# Introduction

This book is a tool for anyone who wants to be part of the solution to climate change. It answers this question: What we can do, right now, in the landscapes of our own backyards and communities?

Predictions about the effects of climate change range from mild to unsettling to dire. But we are already experiencing warmer winters, longer summers, more frequent heat waves, and more extreme rains. Proposed solutions, at turns contentious, expensive, and complex, can leave the average person at a loss for what to do, or wondering whether anything can be done at all.

On this question, *Climate-Wise Landscaping* takes an optimistic view. Instead of wringing our hands, we prefer to roll up our sleeves. We are committed to making climate change the top priority, and helping others do the same, as we all design, build, and manage the countless gardens and landscapes throughout North America.

In these pages, you will find hundreds of easy, practical *Actions* that achieve at least one of the following goals; most achieve two, and many satisfy all three:

Credit: SReed. Designer: Walter Cudnohufsky.

All across North America, our landscapes can be both climate-wise and beautiful.

- Shrink each landscape's carbon footprint.
- Adjust our practices to create gardens and yards better able to flourish in new, challenging, and unpredictable conditions.
- Assist other species as they adapt to a changing world.

Most of these *Actions* are modifications of what we're already doing, as part of a hobby we love. Many cost little or nothing, and quite a few will save us money either now or later.

Without question, large-scale solutions are needed if we are to curb society's carbon emissions. And in fact, innumerable countries, cities, corporations, and individuals have already switched to renewable energy, or are in the process of doing so. Human ingenuity is blossoming, creating innovative products and solutions. In many places, renewable energy now costs less than fossil-fuel options. Public transportation systems are expanding in cities all over the world. But the big solutions will not be enough. They must be buttressed with millions of smaller steps and actions—one yard, one park, and one landscape at a time. This book lays out a path for those countless small but collectively transformational steps.

## What's In It For You?

Taking just some of the actions presented in this book will:

- Save energy, money, and time
- Shrink the carbon footprint of any landscape
- Create cleaner air and water
- Create greater success with landscaping
- Increase physical comfort during extreme temperatures
- Support birds, butterflies, pollinators, and other wildlife
- Create healthier, toxin-free landscapes

## Who Is This Book For?

The ideas in this book are useful for:

- Hobby gardeners and all homeowners.
- Amateur and professional landscapers.
- Master Gardeners.
- Landscape designers and students.
- Landscape caretakers, municipal planners, and property managers.
- Urban residents who wish to "green" their own cities and create healthier outdoor environments for their own neighborhoods and regions.
- All who are concerned about climate change and want to contribute to the solution.

This book's information applies to every kind of landscape project:

- Creating new gardens
- Renovating or restoring an existing garden
- Cultivating more food
- Expanding a natural area within one's property
- Creating a green roof
- Building a new home
- Countless other endeavors we enjoy in our gardens and grounds

Finally, the ideas presented here will be useful across most of North America. The book focuses on the prevailing conditions in the temperate regions of this continent; special notes point out exceptions for regions where conditions differ substantially from the temperate norm.

## What's In This Book?

As stated above, the central theme of *Climate-Wise Landscaping* is how, in the face of daunting climate change, all of us can take steps to help solve the problem. Toward that end, the *Actions* presented in this book aim to help us shrink our carbon footprint and hold more carbon in the plants and soils of our landscapes. And, as it turns out, many of these *Actions* that lessen our carbon impact will also simultaneously work to make our gardens and yards more resilient, adaptable, and hospitable to wildlife.

The book contains ten Sections. Each one focuses on a familiar component of landscaping/gardening with a view toward particular goals:

- I: Lawn—Reducing the climate impact of lawns and their high-carbon maintenance.
- II: Trees and Shrubs—Cooling the air, storing carbon, stabilizing soil, and providing habitat.
- III: Water—Dealing with the future potential for both too little and too much water.
- IV: Ecosystems—Increasing diversity and carbon storage, and supporting wildlife.
- V: Soil—Taking advantage of soil's potential for greater productivity and carbon sequestration.
- VI: Planning and Design—Designing the whole landscape for resilience, vitality, and comfort.

- VII: Herbaceous Plants—Shrinking the carbon footprint of traditional gardening practices.
- VIII: Urban Issues—Dealing with urban heat and promoting nature in cities.
- IX: Food—Producing food locally and reducing $CO_2$ emissions.
- X: Materials—Assessing the various climate footprints of common landscaping materials.

Within each Section, several numbered *Action Topics* present lists of *Actions*: practical, doable, "close to home" steps many of us can take. Throughout the book, cross-references point readers to related topics and *Actions*.

Please note that this is not a *how-to* book. Although we provide some general guidelines for achieving a particular end, our intention here is to present an array of options that can be implemented in many situations and many ways, as appropriate for each individual landscape and gardener. So this is more of a *what-to* than a *how-to* book, more like an à la carte menu than a collection of recipes.

In addition, although this book does contain hundreds of ideas, it does not and could not possibly include every single good idea for making our landscapes more climate-wise. The aim here is to inspire, inform, and encourage, and to invite everyone to bring his or her unique creativity and genius to solving the problem of climate change—all while working to create beautiful and sustainable landscapes.

> Never have we so hurt and mistreated our common home as we have in the last 200 years…yet all is not lost. Human beings, while capable of the worst, are also capable of rising above themselves, choosing again what is good, and making a new start.
>
> —Pope Francis, Encyclical on the environment, "Care for Our Common Home," May 24, 2015

### A Note about Who Wrote What

Although the authors collaborated on every part of this book, each Section was written primarily by one of us. Our two "voices," each representing specialized knowledge and experience, can be heard in alternating Sections; Sue was the primary author for the Introduction, the Conclusion, and the even-numbered Sections; Ginny was the primary author for the odd-numbered Sections.

## What Is a *Landscape*?

The word *landscape* seems to mean many different things to many people. So, right here at the start, we would like to clarify the definition of landscape as used in this book.

A landscape is not simply a snapshot frozen in time. Nor is it a production to be done and finished, nor a picture to be appreciated only for its appearance. Instead, every landscape represents an ongoing process of change, evolution, experimentation, and surprise over time.

A landscape's visual appeal, which is subjective in any case, is a thing to be appreciated from many perspectives and angles, to be experienced in many ways, at many times of the day, throughout all the season, for many years.

And, beyond being a place that satisfies our own human wishes and desires—for beauty, delight, pleasure, privacy, exercise, creativity, sustenance, relief, or spiritual inspiration—each individual landscape is also a part of the larger natural environment, a home to other creatures whose lives depend on its resources and qualities.

As such, a landscape, then, is a place where we can also make a difference and serve a larger purpose. In our landscapes we have the opportunity to enhance the health and vitality of our own property, our neighborhood or region, and even the planet.

> You can hear the rain on leaves; the burring of tree limbs as they rub together; the hiss of wind across a field of dried grass. But that is not listening to the plants of this green world grow. Listen again—not with your ears this time but with imagination. You may hear the wrenching of bark as it forms its patterns; the whirr of a pollen grain through the air; the report of a bursting seed; the tinkle of sap in the tubes of a tree trunk; the twang of red rays ricocheting from the petal of a cardinal flower; the muffled sounds of roots expanding with the power of dynamite. The landscape is a vast system constantly in action.
>
> —Rutherford Platt, *This Green World*, 1942

## What Is *Landscaping*?

From our perspective, landscaping is not just about creating gardens. Nor is it just decorating with plants and making things pretty. And it's not, as the term *landscaping company* might suggest, mainly about mowing lawns and keeping things tidy. No. Instead, we consider landscaping to be the process of creating experiences, including aesthetic experiences, that support our lives and also, where possible, the lives of other people and other organisms.

## *A PRIMER ON...*

# Climate Change

This book is not going to tell you how many gigatons of $CO_2$ your landscape emits in a year, nor exactly how many carbon equivalents of greenhouse gases your actions could remove or reduce. That specificity would be impossible in a book such as this. What the book *will* give you is ideas and advice about hundreds of ways to shrink your landscape's overall carbon footprint and make your landscape into more of a carbon sink than it is now.

The subject of climate change involves terms that may be unfamiliar or confusing to many people. This primer explains many of those used throughout this book.

### It All Begins with Carbon

Carbon is a chemical element, the core element for life on earth. It can exist in a pure—or nearly pure—form, as in diamonds and graphite. But perhaps its most important quality is its ability to combine with many other elements to form a vast assortment of molecules. Such carbon-based molecules, often called the building blocks of nature, make up most of the tissue of plants, animals, fungi, and bacteria—almost all of life as we know it.

When carbon combines with oxygen, it forms the gas carbon dioxide ($CO_2$). A molecule of $CO_2$ contains one atom of carbon and two atoms of oxygen. In discussions about sequestering carbon—in plants and soil—we are referring to carbon in its *solid* forms. When we talk about greenhouse gases, we mean $CO_2$.

### Greenhouse Gases

Carbon is the main ingredient in all fossil fuels, which consist, after all, of countless decomposed plants that sequestered carbon in their tissues during the eons past. When we burn fossil fuels for energy, their sequestered carbon is released into the air as carbon dioxide. And when large amounts of $CO_2$ enter the atmosphere, as has been happening for the past 200 years, this causes the *greenhouse effect*, i.e., the physical cause of global warming.

The greenhouse effect occurs when the sun warms the Earth's surface and not enough of that heat can escape through the atmosphere to let the planet cool off. The reason heat can't escape is the presence of *greenhouse gas* (GHG) molecules, which intercept infrared light as it is radiating outward. As a result, the lower part of the atmosphere stays warmer than it would be otherwise.

Gases that are considered to be greenhouse gases include water vapor ($H_2O$), carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), ozone ($O_3$), and chlorofluorocarbons.[1] While the first five of these are produced by natural processes, their concentrations have been unnaturally increased by human activities such as burning carbon-based fuels. The chlorofluorocarbons are totally man-made, the result of industrial processes, aerosols, and refrigerants.

Each gas is present in the atmosphere at a different concentration. In addition, each gas has a different capacity for absorbing solar radiation. Methane is considered a much more potent greenhouse gas (in its atmosphere-warming capability) than carbon dioxide, but it lasts only about a decade in the atmosphere, whereas $CO_2$ will affect the climate for thousands of years.

Globally, the primary sources of greenhouse gases are:

- Electrical power plants: 25–30% ($CO_2$)
- Residential buildings: 11% ($CO_2$)
- Road transportation: 11% ($CO_2$)
- Deforestation and land use change: 10% ($CO_2$, nitrous oxide, and methane)

Smaller percentages come from these sources: energy industry processes ($CO_2$ and methane); commercial buildings ($CO_2$); cement and glass production ($CO_2$); livestock (methane); agricultural soil ($CO_2$ and nitrous oxide); waste and waste water ($CO_2$ and methane); coal mining (methane, $CO_2$); and aviation ($CO_2$, water vapor, nitrous oxide, and aerosols).[2]

## Some Basic Facts about Climate Change

It was 1896 when the Swedish scientist Svante Arrhenius first described the existence of the greenhouse effect; it has taken us over 120 years to understand the dangerous implications of global warming, and that it is real and happening in the present, not in some distant future. How do we know?

- For the past 400,000 years, the planet's atmospheric carbon dioxide fluctuated wildly, mainly as a result of small variations in the Earth's orbit. This fluctuation caused cycles of extreme warming and cooling, but $CO_2$ levels in the atmosphere never exceeded 300 parts per million. In 1950, $CO_2$ levels rose above 300 parts per million, and they now stand at over 400 ppm.[3]
- The planet's surface temperature has risen about 2°F (1.1°C) since the late 1880s. Sixteen of the 17 warmest years on record have occurred since 2001.[4]
- Global sea levels rose about eight inches in the past century, with the rate in the last two decades nearly double that of the last century.[5]
- Since 1950, the number of record high-temperature events in the US has increased, while the record lows have decreased.[6]

- Satellite images reveal that the amount of spring snow cover in the Northern Hemisphere has decreased in the past 50 years, and that snow is melting earlier.[7]
- The acidity of the oceans has increased by about 30% since the start of the Industrial Revolution. This is the result of more $CO_2$ in the atmosphere being absorbed by ocean waters.[8]

## A Few More Definitions

*Gigaton* (Gt) is an amount equal to one billion tons. This is the term usually used to indicate the quantity of carbon on earth, or $CO_2$ in the atmosphere.

*Carbon reservoirs* (also *pools* or *stocks*) are the places on the planet where carbon is stored. Aside from the rock that makes up the Earth's mantle, oceans represent the largest reservoir (40,000 Gt), followed by fossil fuels (4,000–5,000 Gt), worldwide soils (2,000–3,000 Gt), the atmosphere (700–800 Gt), and all terrestrial organisms (600–650 Gt). Surprisingly, the soil pool is larger than the atmosphere and all vegetation combined.[9]

The terms *carbon sink* and *carbon source* indicate processes of increasing or decreasing carbon amounts. A carbon *source* is a reservoir that is losing (emitting) more carbon than it is accumulating. Carbon *sinks* are gaining more carbon than they are losing.

Plants are carbon sinks because they continually take $CO_2$ from the atmosphere and convert it, via photosynthesis, into carbon (sugars) held within their biomass until they die and begin to rot. Soil is a carbon sink when it absorbs more carbon from decomposing plant roots (and other processes past and present) than it loses to tillage and disturbance (which allow carbon to combine with oxygen, producing $CO_2$, which is released into the air). Forests can be either carbon sources or sinks, depending on many factors, including how they are managed. Agricultural soils have been carbon sources for many decades, with their continual tillage and erosion, but modern regenerative agriculture is working to reverse that trend. Today the world's oceans are the primary long-term sink for human-caused $CO_2$ emissions—about 2 gigatons net uptake of carbon annually, but the oceans may become less efficient as the absorption of $CO_2$ causes them to become more acidic.

*Carbon sequestration* is a natural or artificial process through which carbon dioxide is removed from the atmosphere and held in solid or liquid form. Sequestration simply means storage. In the context of climate change, its purpose is to permanently reduce the amount of $CO_2$ in the atmosphere in order to help to reduce further warming of the planet. The sequestration process can be geologic, which involves capturing $CO_2$ before it is released into the atmosphere, and injecting it into deep rock formations. Or it can be terrestrial, in which land management practices like no-till farming and wetland/grassland/

forest restoration help to remove $CO_2$ from the atmosphere. In this book, we focus on this second method: the sequestration of carbon in plants and soil.

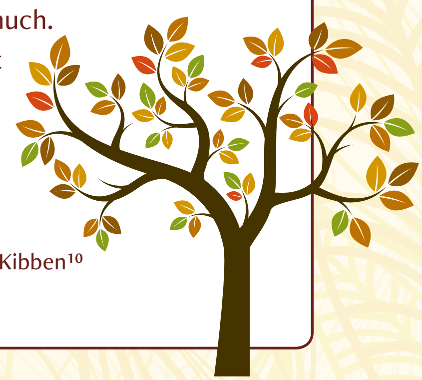
*Carbon footprint* is the total amount of greenhouse gas emissions caused by an individual, product, organization, or event. In most cases, carbon footprint can only be estimated because we don't have enough data yet or understand processes well enough to make absolutely precise calculations.

*Climate footprint* derives from the idea of carbon footprint. A broader concept, this term signifies overall impact on the climate, and contains greenhouse gas emissions along with efforts to sequester carbon and help the planet in general. While carbon footprint might be difficult to quantify, climate footprint really can't be accurately measured at all, at least not at the present time. It's a new and still-evolving term for how our choices and actions affect climate change, whether positively or negatively.

## Regional Effects of Climate Change

Although no one can exactly predict the effects of climate change, evidence already shows that in the coming decades most of North America will probably experience warmer temperatures on average all year long. In the US Northeast and Midwest, this may mean shorter, rainier winters, whereas in the Rockies, Southwest, and Northwest, there will probably be less snowfall and less snowpack, leading to drier spring and summer conditions. We can already see that the Great Plains seems to be getting wetter in the north but drier in the south. And, while the Southeast might be warming less dramatically than the rest of the continent, Alaska and northern Canada appear to be warming twice as fast.

> A little bit of greenhouse gas is good thing—life thrives in its warmth. The question is: how much? On Venus the atmosphere is 97 percent carbon dioxide. As a result, it traps infrared radiation a hundred times more efficiently than the earth. The earth's atmosphere is mostly nitrogen and oxygen; currently only about .035 percent is carbon dioxide, hardly more than a trace. The worries about the greenhouse gas are actually worries about raising that figure from .035 percent to .055 or .06 percent, which is not very much. But plenty, it turns out, to make everything different.
>
> —Bill McKibben[10]



# I LAWN

## Overview

We begin this book with the subject of lawns for one simple reason: in landscapes all across this continent, changing the way we think about and deal with our lawns might be the easiest and most significant step we can take to help the planet.

Let's look at the big picture. The whole idea of *lawn* makes a lot of sense. An expanse of lawn offers a comfortable surface on which to walk, relax, and play. Lawn provides a simple stage where we can showcase our homes and landscaping. Planting grass is affordable and relatively simple, and taking care of it requires little specialized knowledge. In addition, when grass is actively growing, its countless blades give off wonderful oxygenated air all around us. And, at least as originally envisioned, lawn can be a way for us to have a piece of nature up close to where we live.

However. In the 100 years since the first gas-powered mower was invented—which made the lawn an achievable dream for the masses—the North American lawn has developed a big problem. And in the 60 years since the American Garden Club firmly instructed homeowners about the civic responsibility embodied in their well-manicured lawns, the lawn has lost some of the glory its early proponents once imagined.

The problem isn't the idea of lawn. No. Rather, it's what we've *done with it* that causes the trouble. As a society, we have multiplied much that's bad about lawn and in the process lost a lot of the good.

Vibrant expanses of lawn, once full of violets, clover, and many other little flowers, are now expected to be flawless monocultures, like a green carpet just delivered from the factory. To achieve this condition, many among us water lawns relentlessly: one inch per week no matter the season or weather. Regular dousing with synthetic chemicals makes the grass less safe for children and pets, and for wildlife. (See "A Primer on Landscape Chemicals" on page 19.) The emissions of mowers, blowers, and trimmers dirty the air. Summer weekends are full of din and clatter. And for this we spend millions of dollars on fuel, and emit tons of planet-warming carbon dioxide into the air. As a stage for our homes, and perhaps also as a symbol of social status, lawns are often made extremely large. And now, instead of being an inviting swath of nature, many lawns are expensive, barren green deserts, devoid of the vitality they were supposed to bring to our lives.

We can change this scenario, starting today.

Lawns occupy more than 63,000 square miles of the continental US.[2] This is 40 million acres, an area about the size of Texas. If just a portion of that expanse were managed differently or converted to something else—vegetable gardens, orchards, meadows, wildlife gardens—we would save billions of gallons of fossil fuels, reduce our $CO_2$ emissions, save billions of gallons of precious water, and protect countless waterways from being contaminated by polluted runoff. Oh, and while we're at it, we would support vastly more beneficial insects, birds, butterflies, and pollinators.

Figure I-1: More and more empty green lawns are being allowed or encouraged to grow tall and revert to natural vibrancy.

Credit: SReed

## In This Section

On this continent's enormous acreage of lawn, a lot of us can take a lot of little steps to make a big difference. And we can continue to have, if we want it, some amount of traditional and comfortable (but nontoxic) green grass in our lives. This Section explains how to move toward that goal. We give you the following *Action Topics* and include "A Primer on Landscape Chemicals."

- I-1: Liberate the Lawn
- I-2: Reduce the Extent of Lawn
- I-3: Minimize Use of Power Tools
- I-4: Revive Damaged Lawns
- I-5: Provide Good Preparation for New Lawns
- I-6: Replace Some Lawn with Meadow
- I-7: Ideas for Large/Public Lawns

## ACTION TOPIC I-1 Liberate the Lawn

### Why This Matters

Liberating lawns from dependence on chemicals is an important first step toward making the whole landscape more climate-wise. *Note*: For definitions and explanations of the substances commonly used in lawn and landscape maintenance, please read "A Primer on Landscape Chemicals," below.

Lawn-care practices vary widely between regions, neighborhoods, and individual landowners, but typical high-maintenance regimens include some of the following actions—actions that sometimes may be at odds with efforts to reduce our negative impact on the environment and shrink our climate footprint:

- *Regular applications of insecticides*. This will kill insects and other microorganisms in the soil. Unfortunately, the great majority of these living things are not harmful to lawns or grasses but instead play important roles in the soil and wider local ecosystem. For example, most of North America's 4,000 or so native bee species (our most important pollinators) raise their young underground. Some species build up an immunity to lawn poisons, so lawn care services apply them more often and add different poisons in reaction.

> Someday we might look back with a curious nostalgia at the days when profligate homeowners wastefully sprayed their lawns with liquid gold to make the grass grow, just so they could then burn black gold to cut it down on the weekends. Our children and grandchildren will wonder why we were so dumb.
>
> —Michael Webber[1]

- *Regular applications of fungicides*. Fungi play an important role in a healthy soil ecosystem because they digest organic matter and work with plant roots to help them better absorb nutrients, which increases soil carbon. Without enough fungi, the dead matter in soil decays more slowly, which can lead to a buildup of thatch. (See Section V for more details on fungi in soils.)
- *Regular applications of broadleaf herbicides*. In order to maintain a grass-only monoculture, these poisons kill off other types of plants. As with the insects, some weeds build up a resistance to the herbicides, so a lawn service might apply different mixtures to kill the weeds. But this can affect desirable plants, such as clover, which enrich soil and feed pollinators.
- *Regular applications of synthetic fertilizers*. After reducing the natural nutrients in the soil with applications of insecticides and fungicides, lawn services typically apply synthetic fertilizers so the grass will grow and stay green. But the nutrients in fertilizer are not bound to organic matter in the soil, so they tend to leach out during rain or heavy irrigation, polluting the groundwater and/or nearby waterways. Then, because they wash away so quickly, even more fertilizers are required to feed the starving grass.
- *Seasonal over-seeding with grasses*. These grasses grow actively during the normal dormant period. In southern regions, cool-weather grass species are used to keep the lawn green during the winter. In more northern regions, warm-weather grasses may be used to keep the lawn green over

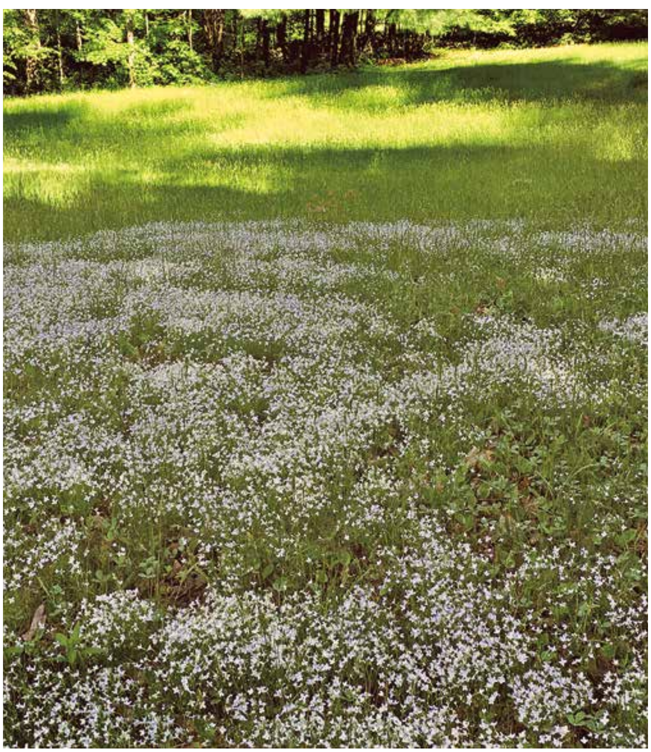



Figure I-2: Who wouldn't love drifts of dainty "Quaker lady" bluets, splashed across the lawn? These blooms on their tiny stems usually fade in a month or so, leaving plenty of space for lawn grass to grow.


Credit: GStibolt

Figure I-3: Automated irrigation systems can be made smarter by adding moisture sensors that shut off the system after a rainfall, and by making sure that the water only irrigates plants—not the street or other hardscape.

the summer. This then requires more energy and more effort for year-round mowing and year-round irrigation.

- *Over-irrigation*. An estimated 30% of household water is used for outside irrigation, and most of that is used for the luxury of keeping lawns perpetually green instead of letting them go temporarily dormant (tan).

In the ultimate irony, these conventional practices stimulate more and more grass growth, which then necessitates more and more frequent mowing, making the lawn a *carbon source* instead of the *carbon sink* it could be if managed more sustainably.

## Actions

**Stop using all pesticides and synthetic fertilizers.** When lawn treatments stop, some initial bug or fungal attacks may occur, creating thin, bare, or brown patches. Eventually, other plants will fill in the spaces, but don't worry about them; just mow everything equally. You might even come to love the diversity!

It may take a full year or more for the poison and synthetic nutrient residues to subside to the point that the lawn and its underlying soil will begin hosting enough alternative plants to be as green as it was before. This process can be speeded up by the addition of clover or other regionally appropriate, mowable species in the brown spots. In the long run, some of the turfgrass may survive, but because it will be mixed with a good variety of other plants, it will no longer be vulnerable to pests. (See I-4 on page 32 for information on repairing lawns sustainably.)

**Reduce irrigation frequency, or stop watering altogether.** In many areas, municipalities have (or may soon have) water-use restrictions, so it's a good idea be ready for the possibility of no irrigation at all. If some irrigation is allowed and needed during a drought, apply water infrequently, but deeply. Frequent, light watering encourages roots to come to the surface, which makes the grass less drought tolerant. Remember: if lawn grows more slowly, this saves on mowing. The most climate-wise action is not to irrigate at all. (See III-2 on page 80 for on irrigation options, and I-4 on page 32 for more on taking care of liberated lawns.)

*Note*: Lawn that goes brown during dry times is not always dead. Instead, it may have entered dormancy, a natural stage of life in many grasses that evolved in regions characterized by occasional or frequent drought. Climate-wise lawns are allowed to go tan in summer or brown in the winter!

*Regional Note*: The one exception to allowing for dormancy is for properties in fire-prone areas, where it's important to keep lawn area mowed and

### Are There Alternatives to Toxic Lawn Care Chemicals?

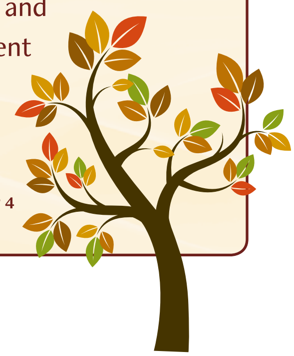
Yes. Natural landscape maintenance programs can achieve a healthy, pest-free landscape using the latest scientific developments in organic agriculture and horticulture. For example, corn gluten is a natural pre-emergent weed killer and fertilizer. Lawns can be enriched naturally by spreading a thin layer of compost in the spring and fall. Also, natural lawn care practices will lead to a healthy soil that supports plants in the lawn so they that resist pests and disease.[3]

relatively green near buildings. Dormant or tall grass could become fuel for a wildfire. (See VI-7 on page 180 for more fire-wise strategies.)

**Use Integrated Pest Management (IPM)** All pesticides involve some amount of risk. The lowest risk for you, your family, and the general ecosystem results from using no pesticides at all. *IPM techniques* encourage natural processes to help ecosystems stay in balance, and let natural predators do most of the work. When done correctly, integrated pest management involves:

- Encouraging the beneficial organisms, including birds, bats, frogs, toads, lizards, predatory insects, and parasitoid insects. In this way, nature itself, with its large arsenal of bio-weapons, aids in keeping pests under control.

> "The IPM approach compels you to consider your landscape as part of the larger community ecosystem to manage responsibly. The impact of your gardening and pest management decisions often extends far beyond your property lines." [4]



## How "Lawn Service" Chemicals Affect Soil Ecosystems

Imagine what happens when we apply a general fungicide to the soil. The intricate dance of fungi and plant roots, which is so important to the health of plants, is slowed down or halted. Plants roots may not die, but their growth and vigor may decline. In addition, any insecticides that are used will poison the grubs, mole crickets, or other pests that feed on turfgrass roots, but they will also kill beneficial insects and macrobes, which means that the toads and other insect-eaters won't have the prey they need to survive. Since macrobes are also important soil aerators, without them plants will have a harder time growing. And, most importantly for climate change, when the soil is poisoned, the population of carbon-based life forms is drastically reduced, so the soil will not sequester nearly as much carbon as it could have. (See Section V on page 129 for more about soil ecosystems.)

- Discouraging the pests in a timely fashion, i.e., by emptying standing water every three days to discourage mosquitoes or by pulling annual weeds before they set seed, using crop rotation in the vegetable beds, cleaning up diseased plant material and removing it from the landscape (do not compost it).
- Planting the right plants for the landscape, and caring for them so they will grow well, which will reduce their susceptibility to infestation by insects and pathogens.

## Last Thoughts

Liberating lawns from artificial fertilizers, pesticides, and unsustainable irrigation will save money, but more importantly, it is the easiest and most significant earth-friendly and climate-friendly action that homeowners, communities, schools, businesses, and municipalities can take. Liberated lawns are likely to be more resilient in an era of climate change, and the underlying soil will be able to sequester more carbon than lawns treated with synthetic lawn chemicals.

To some people, the drawback of the natural system is that it does not appear to work as quickly as the synthetic system. A natural fertilizer applied today may not turn your grass green tomorrow. In time, though, the natural system…will function better and get your grass just as green. Think of it as building a living, breathing underground community. The beneficial soil organisms that are neglected and often killed in the synthetic system will protect your grass, purify the groundwater, and keep your property safe for pets, children, and you.

— Paul Tukey, *The Organic Lawn Care Manual*, 2007

*A PRIMER ON...*

# Landscape Chemicals

This primer defines and describes the substances that are most commonly used in landscaping, and particularly in conventional "lawn care." Before we begin this discussion, note the following:

- Everything is a chemical. Even water is a chemical, with two hydrogen atoms and one oxygen atom forming $H_2O$. So when people say that their yard or food is chemical-free, that's a misstatement. They probably mean free from synthetic chemicals.
- For the purposes of this book, we define a substance as *organic* if it consists of materials that have been alive, and we consider *synthetic* those chemicals made from materials that have not been alive.

## Fertilizers

Early in the process of becoming farmers, humans realized that applying manures to the soil made plants grow better. Fertilizers—organic or synthetic—add nutrients to enhance plant growth. Plants mainly need nitrogen (N), phosphorous (P), and potassium (K), along with myriad micronutrients, which a healthy soil will provide. But if soil has been depleted, fertilizers must supply all these nutrients. The plants don't distinguished between synthetic and organic sources, but the *soil* reacts quite differently to each.

### *Synthetic Fertilizers*

The manufacture of synthetic fertilizers has a huge carbon footprint: for every ton of fertilizer produced, two tons of $CO_2$ are released.[5] In addition, when too much fertilizer is applied, microbes in the soil emit nitrous oxide (a greenhouse gas) exponentially in relation to the amount of excess.[6]

"The use of artificial manure, particularly [synthetic nitrogen]...does untold harm. The presence of nitrogen in an easily usable form stimulates the growth of fungi and other organisms, which, in the search for organic matter needed for energy and building up microbial tissue, use up first the reserve of soil humus and then the more resistant organic matter which cements soil particles. In other words, synthetic nitrogen degrades soil."[7]

### *Organic Fertilizers*

Organic fertilizers, such as compost and fish or seaweed emulsions, differ from synthetic ones because the nutrients are attached to complex structures, which add to the soil's humus (i.e., the organic component of soil, formed by the decomposition of leaves and other plant material by soil microorganisms). As a result, they don't rinse away as easily as synthetic nutrients, and they don't overstimulate soil microbes to consume the available organic (carbon-holding) matter in soil.

## Pesticides

Pesticides are substances designed to kill unwanted living things. These things may be plants, animals, fungi, and even bacteria. Some pesticides target only one type of organism; for example, Bt (*Bacillus thuringiensis*) targets only caterpillars. However, most pesticides, whether organic or not, kill a wide spectrum of organisms. *Pyrethrins*, derived from chrysanthemum flowers, are organic, but they are still highly toxic to many life forms.

In addition to their mostly negative effects on the local ecosystem (see below),

### The Poison Cycle

A balanced ecosystem contains many prey organisms—aphids, whiteflies, mosquitoes, cabbage worms, leafminers, mole crickets, spider mites, etc.—which provide food for a corresponding number of predatory insects, toads, bats, frogs, and birds, which together keep the ecosystem in balance.

When poisons (organic or synthetic) are used on "pests," the majority of all the insects in an area will be killed. But more than 90% of those insects are beneficial or benign. Some of those beneficial insects would have pollinated flowers, while others would have eaten some of the unwanted insects. Other predators such as bats, frogs, and birds will go elsewhere to feed, so the poisoned property will have lost its valuable predators.

As a landscape recovers from the poison, unwanted insects will begin to multiply again, but since their predators were killed or went away, the harmful insects will recover in even greater numbers than before. When sprayed again, the process repeats itself, and each time the most damaging insects will recover in ever-increasing numbers. Repeated poisonings often foster resistance to that pesticide. It would be better, for our own health and the health of the environment, to break that cycle and manage the landscape as a complete ecosystem where prey and predators are balanced.

the carbon footprint of pesticide manufacture and transportation is large. Several types of pesticides are described below.

### Insecticides

Despite the fact that the vast majority of insects in a typical landscape are either beneficial or benign, landscape-wide, broad-spectrum insecticides are regularly applied—usually as part of traditional lawn care, to kill the few insect larvae (grubs) that chew on grass roots.

#### *Neonicotinoids*

There are various types of systemic insecticides that are absorbed into the entire plant. Those called *neonicotinoids* are widely used in the flower-growing trade to keep the plants looking good (uneaten) on the shelves of garden centers. These substances target the nerve impulses of sap-sucking and leaf-chewing insects and other invertebrates, and so are thought (but not yet conclusively proven) to be safe for humans and other mammals. However, when these substances are incorporated into pollen and nectar, many beneficial pollinator insects (including thousands of native bee species) are harmed by these poisons.

#### *Homemade Insecticides*

There are concoctions (mostly mixtures of soaps or oils) that can be used on insect infestations such as aphids, but if a substance kills aphids, it will also kill predatory insects like ladybug larvae. Soaps also dissolve the plant's waxy cuticle that protects it from insect and fungal attacks. Just because it's homemade doesn't mean that it's not toxic.

### Fungicides

Fungicides are often included as part of a routine lawn-care regimen and are used preventively for fruit trees. In most landscapes, regular use of fungicides generally causes more harm than good because, as will be further discussed in this section and in Section V, fungi play vital roles in a healthy, balanced soil ecosystem. They help plants survive by aiding in the absorption of water and breaking down organic matter in the soil. In addition, fungi can help to limit soil pathogens. In climate-wise landscapes, it's preferable to keep and encourage soil fungi.

### Herbicides

Herbicides kill plants. *Pre-emergent* herbicides suppress seed germination, and *post-emergent* herbicides target existing plants/weeds. In this latter group are two types:

#### *Broad-spectrum Weed Killers*

There are a number of broad-spectrum weed killers on the market, but glyphosate-based products are most commonly used. Widespread application of these products, particularly for crop management (on both GMO and non-GMO crops such as wheat) can have far-reaching effects that we are only now beginning to fully understand. There is mounting evidence that traces of glyphosate are in our food. (A side effect of their use is that milkweed, which once was plentiful around crop fields, is now mostly missing, and, as a result, the numbers of migrating monarch butterflies have been depleted.)

*Note*: Smaller, non-farm landscapes might not have these problems, but let's work to minimize broad-spectrum herbicides and their unknown side effects. One strategy, instead of spraying widely, is to cut back any persistent weeds to the ground; when they grow back, apply the herbicide just on that new growth—when the plant is most vulnerable.

### *Broadleaved Weed Killers*

2,4-D (2,4-Dichlorophenoxyacetic acid) is probably the most-used weed killer for lawn-care regimens, but in the 15 days or so that it is active, it can leak into groundwater and nearby waterways, where certain forms of it are toxic to fish.[8] Other products such as Dicamba and Triclopyr are also used in lawns. These can sometimes be absorbed by tree roots growing under lawns, harming the trees themselves.[9] Ironically, the use of broadleaved weed killers also weakens the grass, making it more susceptible to fungal and insect infestations. The widespread practice of creating monoculture lawns, which can only be supported by chemical treatments that then stimulate the need for more chemicals, can be an expensive and self-defeating cycle for homeowners.

### *Homemade Weed Killers*

Most recipes for homemade weed killers include vinegar, salt, and/or soap. Yes, these substances will sometimes kill plants given the proper conditions, but vinegar sprayed into a bunch of weeds will also kill toads that were hiding there, and it will leach into the soil where it might also kill worms and other soil inhabitants as it acidifies the soil. With any homemade herbicide, be careful to spray only the plants.

## A Cautionary Note about Herbicides

Although herbicides can be effective in eliminating unwanted vegetation, they also pose multiple threats to the environment if used improperly. Plus, even if used properly, herbicides may affect soil microorganisms and the functioning of soil ecosystems, which will reduce the soil's ability to sequester carbon.


Credit: SReed

Figure I-4: This sign says it all.