

Gardeners Anticipate

Gardeners and the horticulture industry are adapting practices and plant choices in the face of subtle but steady climate changes.

BY ALEXANDRA GOHO

EACH SPRING, a wave of green spreads across the land, signaling the start of the growing season. Embedded in this wave are the telltale signs of a changing climate. Over the last half-century, the timing of leaf bursts, flower blooms, bird migrations, and other seasonal activities has shifted gradually in response to rising global temperatures. Although these shifts are subtle—and variable—from year to year, historical records show that the long-term trend is clear: Spring is arriving earlier. These records also offer a preview of what the world might look like in a warming environment. No, it won't be the over-the-top catastrophe depicted in this summer's blockbuster movie *The Day After Tomorrow*, but gardeners are already encountering challenges to adapt to climate changes.

Despite the odd bone-chilling winter, there is widespread consensus among scientists that the world indeed is getting warmer. Average global temperatures have increased 1.3 degrees Fahrenheit (0.6 degrees Celsius) over the past 100 years. In the northeastern United States, the winter month temperatures have increased by 3.4 degrees F (1.6 degrees C). The 1990s alone were the warmest decade on record. All in all, winters are getting shorter as the growing season is getting longer.

In some cases, that could bode well for farmers and gardeners alike. However, climatologists warn that some regions could expect more floods while others get exten-



“Whether gardening is your hobby or your business, it’s going to be directly affected by climate change.”

—David Wolfe, plant physiologist, Cornell University

sive periods of drought. Colorado garden centers are already adapting to dry conditions by selling more drought-tolerant plants, says Melanie Hinkle, industrial relations manager at the American Nursery and Landscape Association in Washington, D.C. “This practice is increasing because droughts have really become less of a phenomenon and more of a norm countrywide,” she says. “In the Midwest, people are also adapting to these conditions.”

One way gardeners can adapt is by changing the types of plants they choose to grow. In England, where climate change trends have received more public

recognition than in the United States, “more and more private gardens are moving towards Mediterranean-style gardens or dry gardens,” says Richard Bisgrove of the Centre for Horticulture and Landscape at the University of Reading. Bisgrove and his colleague, Paul Hadley, recently completed a report titled “Gardening in the Global Greenhouse” (see “Resources,” page 39) The report, commissioned by the U.K. Climate Impacts Programme and sponsored by the Royal Horticultural Society and the National Trust, offers predictions of how climate change is going to affect gardens in the

Climate Change



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—Dr. H. Marc Cathey, *American Horticultural Society President Emeritus*

United Kingdom and what steps gardeners can take to minimize the effects.

Climate change may also elevate risks to the environment posed by non-native plants, says Lewis Ziska, a plant biologist at the United States Department of Agriculture (USDA) in Beltsville, Maryland. Since the dawn of the industrial age, global carbon dioxide (CO₂) concentrations in the atmosphere have increased by more than 25 percent. Carbon dioxide, derived from the burning of fossil fuels, traps heat near the Earth's surface and is the biggest contributor to global warming. According to Ziska, with increasing levels of the

greenhouse gas, imported species have the potential to respond to climate change more aggressively than native plants. Alternatively, “If you bring in something that is normally limited by frost in your area and the number of frost days is decreasing, there's a chance it could escape and proliferate in the environment,” says Ziska.

Climate change is indeed complex and scientists are struggling to make sense of the myriad factors involved. To get a better handle on all this, researchers like Ziska are hard at work manipulating plants in the laboratory to see how they respond to different stimuli.

Others are keeping track of what's going on in the wild. Phenology—the study of the timing of biological processes and their relationship to climate—and climate records from the past are yielding important clues on the effects of climate change. Researchers are now racing to collect data on the present.

SPRING IS COMING EARLIER

In the 1960s, the USDA established a network of lilac-monitoring stations throughout the northcentral and northeastern United States, with more than 90 sites spanning eight states in the Northeast alone. All of the sites were planted with the same clone—genetically identical selection—of Chinese lilac (*Syringa x chinensis* ‘Red Rothomagensis’). The USDA distributed brochures to all the participants describing how to measure first leaf and first bloom. Every year thereafter, researchers at agricultural stations, horticulturists, and local citizens have recorded the signs of the onset of spring.

Although the original purpose of the project had nothing to do with climate change—it was designed to provide phenological information to help farmers determine when to plant their wheat or whether to expect an infestation of insects due to a milder winter—the data on lilac bloom dates is now offering scientists a glimpse of the effects of climate change.

David Wolfe, a plant physiologist at Cornell University, and Mark D. Schwartz, a climatologist at the University of Wisconsin–Milwaukee, pooled all the lilac phenology data for the Northeast and looked for trends. “Based on our analysis, we're definitely getting earlier blooms,” says Wolfe. From 1960 to 2000, lilacs bloomed on average one to three days earlier per decade; at some specific sites, first flowering dates advanced by nearly two weeks.

This phenomenon is not just restricted to the Northeast. By Schwartz's calculations, compared with the late 1950s, spring

is arriving on average six days earlier across North America. By pooling all the bloom data for lilacs in the East with those in the West, as well as in parts of Canada, and by modeling lilac growth in response to changes in weather, Schwartz was able to detect a dramatic trend continent-wide.

The studies on lilacs are consistent with other studies in the United States and abroad. Researchers from the Smithsonian Institution's Department of Botany found that the Japanese cherry trees around the Tidal Basin and elsewhere in Washington, D.C., are flowering about a week earlier than they did 30 years ago. In Wisconsin, between 1936 and 1998, spring events advanced by six days. In the south-central parts of England, the average first flowering date has advanced by four and a half days in the past decade alone. The latter study, conducted by researchers at the University of York, was based on an analysis of 385 different plant species.

By combining the records of studies conducted around the world, researchers at the University of Texas in Austin identified a so-called "fingerprint of climate change." In addition to plant response, the researchers looked at frog breeding, bird nesting, and the arrival of butterflies, among other events. Overall, the researchers found that spring had advanced at a rate of 2.3 days per decade over the last century and many species had shifted their



The bloom times of lilac, above, have been collected in the Northeast since the 1960s. In research, weeds such as yellow star thistle, right, exhibited aggressive growth when exposed to high levels of carbon dioxide.

natural range toward the poles at a rate of nearly four miles per decade.

UPSETTING THE BALANCE

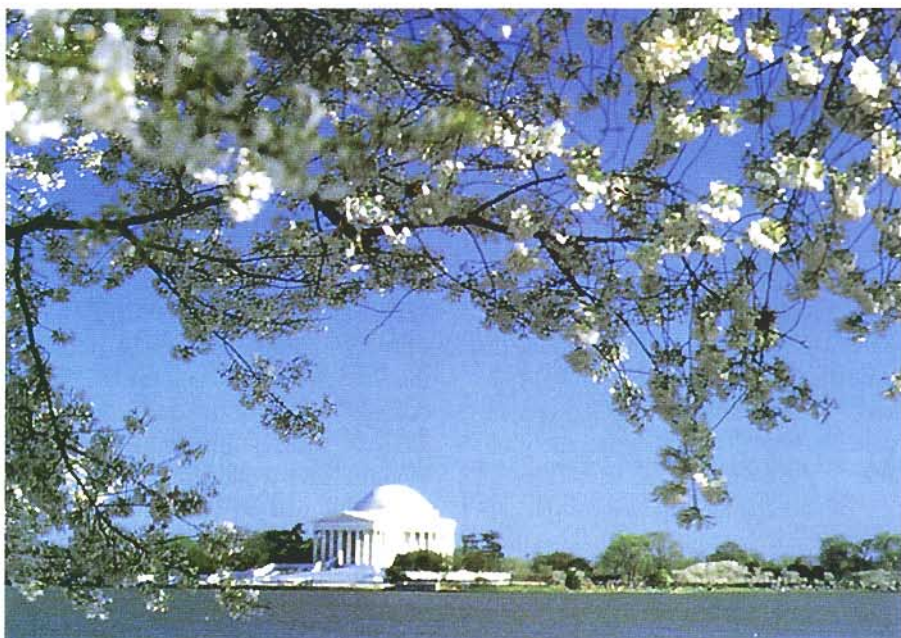
Although mounting evidence suggests that plants are indeed changing their behavior in response to increasing temperatures, studies of the effects of CO₂ on this process offer mixed results. Plants absorb CO₂ from the atmosphere and—with the help of sunlight—convert it to food. Increasing this food source could actually benefit many plants, causing them to grow more. "Higher CO₂ levels have been viewed as being a positive aspect of global change," says USDA's Ziska. "But it isn't necessarily positive with respect to weeds like kudzu, cheatgrass, and ragweed."



To prove this, Ziska and his colleagues grew six noxious weeds, including yellow star thistle (*Centaurea solstitialis*) and Canada thistle (*Cirsium arvense*), in growth chambers under varying concentrations of CO₂. After an 18-month period, the researchers found that plants grown under current atmospheric CO₂ levels had twice the biomass of those grown under turn-of-the-20th-century CO₂ conditions, with Canada thistle being the most aggressive. The growth of these weeds was also three times greater than for any of the plants species previously studied.

Next, Ziska wondered if the efficacy of herbicides might be affected by a warming environment. He found that higher CO₂ levels could, in fact, make herbicides less effective. As temperatures and CO₂ increase, plants grow faster "so the window of opportunity that you have for control by chemical means is much smaller," says Ziska. He and his colleagues grew some Canada thistle plants under normal CO₂ concentrations and others under CO₂ concentrations projected for the atmosphere in the next 50 years. The researchers then sprayed all of the plants with the same glyphosate-based herbicide. After six weeks, only 20 percent of the plants grown under normal CO₂ conditions came back. Yet all of the sprayed plants grown under elevated CO₂ levels came back.

As noxious weeds expand their range, so too will plant pests and pathogens, says Stella Coakley, a plant biologist at Oregon State University. Already, plant pathogens cost the U.S. economy \$137 billion per year, 20 percent of which is due to exotic pathogens introduced from other countries. Viruses and fungal pathogens, notes



Left: The world-famous Japanese cherry trees around the Tidal Basin in Washington, D.C., are now blooming about a week earlier than they did three decades ago.



Warming temperatures mean pests like grain aphids (*Sitobion avenae*), right, emerge earlier to pass diseases such as BYDV on to crops such as winter barley, above, which shows symptomatic yellowing of the leaves.

Coakley, can exist at low levels in a given area but then suddenly erupt into an epidemic as soon as the conditions become favorable. If winter temperatures continue to warm, many pathogens that normally die off during the cold months could survive and become especially virulent the following summer, she says.

Such predictions are not merely theoretical. Many regions in the world are already experiencing the effects of rising temperatures on plant pathogens. For instance, in Britain, aphids that carry the barley yellow dwarf virus (BYDV), among other pathogens, have advanced their spring flight times by three to six days over the past 25 years in association with increases in temperatures. If aphids are arriving earlier in the season, then plant viruses can potentially infiltrate plant populations earlier when the plants are more vulnerable.

DEALING WITH UNCERTAINTY

Based on computer climate models, the United Nations' Intergovernmental Panel on Climate Change predicts a 3 to 12.3 degrees F rise in global temperatures along with a potential doubling of CO₂ levels over the next century. However, scientists still debate exactly how different regions of the globe will respond to those changes. "Climatologists say no doubt we're warm-

ing," says Wolfe. "But they can't reach consensus on how fast it's going to warm and how precipitation will be affected. There's tremendous regional variability."

What exactly that means for the average American gardener is still unclear, but most experts caution against making radical changes to planting practices. "You don't want to be too quick to relate poor plant performance to climate changes," says AHS President Emeritus Dr. H. Marc Cathey. "Every plant is an experiment, and there are microclimates in every garden—problems may be related to poor site choice or disease or pest susceptibility rather than to climate change."

Yet Cathey acknowledges that temperature and weather trends over the past few decades have altered the way we gar-

Resources

Heat-Zone Gardening: How to Choose Plants that Thrive in Your Region's Warmest Weather by H. Marc Cathey with Linda Bellamy. Time-Life Books, Alexandria, Virginia. 1998.

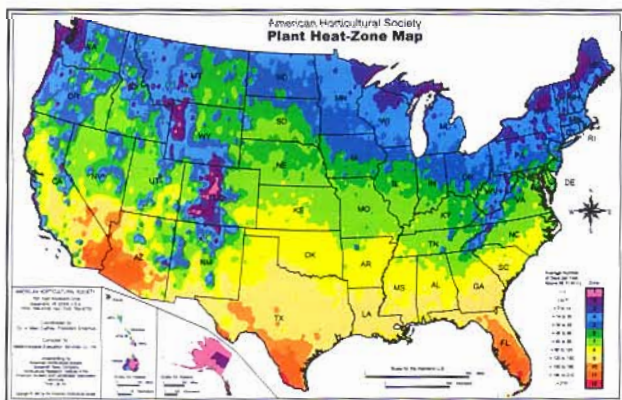
AHS Plant-Heat Zone Map. To order a 2-by-3-foot map for \$9.95, call (800) 777-7931, or visit www.ahs.org and click on Publications.

"Gardening in the Global Greenhouse: The Impact of Climate Change on Gardens in the UK," by Richard Bisgrove and Paul Hadley. The UK Climate Impacts Programme, Oxford, England, 2002. This report can be viewed online at www.ukcip.org.uk/gardens/gardens.htm.

den. "Drip irrigation systems are becoming a way of life for gardeners," notes Cathey. "Many gardeners are also discovering a whole new season for flowers because plants—like kale, pansies, and violets—are wintering over that didn't 30 years ago."

In 1997, Cathey coordinated the development of the AHS Plant-Heat Zone Map and a new coding system designed to help gardeners select plants suited to their region's summer heat. The map is divided into 12 zones based on the average number of days per year in which the temperature rises above 86 degrees (see "Resources," above), which is the point at which plant physiologists have determined that plant cells begin to break down.

Another potential effect of warming



Until the debut of AHS's Heat Zone map in 1997, American gardeners primarily relied on cold-hardiness in choosing plants appropriate for their gardens. Now plants can also be selected based on how well they tolerate heat, an increasingly important criteria as average temperatures rise.

GETTING INVOLVED

If you're interested in playing an active role in monitoring climate change, a number of organizations across Europe and the United States are getting local citizens involved in tracking phenological events such as first leaf dates, bird migrations, first frosts, and other marker activities.

The U.K. Phenology Network has more than 14,500 volunteers in the country collecting data. The European Phenology Network, based in the Netherlands, integrates phenological data from a number of countries in Europe and monitors continental trends related to climate change. "Germany has a network that is institutionalized," says University of Wisconsin climatologist Mark Schwartz. "It's part of the national weather service."

Recently, in the U.S., Cornell Plantations in Ithaca, New York; Harvard University's Arnold Arboretum in Boston, Massachusetts; and Missouri Botanical Garden in St. Louis, Missouri, have committed to join David Wolfe and Mark Schwartz's lilac phenology monitoring program.

In addition, Schwartz hopes to enhance the lilac program by setting up a national phenology network that would involve not just botanic gardens, but federal agencies, institutions, local citizens, and just about anyone interested in phenology.

Participants will monitor seasonal changes for half a dozen native plant species and enter the data on the network's Web site. The National Climatic Data Center has agreed to produce the site and manage the data. The Web site, which is currently under construction, would have a map of the United States and users would click on the region where they live and a list of different plants for that area would pop up, says Schwartz.

Individuals or organizations interested in participating in this project can contact Mark Schwartz at mds@uwm.edu or David Wolfe at dww5@cornell.edu. —A.G.



Boston University students Dan Primack and Carolyn Imbres record flowering times of pinkshell azalea (*Rhododendron vaseyi*) at the Arnold Arboretum in May 2003.

climates is that in some areas certain plants—such as spring bulbs and fruit trees—may no longer get enough winter chilling to flower and fruit properly. "When you buy your trees and perennials, you might want to make sure their range isn't on the edge of the USDA plant hardiness zones for your area," says Oregon State University plant biologist Coakley. "Instead, assume that it's going to get warmer and pick a plant that grows right in the middle of your zone range."

To address issues like these, the American Society for Horticultural Science held a symposium in Providence, Rhode Island last fall titled "Impacts of Climate Change on Horticulture." Scientists specializing in everything from climate studies to plant disease management discussed the evidence and pondered solutions. One of the participants, the University of Reading's Richard Bisgrove, noted that water conservation is going to become critical in the future. In areas afflicted with drought, gardeners will have to adapt by capturing rainwater in storage tanks, for instance, and switching to water-thrifty plants.

ADJUSTING ATTITUDES AND PRACTICES

Coping with changing climate will require changing attitudes and expectations built up over time. Bisgrove says that over the last several years some British gardeners

have noticed their lawns turning brown in the summer because of the reduced rainfall in the country, once legendary for its soggy weather. Before the climatic reality check, Bisgrove notes, "We just assumed that lawns would be green year round."

As the climate changes, gardeners will no doubt find ways to adapt their practices, says Bisgrove. But he points out that the natural world is far less equipped to handle such changes. For instance, as mountainous regions get warmer, alpine species will migrate up the mountain in search of cooler temperatures. But they can only migrate so far. Hence entire plant populations can become endangered.

Gardeners can address climate change proactively in many ways notes Don Rakow, director of Cornell Plantations in Ithaca, New York. By monitoring changes in their own backyards, gardeners can help scientists better understand the complexities of climate change and how it affects plant and animal ecology (see sidebar, left). Gardeners can also work to persuade government and industry leaders to alter their practices and policies, he says. Bisgrove concurs, noting that "gardeners could play a huge role in promoting awareness of the global impacts of climate change." ☺

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