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Climate Maps of the United States

• WHAT IS CLIMATE?

Weather is the day-to-day, sometimes minute-to-minute, changes in the atmosphere. Everyone has an intuitive idea what weather is. But when the time period is extended to months, seasons, years, decades, and longer, we talk about climate. Climate is the long-term state of the atmosphere. It is how you expect the atmosphere to behave.

The change of seasons is part of what climate is. In the Midwestern United States, residents expect hot, humid summer weather to gradually yield to autumn, characterized by cool mornings and toasty warm afternoons dominated by blue sky. In southern and central California, residents know that the brown hillsides that dominate the landscape from late spring into late autumn will begin to green as seasonal rains replenish soil moisture and plants begin to grow.

In Hawaii there is hardly any seasonal temperature change at all, but there are subtle differences from summer into winter in wind and rain events.

Climate is much more than seasonal change. It has been called the "average" of all weather, but it is still more. It can also be the daily, weekly, monthly, or annual range of a weather variable. Climate can be the frequency of occurrence of any weather event such as lightning. In addition there are more complex statistical measures, such as standard deviation that measures the variation about the average, that can help define climate.

Climate can be the average relative humidity at a specific hour of the day or the number of days the relative humidity drops below a certain value. The number of days snow fall exceeds a given amount gives you an idea of the frequency of traffic snarls, while the number of hours the average wind exceeds a given value during a year may help decide about the placement of a wind-powered turbine.

Climate can be defined however you need it to be. You decide what weather variables affect your project and develop a climatology that describes what to expect. The average afternoon temperature for a given place may give you an idea of how comfortable the location is but including a humidity variable and wind speed will give you a better idea of the "comfort climate."

If you are projecting the heating cost of locating a new office facility, you would want detailed information about lowest temperatures, how long the temperature is colder than a particular value, how sunny the location is, and how windy it is. Each weather variable is part of the "natural gas for heating" climatology, and each affects the demand for natural gas for heating.

In summer a "residential cooling" climatology would include the same variables as for heating along with a humidity variable to account for electrical power demand.

Think of it this way: weather is a rainy day, while climate is a rainy place. All US cities have rainy days, but Seattle has a rainy climate. Portland, ME, has occasional hot days, but Orlando, FL, has a hot climate.

• THE CLIMATE MAPS

The 42 maps in this chapter represent a detailed picture, a climatology, of what you can expect over the long term in the lower 48 states.

The data were prepared and quality-controlled by the National Climatic Data Center (NCDC) of National Oceanic and Atmospheric Administration (NOAA) for the *Climate Maps of the United States* (CLIMAPS) database. The maps were redesigned and replotted for grayscale reproduction in this volume.

If you have experience with using or creating contour maps, you may be accustomed to having a fixed data interval between contour lines. That almost never works when creating climate maps because the distribution of climate is not regular and there are many factors that complicate how

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quickly values change. The contour intervals used here are the intervals chosen by the NCDC.

Elevation is probably the most difficult complicating factor to deal with. When you examine the maps in this chapter, you will see how small some of the areas can be because of dramatic changes in climate over a short distance in mountainous terrain. For that reason it was decided not to use fill patterns because they can be very confusing when small areas are involved.

For most of the climate maps we opted to use a symmetrical shading scale ranging from white at the minimum value through medium–dark gray back to white at the maximum value. To the unaccustomed this may seem confusing, but it is standard practice in many science publications. There are a few geographical areas where maximum white and minimum white come close together, such as from the Central Valley of California into the Sierra Nevada Mountains. In areas such as this you will need to be careful to interpret the date correctly.

To help guide you in using the climate maps, many have specific values plotted for a contour or an area. Doing this is always problematic because map data can be obscured by the numbers. We carefully considered the placement of each and every number so as to minimize covering fine detail.

Not all the climate maps we prepared are in this chapter; many fit better in chapters on specific topics.

Climate maps covering sunshine, solar radiation, cloud cover, and wind variables are in Chapter 2, covering solar and wind renewable energy-generating technologies.

The climatology of US severe weather is in Chapter 4, with maps of tornado tracks, hail, and lightning occurrence, and the climatic information about Atlantic and eastern Pacific hurricanes is included in Chapter 5. There are maps dealing with specific aspects of past climate (paleoclimate) in Chapter 7. Extensive numerical information about 128 US cities is found in Chapter 10, while weather data for 321 locations outside the United States are found in Chapter 9.

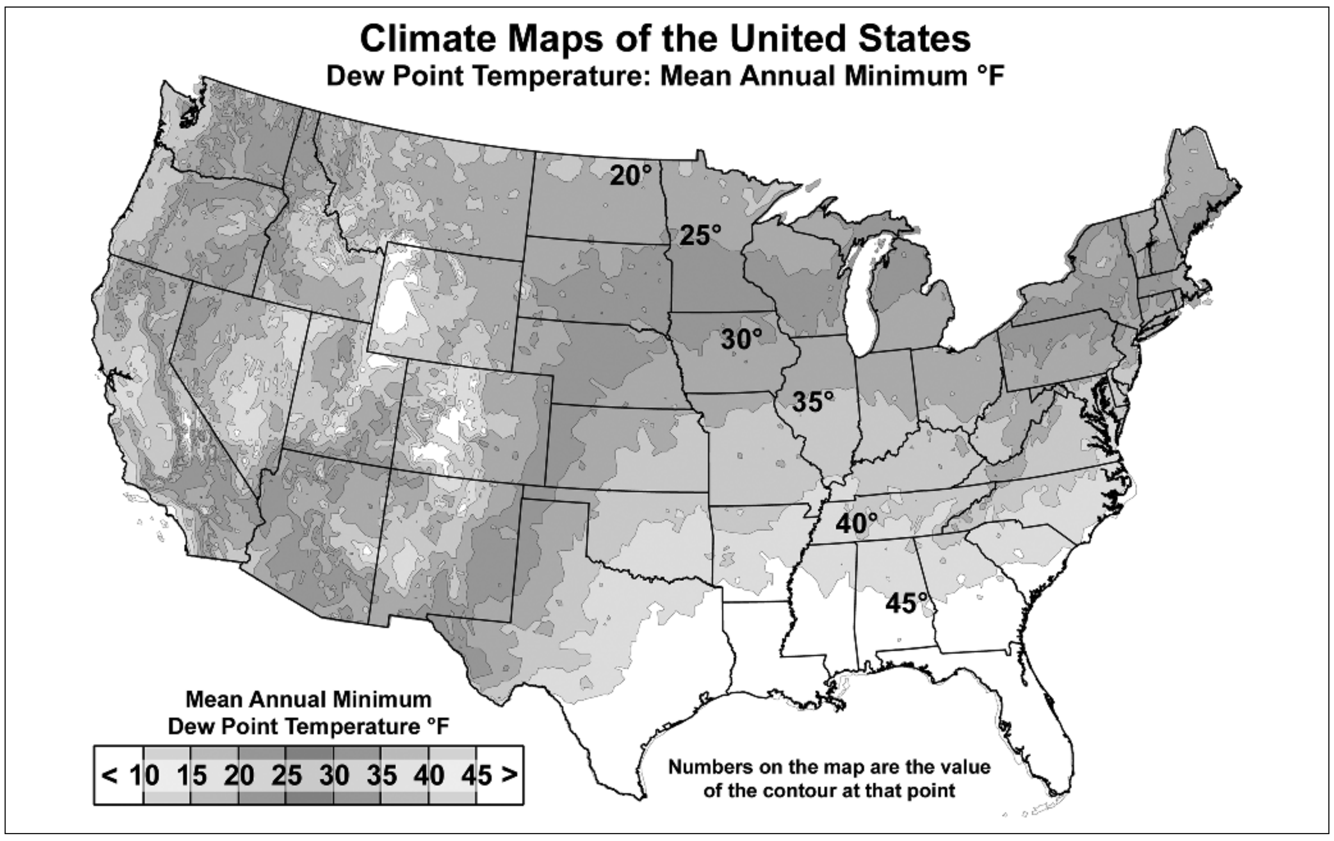

Figure 1.1 Mean annual minimum dew point temperature.

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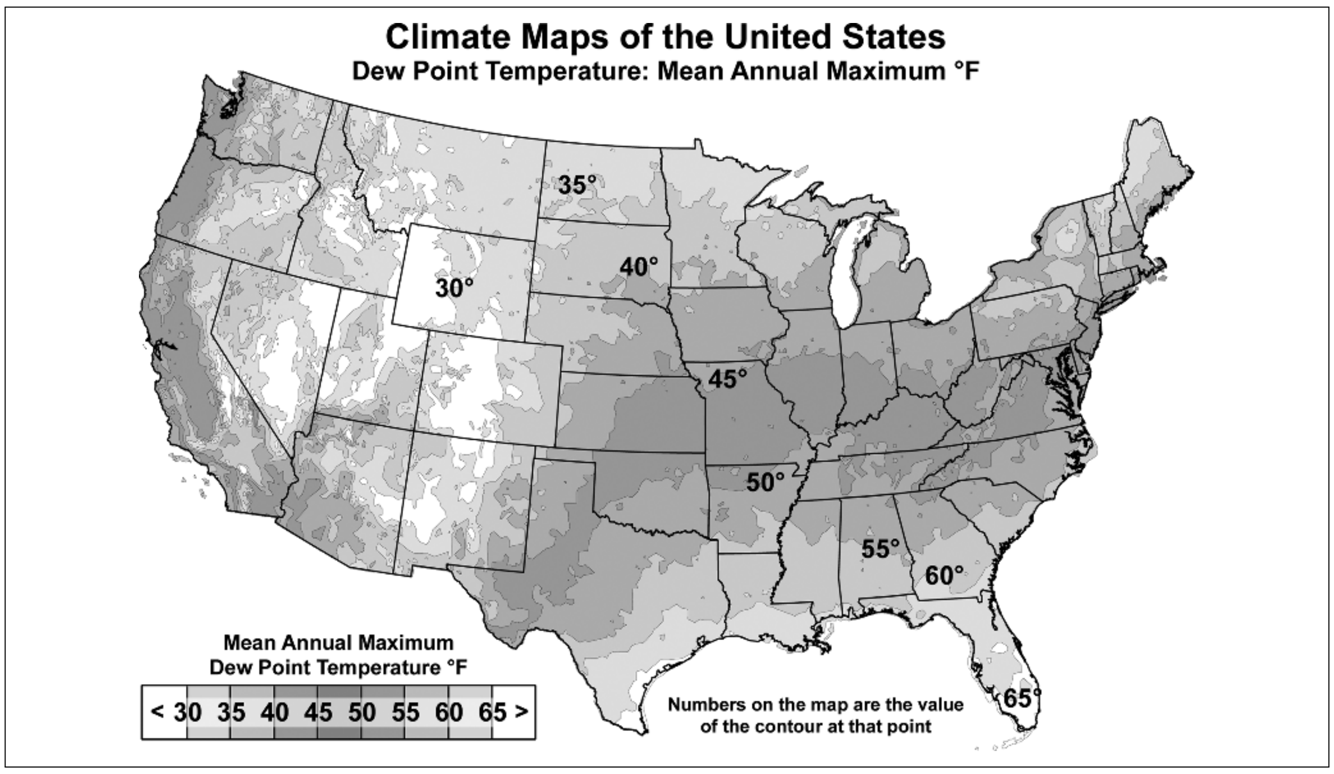

Figure 1.2 Mean annual maximum dew point temperature.

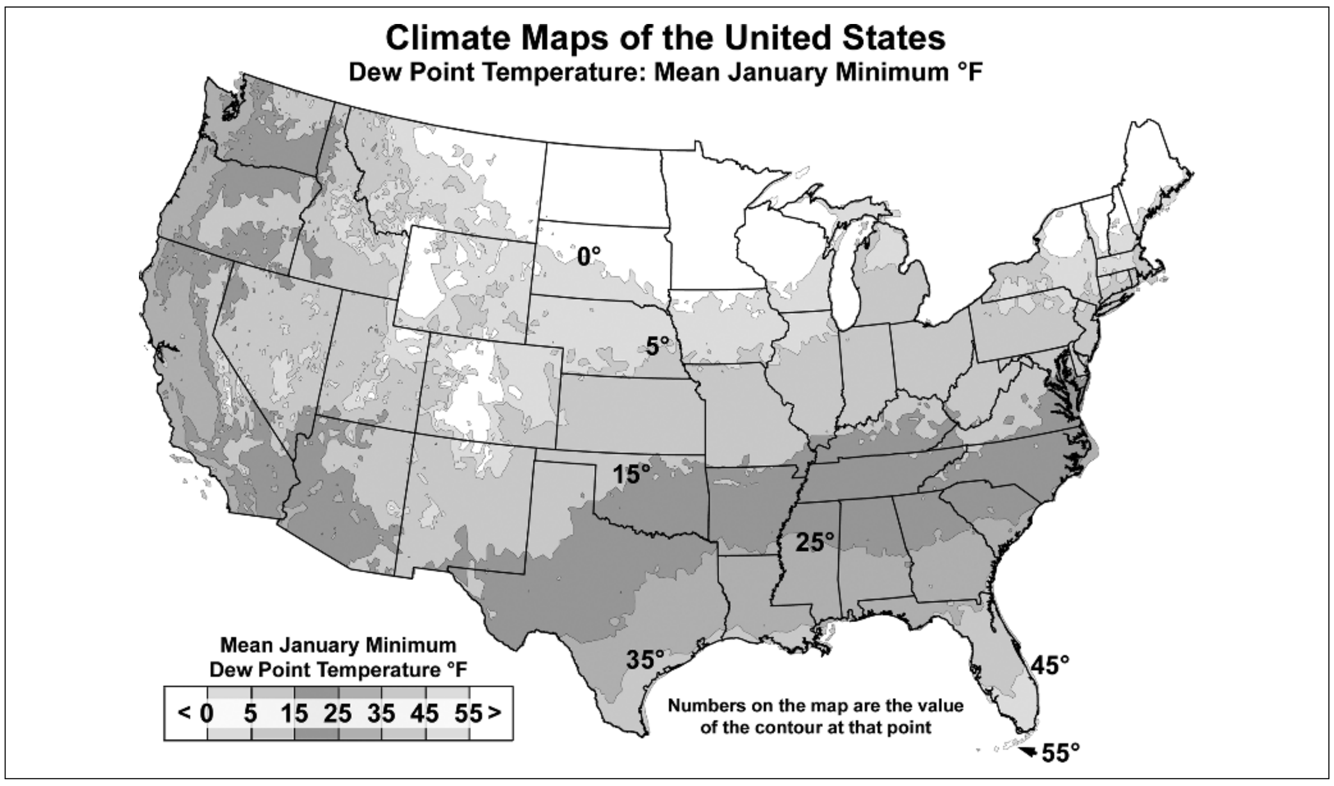

Figure 1.3 Mean January minimum dew point temperature.

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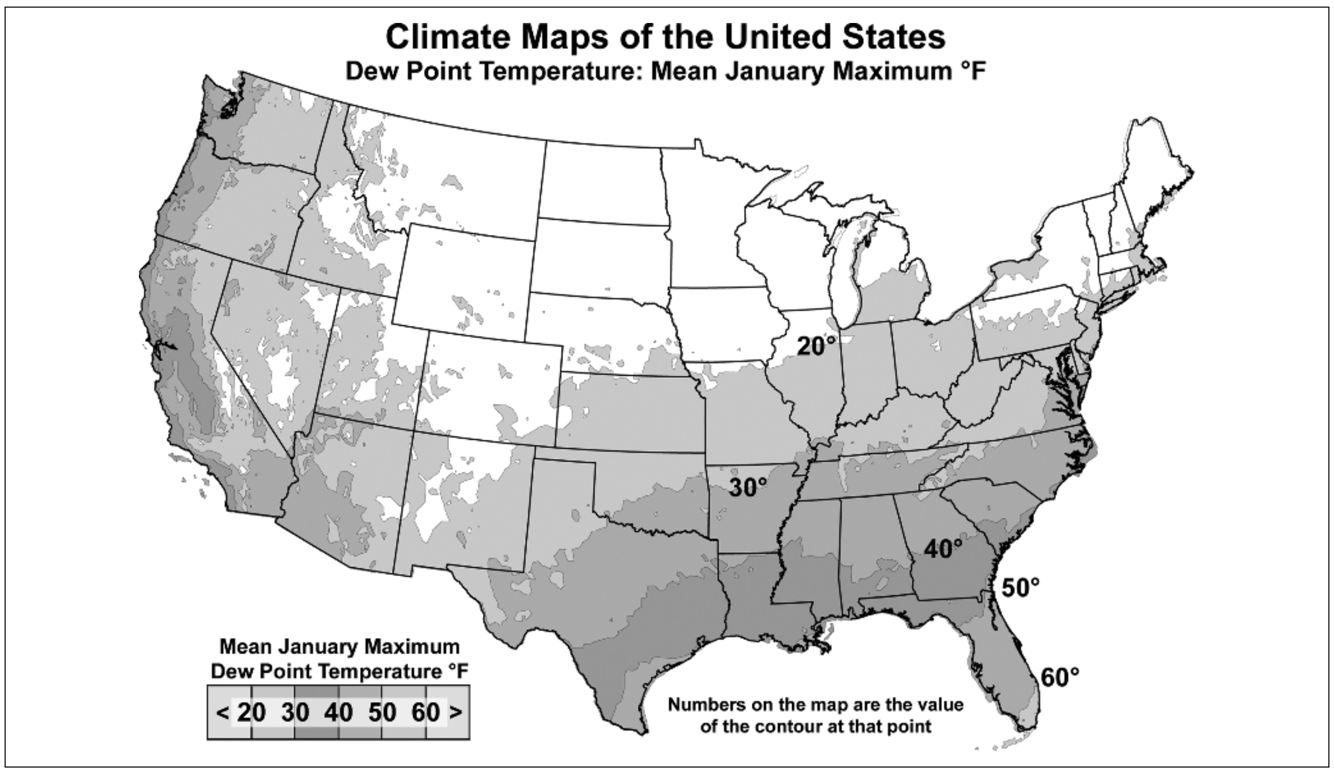

Figure 1.4 Mean January maximum dew point temperature.

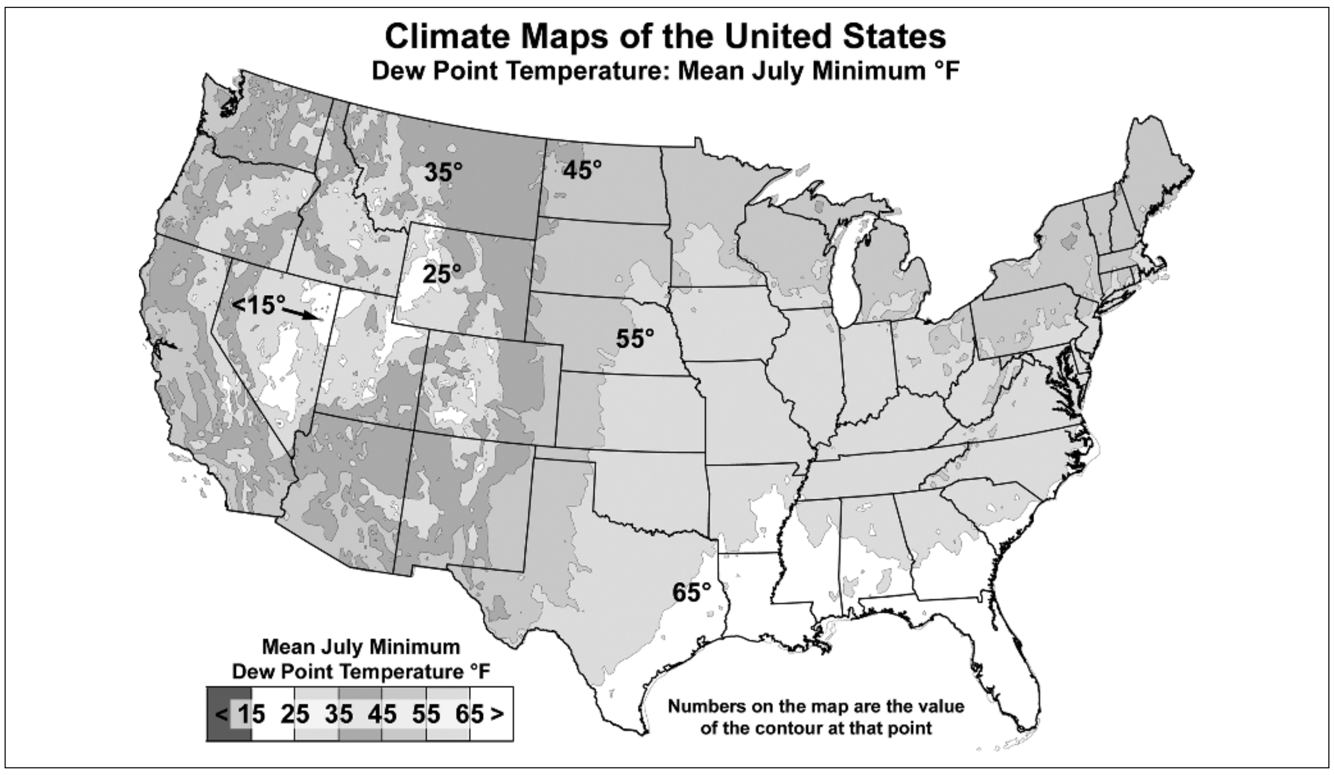

Figure 1.5 Mean July minimum dew point temperature.

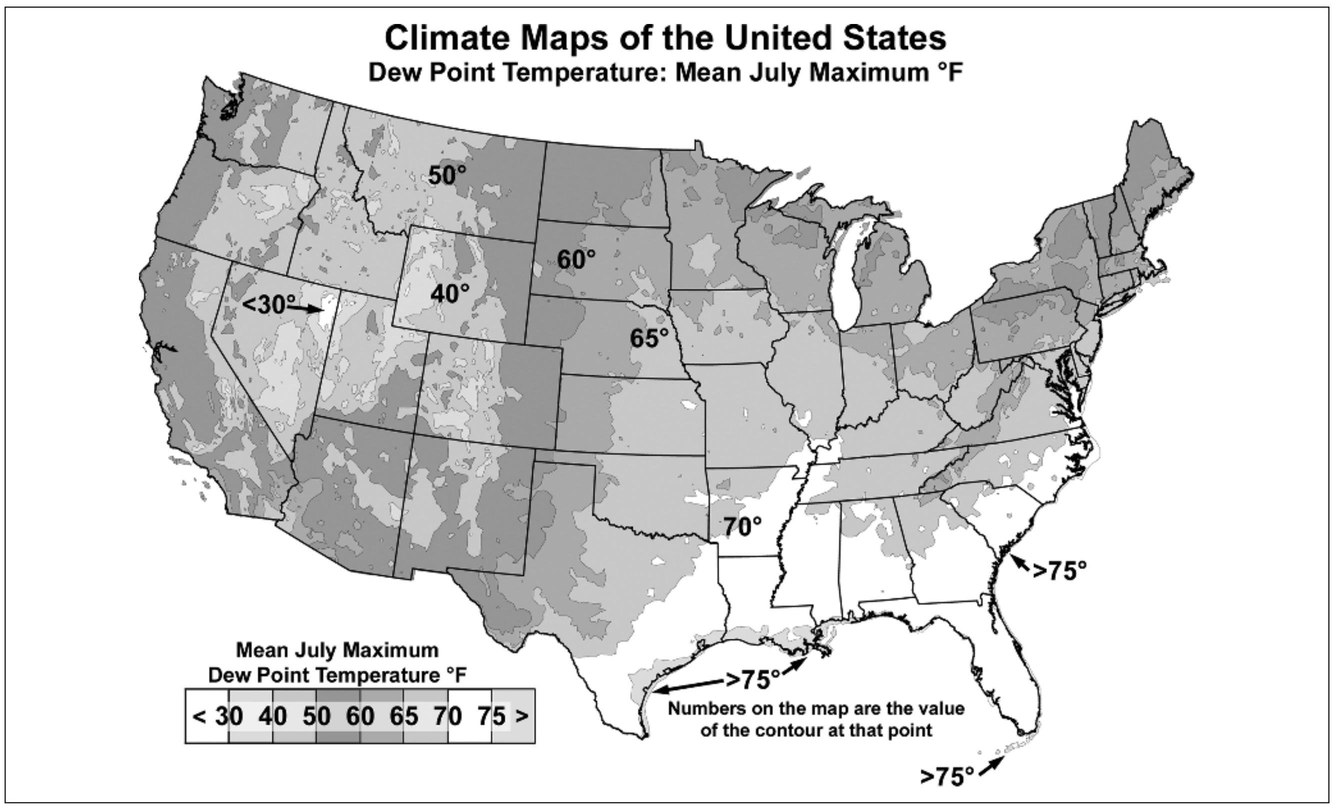

Figure 1.6 Mean July maximum dew point temperature.

Dew Point Temperature

Notes: Dew point temperature is one of the many measures of humidity. It is defined as the temperature to which a mass of air must be cooled for condensation to begin or equivalently the temperature at which a relative humidity of 100% occurs when the air is cooled. It is a measure often used by forecasters, and the smaller the difference between dew point temperature and air temperature, the higher the relative humidity. When the dew point temperature equals the ambient air temperature, the relative humidity is 100%.

When the dew point temperature reaches 60°F, nearly everyone feels the humidity, and when the dew point temperature reaches 70°F, nearly everyone says the weather is sticky. Because of that, dew point temperature along with temperature is a primary predictor of energy usage for cooling.

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Energy Use for Heating and Cooling

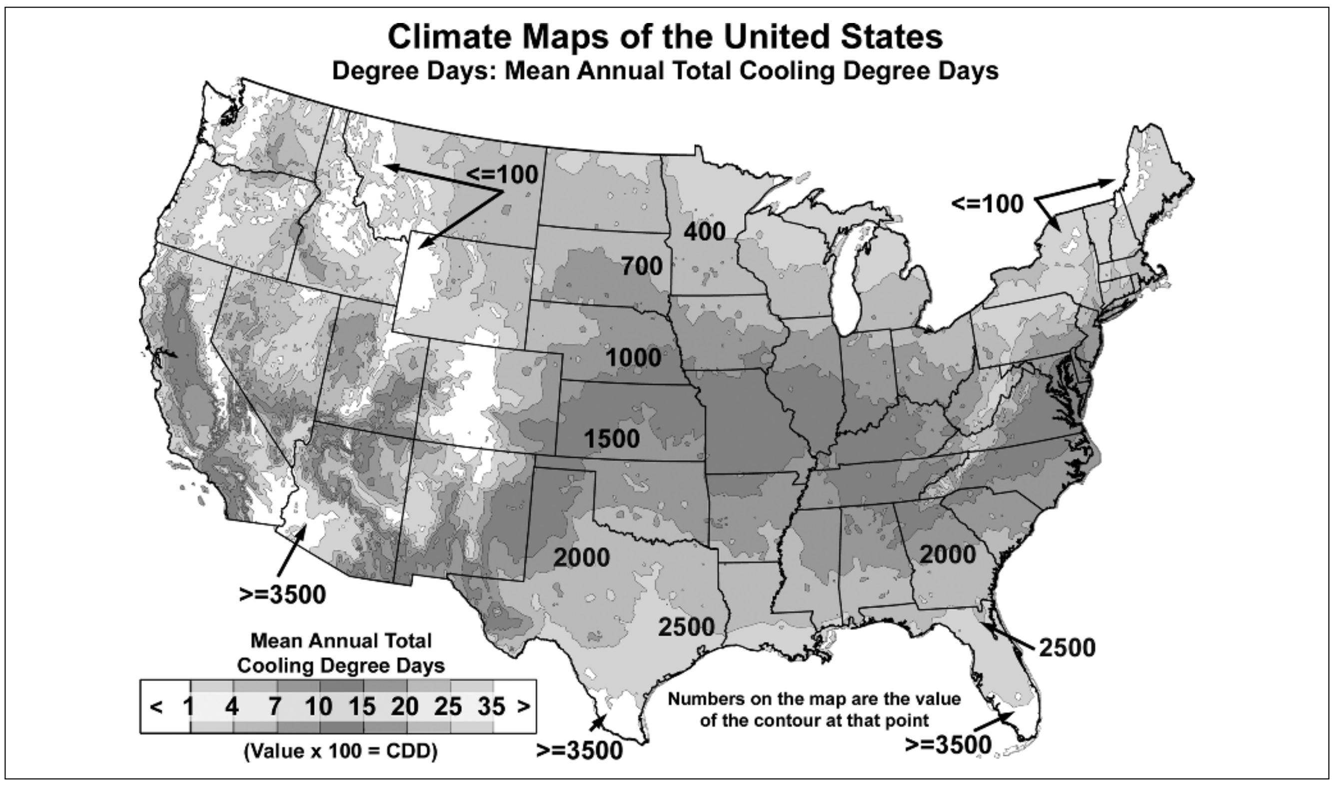

Figure 1.7 Mean annual number of cooling degree days.

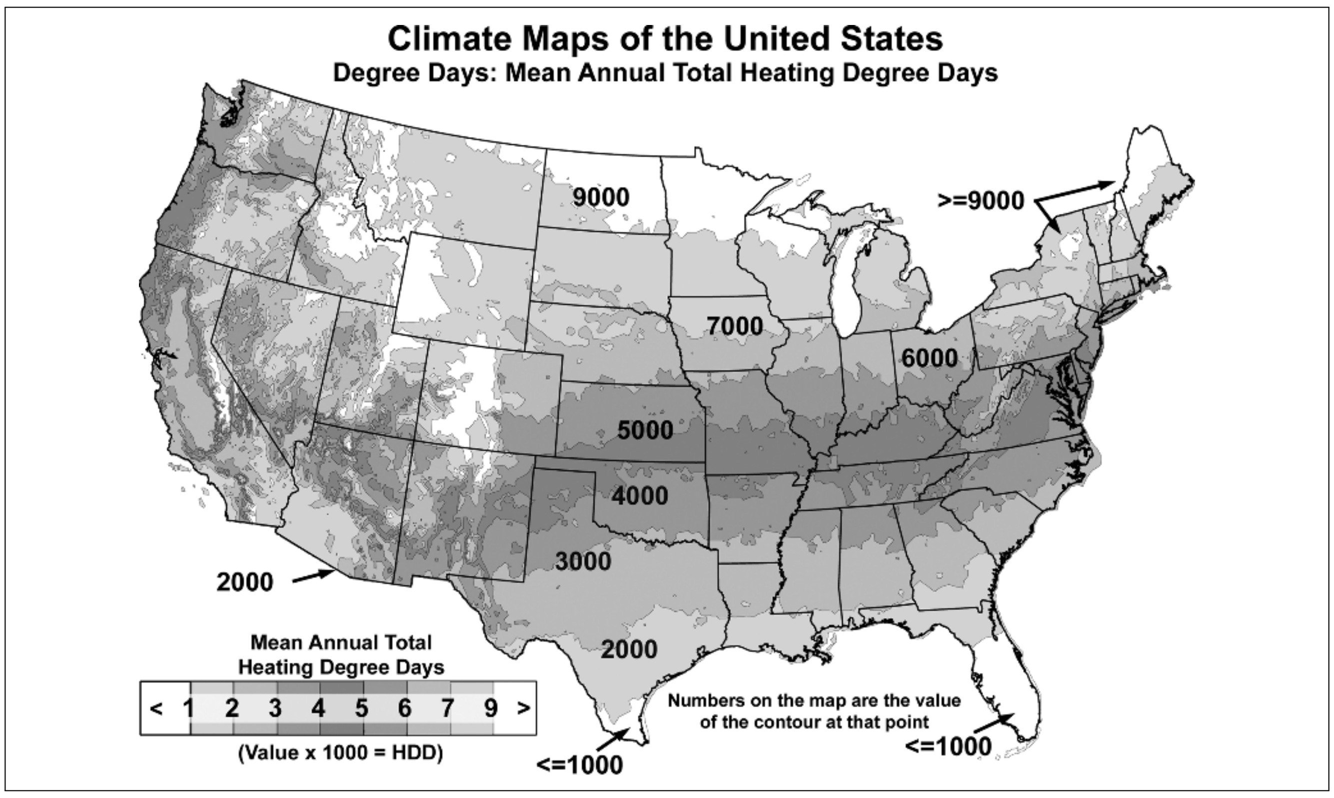

Figure 1.8 Mean annual number of heating degree days.

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Degree Days Maps

Notes: The terms "cooling degree days" and "heating degree days" are confusing and it is best to think of them as cooling units and heating units.

Using a base temperature of 65°F as the dividing point between the need for heating and the need for cooling, both heating and cooling degree days are the difference between the average daily temperature and the base temperature of 65°F. If the average temperature is warmer than 65°F, the difference in °F is the number of cooling degree days. If the average temperature is cooler than 65°F, the difference in °F is equal to the number of heating degree days.

If the high temperature for a day is 80°F and the low is 66°F, the average for the day is 73°F, which is 8°F warmer than the base temperature of 65°F, so the day adds 8 cooling degree days to the running seasonal total.

The way degree days are calculated can lead to a significant error. For example, if at midnight it is 60°F and the temperature drops to 45°F at 1:00 A.M., then for the next 22 hours, the temperature hovers at 40°F; the average temperature for the day using only the high and low is 50°F, but using the 24-hourly temperatures yields an average of 41°F, an 18% difference. Whenever there is a large temperature change early or late in a day, large errors can occur when using only the daily high and daily low to calculate average temperature. For this reason many private utilities use hourly data in forecasting and tracking electrical loads and natural gas demands.

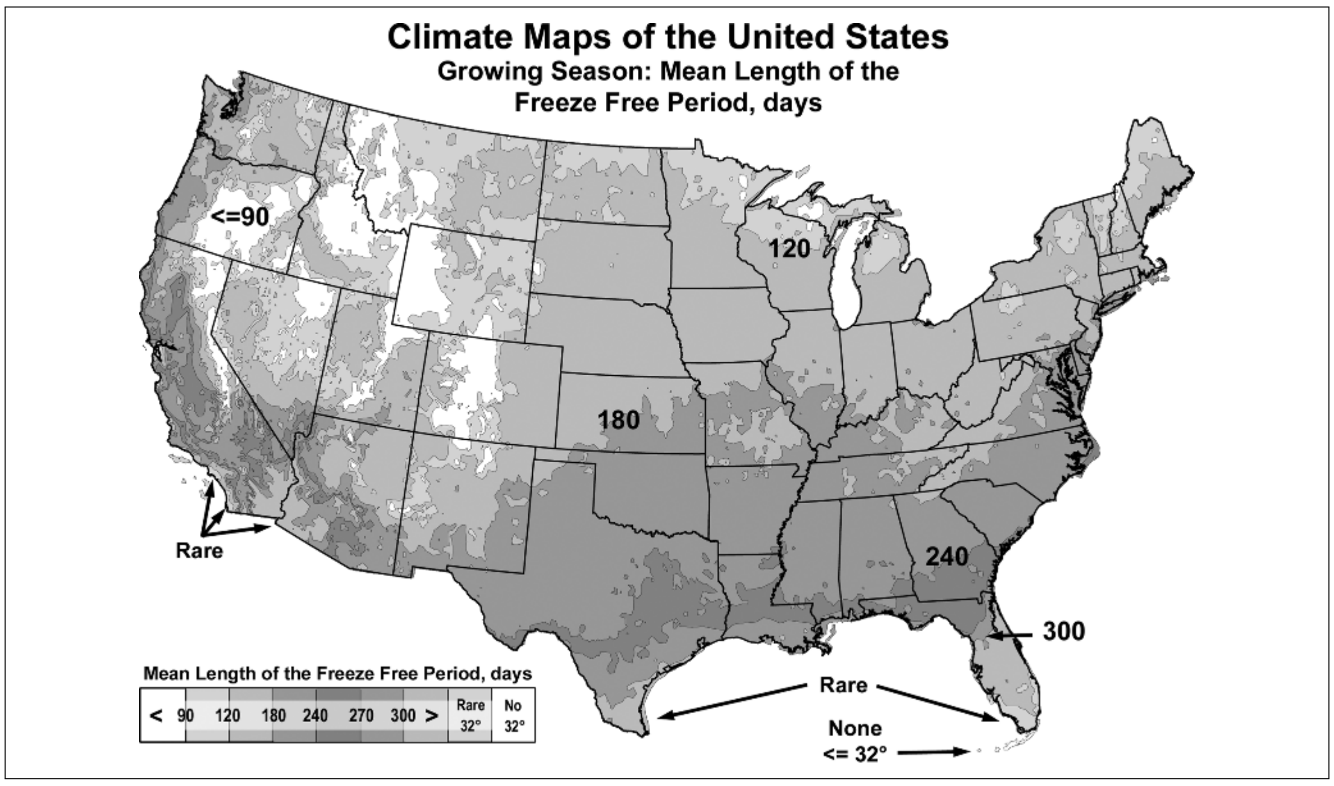

Figure 1.9 Mean length of the freeze-free period.

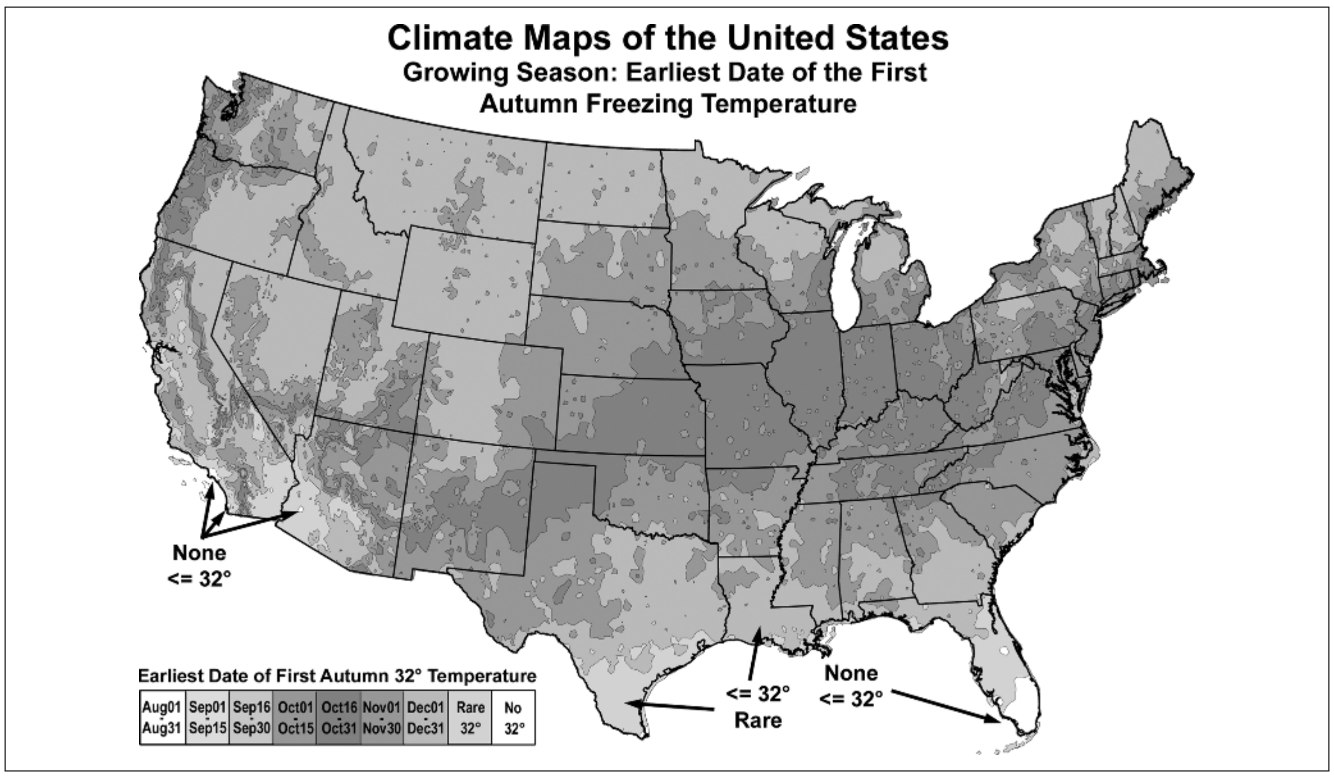

Figure 1.10 Earliest date of the first autumn freezing temperature.

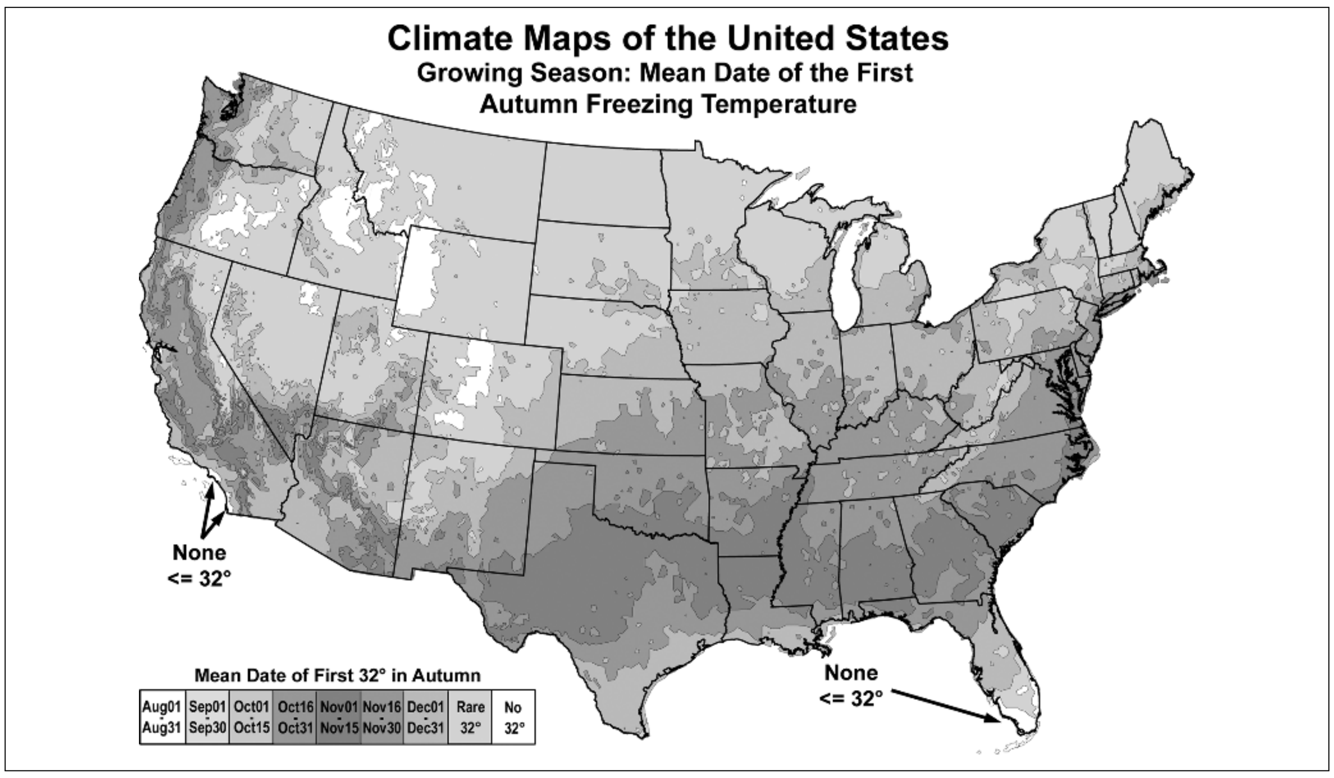

Figure 1.11 Mean date of the first autumn freezing temperature.

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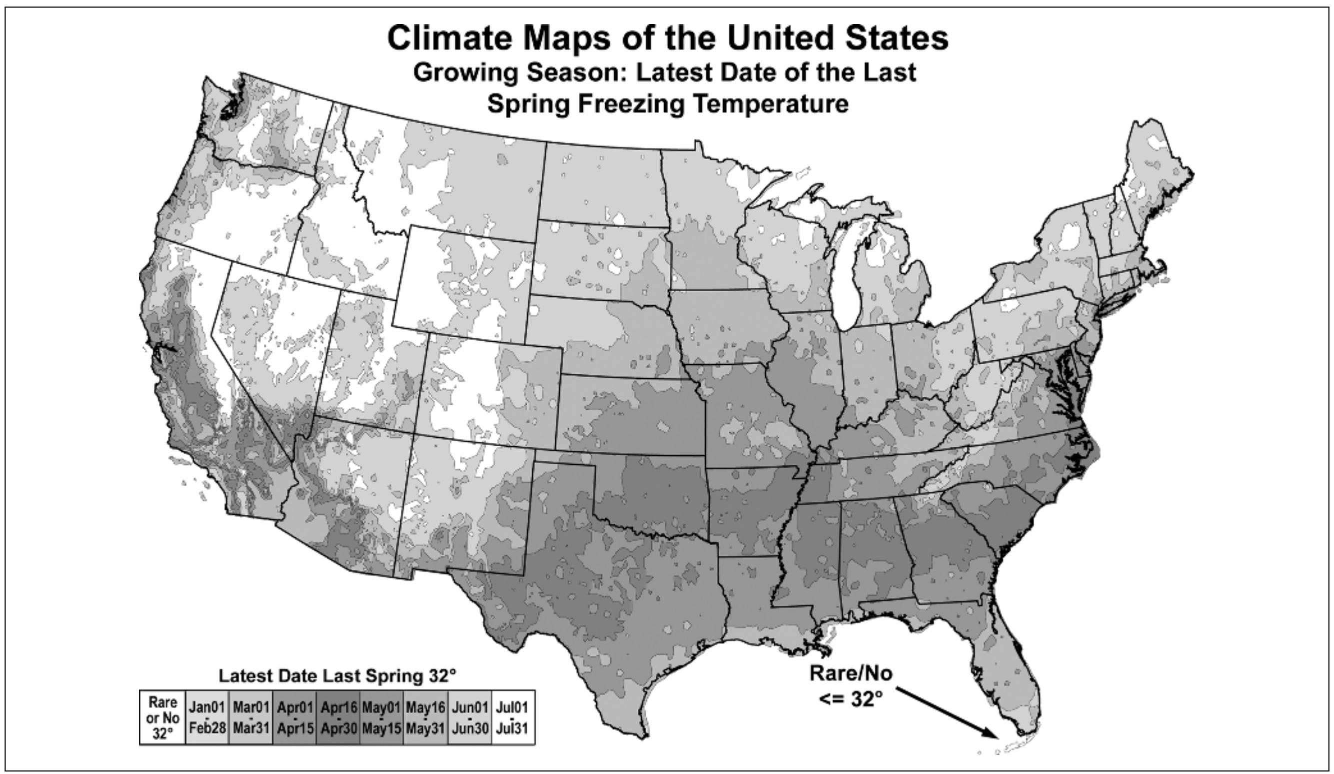

Figure 1.12 Latest date of the last spring freezing temperature.

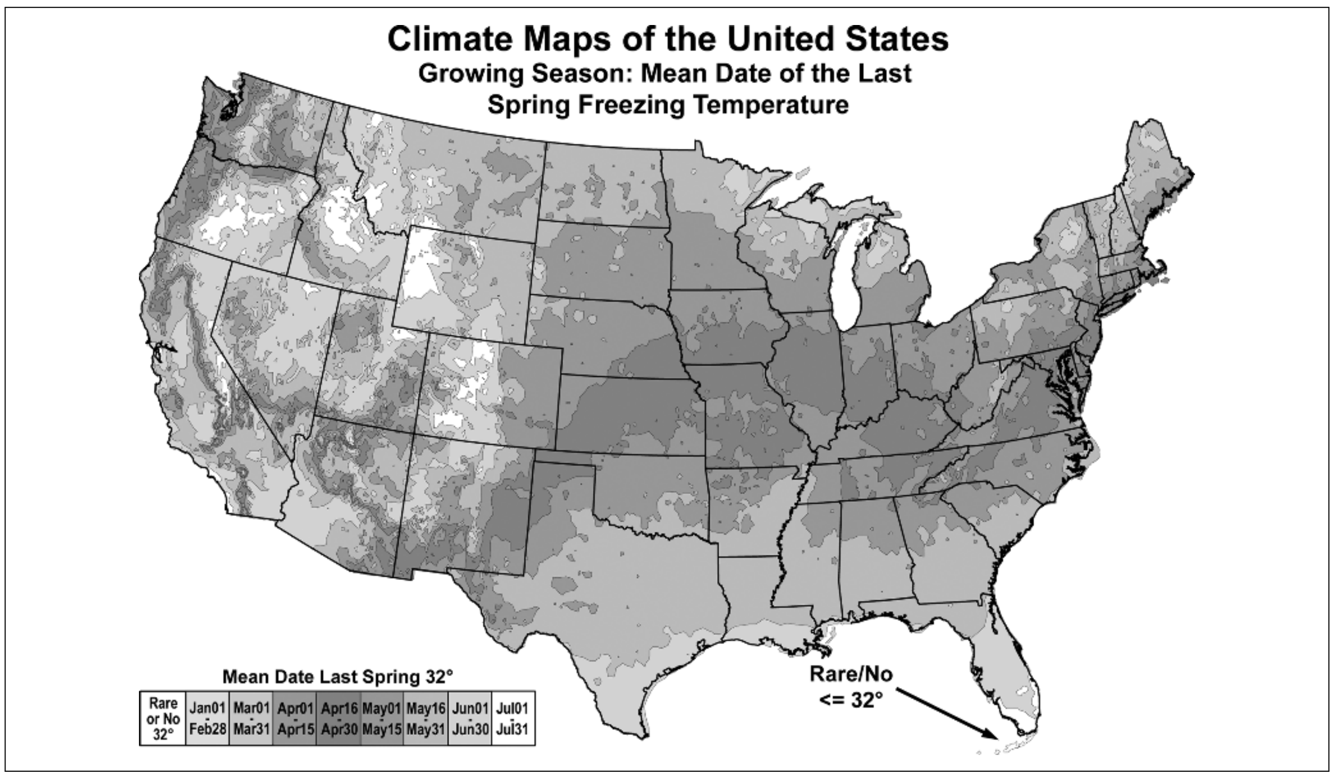

Figure 1.13 Mean date of the last spring freezing temperature.

Growing Season/Freeze–Thaw Maps

Notes: Traditionally, the growing season ends with the first-observed frost and begins again after the last frost. Frost can occur when the air temperature at thermometer height is as warm as 35°F–37°F, but because colder air is denser and settles to the ground, the temperature where the frost occurs is freezing or colder.

Instead of the term "growing season," "freeze-free period" is used, and it is defined as the number of days between the last spring freezing temperature and the first autumn freezing temperature. This use prevents confusion between the traditional definition and the one currently in use.

Just because a location reaches 32°F does not mean plant growth has stopped and plant damage has occurred. The length of time the temperature stays at or below a certain temperature threshold is also important. The freeze-free period gives a general indication of the length of the growing season, but crop-specific and site-specific information is required for practical application in agriculture.

Precipitation Maps

Notes: In the United States, measurable precipitation is defined as an amount of 0.01" or more.

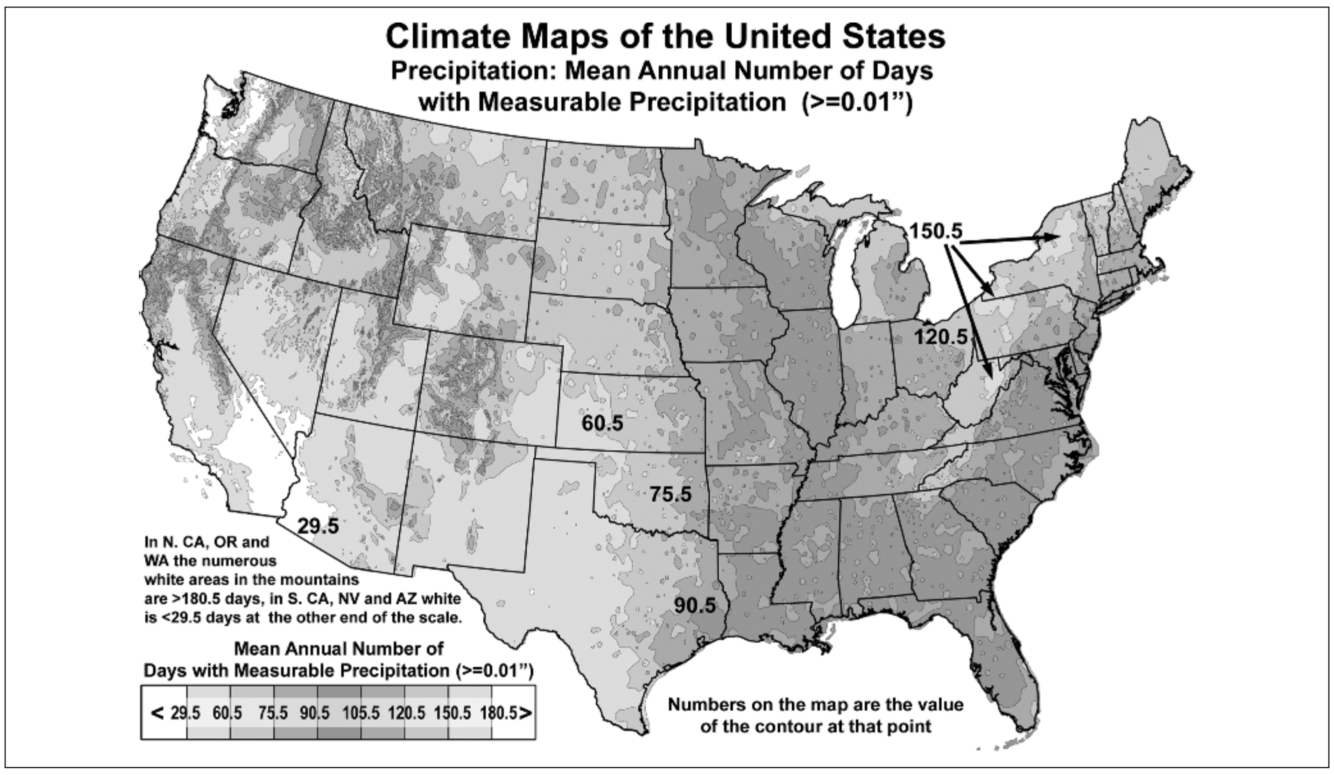

Figure 1.14 Mean annual number of days with measurable precipitation.

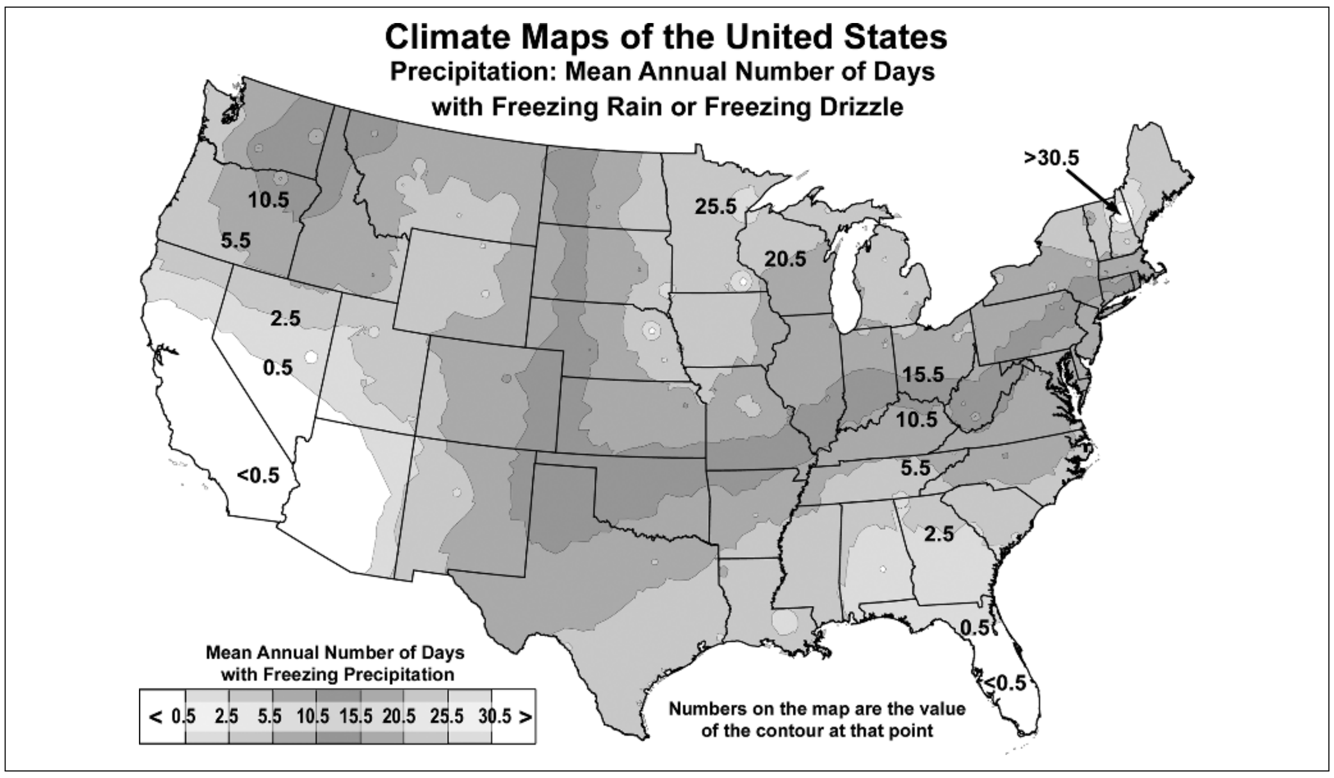

Figure 1.15 Mean annual number of days with freezing rain or freezing drizzle.

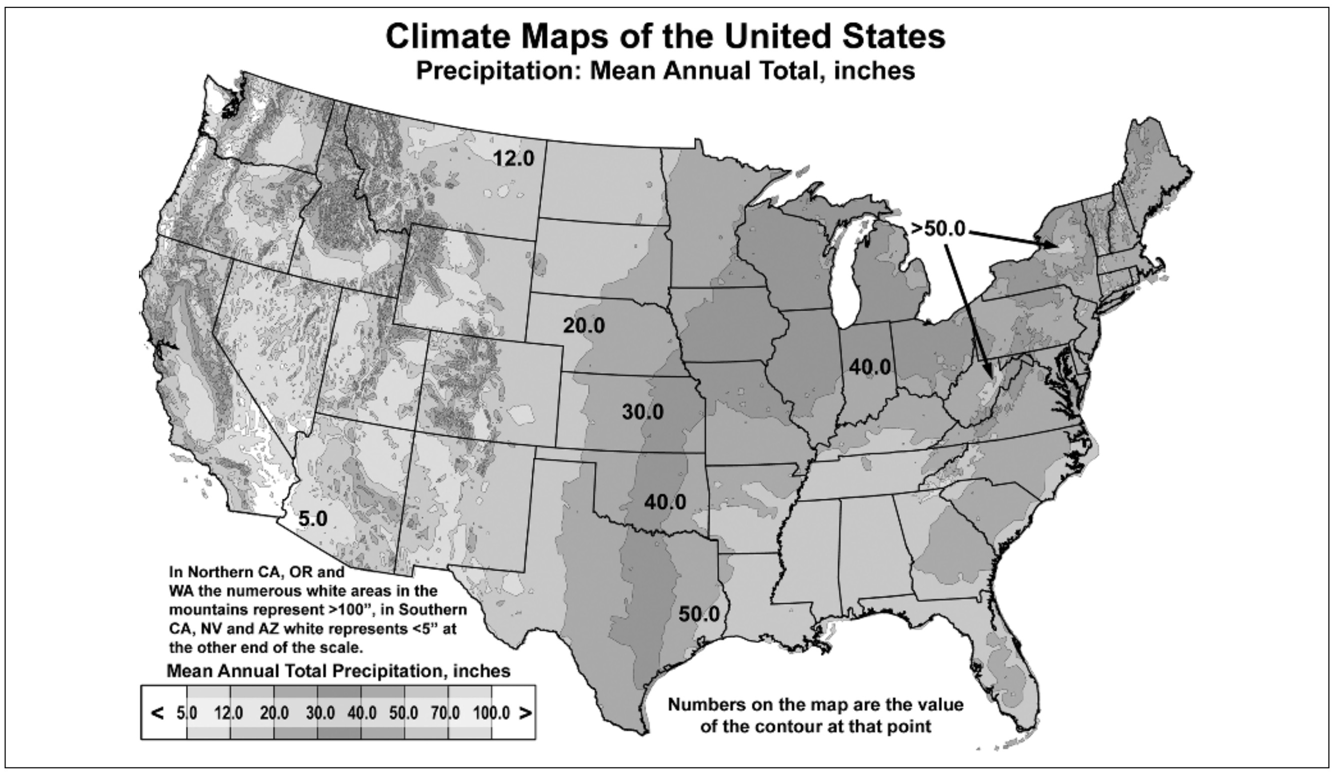

Figure 1.16 Mean annual total precipitation.

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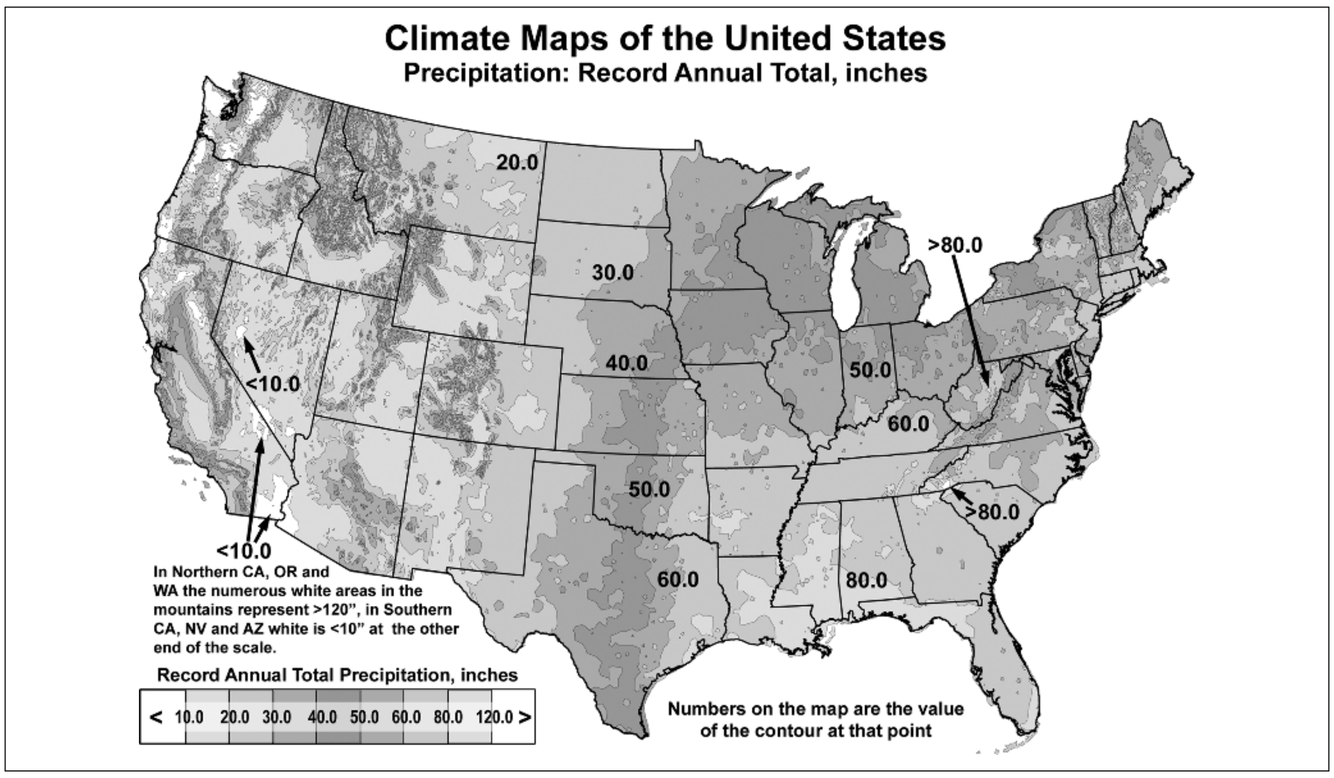

Figure 1.17 Record annual total precipitation.

Atmospheric Pressure (Sea Level)

Notes: Atmospheric pressure is always mathematically adjusted to what it would be at sea level the standard reference level in meteorology. Unadjusted pressure values are referred to as "station pressure."

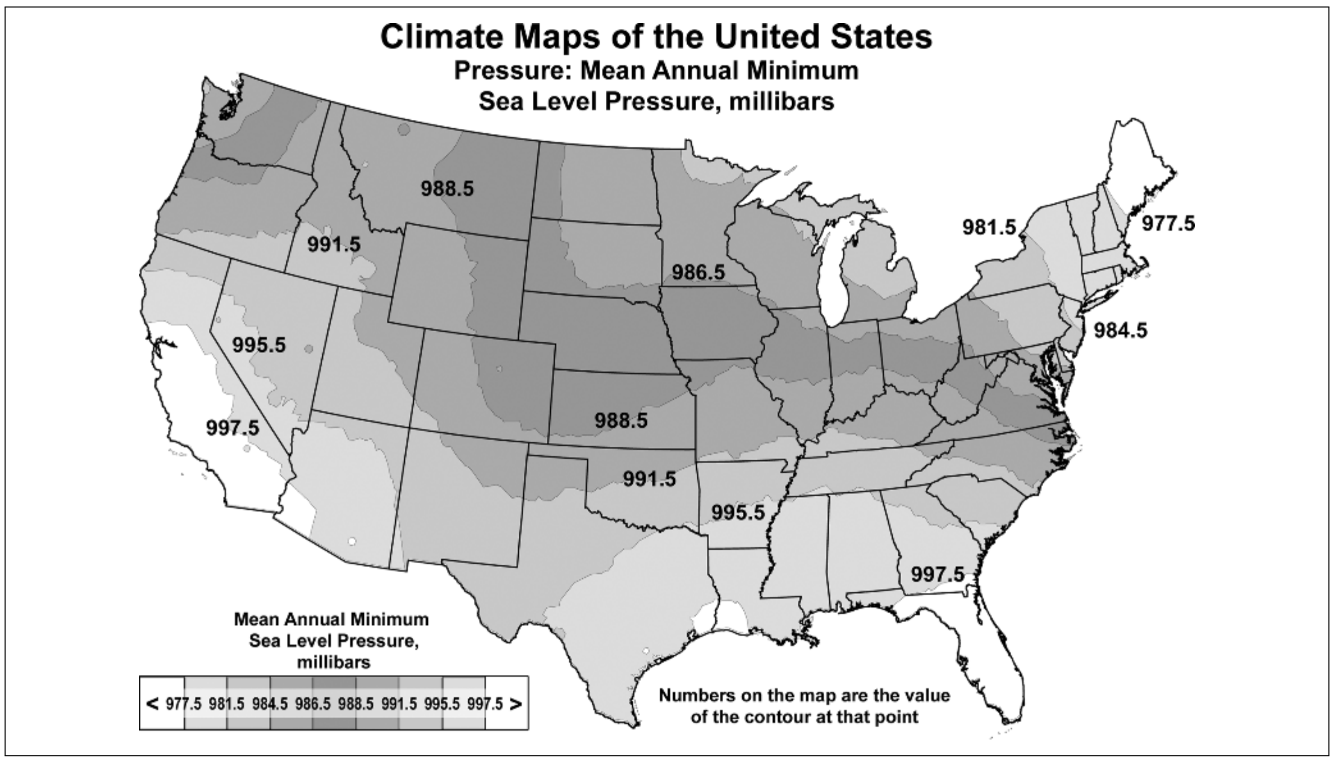

Figure 1.18 Mean annual minimum pressure.

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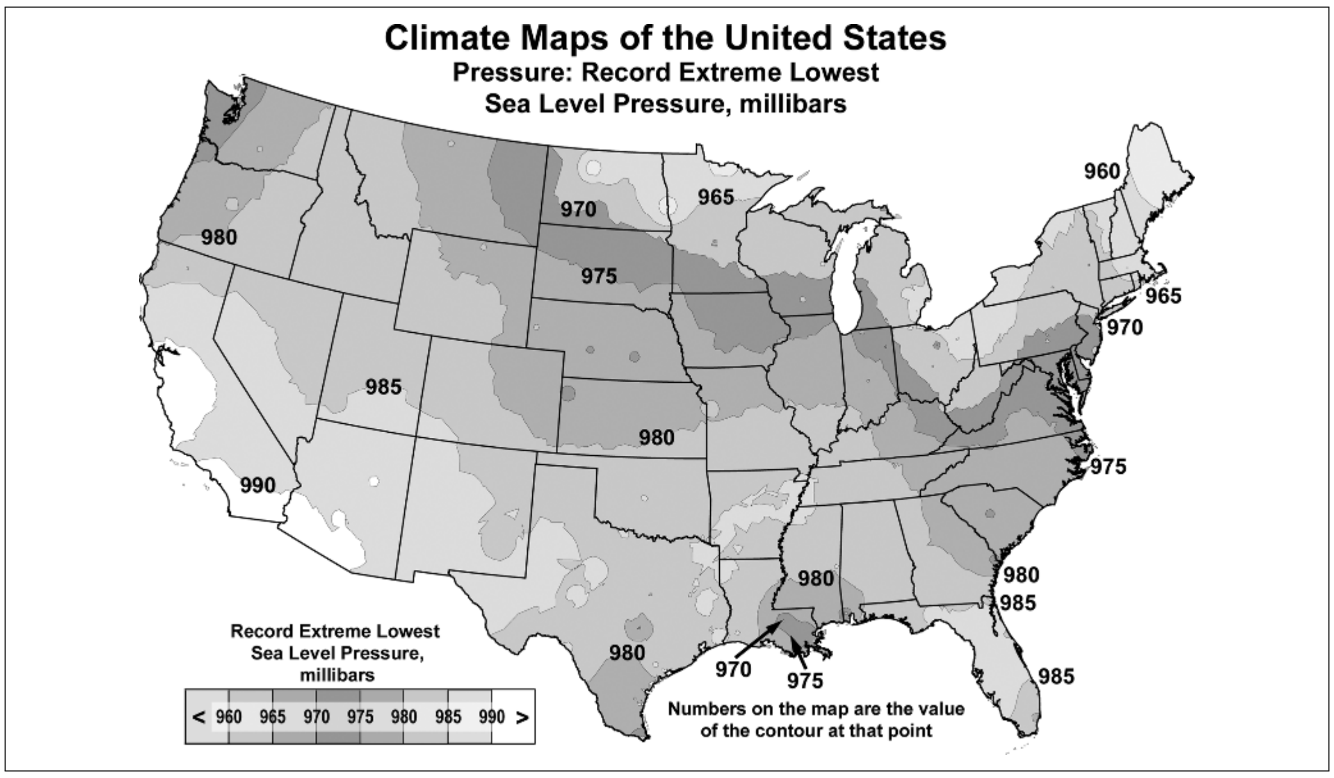

Figure 1.19 Extreme lowest pressure.

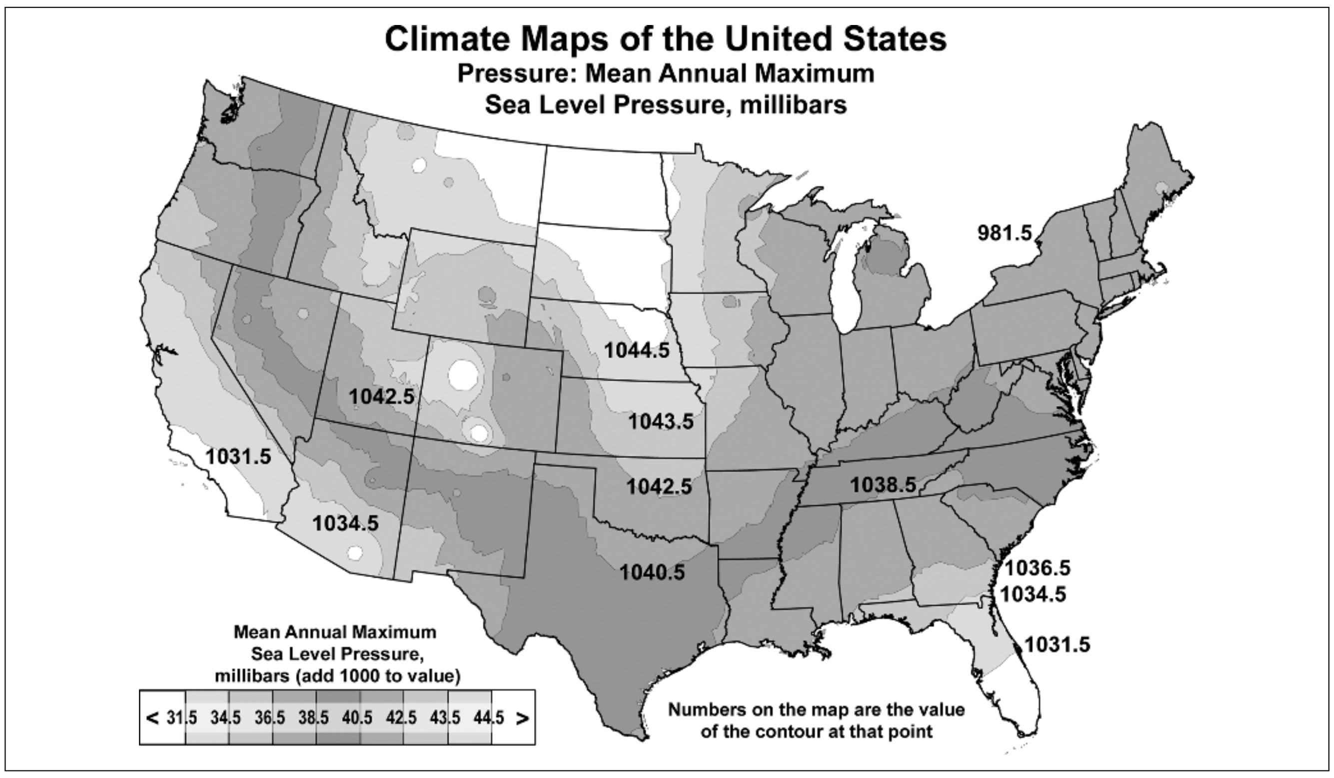

Figure 1.20 Mean annual maximum pressure.

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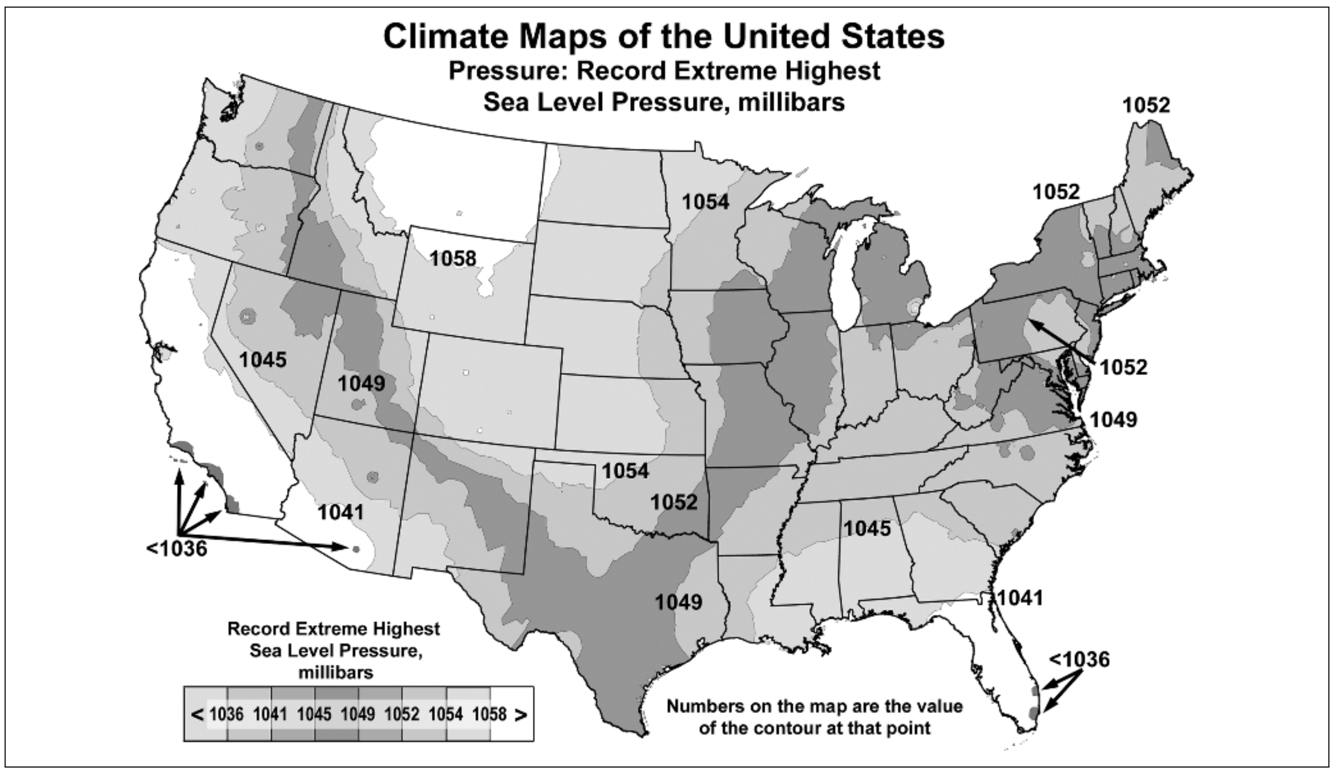

Figure 1.21 Extreme highest pressure.

Snowfall Maps

Notes: In the United States, measurable snowfall is defined as a depth of 0.1” or more.

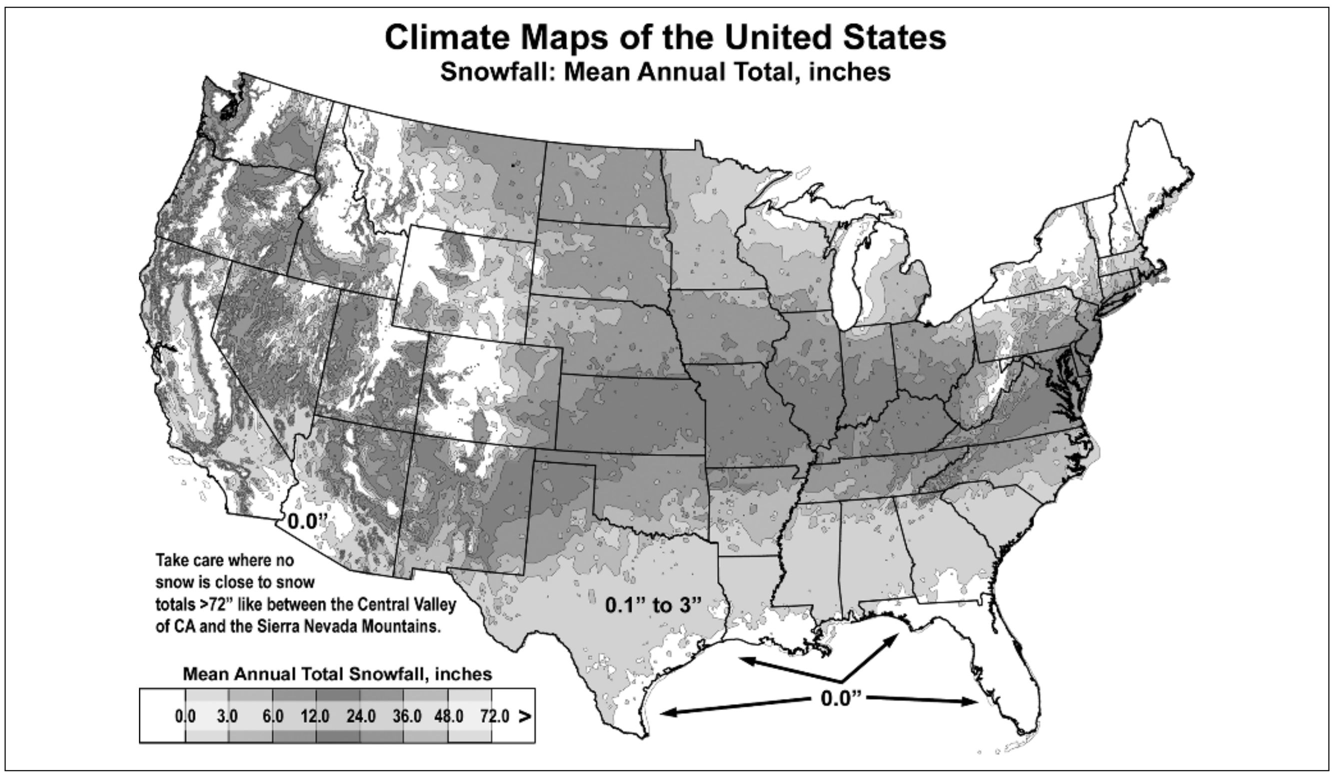

Figure 1.22 Mean annual total snowfall.

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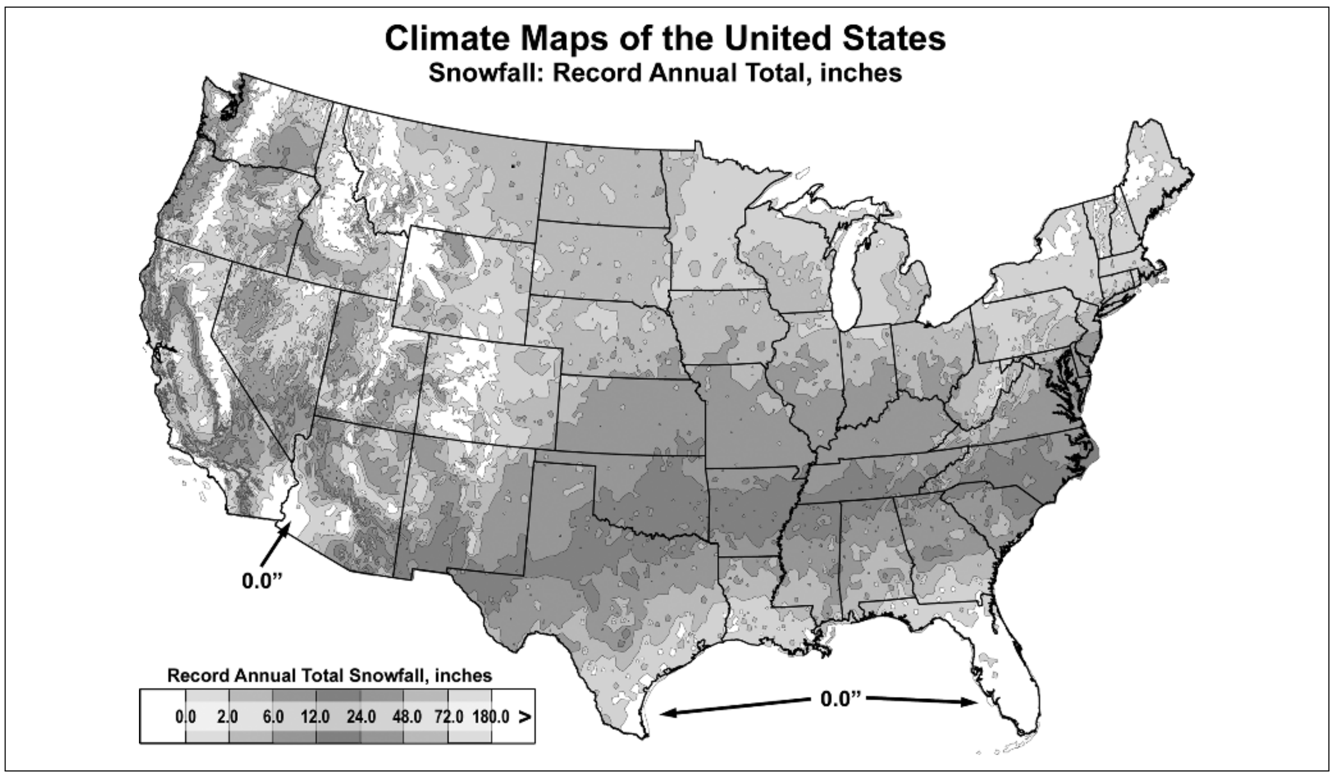

Figure 1.23 Record annual total snowfall.

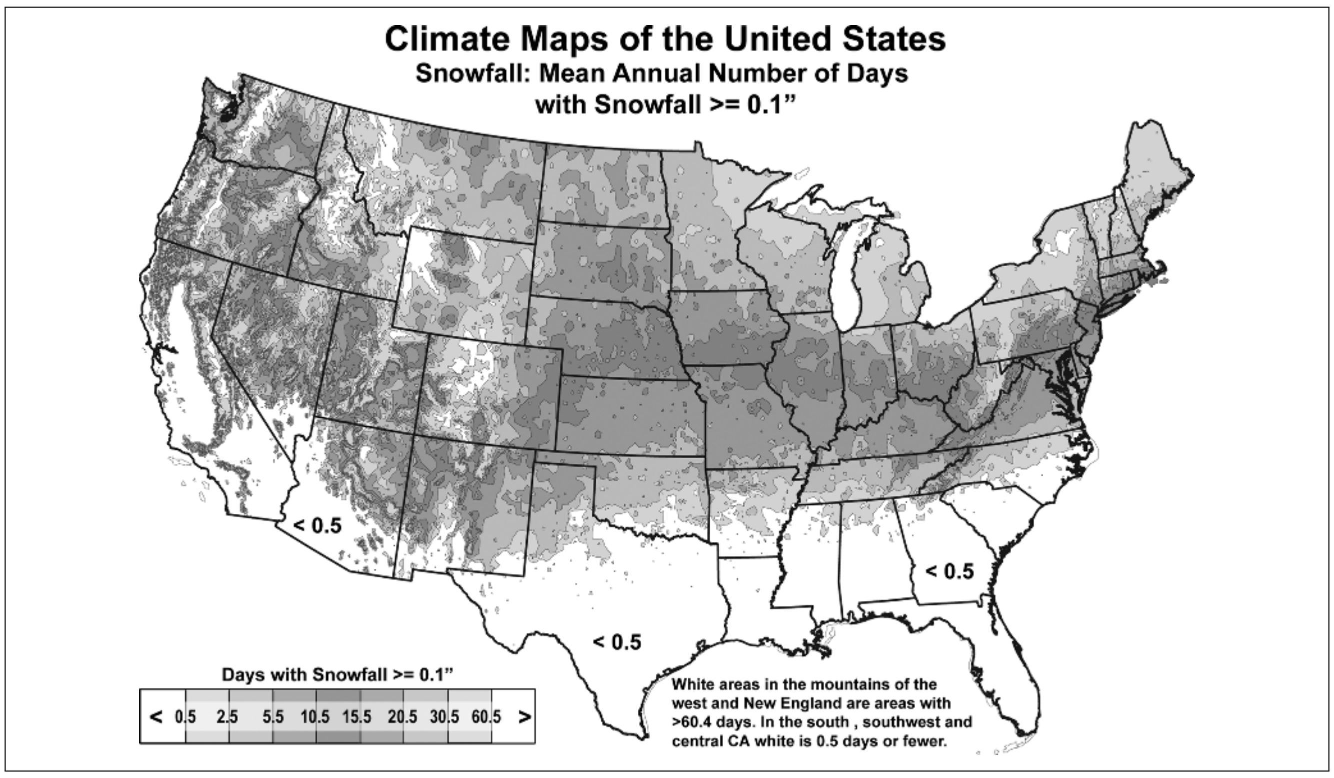

Figure 1.24 Mean annual number of days with snowfall of 0.1” or more.

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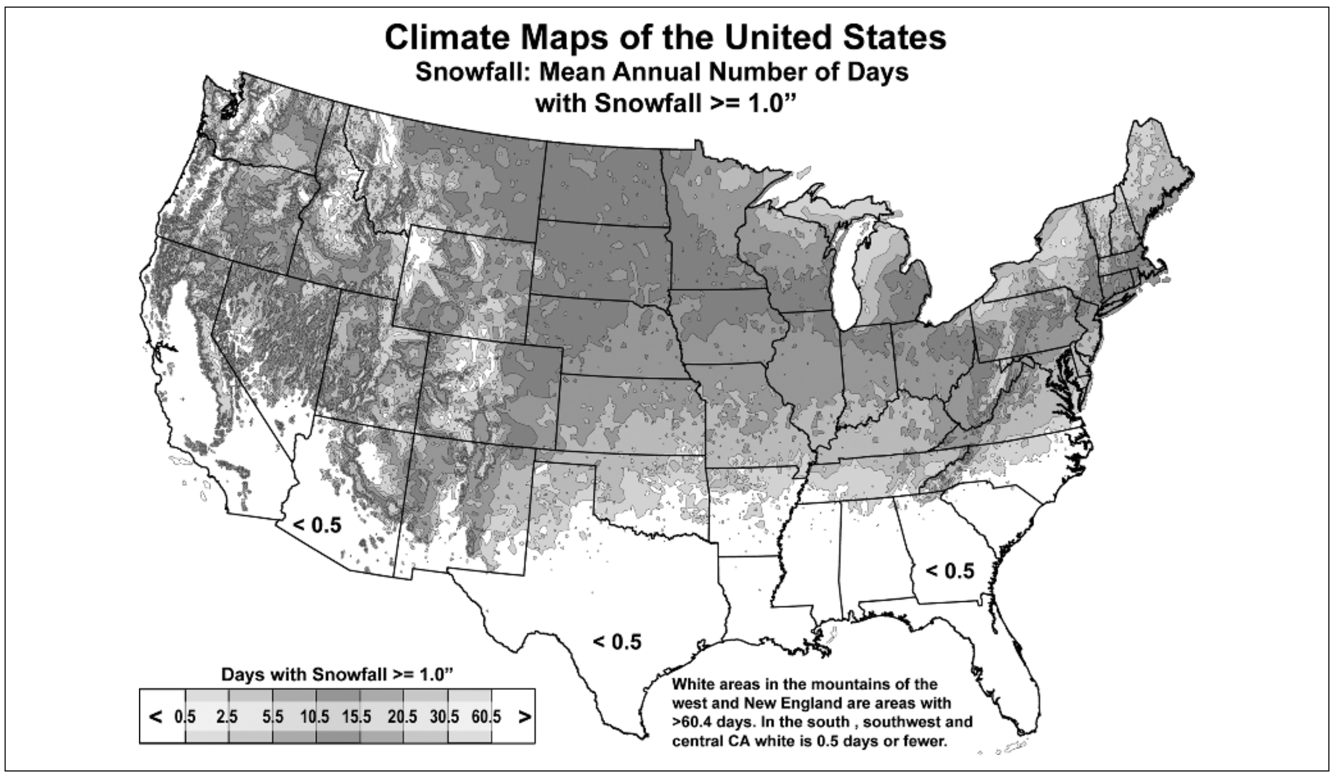

Figure 1.25 Mean annual number of days with snowfall of 1" or more.

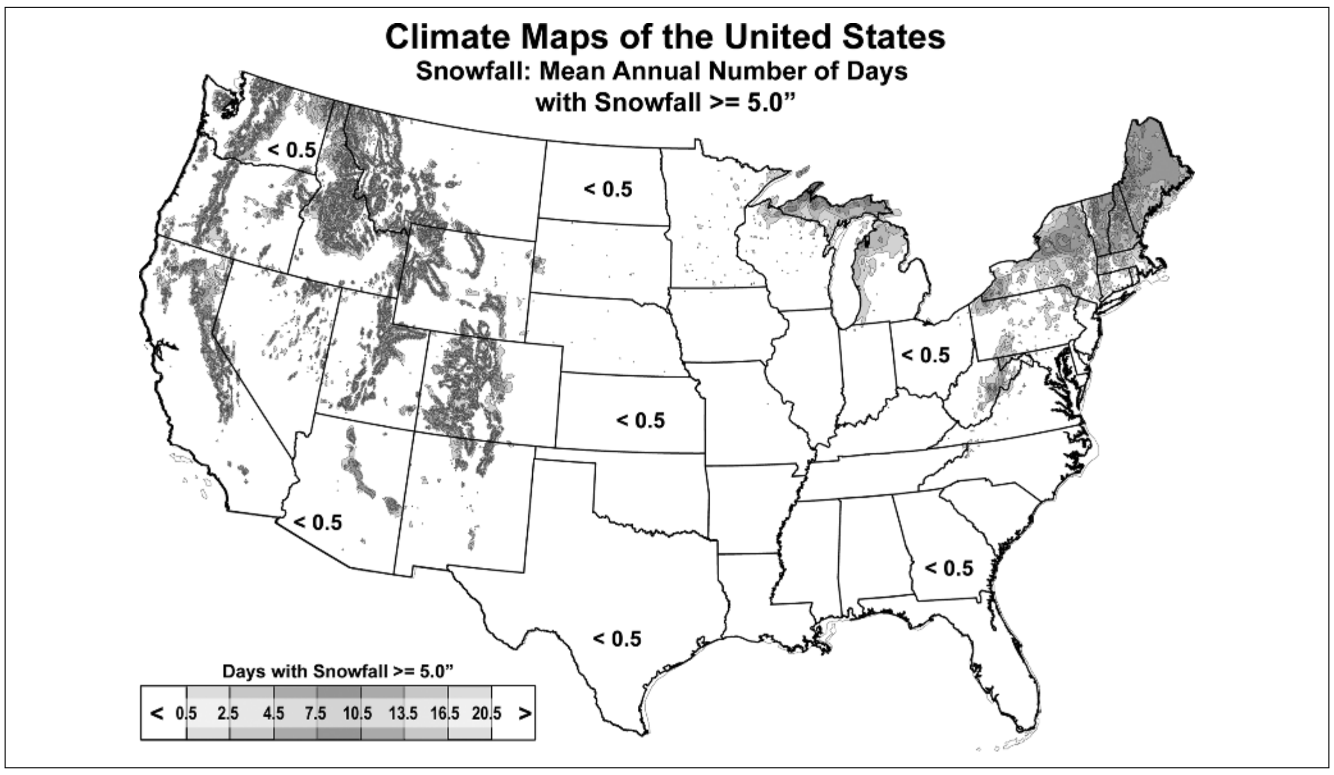

Figure 1.26 Mean annual number of days with snowfall of 5" or more.

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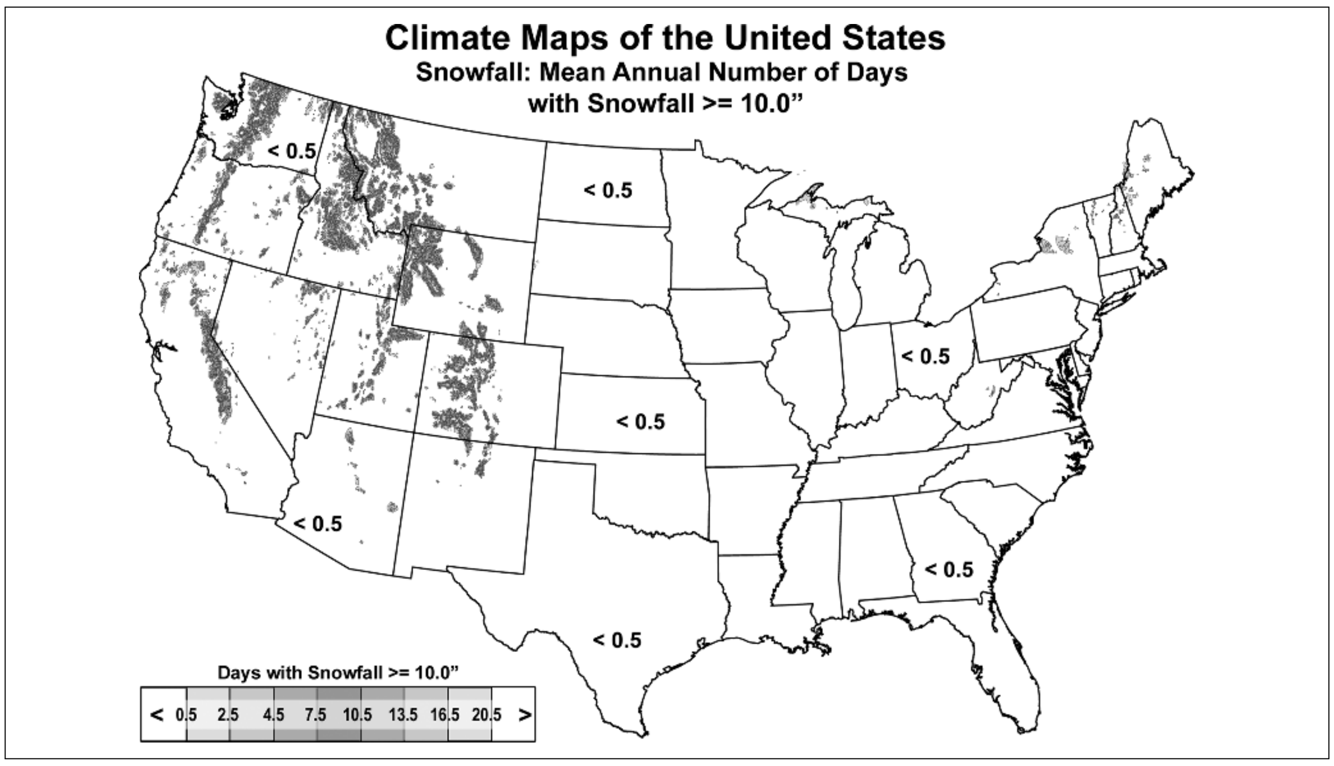

Figure 1.27 Mean annual number of days with snowfall of 10" or more.

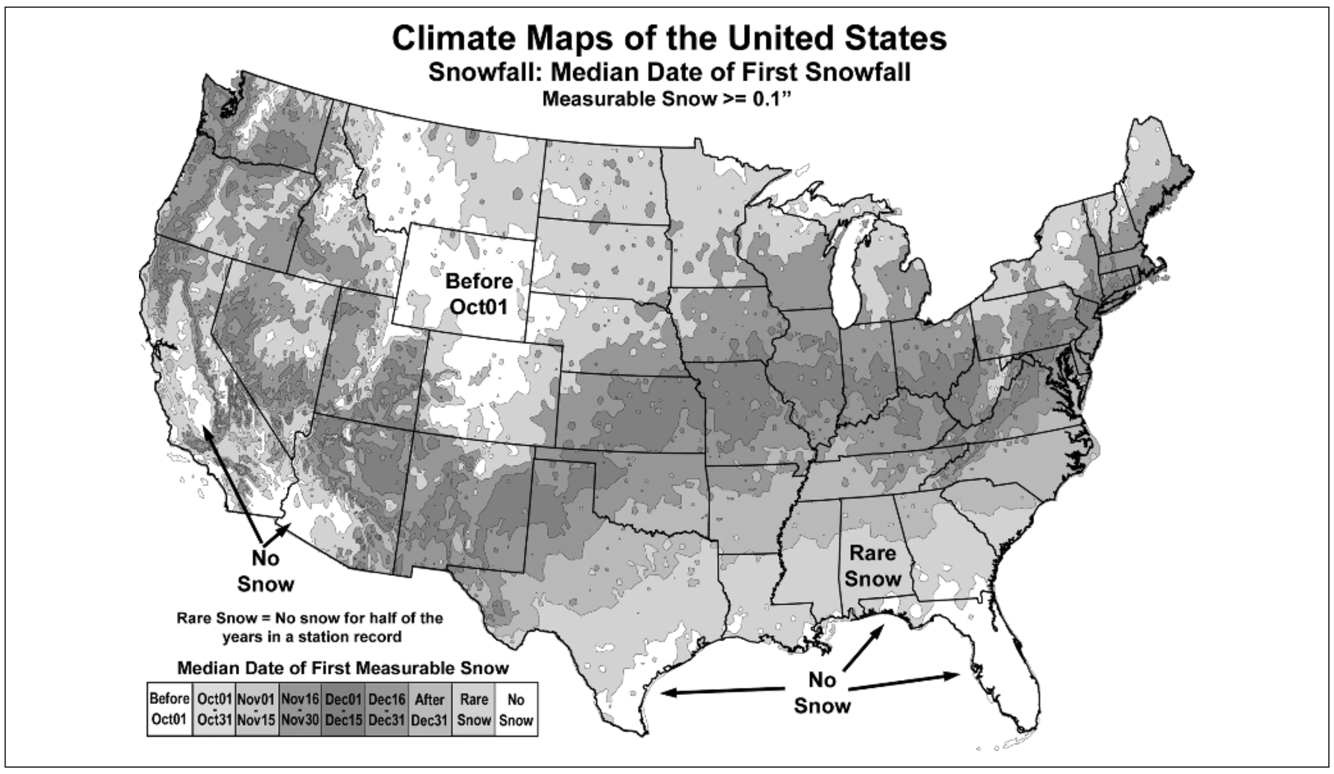

Figure 1.28 Median date of first measurable ($\geq$0.1") snowfall.

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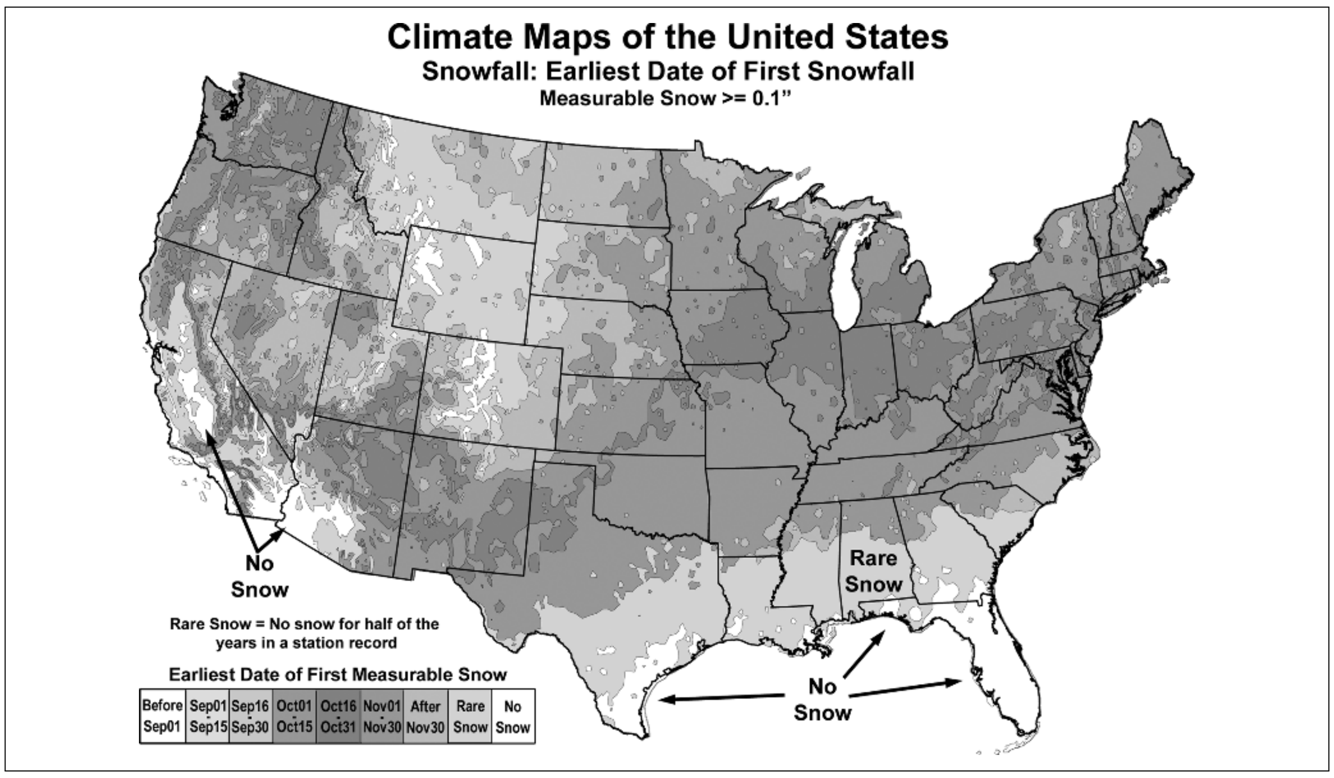

Figure 1.29 Extreme first date of first measurable snowfall.

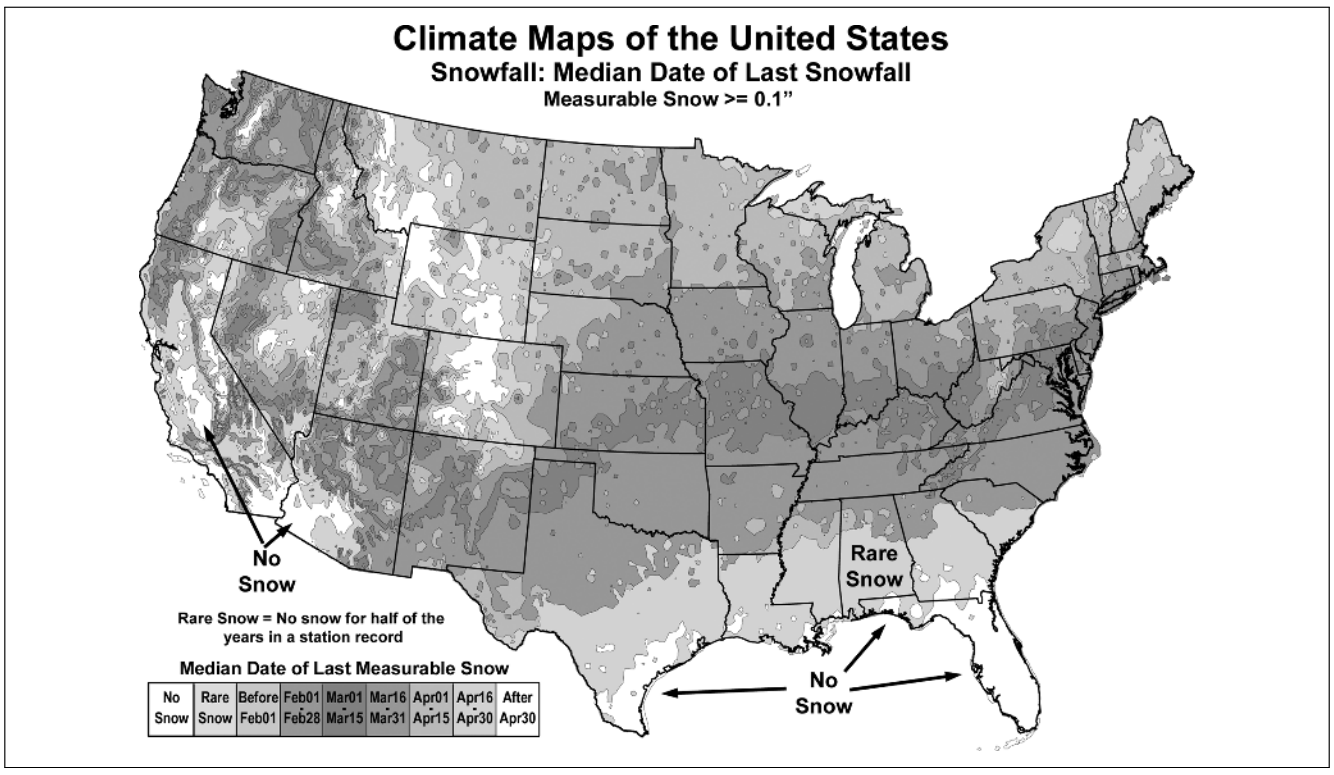

Figure 1.30 Median date of last measurable (0.1") snowfall.

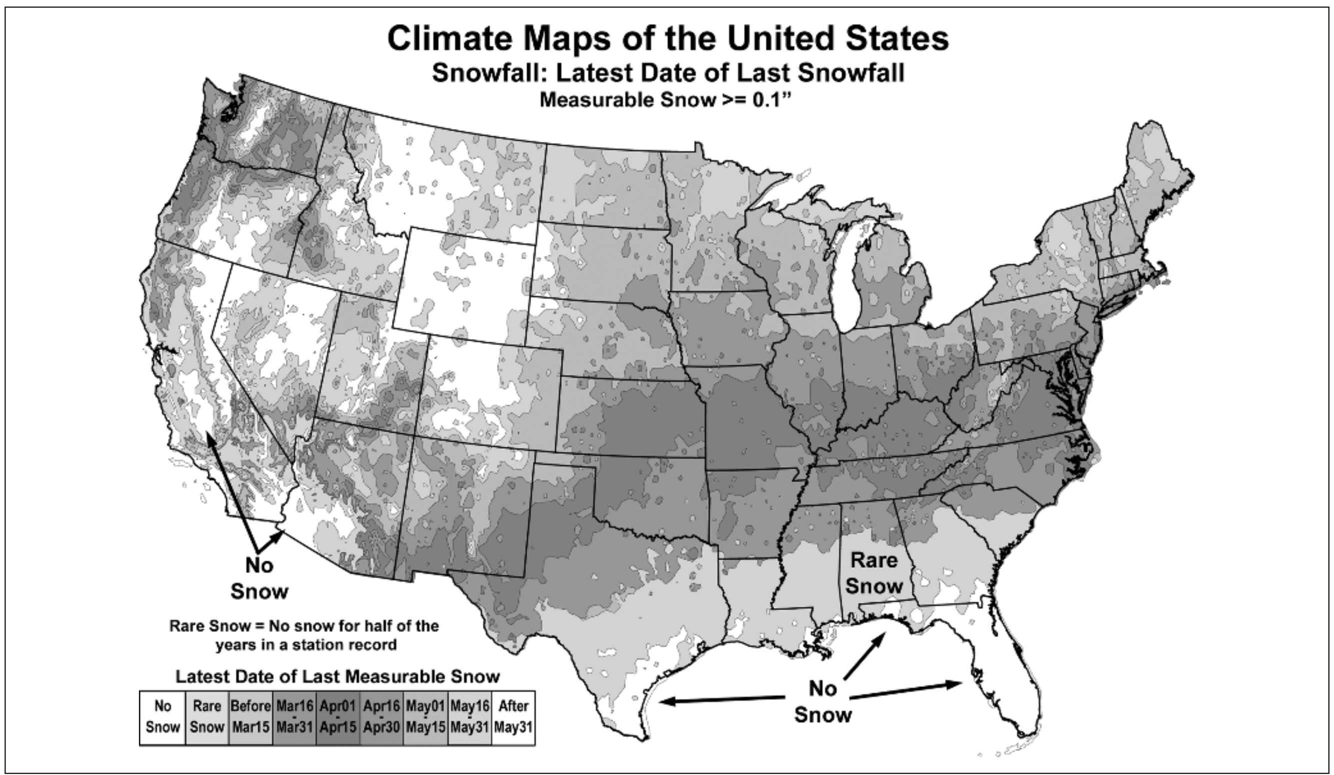

Figure 1.31 Extreme last date of last measurable snowfall.

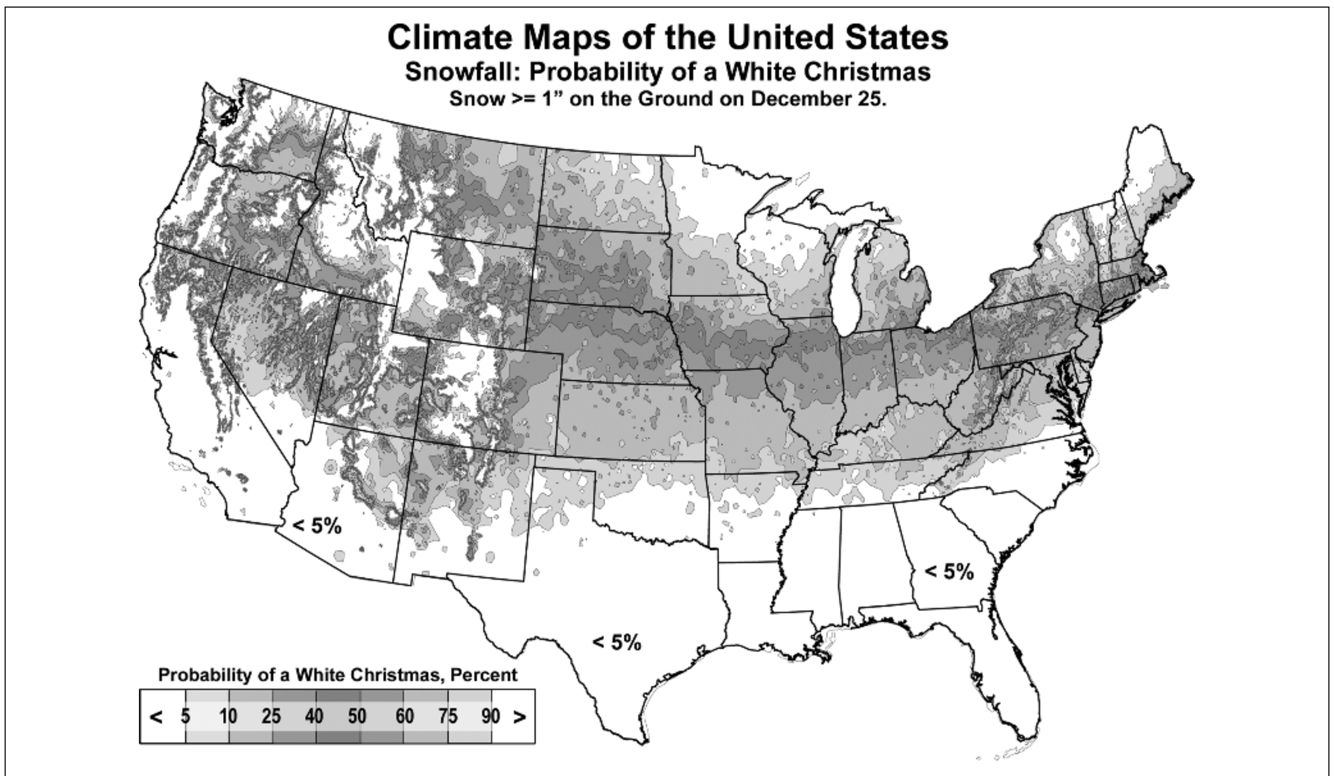

Figure 1.32 Probability of a white Christmas.

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Temperature

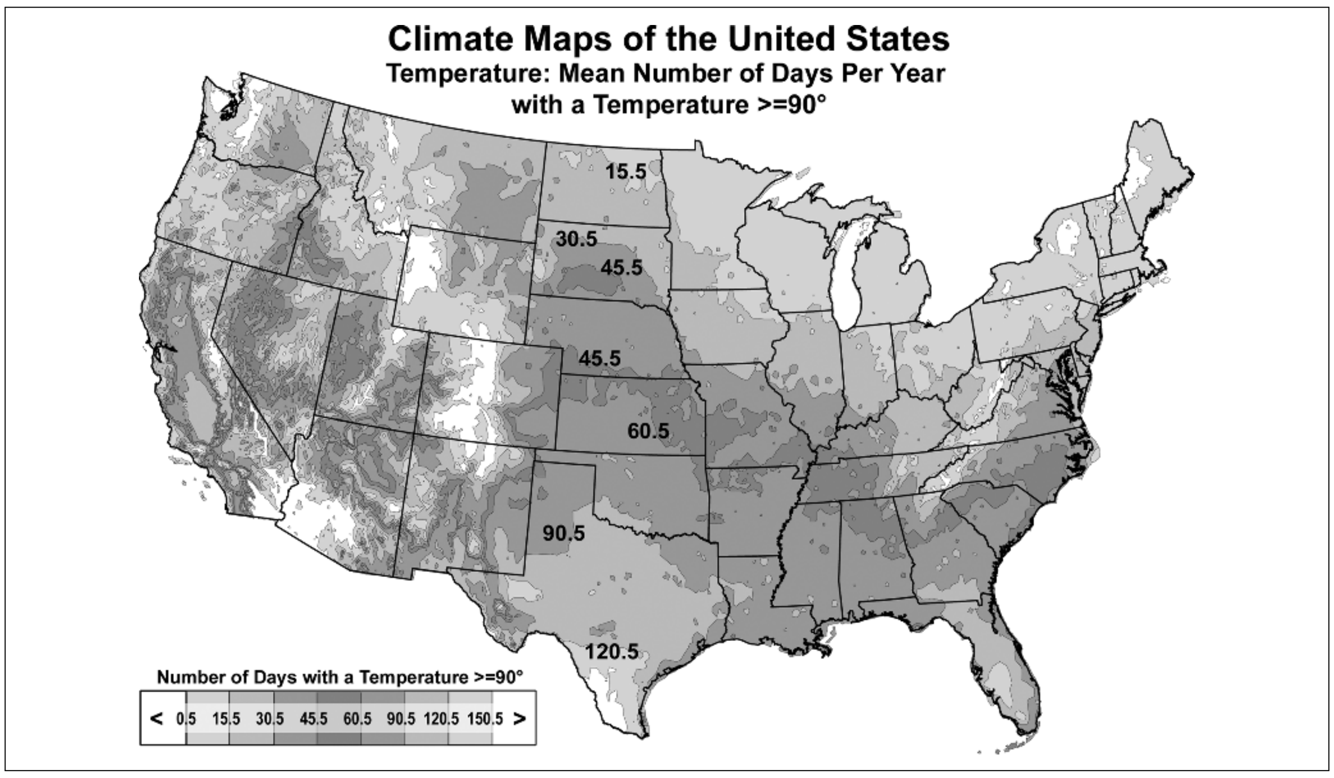

Figure 1.33 Mean annual number of days ≥90°.

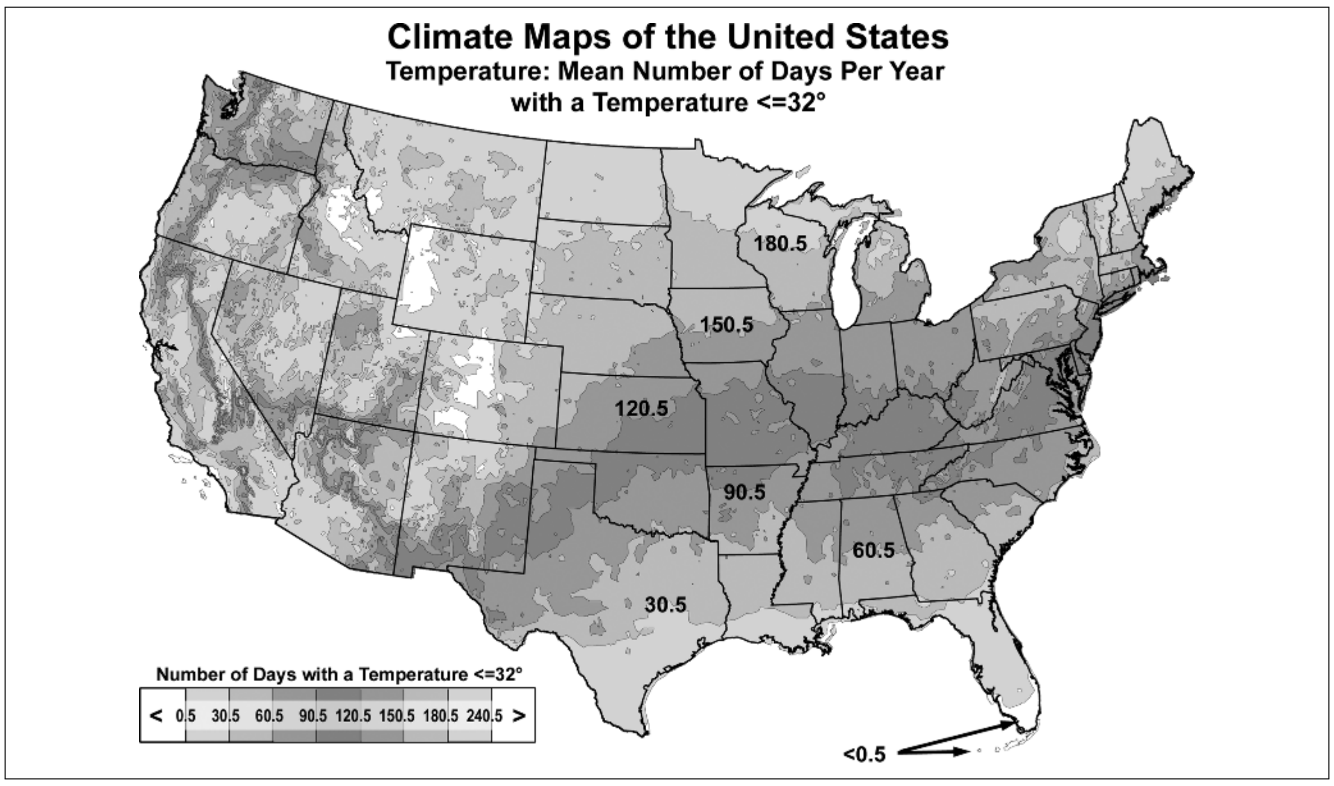

Figure 1.34 Mean annual number of days ≤32°.

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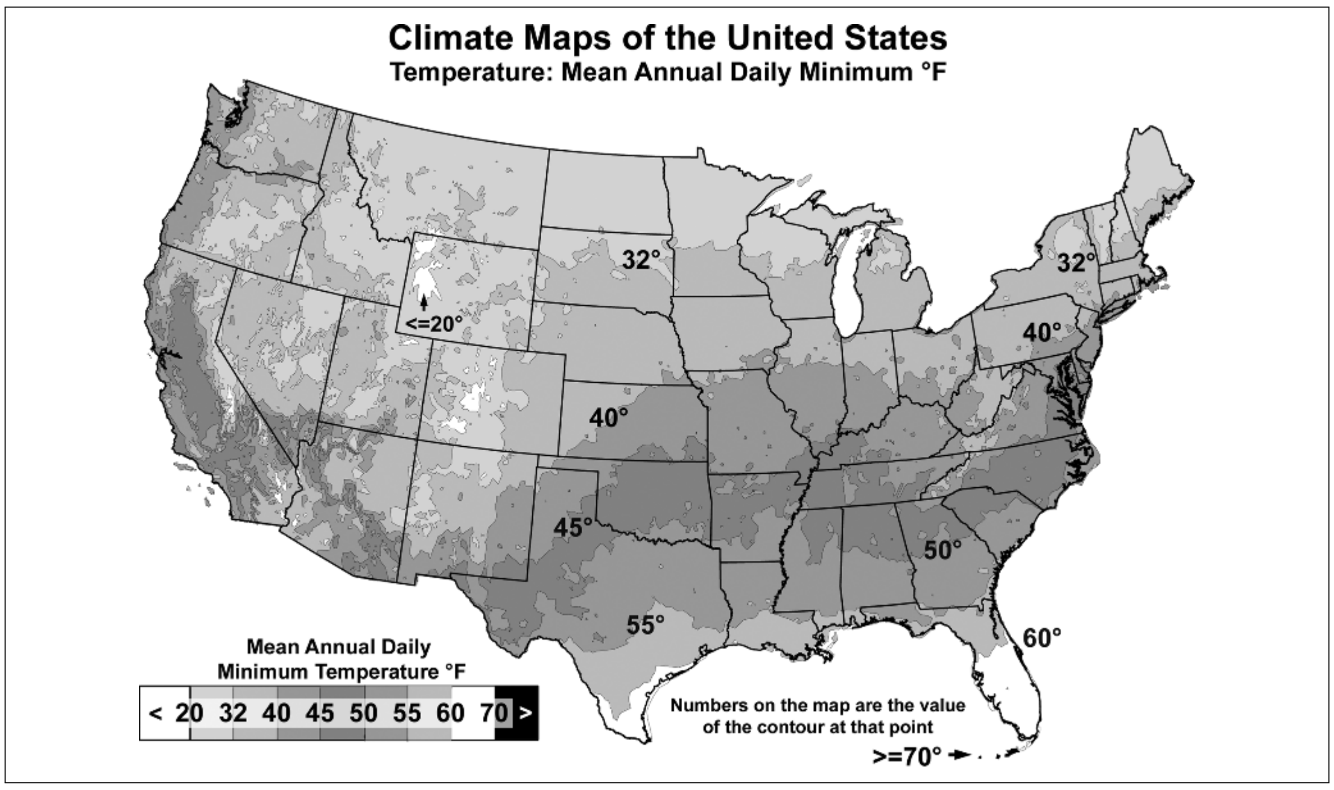

Figure 1.35 Mean annual minimum temperature.

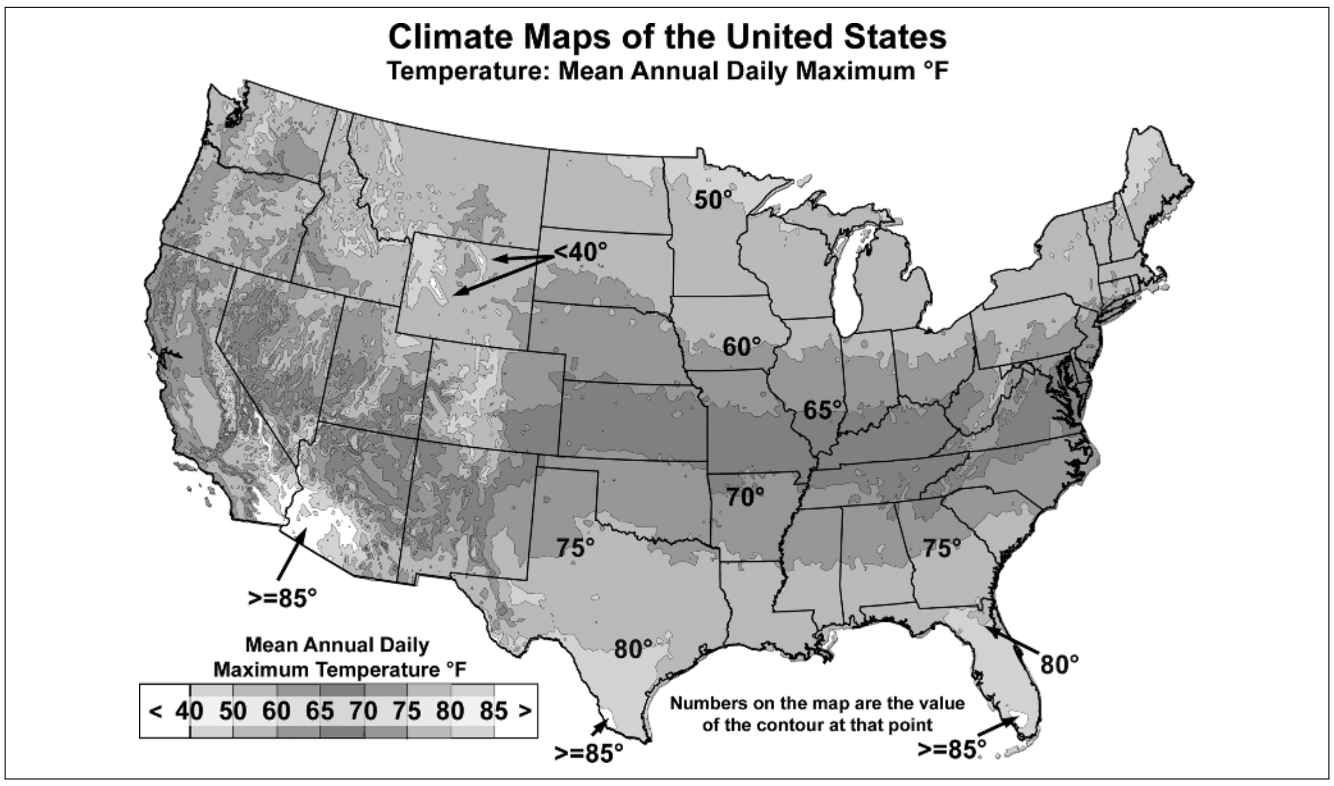

Figure 1.36 Mean annual maximum temperature.

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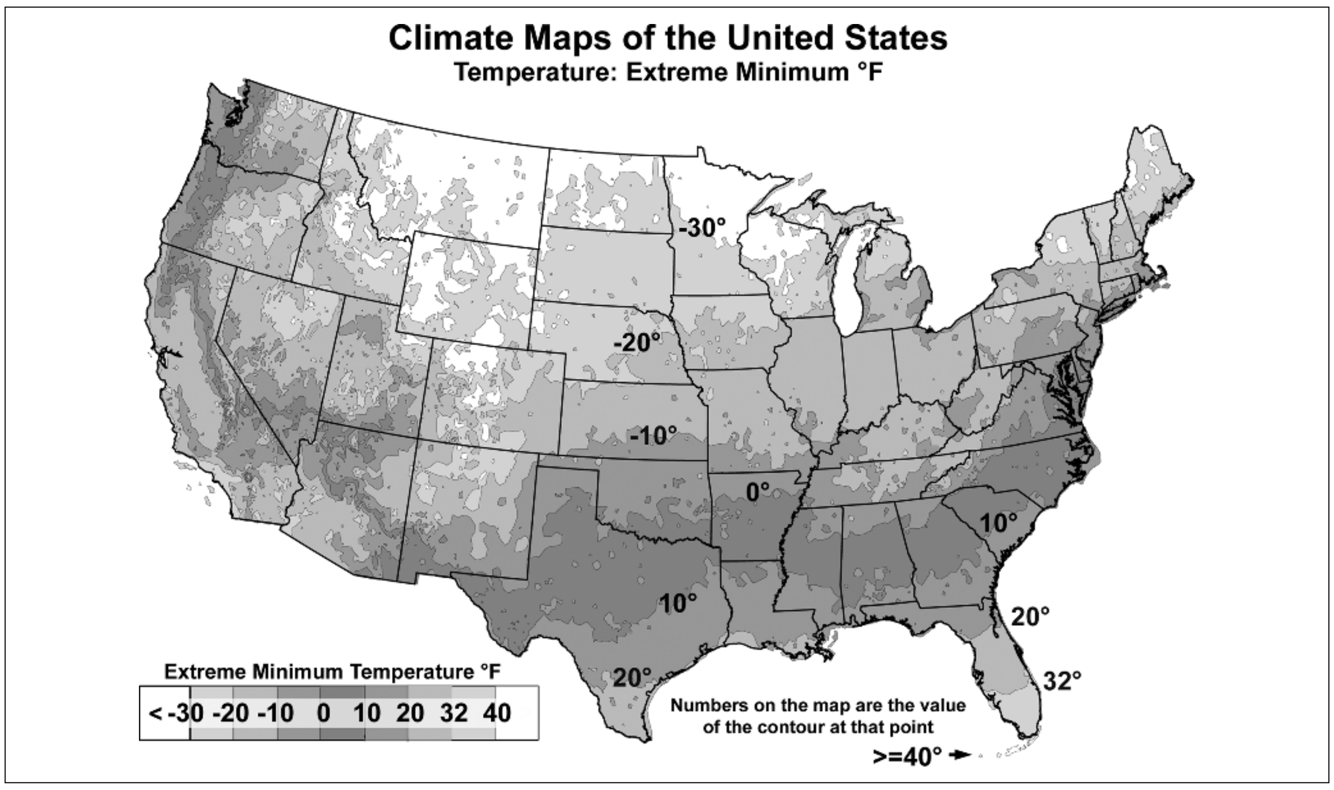

Figure 1.37 Extreme minimum temperature.

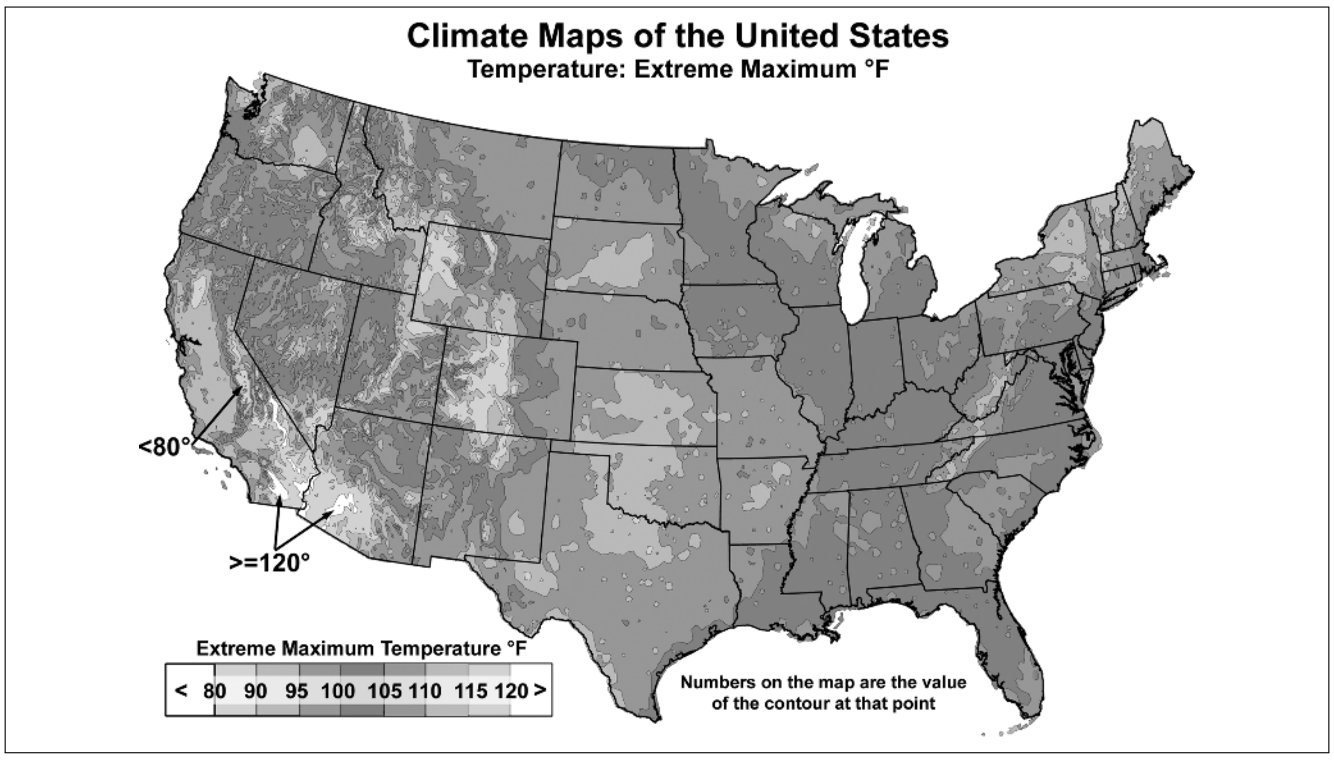

Figure 1.38 Extreme maximum temperature.

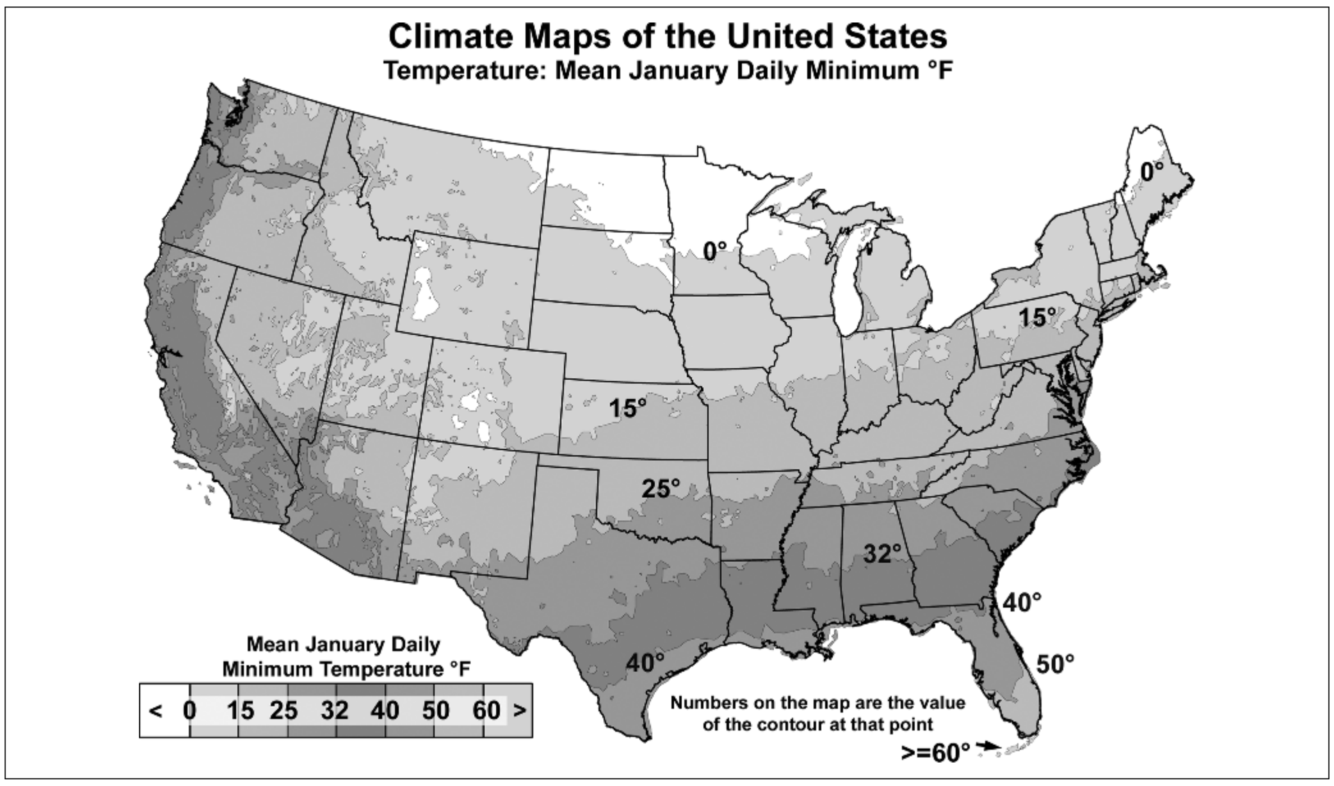

Figure 1.39 Mean January minimum temperature.

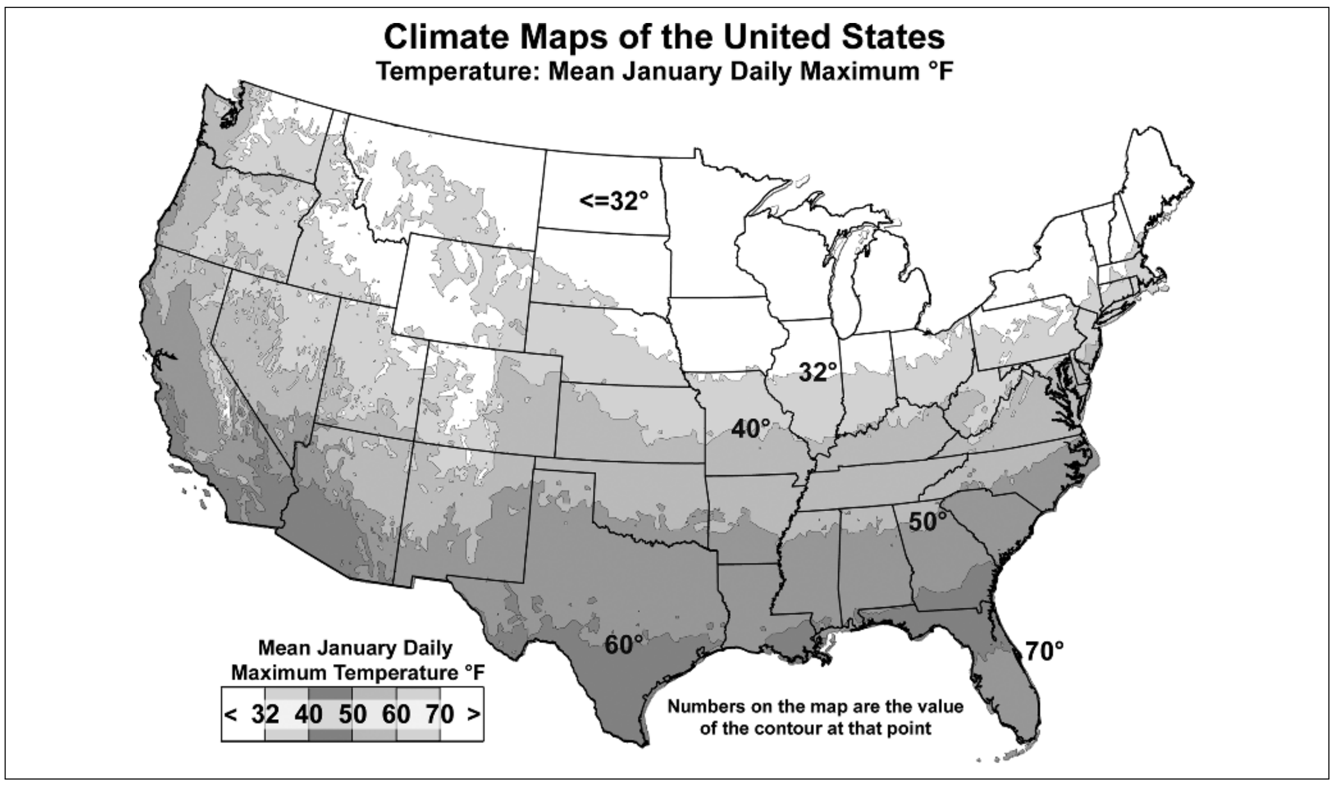

Figure 1.40 Mean January maximum temperature.

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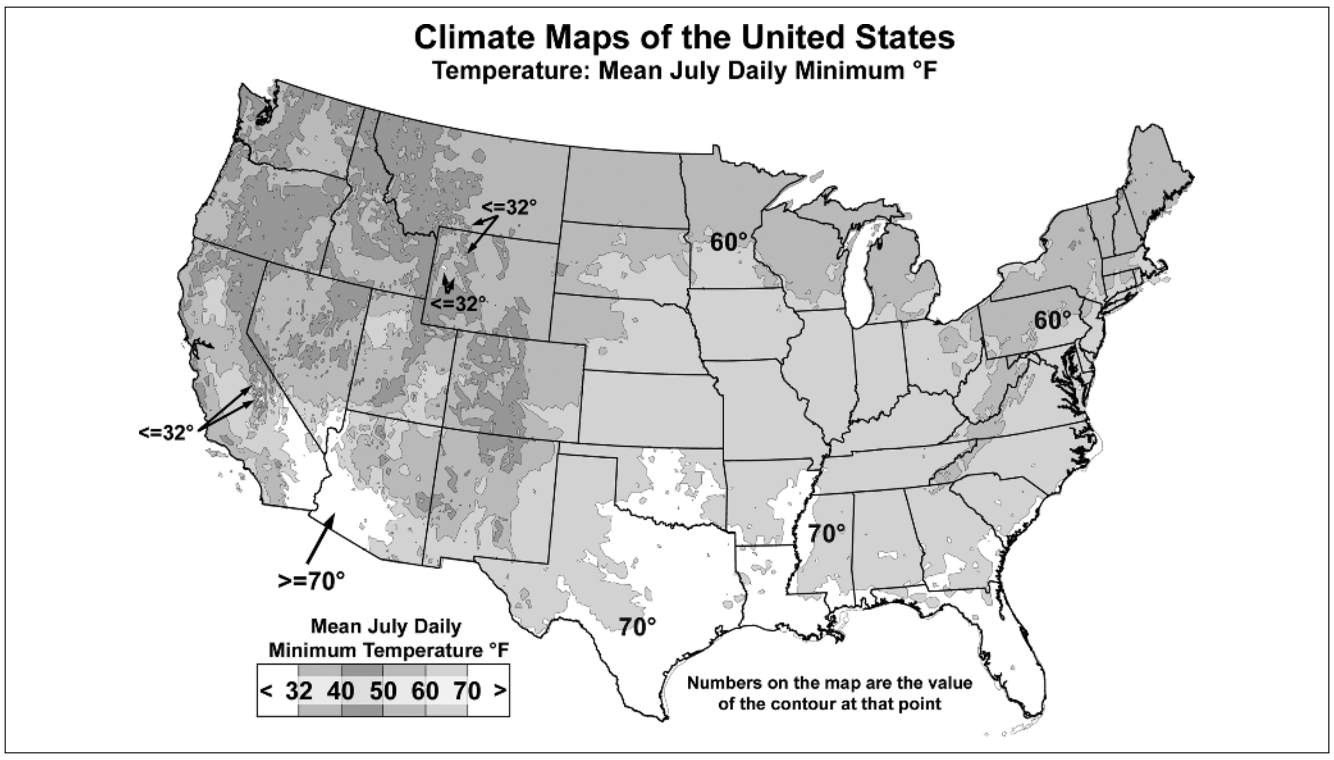

Figure 1.41 Mean July minimum temperature.

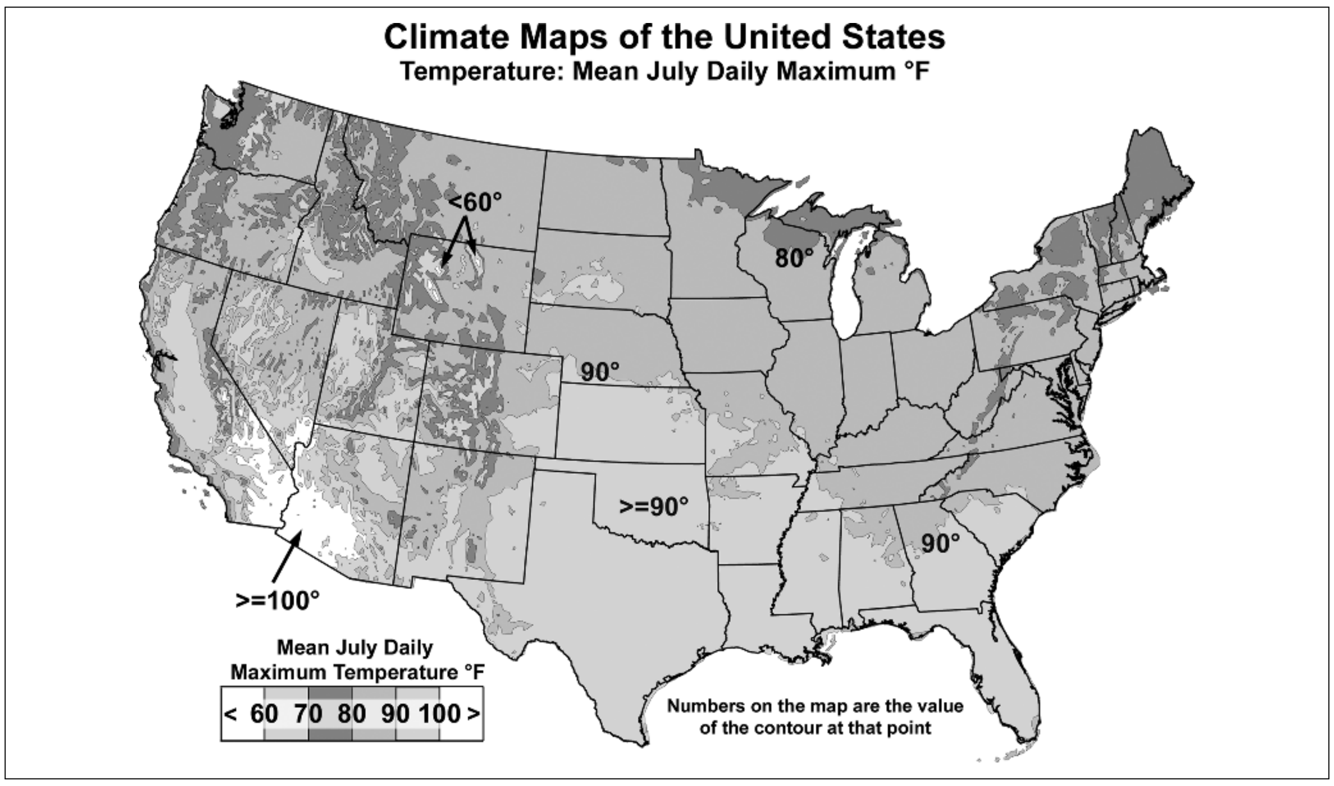

Figure 1.42 Mean July maximum temperature.