Seventh Oregon Climate Assessment

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Changes in the 2023 U.S. Department of Agriculture Plant Hardiness Map

Christopher Daly and Todd Rounsaville

Extreme cold temperatures during winter are the most significant environmental factors for predicting the survival of perennial plants and winter annual crops. Determining the appropriate geographical range for crops and landscape plants is critical for producers, farmers, and home gardeners who seek to cultivate long-lived, healthy, and high-yielding plants. The U.S. Department of Agriculture (USDA) Plant Hardiness Zone Map (PHZM; Figure 1) classifies plant growing zones on the basis of the average annual extreme minimum temperature. Each of the 13 zones, from zone 1 (coldest) to zone 13 (warmest), covers a 10-degree Fahrenheit (F) range. Each zone is subdivided into two 5-degree F half-zones, which are designated as a and b. Temperatures currently are calculated as 30-year averages of the extreme minimum temperature recorded annually (the plant hardiness statistic).

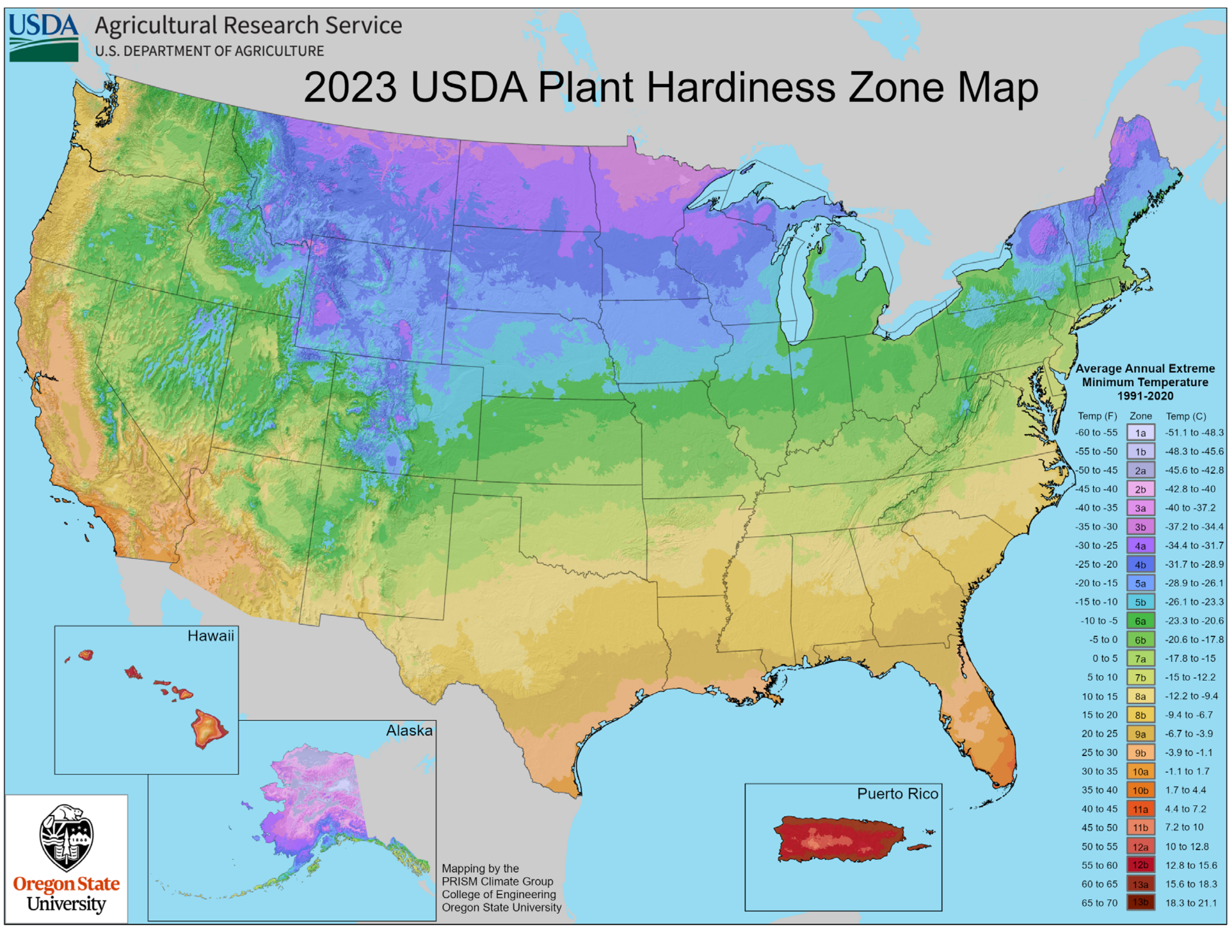


Figure 1. The 2023 USDA Plant Hardiness Zone Map for the United States and Puerto Rico.

The agricultural and horticultural industries have adopted the USDA Plant Hardiness Zones as their standard for selecting regionally adapted plants. Beginning with plant breeders and evaluators, hardiness zones are tested and documented for individual species or varieties of plants. The associations between zones and suitability of plants for those winter conditions are communicated by commercial growers in catalogs, marketing materials, and plant labels. Consumers such as farmers

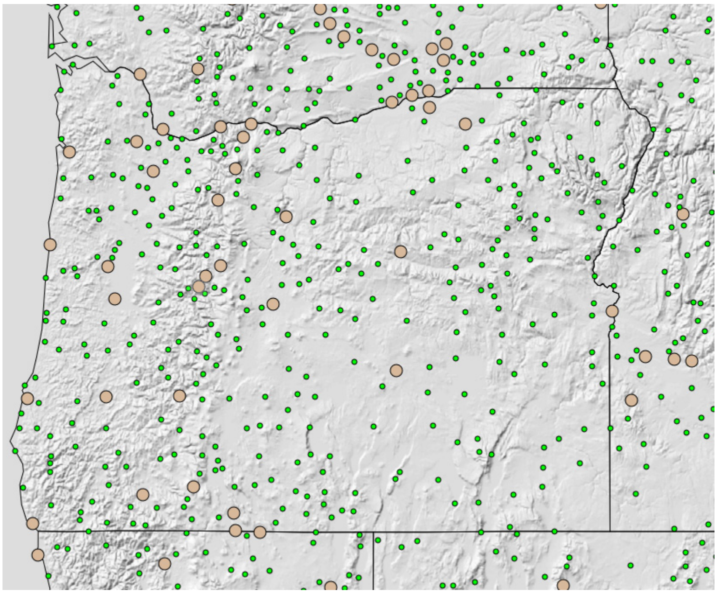


Figure 2. Locations of stations in Oregon and neighboring states used in the development of the 2023 Plant Hardiness Zone Map. Large circles indicate clusters of stations.

and home gardeners then consult the PHZM to determine the hardiness zone for their location, and purchase plants that are suited to their local conditions. Thus, the PHZM serves as a risk management tool, presenting historical minimum-temperature data in a standardized format that expresses the probability that a plant will survive the most extreme cold temperatures at a given location.

Although plant cold-hardiness maps have been in use since the late 1920s, and the first USDA map was released in 1960, the 2012 PHZM was the first to reflect standardized data modeling through the PRISM climate mapping system developed by the PRISM Climate Group at Oregon State

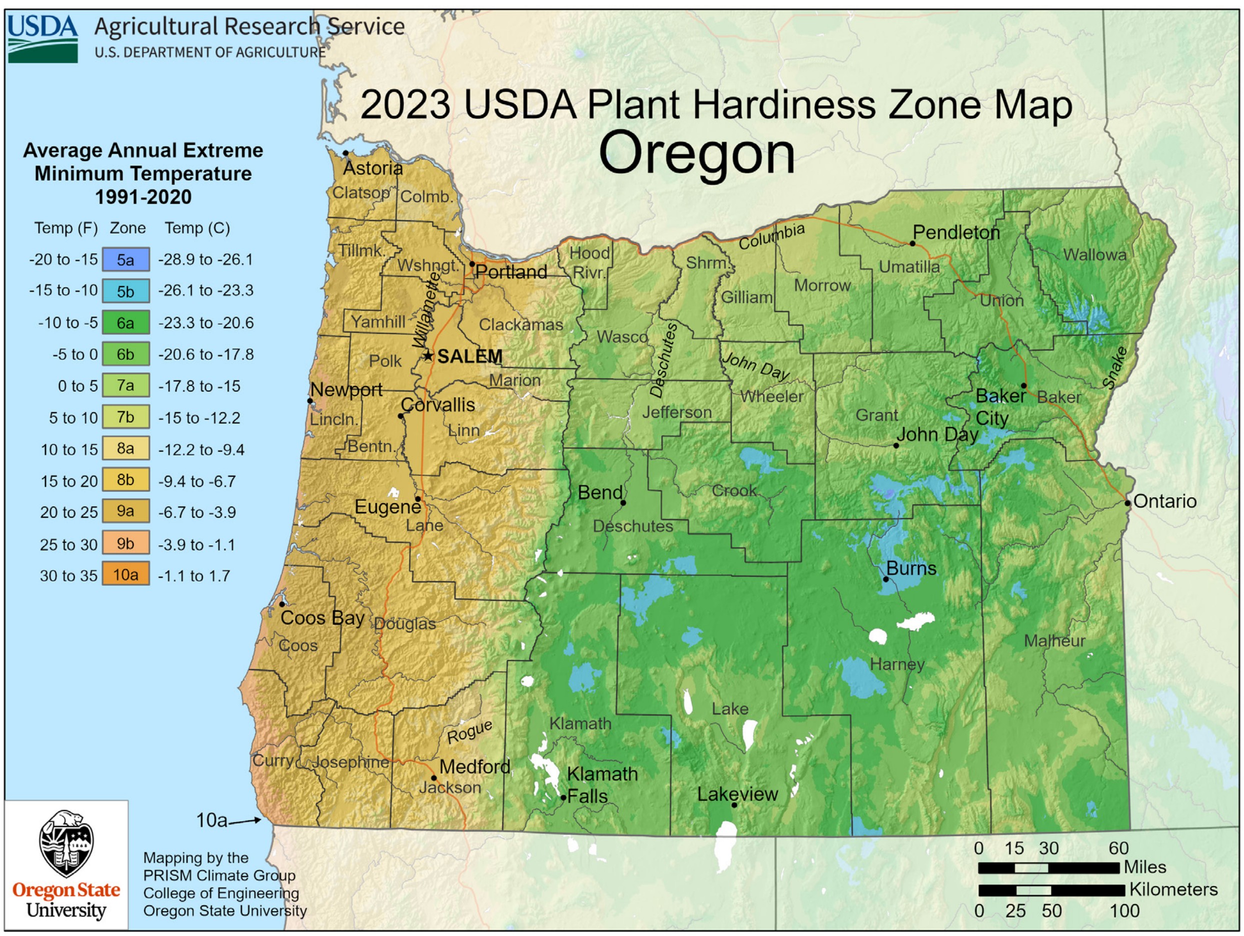


Figure 3. The 2023 USDA Plant Hardiness Zone Map for Oregon.

University, and to be presented in fully digital form. The 2012 PHZM was based on data from 1976–2005. The release of 1991–2020 U.S. Climate Normals data in 2021 presented an opportunity to revise and update the PHZM by analyzing 15 years of more-recent temperature data (2006–2020) and removing 15 earlier years (1976–1990) from the record, while incorporating data from 68 percent more weather stations and improvements to mapping techniques.

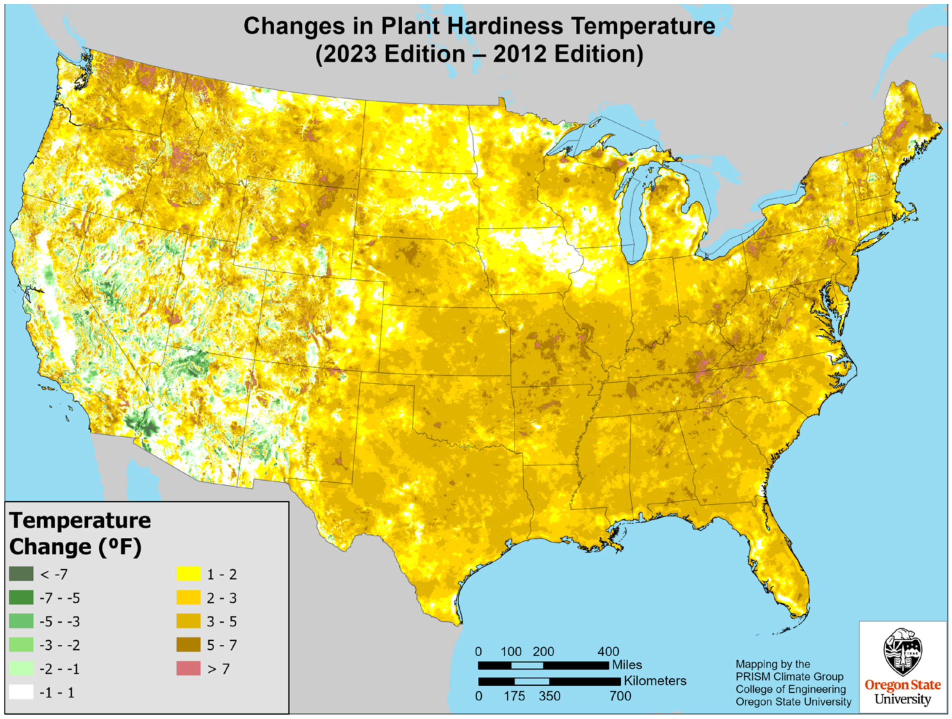


Figure 4. Changes in the plant hardiness temperature statistic in the conterminous United States between the 2012 Plant Hardiness Zone Map (1976–2005 averaging period) and the 2023 Plant Hardiness Zone Map (1991–2020 averaging period).

The 2023 PHZM incorporated data from 13,625 weather stations from national, regional, and state networks. In Oregon (Figure 2), data sources included stations from the National Weather Service Cooperative Observer Program (COOP), Automated Surface Observing System (ASOS), and Weather Bureau–Army–Navy (WBAN); USDA Natural Resources Conservation Service Snow Telemetry (SNOTEL); USDA Forest Service and Bureau of Land Management Remote Automatic Weather Stations (RAWS); Bureau of Reclamation AgriMet; Washington State University AgWeatherNet; and Oregon State University H.J. Andrews Experimental Forest. The greatest number of stations that contributed to the 2023 map are within the COOP network. These stations are operated primarily by volunteer observers, and most are located in human-inhabited areas that can be accessed daily. The SNOTEL automated network is designed to observe conditions in the snow zones of the western United States and provided data for high-elevation regions. The RAWS automated network mainly focuses on fire-weather conditions at elevations between those of the COOP and SNOTEL stations. AgriMet and AgWeatherNet automated stations provided data from agricultural regions of the Pacific Northwest. The H.J. Andrews Experimental Forest, on the western slopes of the central Oregon Cascade Range, provided data at fine spatial resolution in this topographically complex region.

Within Oregon (Figure 3), the 2023 PHZM indicates two distinct climate regimes, a colder regime east of the Cascade Range and a milder regime to the west of the Cascade Range. Areas east of the Cascade Range are shielded from moist, mild air from the Pacific Ocean but are exposed to potential Arctic air outbreaks from Alaska and Canada that penetrate west of the Rocky Mountains. Most of the coldest areas (zone 5; -10° to -20°F) are located in valley bottoms where cold, dense air can pool and persist during the coldest nights of winter. Extreme minimum temperatures are somewhat warmer above the cold pools but decrease again at higher elevations. Extremely cold air rarely penetrates west of the Cascade Range. Instead, winter conditions are dominated by frequent storms and onshore air flow from the relatively warm Pacific Ocean, and hardiness zones are dictated by proximity to the coastline. Most of the Willamette Valley is within zone 8 (10° to 20°F), whereas coastal areas are typically in zone 9 (20° to 30°F). A small area of zone 10a (30° to 35°F) lies on the far southwest coast of Oregon.

Comparing the 2023 PHZM with the 2012 map indicates that, when averaged across the country, the average extreme minimum temperature has increased by 2.5°F (Figure 4). As a result, approximately half of the United States was reclassified into a warmer Plant Hardiness half-zone (Figure 5). The zone change map, although preferred by most users, can be misleading. Changes in the plant hardiness statistic are continuous values (Figure 4), but the key question most users ask is whether their zone has changed (Figure 5). Many locations at the colder end of the half-zone range did not warm enough to move into the next warmer half-zone, whereas numerous locations at the warmer end of the half-zone range, which warmed by a similar amount, moved into a warmer half-zone.

Changes between the 2012 and 2023 PHZMs varied widely across Oregon (Figures 6, 7). Minimum temperatures in low elevation areas east of the Cascade Range and in the central and southern Willamette Valley changed little. Substantial warming in high elevation areas in northeastern Oregon in the PHZM does not reflect climate change per se, but rather improvements in mapping over the past decade that produced more-accurate estimates of temperatures in these data-sparse areas.

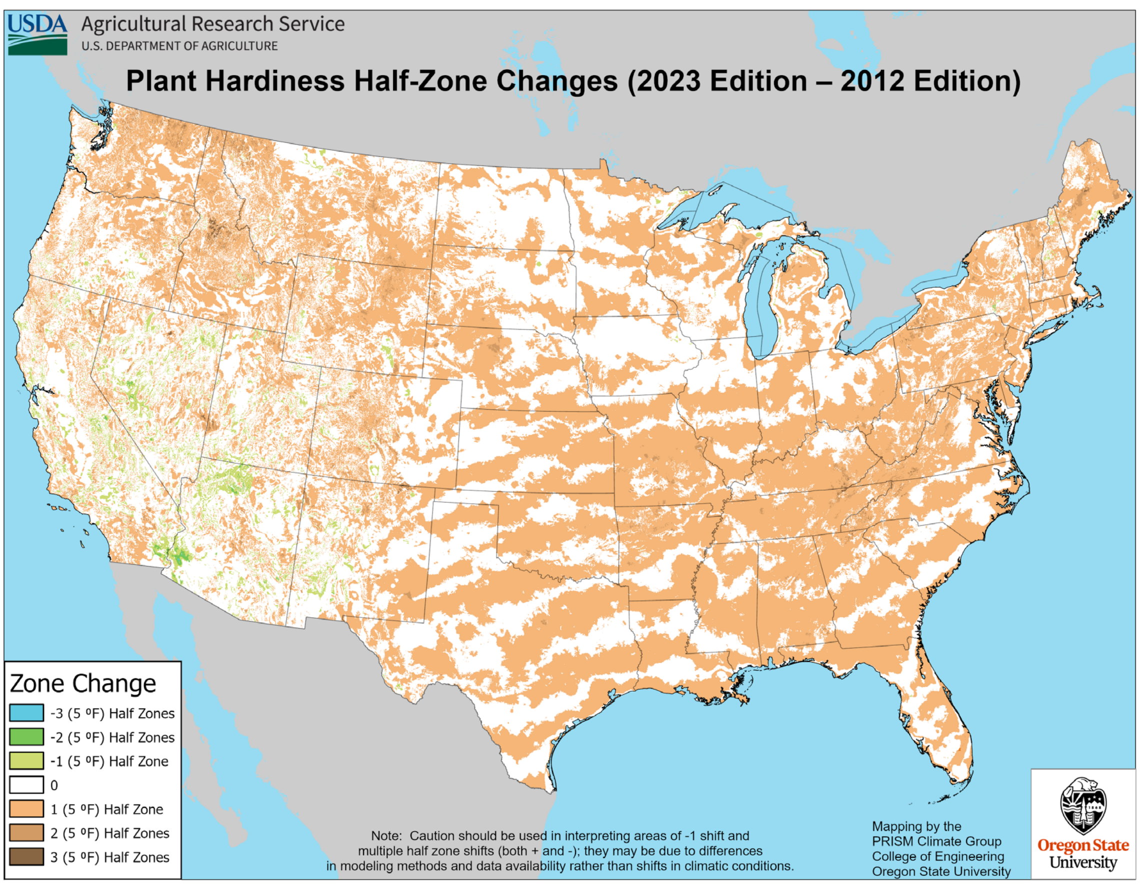


Figure 5. Five-degree half-zone changes in the conterminous United States between the 2012 Plant Hardiness Zone Map (1976–2005 averaging period) and the 2023 map (1991–2020 averaging period).

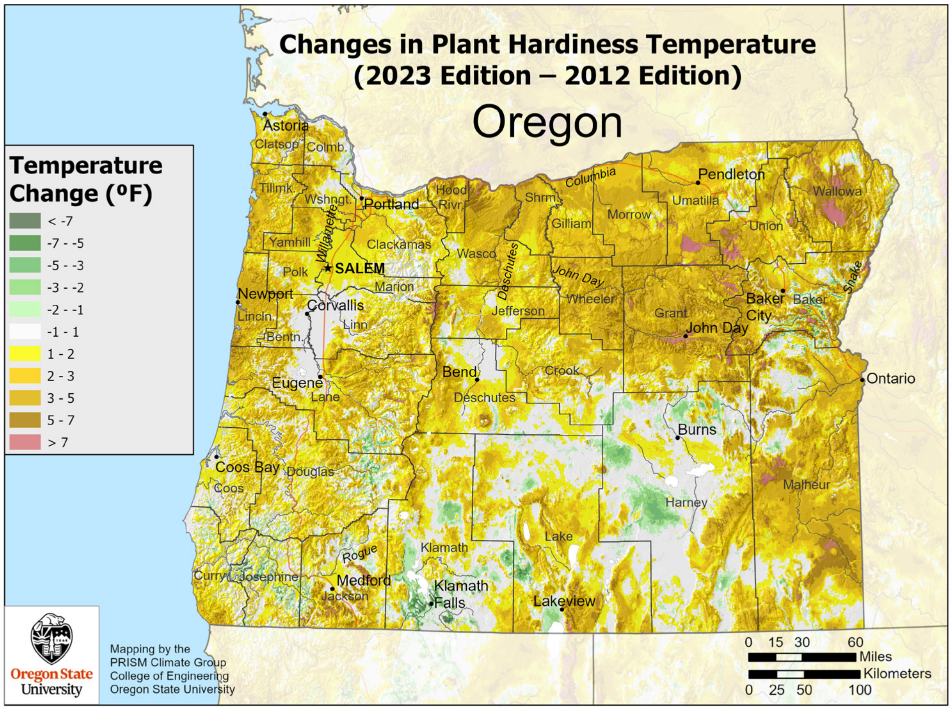


Figure 6. Changes in the plant hardiness temperature statistic in Oregon between the 2012 Plant Hardiness Zone Map (1976–2005 averaging period) and the 2023 Plant Hardiness Zone Map (1991–2020 averaging period).

Apparent local areas of cooling are likely a result of additional station data and improved modeling of cold air pools.

Changes in minimum temperature across the Pacific Northwest between the 2012 and 2023 maps also varied regionally (Figure 8). As in Oregon, considerable warming at high elevations in northern Washington and central Idaho reflects improvements in mapping.

The plant hardiness statistic, defined as the single coldest daily minimum temperature of the year, is inherently volatile from year to year. Therefore, comparing the 2023 PHZM with the 2012 PHZM does not provide a complete picture of longer-term trends and variation in the plant hardiness statistic. Some stations in Oregon have recorded daily temperature data since 1950, which allows for examination of the plant hardiness statistic over a longer duration (Figure 9). Annual extreme minimum temperature at most of these locations is cyclical, with slight cooling in the 1980s, warming in the 2000s, and cooling in the most recent years. These cycles are superimposed on a long-term warming trend that may be a climate change signal but is difficult to attribute with certainty due to the volatility of the statistic.

The variability of the plant hardiness statistic differs across Oregon. The Willamette Valley is in zone 8 on average, but annual variations may yield conditions similar to those in zone 7 or 9. Astoria, although coastal, is susceptible to cold air outbreaks through the Columbia Gorge, which can drop plant hardiness temperatures well below the local average. Stations in interior Oregon have greater year-to-year variability: any given year could be several zones above or below its 30-year average.

What do these changes mean for gardening in Oregon? The 2023 PHZM documents what happened during the period 1991–2020. Therefore, any changes have already been felt in gardens across the state. It is unlikely that Oregon gardeners will radically alter the perennials they grow on the basis of the new map, especially given the microclimatic variation in many gardens that is not accounted for in the PHZM, from sunny south-facing walls where plants rated for warmer zones may thrive, to cold depressions in deep shade where the same plants may struggle. However, the PHZM provides an updated and quantitative standard by which risk can be assessed. Because the

PHZM is based on a long-term average, the volatility of the plant hardiness statistic becomes relevant when planting varieties at zone boundaries; a perennial rated for a warmer zone may do well for a few years, but then be damaged or killed by an unusually severe Arctic air outbreak.

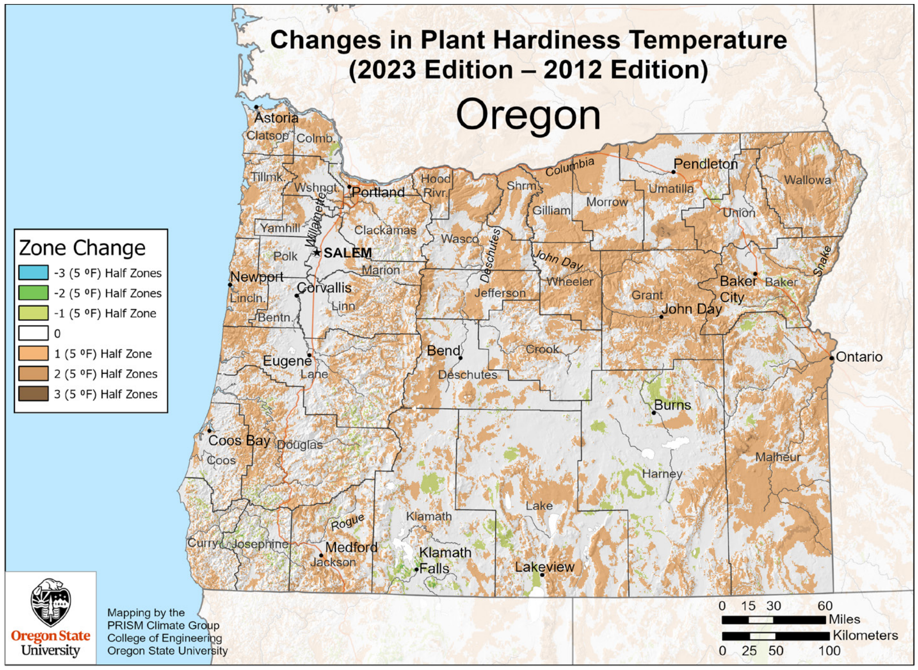


Figure 7. Five-degree half-zone changes in Oregon between the 2012 Plant Hardiness Zone Map (1976–2005 averaging period) and the 2023 Plant Hardiness Zone Map (1991–2020 averaging period).

The PHZM provides information on only one statistic, the mean extreme annual minimum temperature. It does not provide information on the frequency, timing, or duration of winter cold events. Additionally, many factors other than minimum temperature, such as light, soil moisture, humidity, and snow cover, influence plant survival. Details on these factors and other considerations for use of the PHZM are at planthardiness.ars.usda.gov. Technical details on the creation of the 2012 map and its potential uses as a risk management tool are available from prism.oregonstate.edu/documents/pubs/2012jamc_plantHardiness_daly.pdf and prism.oregonstate.edu/documents/pubs/2012horttech_hortApps_widrlechner.pdf.

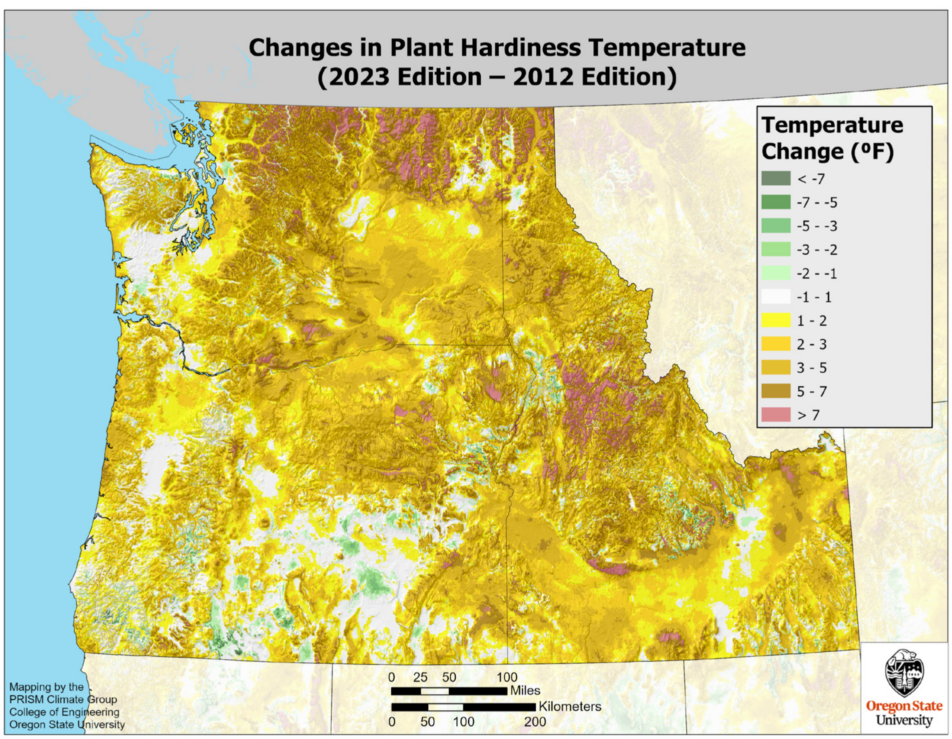


Figure 8. Changes in the plant hardiness statistic in the Pacific Northwest between the 2012 Plant Hardiness Zone Map (1976–2005 averaging period) and the 2023 Plant Hardiness Zone Map (1991–2020 averaging period).

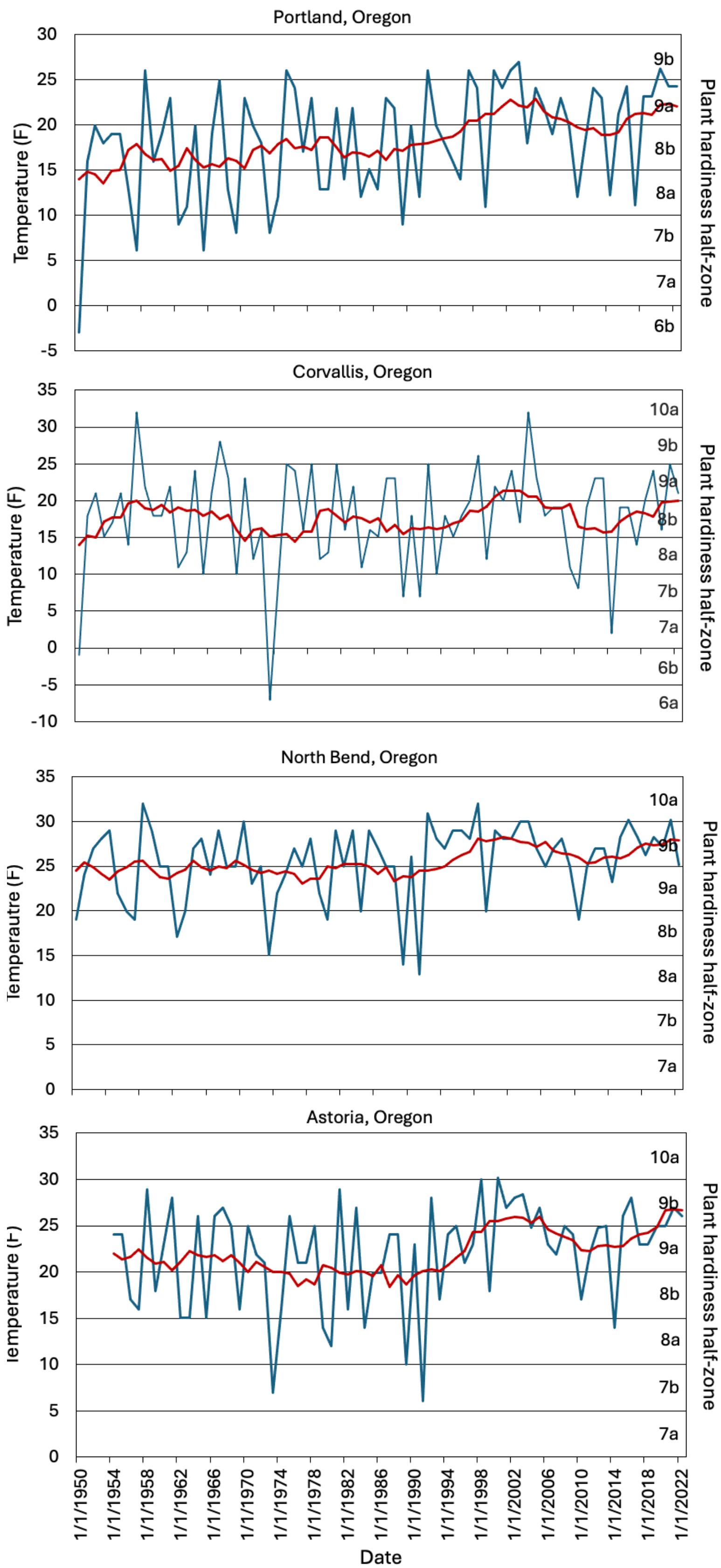
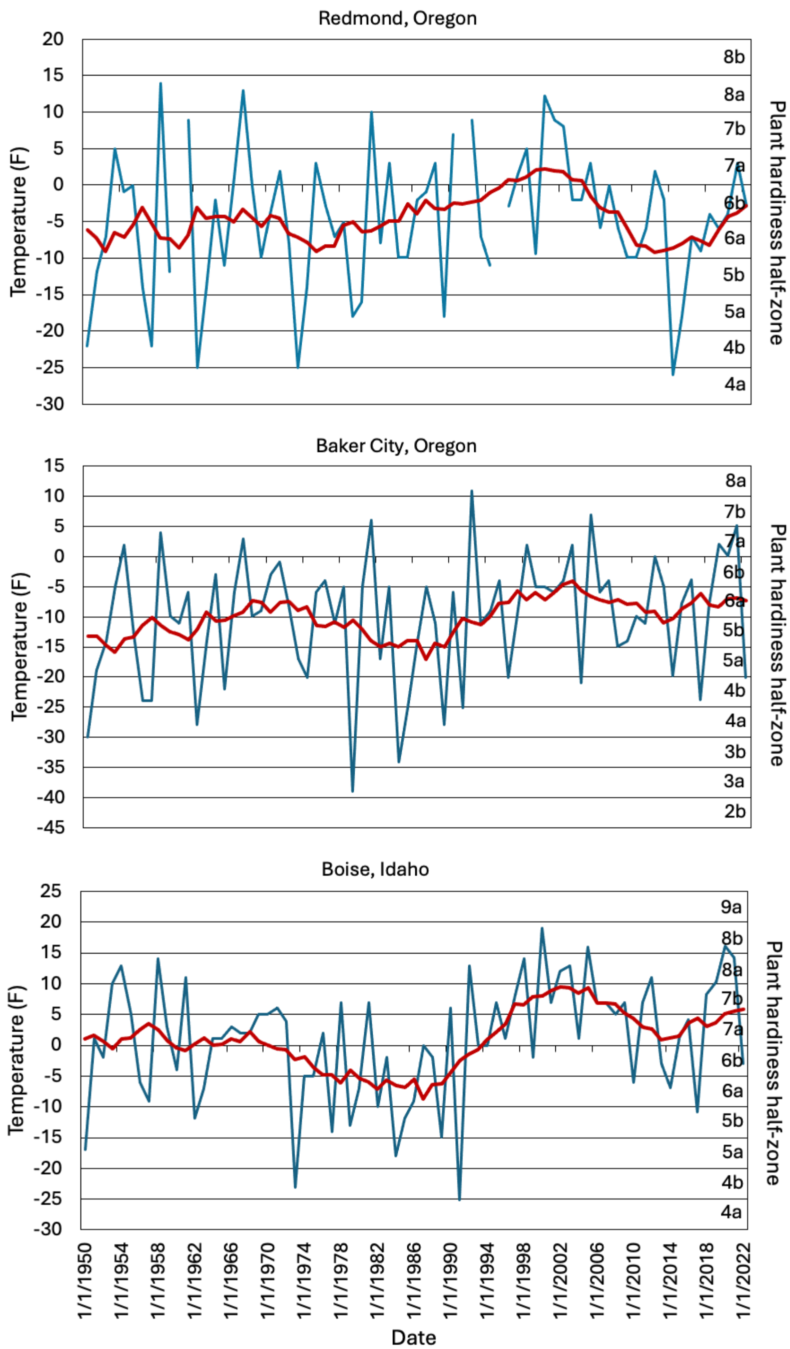


Figure 9. Time series of the plant hardiness statistic at (a) Portland, (b) Corvallis, (c) North Bend, (d) Astoria, (e) Redmond, (f) Baker City, and (g) Boise, Idaho, 1950–2022. Red lines indicate the 10-year moving average.


Redmond, Oregon
Temperature (F)
Plant hardiness half-zone
20
15
10
5
0
-5
-10
-15
-20
-25
-30
8b
8a
7b
7a
6b
6a
5b
5a
4b
4a
Baker City, Oregon
Temperature (F)
Plant hardiness half-zone
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
8a
7b
7a
6b
6a
5b
5a
4b
4a
3b
3a
2b
Boise, Idaho
Temperature (F)
Plant hardiness half-zone
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
9a
8b
8a
7b
7a
6b
6a
5b
5a
4b
4a
1/1/1950
1/1/1954
1/1/1958
1/1/1962
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