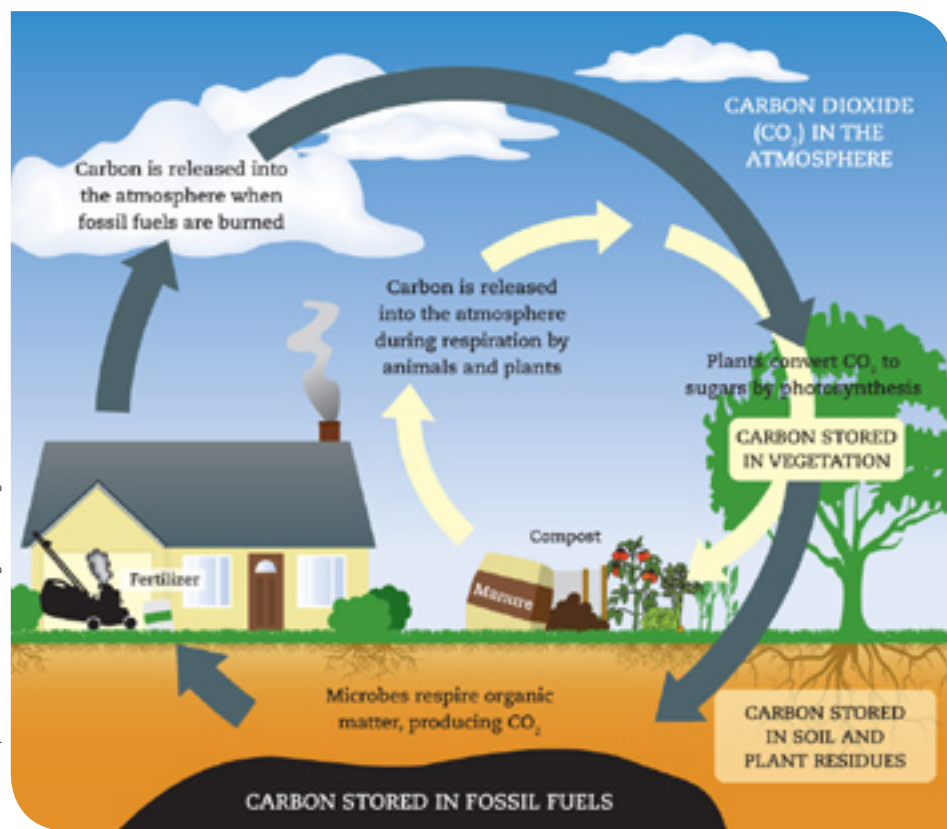
Scientists agree that global warming is well under way, the result of a buildup in the atmosphere of carbon

dioxide (CO<sub>2</sub>) and other heat-trapping gases generated by human activities including the burning of fossil fuels. When too much global warming pollution is released into the air, it acts like a blanket, trapping heat in our atmosphere and altering weather patterns around

the world. This climate disruption is likely to have wide-ranging consequences not only for our own health and well-being, but that of other living things as well.

Many gardeners already see evidence of global warming in their own backyards. Summers are getting hotter, and generally milder winters mean plant hardiness zones are shifting.<sup>2</sup> These changes can make planning your garden—which plants to choose, how soon to put new seedlings in the ground, and when to harvest vegetables—more of a challenge. While a longer growing season will benefit some gardeners, climate disruption is also projected to increase the frequency and severity of extreme weather (for example, droughts, floods) and to benefit some pests and weeds, which will further challenge the ability of gardeners (and farmers) to grow plants successfully.

Gardeners can do more than merely adapt to global warming, however—they can make choices in their gardens that don't add to the problem. That's because each patch of soil (and the plants that grow in it) takes in and gives off various types and amounts of heat-trapping gases, depending on how it is managed.



Carbon is constantly cycling from the air into plants and soil, and back into the air. Global warming is largely a result of an imbalance in this carbon cycle, due to the release of vast quantities of ancient carbon that have been burned as fossil fuel.

Careful attention to the world's soils is one piece of solving the climate problem.

Agriculture and forestry, which dominate managed soils worldwide, clearly have the largest roles to play. However, as cities expand in the United States and elsewhere, there is a growing opportunity for urban and suburban areas to play a part. Recent studies suggest that urban green spaces (lawns, gardens, parks, golf courses, and trees planted along streets) have the potential to capture CO<sub>2</sub> and “store” that carbon over time (see the box to the right).<sup>3,4</sup> Practices that maximize carbon storage without generating too much global warming pollution in the process (such as crop rotation, cover crops, tree planting, and “low-input” lawn and garden maintenance) can help slow the pace of climate change. As a gardener, you can lead the way in your own yard.

## Five Steps to a Climate-Friendly Garden

A garden can be thought of as climate-friendly if it stores (or prevents the release of) more heat-trapping gases than it generates. While the movement of carbon and other global warming pollutants in the garden is highly complex and challenging to measure, researchers in agriculture, climate and soil sciences, forestry, and urban ecology have identified a number of practices likely to move your garden in the right direction:

### Step 1. Minimize Carbon-Emitting Inputs

The kinds of tools and chemicals you use in the garden—what scientists call “inputs”—can affect the amount of heat-trapping gases your garden

## The Secret Is in the Soil

All living organisms are based on carbon. Carbon atoms can bond with as many as four other kinds of atoms, resulting in carbon chains and other compounds such as proteins, fats, and carbohydrates that are essential to life on Earth. Carbon continually moves through living organisms, the oceans, the atmosphere, soil, and rocks in a phenomenon known as the carbon cycle.

Gardeners participate in this complex cycle. Plants capture CO<sub>2</sub> from the air and convert it to carbohydrates (starches and sugars) along with other carbon compounds that become the tissues of the plant. When these carbon-rich plant tissues are consumed by animals, or when the plant dies and microorganisms in the soil cause it to decompose, CO<sub>2</sub> is formed again, and its return to the atmosphere completes the cycle.

Global warming is largely a result of the carbon cycle being out of balance. When we burn oil, coal, and natural gas we release vast quantities of ancient carbon that had been stored underground for millions of years. One way to re-balance the carbon cycle is to “lock up” some of Earth’s carbon atoms again.

In the garden, the key to locking up carbon is soil. Putting carbon-rich organic matter such as plant parts or manure into the soil may store (or “sequester”) the carbon there for a period of time. Although some of this carbon is re-released quickly into the atmosphere as CO<sub>2</sub>, some remains bound to minerals or in organic forms that break down into CO<sub>2</sub> slowly in the soil, helping to reduce the buildup of carbon in the atmosphere. Gardeners can help their soil store more carbon through a number of practices discussed in this guide.

Building carbon-rich soil has other benefits besides combating global warming. Soils rich in organic matter drain well, prevent water pollution, support many beneficial microbes and insects, and sustain plant growth with little or no synthetic fertilizer (which is derived from fossil fuels). A study of Seattle, where single-family yards and gardens account for an estimated 25 percent of the city’s land area, compared a “climate-friendly” lawn and garden care approach with one relying on fossil-fuel-intensive inputs and practices. The study concluded that each household converting to climate-friendly practices produces environmental and public health benefits—not including carbon storage benefits—worth nearly \$75 a year.<sup>5</sup>



## How to Limit Chemicals in Your Garden

**Use people power.** Weed, prune, and rake leaves by hand whenever possible. And if you have a lawn, consider using a push or electric mower rather than a gasoline-powered one; every gallon of gasoline you burn puts 20 pounds of CO<sub>2</sub> into the atmosphere.<sup>6</sup> The average lawn mower also emits as much smog-forming pollution in one hour as an average car traveling almost 200 miles.<sup>7</sup>



**Choose non-synthetic products.** With many more products from which to choose, the number of U.S. households using non-synthetic fertilizers and insect- or weed-control products increased from an estimated 5 million households in 2004 to 12 million in 2008.<sup>8</sup> One organic fertilizer option, composted manure, has a smaller carbon footprint than industrial fertilizers.<sup>9</sup> And compared with chemical pesticides, organic options such as beer bait for slugs, insecticidal soaps, neem oil, and powders and sprays derived from the naturally occurring *Bt* bacterial toxin are more climate-friendly and safer for pets, kids, and wildlife.

**Rotate annual crops.** If you have a large vegetable garden, don't plant the same crops in the same spot year after year. Moving them around your garden in a four-year rotation (for example, leafy vegetables → fruiting crops (like tomatoes) → root vegetables → legumes → [repeat])<sup>10</sup> can help prevent some crop-specific pests and diseases from establishing a foothold, making them easier to manage without chemicals. Additionally, by rotating legumes with non-legumes, you'll need less fertilizer because legumes leave nitrogen in the soil.

**Know your fertilizer needs.** Many gardeners simply guess at what their soil needs when applying compost or other fertilizers. As a result, many either under- or over-apply fertilizer. To get a clearer picture of your soil's fertility, have it professionally analyzed about every three years by a university extension service or private laboratory. Standard soil tests are inexpensive and measure phosphorus, potassium, calcium, and magnesium levels, soil pH, and other indicators. You can also have your soil's organic matter content analyzed. You'll need to take several samples from around your garden in spring or fall; contact your state's Cooperative Extension office (see <http://www.csrees.usda.gov/Extension>) for specific sampling and mailing instructions.<sup>11,12</sup>

**Avoid peat.** Sphagnum peat moss, a component of many potting and seed-starting mixes, has long been controversial because its mining (primarily in Canada and Scandinavia) destroys peat bogs important to wildlife and water quality. Peat bogs also store considerable amounts of carbon that is released when the peat is mined and used.<sup>13</sup> Look for peat-free mixes or use your own compost.

absorbs or emits. Gasoline-powered tools such as lawn mowers and leaf blowers are obvious sources of CO<sub>2</sub>. But common garden chemicals can also contribute to global warming.

Synthetic fertilizers—especially nitrogen-based ones—require a lot of energy to manufacture, which generates a significant amount of CO<sub>2</sub>.<sup>14</sup> Even organic nitrogen-based fertilizers (compost, animal manure) can create additional heat-trapping gases, especially if the timing and amount of fertilizer are not precise.<sup>15</sup> On U.S. farms, crops absorb less than half of the nitrogen fertilizer applied. Some of the excess runs off into rivers and other bodies of water, some seeps into groundwater, and some is converted into nitrous oxide—a heat-trapping gas 320 times more potent than CO<sub>2</sub>.<sup>16,17</sup> Similarly, studies have suggested that fertilizer over-use on home gardens and lawns—especially well-watered lawns—can be a source of nitrous oxide.<sup>18,19</sup>

Pesticides (which include insecticides, herbicides, and fungicides) also contribute to global warming. Like synthetic fertilizers, pesticides require a lot of energy to manufacture, package, and transport. A recent review of farm operations indicates that the production of herbicides (weed killers, the fastest-growing class of pesticides used in the garden<sup>20</sup>) generates more carbon emissions than other kinds of pesticides. And glyphosate—the active ingredient in the widely used herbicide Roundup—is among the most carbon-intensive.<sup>21</sup>

### Step 2. Don't Leave Garden Soil Naked

Whether you grow summer vegetables, annual flowers, or perennial borders, there are periods of time—perhaps as much as half the year, depending on your local



climate—when plants are not actively growing. During these times, bare soil is vulnerable not only to erosion and weeds but carbon loss as well.

The use of cover crops—grasses, cereal grains, or legumes that can be grown when other plants cannot—is a mainstay of organic farming systems because it helps develop healthy and productive soil, reduce the need for energy-intensive chemical fertilizers and pesticides, and store large amounts of carbon. Cover crops are not meant to be harvested but to stabilize, build, and add nutrients to soil that would otherwise remain bare.

Cover crops have been described as a “winter blanket” for soils because they are often planted in fall.<sup>22</sup> They suppress weeds, buffer the soil from rain and wind (reducing erosion and water runoff), and increase the soil’s water-holding properties (improving the ability of crops to withstand drought). But most importantly for the climate-friendly gardener, when cover crops are turned under in the spring, their organic matter improves the soil, which will store carbon for years while providing nutrients for subsequent plantings and a variety of beneficial organisms.

Peas, beans, clovers, and other legumes grown as cover crops may supply most or all of the nitrogen needed for the next season’s plants to thrive, substantially reducing gardeners’ need for synthetic nitrogen fertilizers. Legumes do this by partnering with common soil bacteria to “fix” nitrogen (that is, to convert it from the abundant but unusable form found in the atmosphere into forms that plants can use). During their growing season, legumes incorporate fixed nitrogen into proteins and other large molecules

in their tissues;<sup>23</sup> when this plant matter is returned to the soil, it is broken down by microbes, releasing the fixed nitrogen for use by the next crop.

Non-legume cover crops such as rye and winter wheat are also

useful. When planted at the correct time, they can capture excess nitrogen from fertilizers or decaying plant matter; several studies showed these cover crops reduced nitrogen losses into groundwater by about 70 percent.<sup>24</sup> By holding

## Why You Should Be Growing Your Own Food

Growing food is another way to make your garden climate-friendly. Most supermarket produce travels more than 1,500 miles (often in a refrigerated truck) to get to your dinner plate.<sup>25</sup> Eliminating some of that transportation and refrigeration by growing your own produce not only conserves fossil fuels and prevents carbon emissions, but also saves money. One vegetable gardening expert notes that a typical 20-foot by 30-foot garden produces about 338 pounds of produce—worth more than \$600—per growing season.<sup>26</sup>

Incorporating fruit trees and berry bushes into your yard instead of purely ornamental plants increases the amount of food you can grow. And homegrown produce is fresher and better-tasting because it’s picked ripe and usually eaten within hours of harvest.



*Most supermarket produce travels more than 1,500 miles to get to your dinner plate. Growing food in your garden eliminates some of that transportation and its heat-trapping emissions.*

## How to Use Cover Crops in Your Garden

Farmers have long planted cover crops to promote soil fertility and control erosion. Now, many state and local cooperative extension services recommend cover crops to home gardeners as well.<sup>27,28,29</sup> Planting the seeds and turning the cover crops under before planting your flowers or vegetables takes extra time and effort, but you may find the effort pays off in the form of a more productive garden (not to mention the added climate benefits). A few tips:

- Choose cover crops that will germinate and become established quickly in your local climate, will provide enough shade to prevent weed growth, and will be easy to work into the soil in the spring. Combining a legume with a grass or cereal plant (vetch with rye or oats, for example, or Austrian peas or garden peas with winter wheat or rye) is a good strategy in many parts of the country.<sup>30</sup>
- Winter cover crops should be sown in late summer or early fall, after vegetables have been harvested or summer flowers have faded but temperatures are still warm enough for the seeds to germinate and become established. In some cases, sowing shortly before harvest (between rows of growing plants) does not interfere with the harvest, and gives the cover crop more time to become established.
- You can also grow cover crops at other times of year in any unused portion of your garden (as part of a crop rotation system that will help reinvigorate the soil and retain soil nitrogen).
- About three weeks to a month before you plant your garden for the next season, turn the cover crop under if the soil is not too wet.<sup>31</sup> Or cut it to the ground and leave it as mulch.

Many university extension services have developed cover crop guidelines for gardeners in their regions. Examples include fact sheets from Clemson University (<http://www.clemson.edu/extension/hgic/plants/vegetables/gardening/hgic1252.html>), Cornell University (<http://www.gardening.cornell.edu/factsheets/ecogardening/impsoilcov.html>), Oregon

State University (<http://extension.oregonstate.edu/catalog/html/fs/fs304-e>), and Utah State University (<http://extension.usu.edu/files/publications/publication/HG-521.pdf>). To find your nearest Cooperative Extension office, go to <http://www.csrees.usda.gov/Extension>.



*When planted in the fall and turned under in spring, cover crops such as Austrian winter peas, or field peas, suppress weeds, prevent erosion, improve soil fertility, and store carbon.*

nitrogen in their tissues, they also prevent soil microbes from converting it into heat-trapping nitrous oxide. And non-legume cover crops typically grow larger and faster compared with legumes, absorbing more CO<sub>2</sub> from the atmosphere and returning more organic matter to the soil.

### Step 3. Plant Trees and Shrubs

If you have space in your yard, planting and maintaining one or more trees or large shrubs is an excellent way to remove more heat-trapping CO<sub>2</sub> from the atmosphere over a long period of time. All plants absorb CO<sub>2</sub> through their leaves, storing the carbon in their tissues. But trees and shrubs, because they are large, woody, and long-lived, can store larger quantities of carbon than other plants, for longer periods of time.

A recent multi-city study estimated that, as a whole, the urban trees of the contiguous United States accumulate nearly 23 million tons of carbon in their tissues per year.<sup>32</sup> That's more than all of the homes, cars, and industries in Los Angeles County emit each year, or about as much as all of the homes in Illinois or Pennsylvania, or all of the power plants in Massachusetts.<sup>33</sup>

While all trees store carbon, urban and suburban trees can also prevent CO<sub>2</sub> emissions because they help reduce energy use in nearby homes and buildings. Well-placed trees can shade buildings from the summer sun or buffer them from cold winter winds, reducing the need for air conditioning and heating. And through evapotranspiration (the movement of water from the soil, through plant leaves, and into the air), urban and suburban trees can lower an entire neighborhood's temperature during the summer, further reducing the need for air conditioning.



## How to Capture Carbon with Trees

Because of trees' cooling effect and other benefits, some U.S. cities and towns have adopted tree-planting goals, and the U.S. Environmental Protection Agency has suggested tree planting as a way for cities and states to help meet their clean air targets.<sup>34,35</sup> Individual gardeners and homeowners can contribute to these efforts by following this advice:

**Choose trees for the long run.** Not all trees are equally effective at storing carbon. Trees that grow larger will store more carbon over their lifetimes than smaller trees, and faster-growing trees accumulate carbon faster. Opt for native, long-lived, low-maintenance, moderate- to fast-growing species that are large at maturity, such as sweetgum (*Liquidambar styraciflua*), tulip poplar (*Liriodendron tulipifera*), or white oak (*Quercus alba*).

**Ensure trees stay healthy.** Living trees and intact wood can store carbon for a long time, but dead trees and rotting wood release much of their accumulated carbon back into the atmosphere. Therefore, start with longer-lived trees, which hold their carbon longer,<sup>36</sup> and native species, which are well adapted to local conditions. Think twice about those that would be planted at the southern end of their current hardiness zone, as they may not adapt well to the warmer temperatures resulting from climate change. Finally, don't neglect trees after they are planted; although regular watering and pruning can produce CO<sub>2</sub> (see the section on lawns for more about water use), it's important to help young trees become established to increase their likelihood of a long life. Minimize fossil fuels in tree maintenance. Tree-care equipment powered by fossil fuels (chainsaws, leaf blowers, trucks used by tree-care crews) release heat-trapping gases and other pollutants, offsetting the climate benefits provided by trees. Opt for low-carbon methods such as hand pruning where feasible and safe.

**Location, location, location.** Plant trees in strategic energy-saving locations, such as on the south side of your home in warm climates, or where evergreens will provide a break from prevailing winter winds in colder climates.

More information about tree care and the benefits of planting trees is available on the Arbor Day Foundation website (<http://www.arborday.org>).



Well-placed trees can help homeowners save energy by shading their homes.

Thus, one study found that in addition to storing between 10 and 24 pounds of carbon annually, a single shade tree in Los Angeles helps residents and businesses save enough energy to avoid the release of nearly 40 pounds of carbon from power plants each year.<sup>37</sup> Another study from California estimated that urban trees offset Sacramento County's CO<sub>2</sub> emissions by nearly 2 percent.<sup>38</sup>

Energy savings also translate into cost savings. A recent study of three U.S. cities, for example, found that planting an average of four shade trees per house would reduce annual citywide energy expenditures by \$1.5 million in Salt Lake City, UT, more than \$6 million in Baton Rouge, LA, and nearly \$13 million in Sacramento, CA.<sup>39</sup>

Finally, in addition to their energy and climate benefits, urban trees in the contiguous United States remove an estimated 711,000 tons of toxic pollutants (such as sulfur dioxide and ground-level ozone, or smog) from the air each year.<sup>40</sup>

### Step 4. Expand Recycling to the Garden

According to the U.S. Environmental Protection Agency, yard trimmings and food waste together make up about one-quarter of the country's municipal solid waste.<sup>41</sup> When these organic wastes are disposed of in landfills, much of the carbon is stored underground, but the waste that breaks down releases methane—a heat-trapping gas 23 times more potent than CO<sub>2</sub>. Worldwide, methane produced in landfills and other solid waste disposal sites represents about 3 to 4 percent of all human-caused heat-trapping gases.<sup>42</sup>

Gardeners can help reduce the global warming pollution associated with waste disposal by turning leaves,

grass, woody garden clippings, dead garden plants, and kitchen waste into mulch or compost, then using it in the garden. “Recycling” these wastes will not only reduce methane emissions from landfills but also improve your garden’s soil and help it store carbon.

Compost, which can be any mixture of decaying organic materials (for example, leaves, animal manure, food scraps), is created by a natural process in which bacteria, fungi, and other organisms break down wastes into a nutrient-rich soil amendment. While composting does produce global warming gases, studies indicate that the best practices for creating and using compost have a smaller climate impact than landfills.<sup>43,44,45</sup> That’s because efficient composting takes place aerobically (that is, in the presence of oxygen), which minimizes the formation of methane. By contrast, landfills lack oxygen circulation, so organic materials are broken down primarily by bacteria that thrive in the absence of oxygen and produce methane. One study suggests composting is also better than incinerators for reducing heat-trapping emissions from organic waste disposal.<sup>46</sup>

Some localities, including the cities of San Francisco and Seattle and Minnesota’s Western Lake Superior Sanitary District, collect yard waste, kitchen scraps, or both for centralized composting, which encourages residents to participate.<sup>47</sup> Transporting wastes to centralized facilities produces CO<sub>2</sub> that could be avoided by composting at home, but these emissions are small relative to those averted in the process. And because conditions at centralized facilities are optimal, they may come closer to eliminating methane emissions than the average home composting pile or bin.<sup>48</sup>

## The Best Recipe for Compost

If you don’t have municipal composting in your area, find out whether any local regulations affect your ability to have a compost pile on private property. Then follow these basic guidelines, while taking steps to avoid attracting pests:

**Balance carbon and nitrogen.** The most efficient composting process provides microorganisms with the correct ratio of carbon- and nitrogen-containing materials (carbon serves as the microbes’ energy source and nitrogen supplies the building blocks for proteins). A carbon-to-nitrogen ratio ranging between 25:1 and 30:1 is optimal. Remember that carbon-rich materials tend to be dry and brown (leaves, straw, wood chips), while nitrogen-rich materials are usually wet and green (fresh grass clippings, food waste).

**Let it breathe.** Turning or mixing your compost regularly exposes the decomposing materials to oxygen, which makes the process more efficient and minimizes the production of methane (a potent heat-trapping gas). It also helps the compost heat up to a temperature that kills weed seeds and disease-causing organisms.

**Close the loop.** Compost is finished when it looks dark and crumbly and smells pleasantly earthy. Use it in your garden as a substitute for synthetic fertilizers and peat-based potting or seed-starting mixes; master gardeners recommend anywhere from one-quarter of an inch to three inches of compost per year.<sup>49</sup> It also makes excellent mulch.

To read more about the science of composting and tips for choosing a system appropriate for your yard, visit the University of Illinois Extension website (<http://web.extension.illinois.edu/homecompost/intro.html>).



*Turning garden and kitchen waste into compost reduces heat-trapping methane emissions from landfills, improves your garden’s soil, and helps it store carbon.*



## Step 5. Think Long and Hard about Your Lawn

About 80 percent of all U.S. households have access to a private lawn,<sup>50</sup> and the total area of the contiguous United States covered with turf grass (including home lawns, parks, golf courses, and athletic fields) is estimated at more than 40 million acres—three times the area devoted to our irrigated corn crop.<sup>51</sup> Can lawns be made climate-friendly?

A growing body of research indicates that soils covered in turf grasses can capture and store significant amounts of carbon. On the other hand, a small number of newer studies have shown that lawns have the potential to generate heat-trapping nitrous oxide. Some have found these emissions to be significant;<sup>52,53,54</sup> others have not.<sup>55</sup> Although the science is unsettled, it appears that practices designed to maximize lawn growth and health with minimal inputs of fertilizer and water may achieve the best balance of carbon storage and nitrous oxide emissions.

A lawn is made up of many thousands of individual grass plants, each of which absorbs CO<sub>2</sub> from the air and converts it into carbohydrates through photosynthesis. Grass undergoes a seasonal cycle of rapid growth periods (spring and fall for cool-season grasses, summer for warm-season grasses) and flowering (which may not occur if flowering stalks are frequently mowed). Throughout this cycle, lawn grasses continuously shed root material,<sup>56</sup> depositing carbon in the soil. Grass clippings left on the lawn to decompose after mowing are another source of carbon that can be stored in the soil below. Unlike gardens, which are often tilled and replanted each year, lawns are typically left undisturbed, enabling

## How to Make Your Grass “Greener”

*The watering of lawns appears to play an important role in increasing heat-trapping nitrous oxide emissions. If you must water, do it during the coolest part of the day to minimize losses from evaporation.*



Scientists have yet to reach a consensus on the impact lawns have on global warming, but here are some tips for making yours as climate-friendly as possible:

**Minimize watering.** Added water appears to play an important role in increasing nitrous oxide emissions from lawns,<sup>57</sup> and in some locales, considerable energy is required to pump water from its source to homes, resulting in CO<sub>2</sub> emissions. There is also the fact that outdoor water use, which represents 50 to 75 percent of total residential use in most of the United States, puts pressure on available resources.<sup>58</sup> If you must water, do it during the coolest part of the day to minimize losses from evaporation.

**Fertilize carefully and leave grass clippings on the lawn.** Grass clippings can increase carbon storage in the soil by as much as 59 percent,<sup>59</sup> while also substantially decreasing your need for fertilizer. Mulching mowers create fine clippings automatically.

**Mow high for healthy, less-thirsty roots.** Taller grass shoots mean deeper, healthier roots that require less watering, so set your mower blade to three inches or higher, and never remove more than one-third of the grass blade at a time.<sup>60</sup> Mowing regularly (with an electric or push mower if possible) promotes continuous root growth and shedding, which deposits more carbon into the soil. Also, keep your mower's blade sharp to minimize damage to grass plants and reduce water loss and stress.

**Choose the right grass.** If you're thinking about putting in a new lawn, consider whether native ground covers—which usually require less water and maintenance than grass but don't tolerate heavy foot traffic—could serve your needs. If you decide to go with turf grass, choose varieties that will flourish in the conditions presented by your yard, with a minimum of inputs. For example, southern zoysiagrass and native midwestern buffalograss hold up to summer droughts with minimal watering.<sup>61</sup> Kentucky bluegrass, while popular in many areas, tends to fare poorly in shade and when faced with drought or pests, and demands more fertilizer than other species.<sup>62</sup>

For advice about low-maintenance grasses or ground covers suited to your yard's specific conditions, consult your state's Cooperative Extension office (contact information is listed at <http://www.csrees.usda.gov/Extension>).

the soil to store carbon for long periods of time.

Rates of carbon storage vary depending on the climate, soil type, rainfall, and how the grasses are managed. A study of 15 golf courses documented rapid rates of carbon storage during the first 25 to 30 years of high-input turf management,<sup>63</sup> and other studies have demonstrated that home lawns can also capture carbon.<sup>64,65,66</sup> Well-watered and fertilized lawns store the most carbon—especially those with an ample supply of nitrogen.<sup>67</sup> However, nitrous oxide emissions from lawns have been linked to the application of nitrogen fertilizer and generous watering.<sup>68,69,70</sup>

## Today the Backyard, Tomorrow the Nation

Gardening practices alone won't solve global warming. As with switching to more efficient compact fluorescent lightbulbs or reusable shopping bags, cultivating a climate-friendly garden or lawn is just a small piece of the puzzle. But together, the 81 million U.S. households that own a small piece of the outdoors can play an important part in the fight against climate change by storing carbon in their soil and trees, and reducing heat-trapping emissions from pesticides, fertilizers, and garden waste and equipment.

Moreover, home gardeners can point the way to climate-friendly practices on a much larger scale: our nation's farms. With their 900 million acres of intensively managed soil, U.S. farms and ranches have an opportunity to play a truly significant role in curbing global warming. Many have already adopted practices such as cover cropping, crop rotation, and

low-input agriculture, and the Union of Concerned Scientists is working to ensure that future farm policies encourage many more to do so.

The federal food and farm bill passed by Congress every five years

represents the best vehicle to make climate-friendly practices the norm rather than the exception in American agriculture. For that to happen, climate-savvy gardeners and others will need to weigh in on the debate.

### Change Starts Here

To show your support for climate-friendly gardening and farming practices, sign the Union of Concerned Scientists' Climate-Friendly Garden Pledge at <http://www.ucsusa.org/gardenpledge>.



*By adopting the same climate-friendly practices described here, farms can play a significant role in curbing global warming. Many have already moved in this direction, but new farm policies are needed to encourage many more to follow suit.*



## Endnotes

- National Gardening Association. 2009. Strong lawn and garden sales expected in 2009. Press release. Online at [http://assoc.garden.org/press/press.php?q=show&id=3193&pr=pr\\_research](http://assoc.garden.org/press/press.php?q=show&id=3193&pr=pr_research), accessed January 13, 2010.
- The Arbor Day Foundation's most recent Hardiness Zone Map for the United States, published in 2006, shows that many areas of the country have become warmer since 1990, when the last U.S. Department of Agriculture hardiness zone map was published. Significant portions of many states have shifted at least one full hardiness zone. See the press release and map at <http://www.arborday.org/media/zonechanges2006.cfm>.
- Pouyat, R.V., I.D. Yesilonis, and D.J. Nowak. 2006. Carbon storage by urban soils in the United States. *Journal of Environmental Quality* 35:1566–1575.
- Pataki, D.E., R.J. Alig, A.S. Fung, N.E. Golubiewski, C.A. Kennedy, E.G. McPherson, D.J. Nowak, R.V. Pouyat, and P.R. Lankao. 2006. Urban ecosystems and the North American carbon cycle. *Global Change Biology* 12:1–11.
- Morris, J., and J. Bagby. 2008. Measuring environmental value for natural lawn and garden care practices. *International Journal of Life Cycle Assessment* 13(3):226–234.
- Environmental Protection Agency. 2005. Emission facts: Average carbon dioxide emissions resulting from gasoline and diesel fuel. EPA420-F-05-001. Online at <http://www.epa.gov/OMS/climate/420f05001.htm>, accessed January 28, 2010.
- Environmental Protection Agency. 2009a. Lawn equipment: Additional information. Online at [http://www.epa.gov/air/community/details/yardequip\\_addl\\_info.html](http://www.epa.gov/air/community/details/yardequip_addl_info.html), accessed March 29, 2010.
- National Gardening Association. 2008. Garden market research: How many organic gardeners are there? Online at <http://www.gardenresearch.com/home?q=show&id=2896>, accessed February 11, 2010.
- Lal, R. 2004. Carbon emissions from farm operations. *Environment International* 30:981–990.
- Kuepper, G., and L. Gegner. 2004. Organic crop production overview: Fundamentals of sustainable agriculture. ATTRA publication IP170. Fayetteville, AR: National Sustainable Agriculture Information Service. Online at <http://attra.ncat.org/attra-pub/organiccrop.html>, accessed March 2, 2010.
- Gao, G., J. Boggs, and J. Chatfield. 2009. Soil testing is an excellent investment for garden, lawn, and landscape plants, and commercial crops. The Ohio State University. Online at <http://ohioline.osu.edu/hyg-fact/1000/pdf/1132.pdf>, accessed March 18, 2010.
- Hillock, D. No date. Improving garden soil fertility. Oklahoma Cooperative Extension Service. Online at <http://osufacts.okstate.edu/docushare/dsweb/Get/Document-2659/F-6007web.pdf>, accessed March 18, 2010.
- Clary, J., N.T. Roulet, and T.R. Moore. 2005. Greenhouse gas emissions from Canadian peat extraction, 1990–2000: A life-cycle analysis. *Ambio* 34(6):456–461.
- Lal 2004.
- Intergovernmental Panel on Climate Change. 2006a. N<sub>2</sub>O emissions from managed soils, and CO<sub>2</sub> emissions from lime and urea application. In: *IPCC guidelines for national greenhouse gas inventories*. Online at [http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4\\_Volume4/V4\\_11\\_Ch11\\_N2O&CO2.pdf](http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_11_Ch11_N2O&CO2.pdf).
- Environmental Protection Agency. 2010. Nitrous oxide: Science. Online at <http://www.epa.gov/nitrousoxide/scientific.html>, accessed January 28, 2010.
- Environmental Protection Agency. 2009b. Inventory of U.S. greenhouse gas emissions and sinks: 1990–2007. Online at [http://epa.gov/climatechange/emissions/downloads09/GHG2007entire\\_report-508.pdf](http://epa.gov/climatechange/emissions/downloads09/GHG2007entire_report-508.pdf), accessed January 28, 2010.
- Kaye, J.P., I.C. Burke, A.R. Mosier, and J.P. Guerschman. 2004. Methane and nitrous oxide fluxes from urban soils to the atmosphere. *Ecological Applications* 14(4):975–981.
- Livesley, S.J., B.J. Dougherty, A.J. Smith, D. Navaud, L.J. Wylie, and S.K. Arndt. 2010. Soil atmosphere exchange of carbon dioxide, methane and nitrous oxide in urban garden systems: Impact of irrigation, fertilizer and mulch. *Urban Ecosystems*, January 9.
- Kiely, T., D. Donaldson, and A. Grube. 2004. Pesticides industry sales and usage, 2000 and 2001 market estimates. Washington, DC: U.S. Environmental Protection Agency. Online at <http://www.epa.gov/opbhead1/pestsales>, accessed February 11, 2010.
- Lal 2004.
- Enyart, C. 2009. A winter blanket for our soils. North Carolina Cooperative Extension of Lee County. Online at <http://lee.ces.ncsu.edu/index.php?page=news&ci=AGRI+32>, accessed February 1, 2010.
- Lindemann, W.C., and C.R. Glover. 2003. Nitrogen fixation by legumes. New Mexico State University Cooperative Extension. Online at [http://aces.nmsu.edu/pubs/\\_a/a-129.pdf](http://aces.nmsu.edu/pubs/_a/a-129.pdf), accessed January 12, 2010.
- Gurian-Sherman, D., and N. Gurwick. 2009. No sure fix: Prospects for reducing nitrogen fertilizer pollution through genetic engineering. Cambridge, MA: Union of Concerned Scientists. Online at [http://www.ucsusa.org/food\\_and\\_agriculture/science\\_and\\_impacts/science/no-sure-fix.html](http://www.ucsusa.org/food_and_agriculture/science_and_impacts/science/no-sure-fix.html), accessed February 1, 2010.
- Halweil, B. 2002. Home grown: The case for local food in a global market. Paper no. 163. Worldwatch Institute. November.
- Personal communication with Charlie Nardozzi, author of *Vegetable Gardening for Dummies*, March 11, 2010.
- Schalau, J. 2005. Backyard gardener: Plant a cover crop. Arizona Cooperative Extension, Yavapai County. Online at <http://ag.arizona.edu/yavapai/anr/hort/byg/archive/covercrop2005.html>, accessed February 1, 2010.
- Rackham, R.L., and R. McNeilan. 2001. Cover crops for home gardens. Oregon State University Extension Service. Online at <http://extension.oregonstate.edu/catalog/html/fs/fs304-e>, accessed February 1, 2010.
- Penn State Cooperative Extension, Berks County. 2001. The vegetable garden. Online at <http://berks.extension.psu.edu/MG/seasadv/veggar.html>, accessed February 1, 2010.
- Rackham and McNeilan 2001.
- Shaughnessy, D., and B. Polomski. 2006. Cover crops. Clemson University Extension, Home & Garden Information Center. Online at <http://www.clemson.edu/extension/hgic/plants/pdf/hgic1252.pdf>, accessed February 1, 2010.
- Nowak, D.J., and D.E. Crane. 2002. Carbon storage and sequestration by urban trees in the USA. *Environmental Pollution* 116(3):381–389.
- Environmental Protection Agency. 2008. State CO<sub>2</sub> emissions from fossil fuel combustion, 1990–2007. Online at [http://epa.gov/climatechange/emissions/downloads/C02FFC\\_2007.pdf](http://epa.gov/climatechange/emissions/downloads/C02FFC_2007.pdf), accessed January 14, 2010. Also see <http://www.sciencedaily.com/releases/2008/04/080416175442.htm>.
- State of Maryland. No date. Marylanders plant trees. Online at <http://www.trees.maryland.gov>, accessed February 25, 2010.
- Forest Service Northern Research Station. No date. Strategic tree planting as an EPA encouraged pollutant reduction strategy: How urban trees can obtain credit in state implementation plans. Online at [http://www.nrs.fs.fed.us/units/urban/local-resources/downloads/Emerging\\_Measures\\_Summary.pdf](http://www.nrs.fs.fed.us/units/urban/local-resources/downloads/Emerging_Measures_Summary.pdf), accessed February 25, 2010.
- Nowak, D.J., J.C. Stevens, S.M. Sisinni, and C.J. Luley. 2002. Effects of urban tree management and species selection on atmospheric carbon dioxide. *Journal of Arboriculture* 28(3):113–122.
- Akbari, H. 2002. Shade trees reduce building energy use and CO<sub>2</sub> emissions from power plants. *Environmental Pollution* 116: S119–S126.
- McPherson, E.G. 1998. Atmospheric carbon dioxide reduction by Sacramento's urban forest. *Journal of Arboriculture* 24(4):215–223.
- Konopacki, S., and H. Akbari. 2000. Energy savings calculations for urban heat island mitigations strategies in Baton Rouge, Sacramento, and Salt Lake City. Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings 9:215. Cited in: Akbari 2002.
- Nowak, D.J., D.E. Crane, and J.C. Stevens. 2006. Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry & Urban Greening* 4:115–123.
- Environmental Protection Agency. 2009c. Composting. Online at <http://www.epa.gov/waste/conserve/rrr/composting/index.htm>, accessed February 1, 2010.
- Intergovernmental Panel on Climate Change. 2006b. Solid waste disposal. In: *IPCC guidelines for national greenhouse gas inventories, Volume 5: Waste*. Online at [http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5\\_Volume5/V5\\_3\\_Ch3\\_SWDS.pdf](http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf), accessed February 27, 2010.
- Lou, X.F., and J. Nair. 2009. The impact of landfilling and composting on greenhouse gas emissions: A review. *Bioresource Technology* 100:3792–3798.
- Brown, S., C. Kruger, and S. Subler. 2008. Greenhouse gas balance for composting operations. *Journal of Environmental Quality* 37:1396–1410.
- Recycled Organics Unit. 2003. Life cycle inventory and life cycle assessment for windrow systems. Report prepared for NSW Department of Environment and Conservation (Sustainability Division). Sydney: The University of New South Wales.
- Termorshuizen, A.J., S.W. Moolenaar, A.H.M. Veeken, and W.J. Blok. 2004. The value of compost. *Reviews in Environmental Science & Bio/Technology* 3:343–347.
- Biodegradable Products Institute. No date. Municipal composting programs. Online at <http://www.bpiworld.org/Default.aspx?pagelid=190309>, accessed February 1, 2010.
- Smith, A., K. Brown, S. Ogilvie, K. Rushton, and J. Bates. 2001. Waste management options and climate change. Report to the European Commission, DG Environment. Online at [http://ec.europa.eu/environment/waste/studies/pdf/climate\\_change.pdf](http://ec.europa.eu/environment/waste/studies/pdf/climate_change.pdf), accessed February 27, 2010.
- Personal communication with Ed Bruske of D.C. Urban Gardeners, March 15, 2010.
- Environmental Protection Agency Region 3. No date. Healthy yards, healthy lawns, healthy environment. Online at <http://www.epa.gov/reg3wcmd/pesticideslawn.htm>, accessed January 26, 2010.
- Milesi, C., S.W. Running, C.D. Elvidge, J.B. Dietz, B.T. Tuttle, and R.R. Nemani. 2005. Mapping and modeling the biogeochemical cycling of turf grasses in the United States. *Environmental Management* 36(3):426–438.
- Qian, Y.L., W. Bandaranayake, W.J. Parton, B. Meham, M.A. Harivandi, and A.R. Mosier. 2003. Long-term effects of clipping and nitrogen management in turfgrass on soil organic carbon and nitrogen dynamics: The CENTURY model simulation. *Journal of Environmental Quality* 32:1694–1700.
- Bremer, D. 2006. Nitrous oxide fluxes in turfgrass: Effects of nitrogen fertilization rates and types. *Journal of Environmental Quality* 35:1678–1685.
- Livesley et al. 2010.
- See, for example: Raciti, S.M., P.M. Groffman, and T.J. Fahey. 2008. Nitrogen retention in urban lawns and forests. *Ecological Applications* 18(7):1615–1626.
- University of Minnesota. 2006. Grass plant growth and its relationship to lawn care. Sustainable Urban Landscape Information Series. Online at <http://www.sustland.umn.edu/maint/grasspla.htm>, accessed January 28, 2010.
- Groffman, P.M., C.O. Williams, R.V. Pouyat, L.E. Band, and I.D. Yesilonis. 2009. Nitrate leaching and nitrous oxide flux in urban forests and grasslands. *Journal of Environmental Quality* 38:1848–1860.
- Milesi et al. 2005.
- Qian et al. 2003.
- Cornell University. 2006a. Lawn care library: Mowing. Online at <http://www.gardening.cornell.edu/homegardening/scenec8a.html>, accessed January 28, 2010.
- American-Lawns.com. 2010. Types of grasses found in America. Online at <http://www.american-lawns.com/grasses/grasses.html>, accessed March 3, 2010.
- Cornell University. 2006b. Lawn care library: Choosing lawn grasses. Online at <http://www.gardening.cornell.edu/homegardening/scenededa.html>, accessed January 26, 2010.
- Qian, Y., and R.F. Follett. 2002. Assessing soil carbon sequestration in turfgrass systems using long-term soil testing data. *Agronomy Journal* 94:930–935.
- Zirkle, G.N., B. Augustin, and R. Lal. 2009. The potential for soil organic carbon sequestration in home lawns. Presented at the ASA-CSSA-SSSA International Annual Meetings, November 2.
- Qian et al. 2003.
- Pouyat, R.V., I.D. Yesilonis, and N.E. Golubiewski. 2009. A comparison of soil organic carbon stocks between residential turf grass and native soil. *Urban Ecosystems* 12:45–62.
- Milesi et al. 2005.
- Qian et al. 2003.
- Bremer 2006.
- Livesley et al. 2010.



## Ask a Garden Guru

Gardening experts will attend Iowa City gardens at regular times throughout the growing season.

- Chadek Green Park Community Garden
- Edible Classroom at Robert A. Lee Rec Center
- Wetherby Park Edible Forest

Wondering about that strange bug? When is the best time to plant garlic? Why did my lettuce grow so tall?

Bring your curious questions for hands-on learning about growing fun gardens and how you can mitigate climate change.

Learn more at [BackyardAbundance.org/guru](http://BackyardAbundance.org/guru)


## Climate-Friendly Garden Contest

Join neighbors to transform landscapes into spaces that help reduce the impact of climate change.

From July through October, post **pictures or videos** of your climate-friendly gardening practices to social media sites with the **#ClimateFriendlyGarden** tag. Also tag Backyard Abundance:

 Facebook @backyardabundance

 Instagram @backyardabundance

 Twitter @ICBYA

Your post enters you into a weekly drawing for a **\$25 gift card** to garden centers in the Iowa City area.

Eligible posts show you having fun, gardening outside...

- Growing or harvesting vegetables, herbs or fruits.
- Planting trees or shrubs.
- Covering bare soil with mulch or ground covers.
- Composting.
- Seeding or growing cover crops.
- Seeding lawn with Dutch white clover or violets.
- Using natural products instead of synthetic pesticides or fertilizers.

Learn more at [BackyardAbundance.org/guru](http://BackyardAbundance.org/guru)



*These activities and information are specific to the Backyard Abundance Garden Guru program and are not associated with the Union of Concerned Scientists, Facebook, Instagram or Twitter.*

## Project Drawdown

Your climate-friendly gardening activities may contribute to the 100 solutions created by Project Drawdown: a comprehensive plan to reverse global warming.

The following solutions—ordered by their impact—may be directly relevant to your activities:

- #4 Plant-rich diet
- #11 Regenerative agriculture (grow soil and food)
- #15 Afforestation (grow new forests)
- #16 Conservation agriculture (minimize soil disturbance)
- #17 Tree intercropping (grow trees and food together)
- #28 Multistrata agroforestry (edible forest gardens)
- #60 Composting
- #65 Nutrient management (minimize fertilizer use)

Learn about these solutions at [Drawdown.org](http://Drawdown.org)

**Event: Introduction to Drawdown**

Monday, September 30

6:30 pm – 8:30 pm

Iowa City Senior Center

28 S. Linn St, Iowa City

**DRAWDOWN.**

