HEALTH AND SOCIETY

Changes in the Earth's climate can affect public health, agriculture, water supplies, energy production and use, land use and development, and recreation. The nature and extent of climate change effects, and whether these effects will be harmful or beneficial, will vary regionally and over time. This chapter looks at some of the ways that climate change is affecting human health and society, including changes in Lyme disease, ragweed pollen season, heat-related deaths, heating and cooling needs, and the agricultural growing season across the United States.

Because impacts on human health are complex, often indirect, and dependent on multiple societal and environmental factors, the development of appropriate health-related climate indicators is challenging and still emerging. It is important for health-related climate indicators to be clear, measurable, and timely to better understand the link between climate change and health effects.

WHY DOES IT MATTER?

Changes in climate affect the average weather conditions to which we are accustomed. These changes may result in multiple threats to human health and welfare. Warmer average temperatures will likely lead to hotter days and more frequent and longer heat waves, which could increase the number of heat-related illnesses and deaths. Increases in the frequency or severity of extreme weather events, such as storms, could increase the risk of dangerous flooding, high winds, and other direct threats to people and property. Warmer temperatures could also reduce air quality by increasing the chemical reactions that produce smog, and, along with changes in precipitation patterns and extreme events, could enhance the spread of some diseases.

In addition, climate change could require adaptation on larger and faster scales than in the past, presenting challenges to human well-being and the economy. The more extensively and more rapidly the climate changes, the larger the potential effects on society. The extent to which climate change will affect different regions and sectors of society will depend not only on the sensitivity of those systems to climate change, but also on their ability to adapt to or cope with climate change. Vulnerable populations, including the poor, the elderly, those already in poor health, the disabled, and indigenous populations, are most at risk.

Summary of Key Points

Heating and Cooling Degree Days. Heating and cooling degree days measure the difference between outdoor temperatures and the temperatures that people find comfortable indoors. As the U.S. climate has warmed in recent years, heating degree days have decreased and cooling degree days have increased overall, suggesting that Americans need to use less energy for heating and more energy for air conditioning. This pattern stands out the most in the North and West, while much of the Southeast has experienced the opposite results.

Heat-Related Deaths. Over the past three decades, nearly 8,000 Americans were reported to have died as a direct result of heat-related illnesses such as heat stroke. The annual death rate is higher when accounting for other deaths in which heat was reported as a contributing factor. Considerable year-to-year variability in the data and certain limitations of this indicator make it difficult to determine whether the United States has experienced long-term trends in the number of deaths classified as "heat-related."

Lyme Disease. Lyme disease is a bacterial illness spread by ticks that bite humans. Tick habitat and populations are influenced by many factors, including climate. Nationwide, the rate of reported cases of Lyme disease has approximately doubled since 1991. Lyme disease is most common in the Northeast and the upper Midwest, where some states now report 50 to 90 more cases of Lyme disease per 100,000 people than they did in 1991.

Length of Growing Season. The average length of the growing season in the contiguous 48 states has increased by nearly two weeks since the beginning of the 20th century. A particularly large and steady increase has occurred over the last 30 years. The observed changes reflect earlier spring warming as well as later arrival of fall frosts. The length of the growing season has increased more rapidly in the West than in the East.

Ragweed Pollen Season. Warmer temperatures and later fall frosts allow ragweed plants to produce pollen later into the year, potentially prolonging the allergy season for millions of people. The length of ragweed pollen season has increased at 10 out of 11 locations studied in the central United States and Canada since 1995. The change becomes more pronounced from south to north.

Heating and Cooling Degree Days

This indicator examines changing temperatures from the perspective of heating and cooling needs for buildings.

KEY POINTS

- Heating degree days have declined in recent years as the U.S. climate has warmed (see Figure 1). This change suggests that heating needs have decreased overall.
- Overall, cooling degree days have not increased significantly over the past 100 years. However, a slight increase is evident over the past few decades, suggesting that air conditioning energy demand has also been increasing recently (see Figure 1).
- Heating degree days have generally decreased in the North and West, and cooling degree days have generally increased in the West. The Southeast has seen the opposite: more heating degree days and fewer cooling degree days (see Figures 2 and 3).

Outdoor temperatures can affect daily life in many ways. In particular, temperature affects our comfort level and our demand for heating and air conditioning. Collectively, heating and cooling the spaces in which we live accounts for 48 percent of the energy that American households use every year.[1] As climate change contributes to an increase in average temperatures, an increase in unusually hot days, and a decrease in unusually cold days (see the U.S. and Global Temperature and High and Low Temperatures indicators on pp. 28 and 30), the overall demand for heating is expected to decline and the demand for cooling is expected to increase.

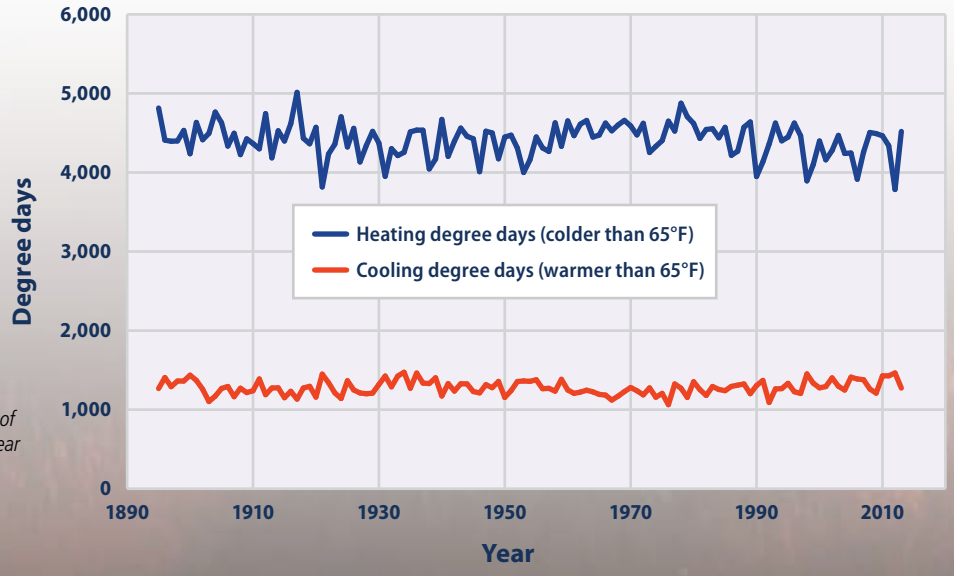
One way to measure the influence of temperature change on energy demand is using heating and cooling degree days, which measure the difference between outdoor temperatures and a temperature that people generally find comfortable indoors. These measurements suggest how much energy people might need to use to heat and cool their homes and workplaces, thus providing a sense of how climate change could affect people's daily lives and finances.

ABOUT THE INDICATOR

This indicator uses daily temperature data from thousands of weather stations across the United States to calculate heating and cooling degree days. A "degree day" is determined by comparing the daily average outdoor temperature with a defined baseline temperature for indoor comfort (in this case, 65°F). For example, if the average temperature on a particular day is 78°F, then that day counts as 13 cooling degree days, as a building's interior would need to be cooled by 13°F to reach 65°F. Conversely, if the average outdoor temperature is 34°F, then that day counts as 31 heating degree days, as a building's interior would need to be warmed by 31°F to reach 65°F. For reference, New York City experiences far more heating degree days than cooling degree days per year—a reflection of the relatively cool climate in the Northeast—while Houston, Texas, has far more cooling degree days than heating degree days—a reflection of the much warmer climate in the South.[2]

Figure 1 shows each year's average heating and cooling degree days across the contiguous 48 states. Figures 2 and 3 show how heating and cooling degree days have changed by state, based on a comparison of the first 59 years of available data (1895–1953) with the most recent 60 years (1954–2013). State and national averages were calculated by finding the total number of heating and cooling degree days per year at each weather station, averaging the results from all stations within regions called climate divisions (each state has up to 10 climate divisions), then calculating state and national averages weighted by the population of each climate division. With this population-weighting approach, average state and national heating and cooling degree days more closely reflect the conditions that the average resident would experience.

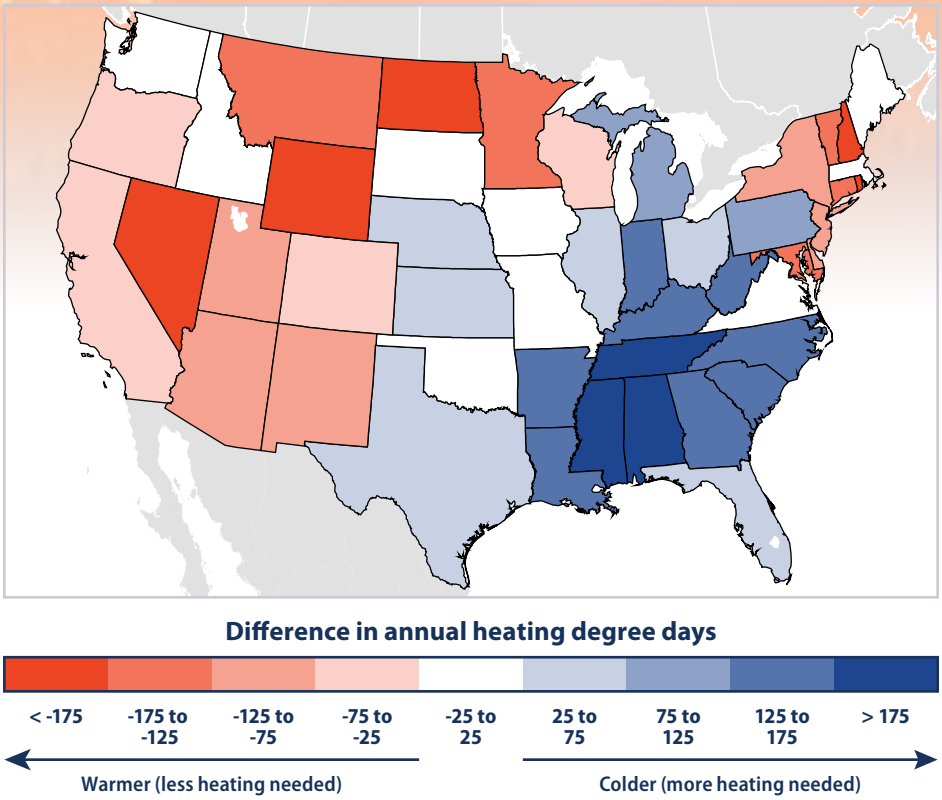
Figure 1. Heating and Cooling Degree Days in the Contiguous 48 States, 1895–2013



This figure shows the average number of heating and cooling degree days per year across the contiguous 48 states.

Data source: NOAA, 2014[3]

Figure 2. Change in Annual Heating Degree Days by State, 1954–2013 Versus 1895–1953



This map shows how the average number of heating degree days per year has changed in each state over time. The map was created by comparing the first 59 years of available data (1895–1953) with the most recent 60 years (1954–2013). "Warmer" colors indicate an increase in temperatures between the two periods, leading to less of a need to turn on the heat—that is, fewer heating degree days. "Cooler" colors indicate a decrease in temperatures, leading to more of a need to turn on the heat—that is, more heating degree days.

Data source: NOAA, 2014[4]

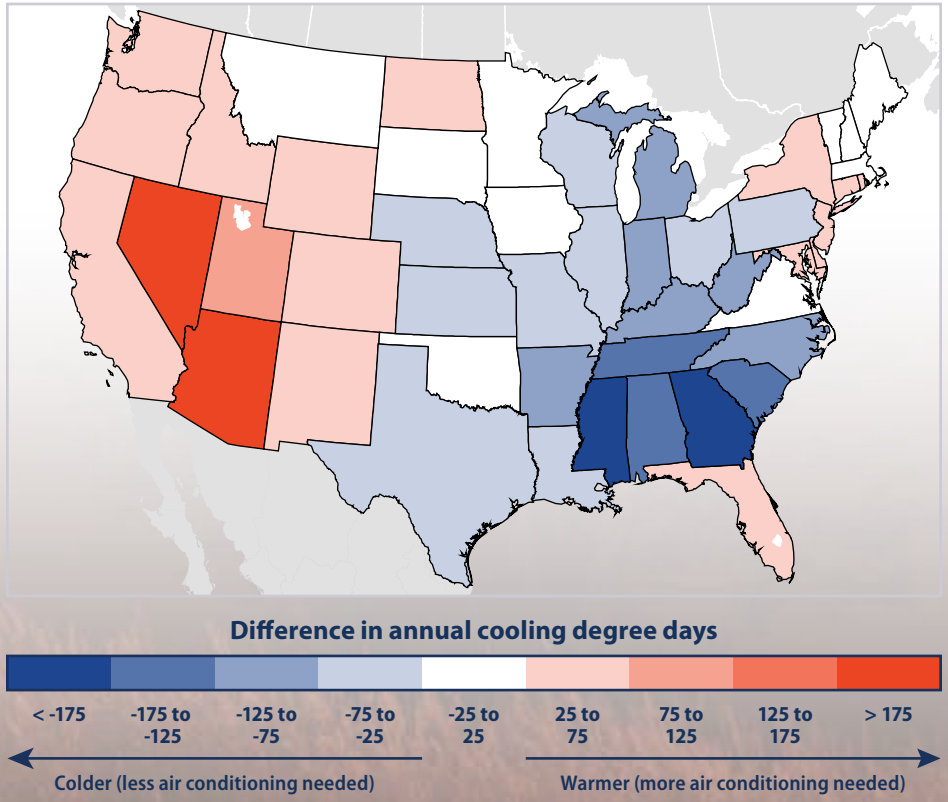
INDICATOR NOTES

Heating and cooling degree days suggest how temperature changes affect energy demand, but they do not necessarily reflect actual energy use. Many other factors have influenced energy demand over time, such as more energy-efficient heating systems, the introduction and increasingly widespread use of cooling technologies, larger but better-insulated homes, behavior change, and population shifts (such as more people moving to warmer regions). All of the population-weighting in this indicator is based on the population distribution according to the 1990 U.S. Census, so any changes in heating and cooling degree days over time in this indicator reflect actual changes in the climate, not the influence of shifting populations. A nationally applied baseline—in this case, 65°F—has certain limitations considering the various climate regimes across the United States.

DATA SOURCES

The data for this indicator were provided by the National Oceanic and Atmospheric Administration's National Climatic Data Center, which maintains a large collection of climate data online at: www.ncdc.noaa.gov/oa/ncdc.html.

Figure 3. Change in Annual Cooling Degree Days by State, 1954–2013 Versus 1895–1953



This map shows how the average number of cooling degree days per year has changed in each state over time. The map was created by comparing the first 59 years of available data (1895–1953) with the most recent 60 years (1954–2013). "Warmer" colors indicate an increase in temperatures between the two periods, leading to more demand for air conditioning—that is, more cooling degree days. "Cooler" colors indicate a decrease in temperatures, leading to less demand for air conditioning—that is, fewer cooling degree days.

Data source: NOAA, 2014[5]

Heat-Related Deaths

This indicator presents data on deaths classified as "heat-related" in the United States.

KEY POINTS

- **Between 1979 and 2010, the death rate as a direct result of exposure to heat (underlying cause of death) generally hovered around 0.5 deaths per million population, with spikes in certain years (see Figure 1). Overall, a total of nearly 8,000 Americans suffered heat-related deaths since 1979. This number does not capture the full extent of heat-related deaths for several reasons (see example on p. 77).**
- **For years in which the two records overlap (1999–2010), accounting for those additional deaths in which heat was listed as a *contributing* factor results in a higher death rate—nearly double for some years—compared with the estimate that only includes deaths where heat was listed as the *underlying* cause. However, even this expanded metric does not necessarily capture the full extent of heat-related deaths.**
- **The indicator shows a peak in heat-related deaths in 2006, a year that was associated with widespread heat waves and was the second-hottest year on record in the contiguous 48 states (see the U.S. and Global Temperature indicator on p. 28).**
- **Considerable year-to-year variability in the data and certain limitations of this indicator make it difficult to determine whether the United States has experienced a meaningful increase or decrease in deaths classified as "heat-related" over time. Dramatic increases in heat-related deaths are closely associated with both the occurrence of hot temperatures and heat waves, though these deaths may not be reported as "heat-related" on death certificates. For example, studies of the 1995 heat wave event in Chicago (see example on p. 77) suggest that there may have been hundreds more deaths than were actually reported as "heat-related" on death certificates.**

When people are exposed to extreme heat, they can suffer from potentially deadly heat-related illnesses, such as heat exhaustion and heat stroke. Heat is the leading weather-related killer in the United States, even though most heat-related deaths are preventable through outreach and intervention (see EPA's *Excessive Heat Events Guidebook* at: www.epa.gov/heatisland/about/pdf/EHEguide_final.pdf).

Unusually hot summer temperatures have become more frequent across the contiguous 48 states in recent decades[6] (see the High and Low Temperatures indicator on p. 30), and extreme heat events (heat waves) are expected to become longer, more frequent, and more intense in the future.[7] As a result, the risk of heat-related deaths and illness is also expected to increase.[8]

Increases in summertime temperature variability may increase the risk of heat-related death for the elderly and other vulnerable populations.[9] Older adults have the highest risk of heat-related death, although young children are also sensitive to the effects of heat. Across North America, the population over the age of 65 is growing dramatically. People with certain diseases, such as cardiovascular and respiratory illnesses, are especially vulnerable to excessive heat exposure, as are the economically disadvantaged.

Some studies suggest that the number of deaths caused by extremely cold temperatures might drop in certain areas as the climate gets warmer, while others do not expect the number to change at all.[10,11] Any decrease in cold-related deaths will most likely be substantially less than the increase in summertime heat-related deaths.[12,13,14]

ABOUT THE INDICATOR

This indicator shows the annual rate for deaths classified by medical professionals as "heat-related" each year in the United States, based on death certificate records. Every death is recorded on a death certificate, where a medical professional identifies the main cause of death (also known as the underlying cause), along with other conditions that contributed to the death. These causes are classified using a set of standard codes. Dividing the annual number of deaths by the U.S. population in that year, then multiplying by one million, will result in the death rates (per million people) shown in Figure 1.

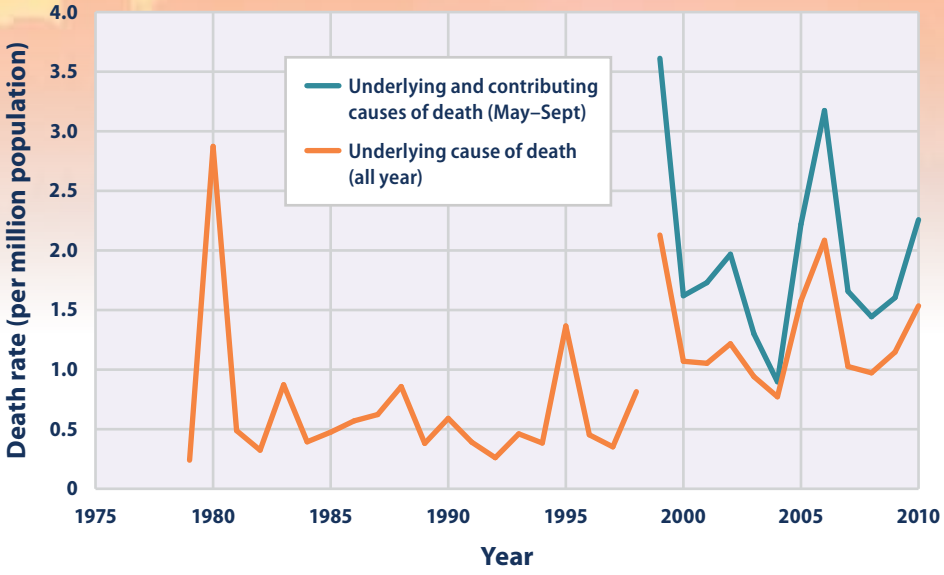
This indicator shows heat-related deaths using two methodologies. One method shows deaths for which excessive natural heat was stated as the underlying cause of death from 1979 to 2010. The other data series shows deaths for which heat was listed as either the underlying cause or a contributing cause, based on a broader set of data that at present can only be evaluated back to 1999. For example, in a case where cardiovascular disease was determined to be the underlying cause of death, heat could be listed as a contributing factor because it can make the individual more susceptible to the effects of this disease. Because excessive heat events are associated with summer months, the 1999–2010 analysis was limited to May through September.

INDICATOR NOTES

Several factors influence the sensitivity of this indicator and its ability to estimate the true number of deaths associated with extreme heat events. It has been well-documented that many deaths associated with extreme heat are not identified as such by the medical examiner and might not be correctly coded on the death certificate. In many cases, the medical examiner might classify the cause of death as a cardiovascular or respiratory disease, not knowing for certain whether heat was a contributing factor, particularly if the death did not occur during a well-publicized heat wave. By studying how daily death rates vary with temperature in selected cities, scientists have found that extreme heat contributes to far more deaths than the official death certificates might suggest.[15] This is because the stress of a hot day can increase the chance of dying from a heart attack, other heart conditions, or respiratory diseases such as pneumonia.[16] These causes of death are much more common than heat-related illnesses such as heat stroke. Thus, this indicator very likely underestimates the number of deaths caused by exposure to heat.

Just because a death is classified as "heat-related" does not mean that high temperatures were the only factor that caused or contributed to the death. Pre-existing medical conditions can significantly increase an individual's vulnerability to heat. Other important factors, such as the overall vulnerability of the population, the extent to which people have adapted and acclimated to higher temperatures, and the local climate and topography, can affect trends in "heat-related" deaths. Heat response measures, such as early warning and surveillance systems, air conditioning, health care, public education, cooling centers, infrastructure standards, and air quality management, can also make a big difference in death rates. For example, after a 1995 heat wave, the city

Figure 1. Deaths Classified as "Heat-Related" in the United States, 1979–2010

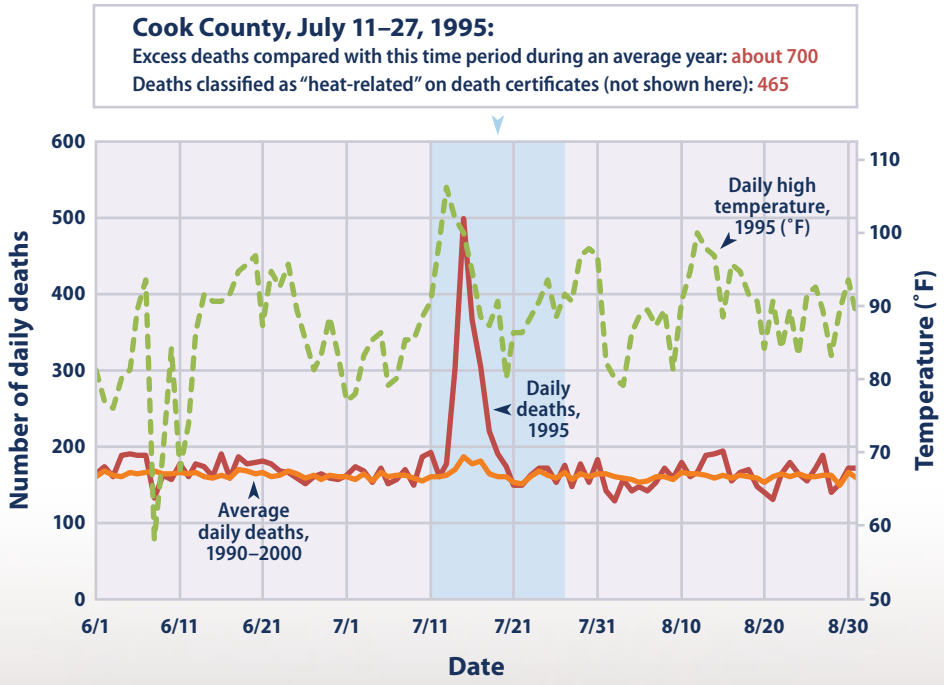


This figure shows the annual rates for deaths classified as "heat-related" by medical professionals in the 50 states and the District of Columbia. The orange line shows deaths for which heat was listed as the main (underlying) cause. The blue line shows deaths for which heat was listed as either the underlying or contributing cause of death during the months from May to September, based on a broader set of data that became available in 1999.*

** Between 1998 and 1999, the World Health Organization revised the international codes used to classify causes of death. As a result, data from earlier than 1999 cannot easily be compared with data from 1999 and later.*

Data source: CDC, 2014[18,19]

Example: Examining Heat-Related Deaths During the 1995 Chicago Heat Wave



Many factors can influence the nature, extent, and timing of health consequences associated with extreme heat events.[20] Studies of heat waves are one way to better understand health impacts, but different methods can lead to very different estimates of heat-related deaths. For example, during a severe heat wave that hit Chicago between July 11 and July 27, 1995, 465 heat-related deaths were recorded on death certificates in Cook County.[21] However, studies that compared the total number of deaths during this heat wave (regardless of the recorded cause of death) with the long-term average of daily deaths found that the heat wave likely led to about 700 more deaths than would otherwise have been expected.[22] Differences in estimated heat-related deaths that result from different methods may be even larger when considering the entire nation and longer time periods.*

** This graph shows data for the Chicago Standard Metropolitan Statistical Area.*

Data sources: CDC, 2012;[23] NOAA, 2012[24]

of Milwaukee developed a plan for responding to extreme heat conditions; during the 1999 heat wave, heat-related deaths were roughly half of what would have been expected.[17]

Future development related to this indicator should focus on capturing *all* heat-related deaths, not just those with a reported link to heat stress, as well as examining heat-related illnesses more systematically.

DATA SOURCES

Data for this indicator were provided by the U.S. Centers for Disease Control and Prevention (CDC). The 1979–2010 underlying cause data are publicly available through the CDC WONDER database at: http://wonder.cdc.gov/mortSQL.html. The 1999–2010 analysis was developed by CDC's Environmental Public Health Tracking Program, which provides a summary at: www.cdc.gov/nceh/tracking.

Lyme Disease

This indicator tracks the rate of reported Lyme disease cases across the United States.

KEY POINTS

- The incidence of Lyme disease in the United States has approximately doubled since 1991, from 3.74 reported cases per 100,000 people to 7.01 reported cases per 100,000 people in 2012 (see Figure 1).
- Among the states where Lyme disease is most common, New Hampshire and Delaware have experienced the largest increases in reported case rates since 1991, followed by Maine, Vermont, and Massachusetts. On average, these five states now report 50 to 90 more cases per 100,000 people than they did in 1991 (see Figure 2).
- Driven by multiple factors, the number and distribution of reported cases of Lyme disease appear to be increasing over time (see example maps).

Lyme disease is a bacterial illness that can cause fever, fatigue, joint pain, and skin rash, as well as more serious joint and nervous system complications. Lyme disease is the most common vector-borne disease (that is, a disease transmitted by mosquitoes, ticks, or fleas) in the United States. In recent years, approximately 20,000–30,000 confirmed cases of Lyme disease per year have been reported to the Centers for Disease Control and Prevention.[25] However, the actual number of illnesses is likely greater than what is reported to health officials.[26] Lyme disease is transmitted through the bite of certain species of infected ticks (referred to commonly as deer ticks) that carry the bacteria that cause Lyme disease. These ticks live not only on deer, but also on rodents, birds, and other host animals. Deer do not harbor the bacteria that cause Lyme disease, but certain other hosts such as white-footed mice do, and ticks pick up the bacteria by feeding on these infected hosts.

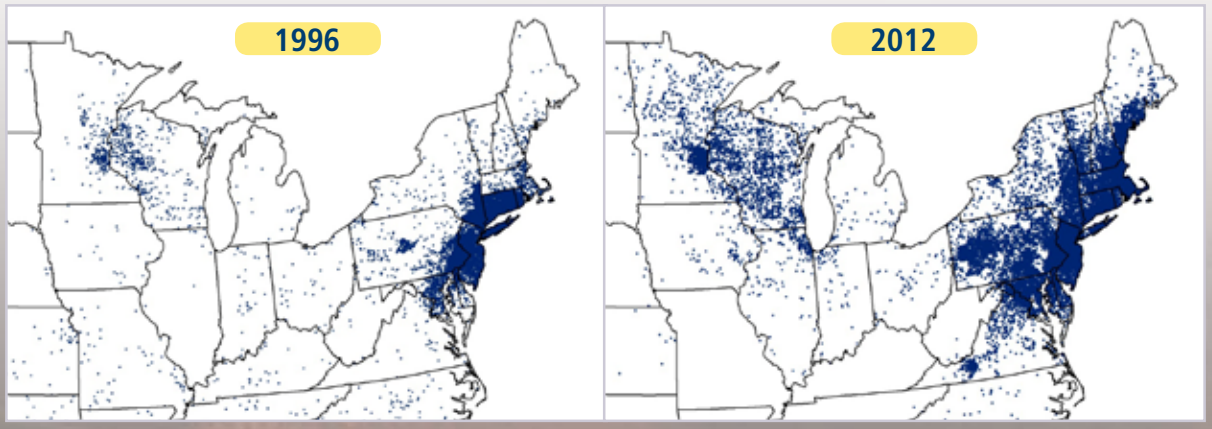
Climate is just one of many important factors that influence the transmission, distribution, and incidence of Lyme disease. However, studies provide evidence that climate change has contributed to the expanded range of ticks,[27] increasing the potential risk of Lyme disease, such as in areas of Canada where the ticks were previously unable to survive. The life cycle and prevalence of deer ticks are strongly influenced by temperature.[28] For example, deer ticks are mostly active when temperatures are above 45°F, and they thrive in areas with at least 85 percent humidity. Thus, warming temperatures associated with climate change could increase the range of suitable tick habitat, and are therefore one of multiple factors driving the observed spread of Lyme disease.[29] Because tick activity depends on temperatures being above a certain minimum, shorter winters could also extend the period when ticks are active each year, increasing the time that humans could be exposed to Lyme disease. Unlike some other vector-borne diseases, tick-borne disease patterns are generally less influenced by short-term changes in weather (weeks to months) than by longer-term climate change.

Other factors that affect the number of Lyme disease cases include changes in the populations of host species (particularly deer), which affect tick population size. The percentage of ticks that are infected depends on the prevalence and infection rates of white-footed mice and certain other hosts. Host species populations and habitats can be affected by climate change and other ecosystem disturbances. Human exposure to infected ticks is also influenced by multiple factors, including changes in the proximity of human populations to ticks and other hosts, increased awareness of Lyme disease, and modified behaviors, such as spending less time outdoors, taking precautions against being bitten, and checking more carefully for ticks.

ABOUT THE INDICATOR

This indicator looks at the incidence of Lyme disease, which reflects the rate of new cases contracted in a given geographic area and time period. Incidence is typically calculated as the number of cases per 100,000 people per year. Annual Lyme disease totals and rates for each state were provided by the Centers for Disease Control and Prevention. The original data were collected by state and local health departments, which track confirmed cases of Lyme disease that are diagnosed by health care providers and report these cases to the National Notifiable Diseases Surveillance System. Nationwide reporting of Lyme disease began in 1991.

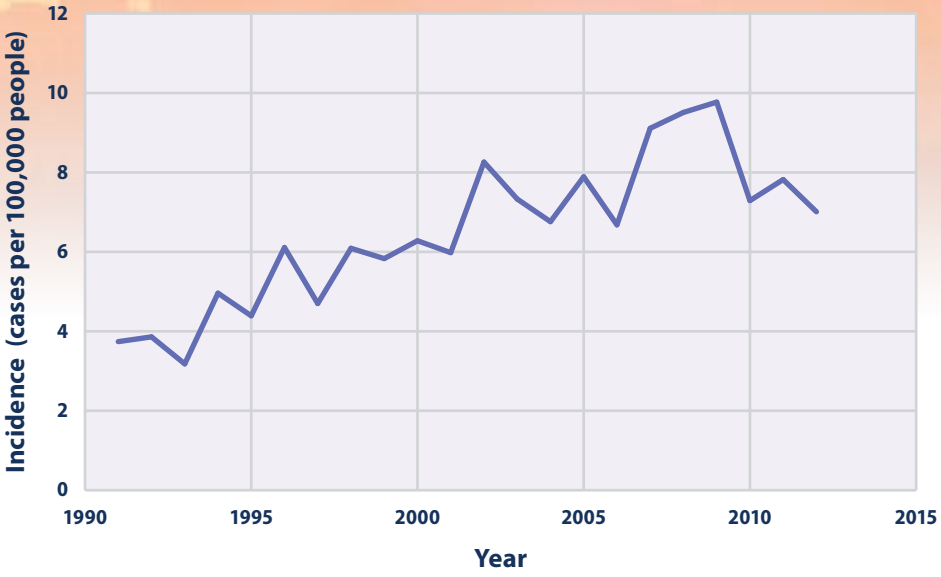
Example: Reported Lyme Disease Cases in 1996 and 2012



These maps show the distribution of reported cases of Lyme disease in 1996 and 2012. Each dot represents an individual case placed according to the patient's county of residence, which may be different than the county of exposure. The year 1996 was chosen as a reasonable starting point for comparison with recent years. These maps focus on the parts of the United States where Lyme disease is most common.

Data source: CDC, 2014[30]

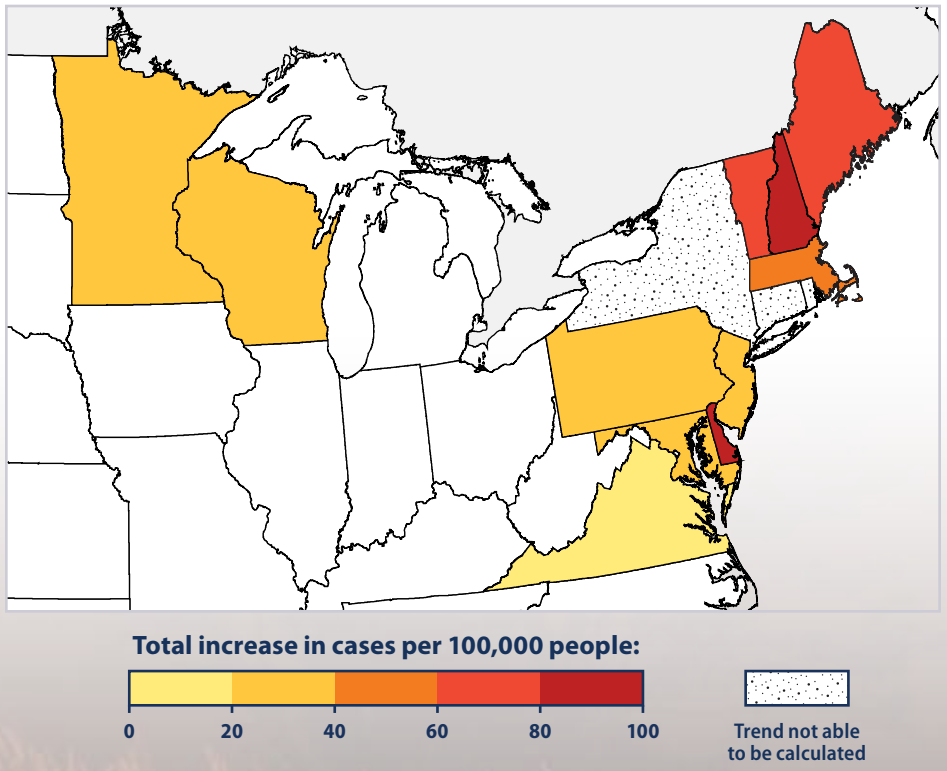
Figure 1. Reported Cases of Lyme Disease in the United States, 1991–2012



This figure shows the annual incidence of Lyme disease, which is calculated as the number of new cases per 100,000 people. The graph is based on cases that local and state health departments report to CDC's national disease tracking system.

Data source: CDC, 2014[31]

Figure 2. Change in Reported Lyme Disease Incidence in the Northeast and Upper Midwest, 1991–2012



This map shows how reported Lyme disease incidence has changed by state since 1991, based on the number of new cases per 100,000 people. The total change has been estimated from the average annual rate of change in each state. This map is limited to the 14 states where Lyme disease is most common, where annual rates are consistently above 10 cases per 100,000. Connecticut, New York, and Rhode Island had too much year-to-year variation in reporting practices to allow trend calculation.

Data source: CDC, 2014[32]

Figure 1 shows the national incidence of Lyme disease since 1991, and Figure 2 shows trends in incidence over time in 14 states that collectively account for about 95 percent of the nation's reported cases. To provide a simple illustration of changes over time, example maps show the distribution of reported cases in the years 1996 and 2012.

INDICATOR NOTES

For consistency, this indicator only includes data for confirmed cases of Lyme disease that are reported to CDC, not cases that are considered "probable." Changes in diagnosing practices and awareness of the disease over time can affect trends. Cases are reported based on the patient's county of residence, which is not necessarily the place where they were infected. Risk of infection is focused in certain regions of the country, and confirmed reports from low-incidence states are often the result of travel to an area of higher incidence. Evidence suggests that expanding ranges of ticks in certain northern states may be more related to a warming climate than expanding ranges in southern states.[33,34] However, because of the many factors affecting tick populations and reporting of Lyme disease, this indicator does not provide sufficient information to determine what proportion of the observed changes in Lyme disease incidence is directly driven by climate change. Further study is critical to improving the usefulness of this indicator and informing decisions affecting public health. For information on prevention, symptoms, and treatment of Lyme disease, see: www.cdc.gov/lyme.

DATA SOURCES

All three figures are based on publicly available Lyme disease data compiled by the Centers for Disease Control and Prevention at: www.cdc.gov/lyme/stats/index.html. Incidence was calculated using mid-year population estimates from the U.S. Census Bureau.[35]

Length of Growing Season

This indicator measures the length of the growing season in the contiguous 48 states.

KEY POINTS

- The average length of the growing season in the contiguous 48 states has increased by nearly two weeks since the beginning of the 20th century. A particularly large and steady increase occurred over the last 30 years (see Figure 1).
- The length of the growing season has increased more rapidly in the West than in the East. In the West, the length of the growing season has increased at an average rate of about 22 days per century since 1895, compared with a rate of about eight days per century in the East (see Figure 2).
- In recent years, the final spring frost has been occurring earlier than at any point since 1895, and the first fall frosts have been arriving later. Since 1980, the last spring frost has occurred an average of three days earlier than the long-term average, and the first fall frost has occurred about two days later (see Figure 3).

The length of the growing season in any given region refers to the number of days when plant growth takes place. The growing season often determines which crops can be grown in an area, as some crops require long growing seasons, while others mature rapidly. Growing season length is limited by many different factors. Depending on the region and the climate, the growing season is influenced by air temperatures, frost days, rainfall, or daylight hours.

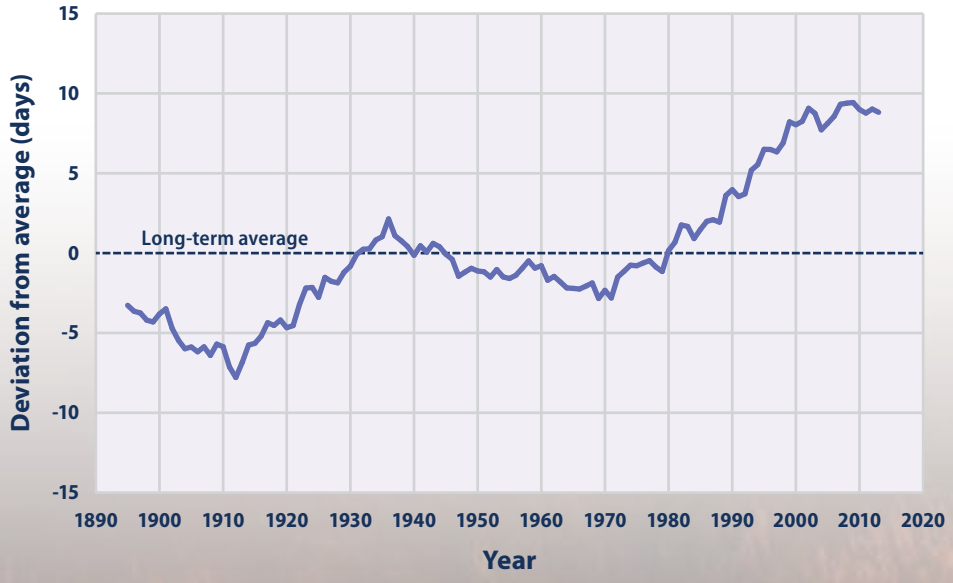
Changes in the length of the growing season can have both positive and negative effects on the yield and prices of particular crops. Overall, warming is expected to have negative effects on yields of major crops, but some individual locations may benefit.[36] A longer growing season could allow farmers to diversify crops or have multiple harvests from the same plot. However, it could also limit the types of crops grown, encourage invasive species or weed growth, or increase demand for irrigation. A longer growing season could also disrupt the function and structure of a region's ecosystems and could, for example, alter the range and types of animal species in the area.

ABOUT THE INDICATOR

This indicator looks at the impact of temperature on the length of the growing season in the contiguous 48 states, as well as trends in the timing of spring and fall frosts. For this indicator, the length of the growing season is defined as the period of time between the last frost of spring and the first frost of fall, when the air temperature drops below the freezing point of 32°F. This is referred to as the frost-free season.

Trends in the growing season were calculated using temperature data from 750 weather stations throughout the contiguous 48 states. These data were obtained from the National Oceanic and Atmospheric Administration's National Climatic Data Center. Growing season length and the timing of spring and fall frosts were averaged across the nation, then compared with long-term average numbers (1895–2013) to determine how each year differed from the long-term average.

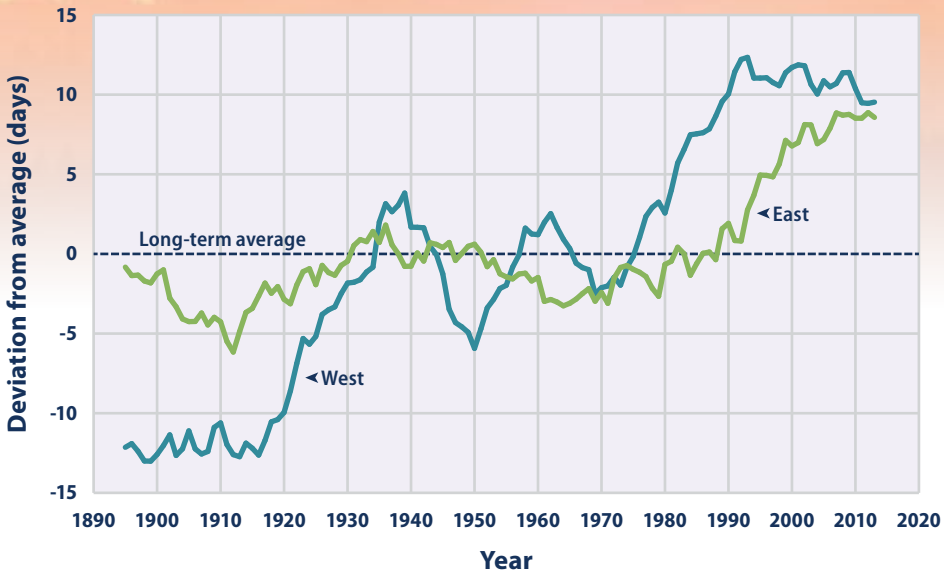
Figure 1. Length of Growing Season in the Contiguous 48 States, 1895–2013

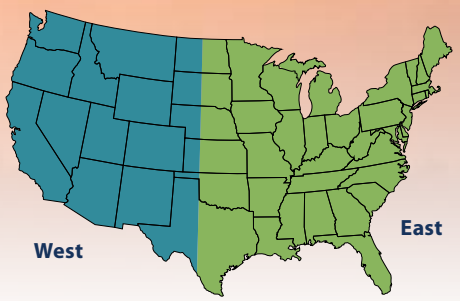


This figure shows the length of the growing season in the contiguous 48 states compared with a long-term average. For each year, the line represents the number of days shorter or longer than average. The line was smoothed using an 11-year moving average. Choosing a different long-term average for comparison would not change the shape of the data over time.

Data source: Kunkel, 2014[37]

Figure 2. Length of Growing Season in the Contiguous 48 States, 1895–2013: West Versus East

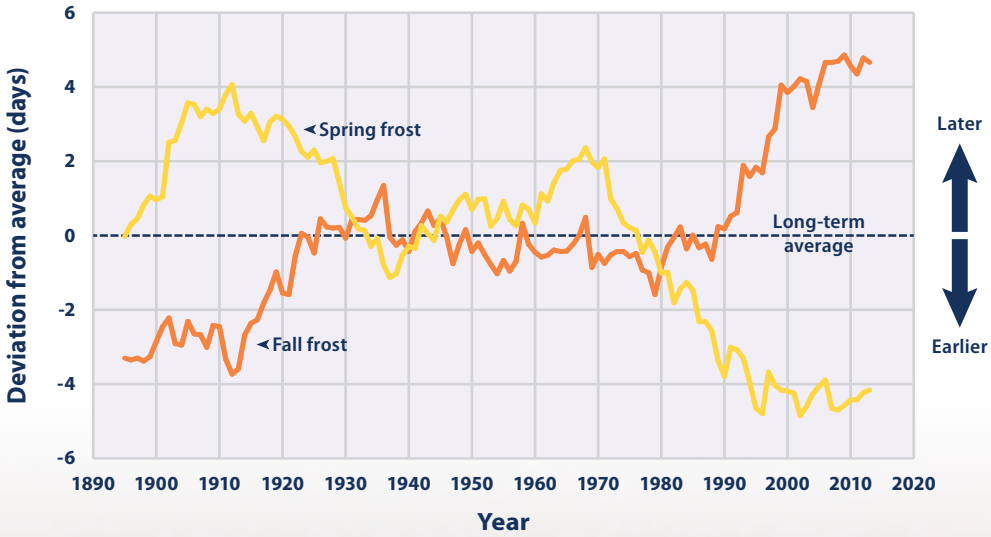




This figure shows the length of the growing season in the western and eastern United States compared with a long-term average. For each year, the line represents the number of days shorter or longer than average. The lines were smoothed using an 11-year moving average. Choosing a different long-term average for comparison would not change the shape of the data over time.

Data source: Kunkel, 2014[38]

Figure 3. Timing of Last Spring Frost and First Fall Frost in the Contiguous 48 States, 1895–2013



This figure shows the timing of the last spring frost and the first fall frost in the contiguous 48 states compared with a long-term average. Positive values indicate that the frost occurred later in the year, and negative values indicate that the frost occurred earlier in the year. The lines were smoothed using an 11-year moving average. Choosing a different long-term average for comparison would not change the shape of the data over time.

Data source: Kunkel, 2014[39]

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INDICATOR NOTES

Changes in measurement techniques and instruments over time can affect trends. This indicator only includes data from weather stations with a consistent record of data points for the time period.

DATA SOURCES

All three figures are based on temperature data compiled by the National Oceanic and Atmospheric Administration's National Climatic Data Center, and these data are available online at: www.ncdc.noaa.gov/oa/ncdc.html. Frost timing and growing season length were analyzed by Kunkel (2014).[40]

Ragweed Pollen Season

This indicator depicts changes in the length of ragweed pollen season in the United States and Canada.

KEY POINTS

- Since 1995, ragweed pollen season has grown longer at 10 of the 11 locations studied (see Figure 1).
- The increase in ragweed season length generally becomes more pronounced from south to north. Ragweed season increased by 27 days in Saskatoon, Saskatchewan; 22 days in Winnipeg, Manitoba; 21 days in Minneapolis, Minnesota; and 19 days in Fargo, North Dakota (see Figure 1). This trend is consistent with many other observations showing that climate is changing more rapidly at higher latitudes.[41]
- The trends in Figure 1 are strongly related to changes in the length of the frost-free season and the timing of the first fall frost. Northern areas have seen fall frosts happening later than they used to, with the delay in first frost closely matching the increase in pollen season. Meanwhile, some southern stations have experienced only a modest change in frost-free season length since 1995.[42]

Allergies are a major public health concern, with hay fever (congestion, runny nose, itchy eyes) accounting for more than 13 million visits to physicians' offices and other medical facilities every year.[43] One of the most common environmental allergens is ragweed, which can cause hay fever and trigger asthma attacks, especially in children and the elderly. An estimated 26 percent of all Americans are sensitive to ragweed.[44]

Ragweed plants mature in mid-summer and produce small flowers that generate pollen. Ragweed pollen season usually peaks in late summer and early fall, but these plants often continue to produce pollen until the first frost. A single ragweed plant can produce up to a billion pollen grains in one season, and these grains can be carried long distances by the wind.[45]

Climate change can affect pollen allergies in several ways. Warmer spring temperatures cause some plants to start producing pollen earlier (see the Leaf and Bloom Dates indicator on p. 94), while warmer fall temperatures extend the growing season for other plants, such as ragweed (see the Length of Growing Season indicator on p. 80). Warmer temperatures and increased carbon dioxide concentrations also enable ragweed and other plants to produce more pollen.[46] This means that many locations could experience longer allergy seasons and higher pollen counts as a result of climate change.

ABOUT THE INDICATOR

This indicator shows changes in the length of the ragweed pollen season in 11 cities in the central United States and Canada. These locations were selected as part of a study that looked at trends in pollen season at sites similar in elevation, but across a range of latitudes from south to north. At each location, air samples have been collected and examined since at least the 1990s as part of a national allergy monitoring network. Pollen spores are counted and identified using microscopes.

Pollen counts from each station have been analyzed to determine the start and end dates of each year's ragweed pollen season. Because the length of ragweed season naturally varies from year to year, statistical techniques have been used to determine the average rate of change over time. This indicator shows the total change in season length from 1995 to 2013, which was determined by multiplying the average annual rate of change by the number of years in the period.

INDICATOR NOTES

This indicator is based on data from a limited number of cities in the central states and provinces. These cities cover a broad range from north to south, however, which allows researchers to establish a clear connection between pollen season changes and latitude.

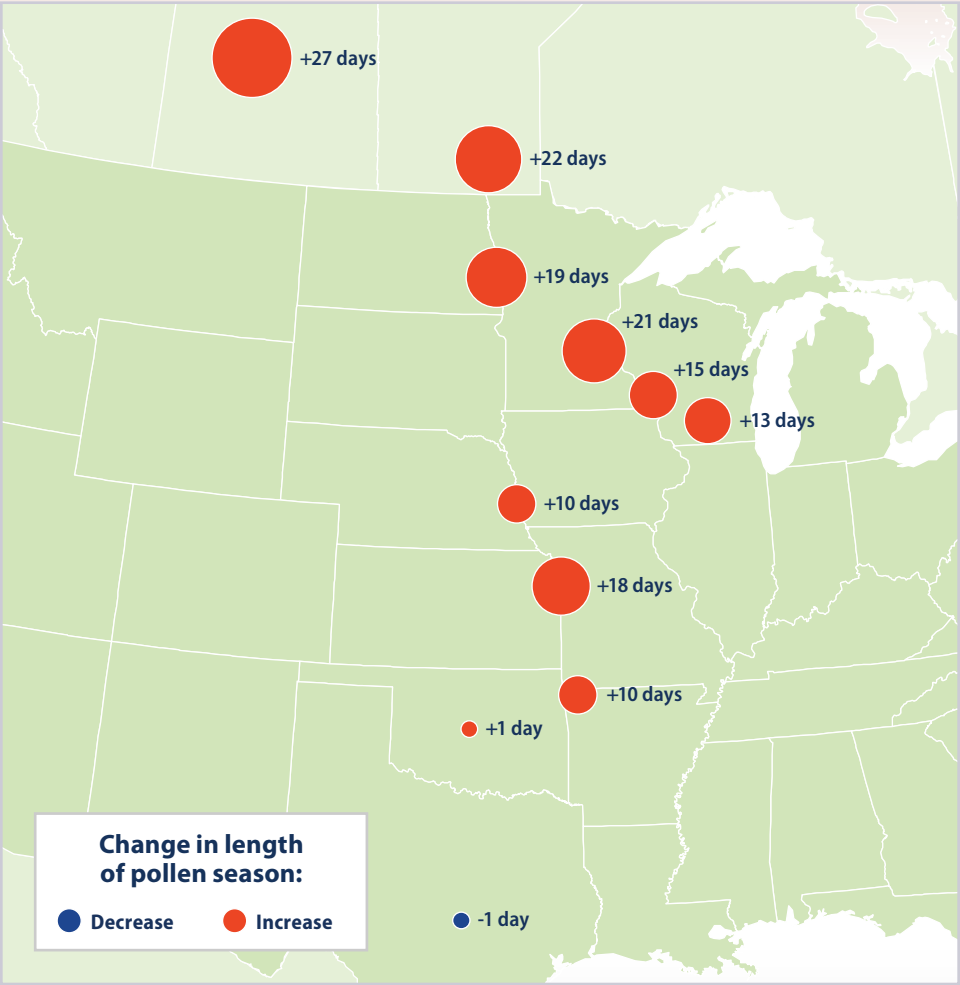
Many factors can influence year-to-year changes in pollen season, including typical local and regional variations in temperature and precipitation, extreme events such as floods and droughts, and changes in plant diversity. Adding more years of data would provide a better picture of long-term trends, but widespread data were not available prior to 1995.

This indicator does not show how the intensity of ragweed pollen season (pollen counts) might also be changing.

DATA SOURCES

Data for this indicator come from the National Allergy Bureau, which is part of the American Academy of Allergy, Asthma, and Immunology's Aeroallergen Network. Data were compiled and analyzed by a team of researchers who published a more detailed version of this analysis in a scientific journal with data through 2009.[47]

Figure 1. Change in Ragweed Pollen Season, 1995–2013



This figure shows how the length of ragweed pollen season changed at 11 locations in the central United States and Canada between 1995 and 2013. Red circles represent a longer pollen season; the blue circle represents a shorter season. Larger circles indicate larger changes.

Data source: Ziska et al., 2014[48]