# Montana and Climate Change

## Carbon Dioxide on Trial

CO2 COALITION

# Montana and Climate Change

## Carbon Dioxide on Trial

CO2 COALITION

# TABLE OF CONTENTS

## LIST OF TABLES



## LIST OF FIGURES

## EXECUTIVE SUMMARY

In March 2020, the Held v. State of Montana "climate lawsuit" was filed against the state government of Montana by a group of 16 Montana youths. They claimed that their government's support of the burning of fossil fuels exacerbated a climate crisis, which was harming them. The case went to court in June 2023, and the judge ruled in favor of the plaintiffs that August. In December 2024, the decision was upheld by the Montana Supreme Court enshrining "science-based protections for children's fundamental rights" into law.

Is there a climate crisis in Montana? This report is intended to answer this question with scientific data from government agencies, universities, and peer-reviewed literature.

Based on these data:

- Agriculture is thriving in Montana partly because of modest warming, which has brought longer growing seasons, higher levels of atmospheric $CO_2$, and increased nitrogen.
- Climate models overpredict warming by more than twice the observed value.
- Annual snowfalls in Montana show no sign of decreasing since 1980.
- Glacial retreat began in the early-to-mid 1800s, i.e., long before carbon dioxide ($CO_2$) emissions from human activity were significant.
- Heat waves in Montana and the United States peaked in the 1930s and have been consistently more moderate since then.
- There has been no discernible trend of increasing or decreasing precipitation in Montana since the late 1800s.
- Droughts in Montana are not increasing in frequency or severity.
- The area burned by wildfires in the United States has dropped by more than 80% since its peak in 1930.
- Floods are not becoming more frequent in Montana.
- The frequency of tornadoes in Montana has been declining.
- Air quality in the United States has significantly improved since detailed record keeping began.
- Compared to the geological past, today's atmospheric $CO_2$ concentration is low.
- $CO_2$ is beneficial, and more of it allows plants to grow bigger, produce more food, and better resist drought, thus "greening" the Earth.

Our analysis shows no climate crisis in Montana and that $CO_2$ is not only beneficial but essential for life in Montana and all of Earth. Measures for combating a purported climate crisis by reducing $CO_2$ emissions are unnecessary, economically destructive, and would harm Montana's citizens.

## INTRODUCTION

In March 2020, the Held v. State of Montana "climate lawsuit" was filed by a group of 16 Montana youths against the state government of Montana (Our Children's Trust, 2024). The plaintiffs alleged in the lawsuit that:

> *"… their government has been promoting and supporting the extraction and burning of fossil fuels, worsening the climate crisis, and harming the youth … violating the youth's equal rights to a healthy environment, life, dignity, and freedom."*

After bringing their case to court on June 12–20, 2023, Lewis and Clark District Court Judge Kathy Seeley ruled in favor of the plaintiffs in August 2023, labeling her judgement *Findings of Fact, Conclusions of Law, and Order* (hereafter, "*Findings of Fact*") (Held v. Montana, 2023). Judge Seeley said:

> *"Anthropogenic climate change is impacting, degrading, and depleting Montana's environment and natural resources, including through increasing temperatures, changing precipitation patterns, increasing droughts and aridification, increasing extreme weather events, increasing severity and intensity of wildfires, and increasing glacial melt and loss."*

The state appealed the decision to the Montana Supreme Court, arguing that greenhouse gases released from Montana's fossil fuel projects are minuscule on a global scale and that reducing them would have no effect on temperatures. The justices, in a 6 to 1 ruling, rejected the state's argument, asking: "If everyone else jumped off a bridge, would you do it too?"

Using scientific data, this report will determine the accuracy of the claims made in the *Findings of Fact*. These data include those from the National Oceanic and Atmospheric Administration (NOAA), the United States Environmental Protection Agency (U.S. EPA), the National Aeronautics and Space Administration (NASA), the United States Department of Agriculture (USDA), universities, and peer-reviewed literature.

We found that not only is there no climate crisis in Montana (Figure 1), but the ecosystems and the people of Big Sky Country are thriving and prospering. The combination of modest warming and carbon dioxide ($CO_2$) emissions from the burning of fossil fuels are helping to create the healthy environment that the plaintiffs desire.

## CARBON DIOXIDE ON TRIAL

The crux of the lawsuit was that the continued burning of fossil fuels in Montana would add more of the greenhouse gas carbon dioxide to the atmosphere. This increase in atmospheric $CO_2$ would then cause unusual and unprecedented warming that would lead to a climate crisis.

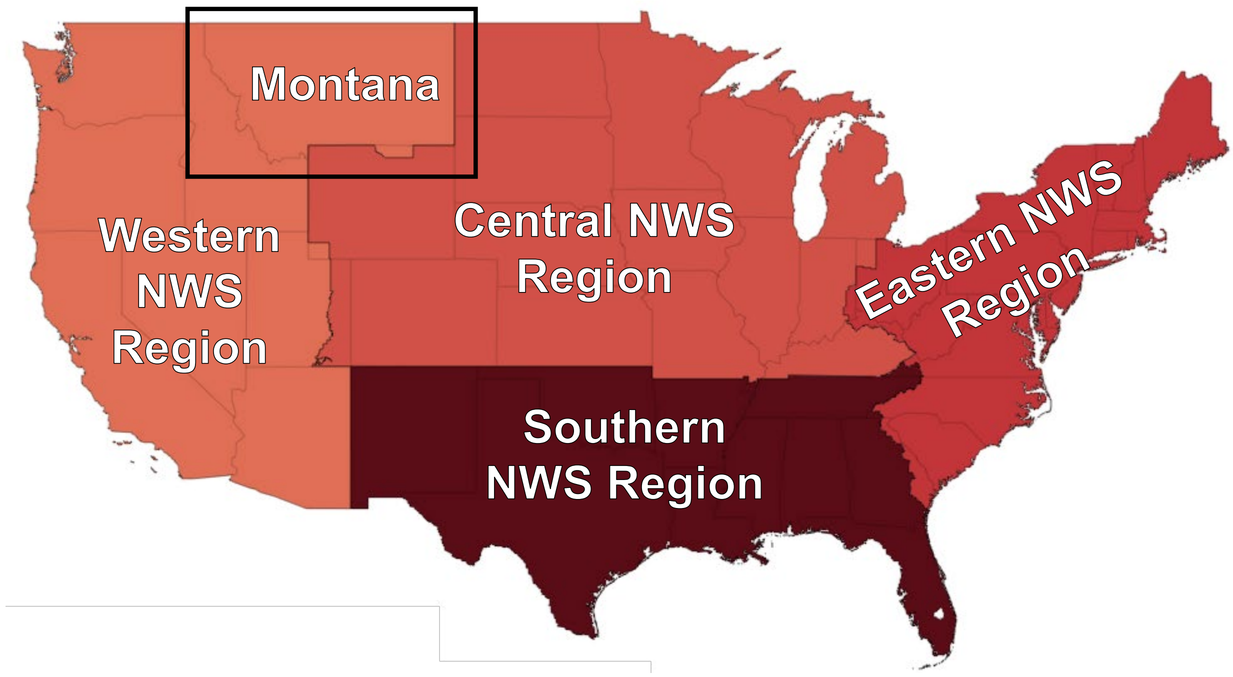


**Figure 1:** *National Weather Service (NWS) Regions of the United States. NOAA NCEI (2025a)*

The *Findings of Fact* noted the recent rise in atmospheric $CO_2$ concentrations:

> *"… $CO_2$ has continued to rise every year from 1958 to the present from an initial concentration of 315–316 ppm in 1958, to an annual mean level of around 424 ppm today."*

This statement from the *Findings of Fact* was one of the few verifiably true statements in the judge's ruling and drew on data provided by the Mauna Loa Observatory in Hawaii (Lan and Keeling, 2026). The observatory there has been reporting $CO_2$ concentrations in the atmosphere since 1958. The level of $CO_2$, as measured at the Mauna Loa Observatory, averaged about 427 parts per million (ppm) during 2025 (Lan and Keeling, 2026).

Prior to the Industrial Revolution in the late 1700s, atmospheric $CO_2$ was nearly at a historic low of about 280 ppm. An increased use of coal to power machines initiated a period of a slight rise in the concentration of $CO_2$ in the atmosphere. Significant increases of atmospheric $CO_2$ occurred in the mid-20$^{th}$ century during the economic boom following World War II (Figure 2). Our current concentration of about 430 ppm (Lan and Keeling, 2026) represents an increase of approximately 50% over the last 200 years. Bear in mind that if $CO_2$ were driving warming, it should be apparent in the period of the last 70-plus years, when levels were increasing at a significant rate.

The increase of about 150 ppm from the pre-industrial concentration appears significant when viewed through the narrow time frame of a few decades or centuries. However, appearances

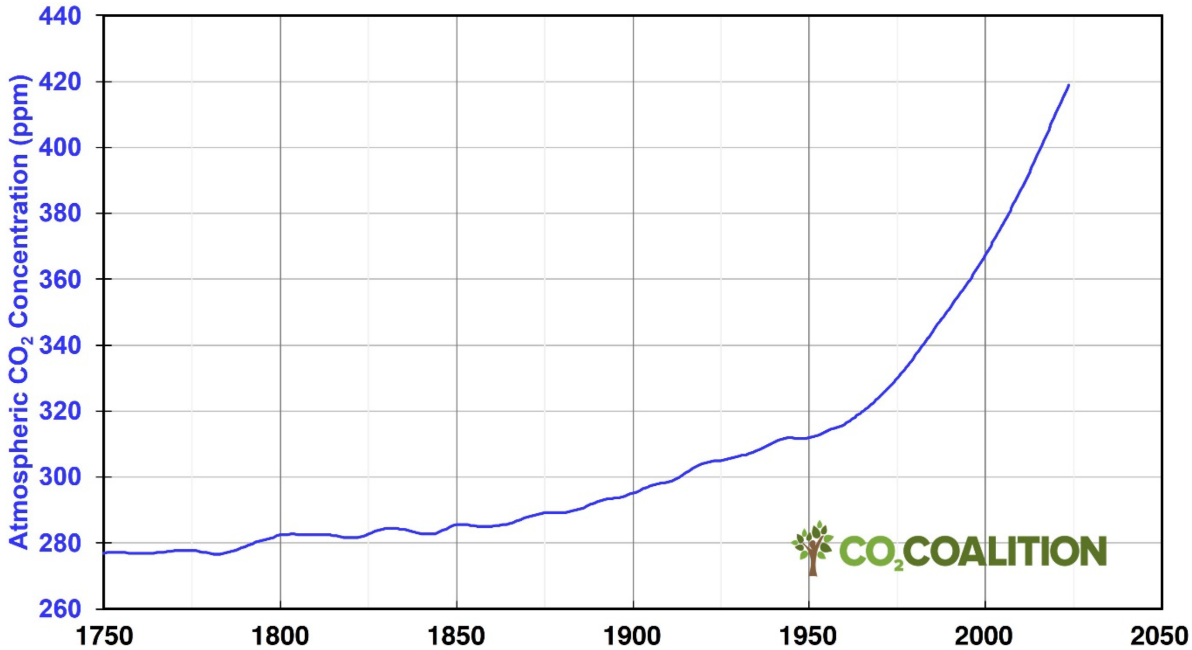


**Figure 2:** *Atmospheric carbon dioxide concentration. Keeling et al. (2025)*

can be deceiving. Time scale is important. Put in a longer geologic perspective, today's level of $CO_2$, while reflecting a recent increase, is seen to be significantly lower than during nearly all of Earth's history. Figure 3 shows that atmospheric $CO_2$ concentration over the past 570 million years averaged about 2,600 ppm, roughly six times our current concentration. Today's $CO_2$ concentration—nearly at an historical low—is preventing crops, trees, and other plants from reaching their full growth potential via photosynthesis. Claims that modern levels of atmospheric $CO_2$ are unprecedented are false.

As shown in Figure 3, the atmospheric $CO_2$ concentration peaked at values exceeding 7,000 ppm during the past 570 million years. The overall decline in the atmospheric $CO_2$ concentration occurring since the Devonian period was a result of: (1) the uptake of $CO_2$ by terrestrial plants, including trees that were buried deeply and became the coal now being mined in Montana; (2) algal blooms dying and sinking to the bottom of oceans and lakes, forming carbon-rich muds that were buried deeply, heated, and converted into oil and natural gas; and (3) oceanic carbon reacting to form calcium carbonate ($CaCO_3$) rocks, primarily limestones.

The modern increase in atmospheric $CO_2$ is primarily the result of industrial $CO_2$ emissions from the burning of fossil fuels (Engelbeen et al., 2024). Oceans and the biosphere act as $CO_2$ sinks, rather than $CO_2$ sources. The atmospheric $CO_2$ level is rising only about half as fast as one would expect from the rate of human $CO_2$ emissions, because natural carbon sinks are removing $CO_2$ from the atmosphere about half as fast as humans are adding it. The two main natural carbon sinks are uptake by the oceans and huge increases in vegetative photosynthesis (Figure 4). This development is leading to increasing crop productivity, expanding forests, and shrinking deserts.

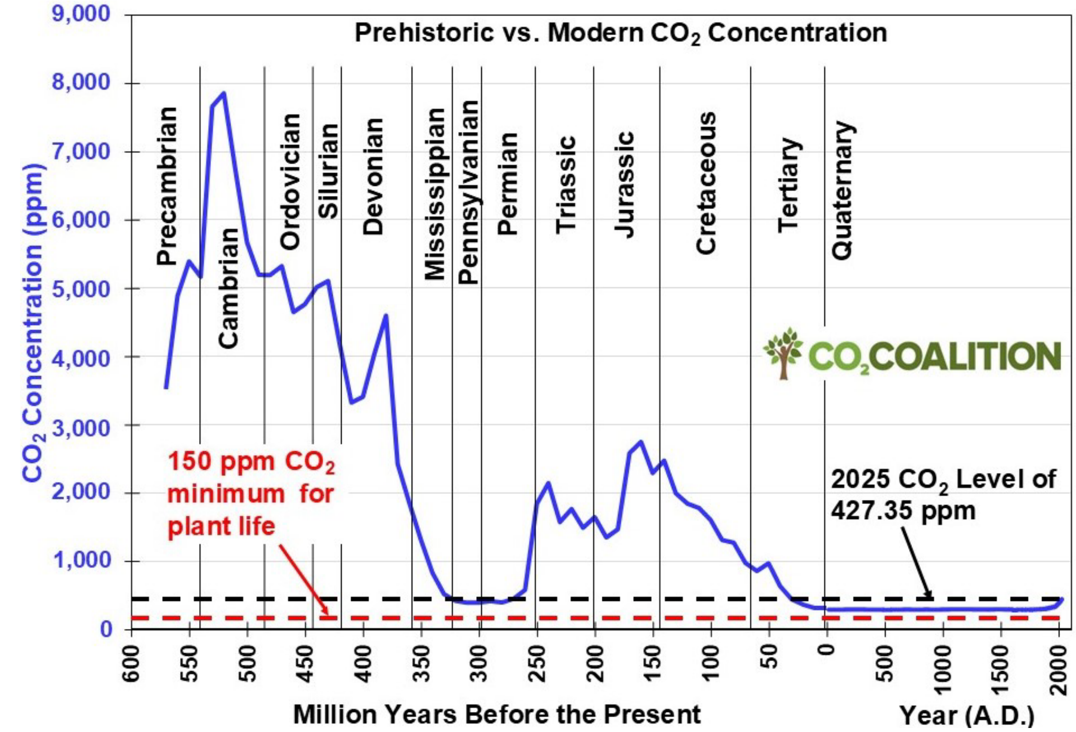


**Figure 3:** 570 *million years of $CO_2$ concentration, plotted with recent $CO_2$ concentrations (since A.D. 154), for comparison. Prehistoric $CO_2$ Concentration: Berner and Kothavala (2001a, 2001b) (NOAA), Recent $CO_2$ Concentration: Keeling et al. (2026); Lan and Keeling (2026)*

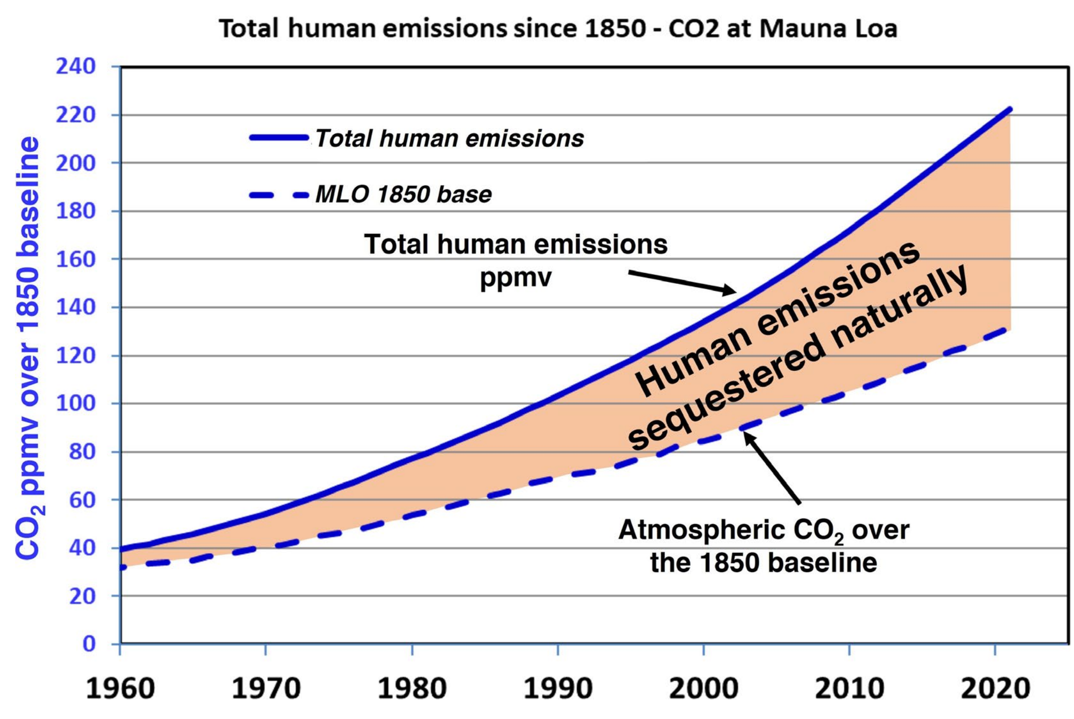


**Figure 4:** *$CO_2$ level is rising only half as fast as the human emission rate. $CO_2$ emissions: Global Carbon Budget (2025), atmospheric $CO_2$ concentration: Lan and Keeling (2026), image source: Engelbeen (2023)*

# PHYSICAL SCIENCE BASIS: CLIMATE CHANGE IN MONTANA

## GLOBAL TEMPERATURE

The *Findings of Fact* claims that $CO_2$ is causing dangerous warming:

> *"… the more $CO_2$ that was added to the atmosphere, the more the surface of the Earth would warm."*

The two most important questions to be addressed are:

- Is increasing atmospheric $CO_2$ the primary cause of warming over the last 100-plus years?
- Is a modest increase in temperature dangerous?

According to the Met Office Hadley Centre (2026), the global temperature has increased about 2.7 °F (1.5 °C) over the last 175 years. Importantly, just as $CO_2$ levels began increasing in the late 1940s, Earth went into a 33-year decrease in temperature (Figure 5).

> **Note:** A temperature anomaly shows changes in temperature compared to an average over a period of time, in this case the average temperature during 1961–1990.

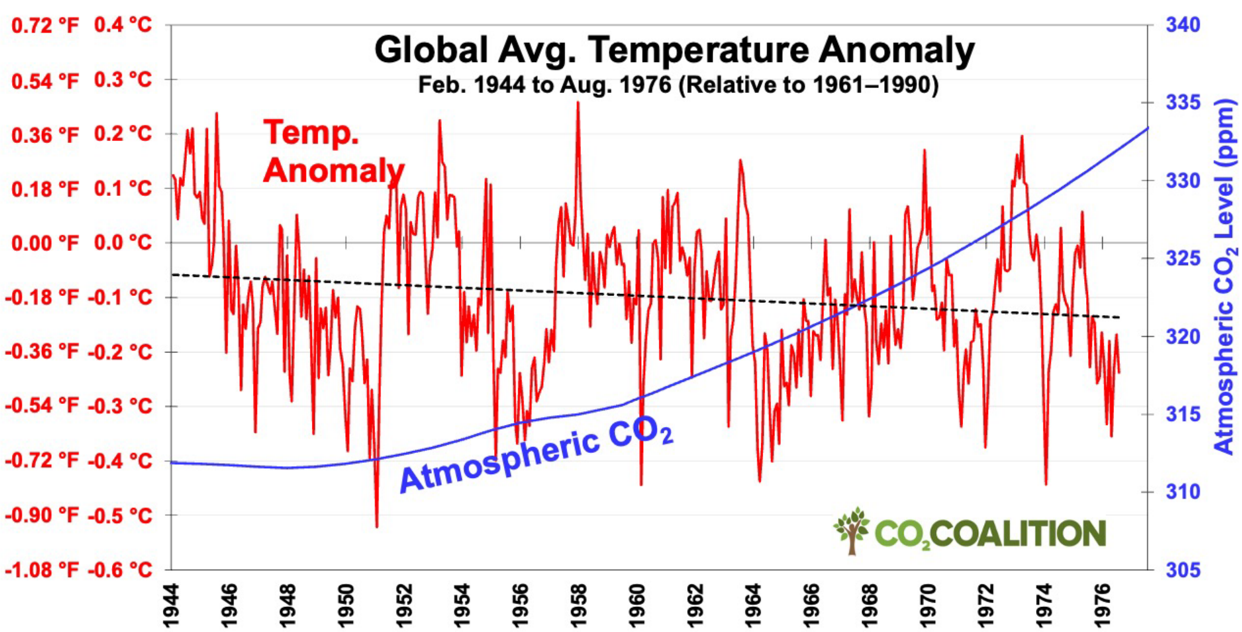


**Figure 5:** *Annual mean global temperature anomaly, from 1944 to 1976, relative to 1961–1990, vs. atmospheric $CO_2$ concentration. Temperature: Met Office Hadley Centre (2026), $CO_2$: Keeling et al. (2025)*

Looking at a longer timescale, the Central England temperature record, the longest instrumental climate record available (Figure 6), dates to the year 1659, during one of the coldest periods of the last 10,000 years, known as the Little Ice Age (A.D. 1250 to 1850). Its earliest data were from the Maunder Minimum, a period of extreme cold within the Little Ice Age.

The current modern warming began nearly 250 years before there was any significant increase in atmospheric carbon dioxide in the mid-20th century from human emissions. Therefore, modern temperature rise cannot be attributed primarily to the rising concentration of atmospheric $CO_2$ from anthropogenic activities.

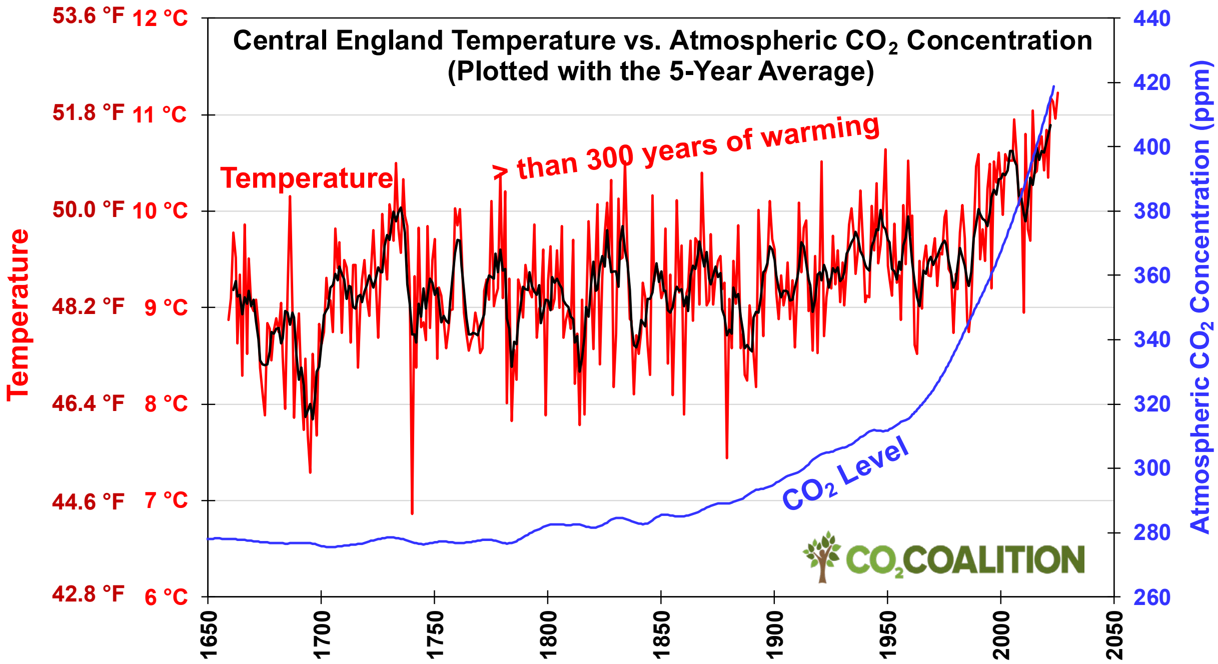


**Figure 6:** *More than 300 years of warming from 1659–2025. Temperature: Met Office Hadley Centre for Climate Change (2026), $CO_2$: Keeling et al. (2025)*

## MONTANA TEMPERATURE STATIONS

Concerning temperatures in Montana, below is the claim from the *Findings of Fact*:

> "*Montana is warming, and the rate of warming is increasing.*"

To determine the validity of the claims regarding an unusual and unprecedented warming in Montana, we relied on data from the U.S. Historical Climatology Network (USHCN) (NOAA NCEI, 2025e). Montana has 44 USHCN stations spread throughout the state that record temperature and precipitation data. The locations of these stations are shown in Figure 7.

## TEMPERATURE ADJUSTMENTS AND FABRICATION OF DATA

The sites for the USHCN stations were selected by NOAA based on "their spatial coverage, record length, data completeness, and historical stability" (Menne et al., 2009; NOAA NCEI, 2025e). The data from USHCN are the highest quality, long-term, direct thermometer records available for Montana. Even so, there are several factors intrinsic to the data that serve to overstate modern warming and reduce temperatures of earlier periods:

- Urban heat island effect is reduced but not eliminated (Spencer et al., 2025; Watts, 2022, 2026).
- Adjustments are made to raw historical temperatures (Menne et al., 2009; NOAA NCEI, 2025e).
- Models are used to fill the data gaps for stations that no longer exist or are no longer reporting (Heller, 2022).

These adjustments are explained in more detail in the accompanying Appendix.

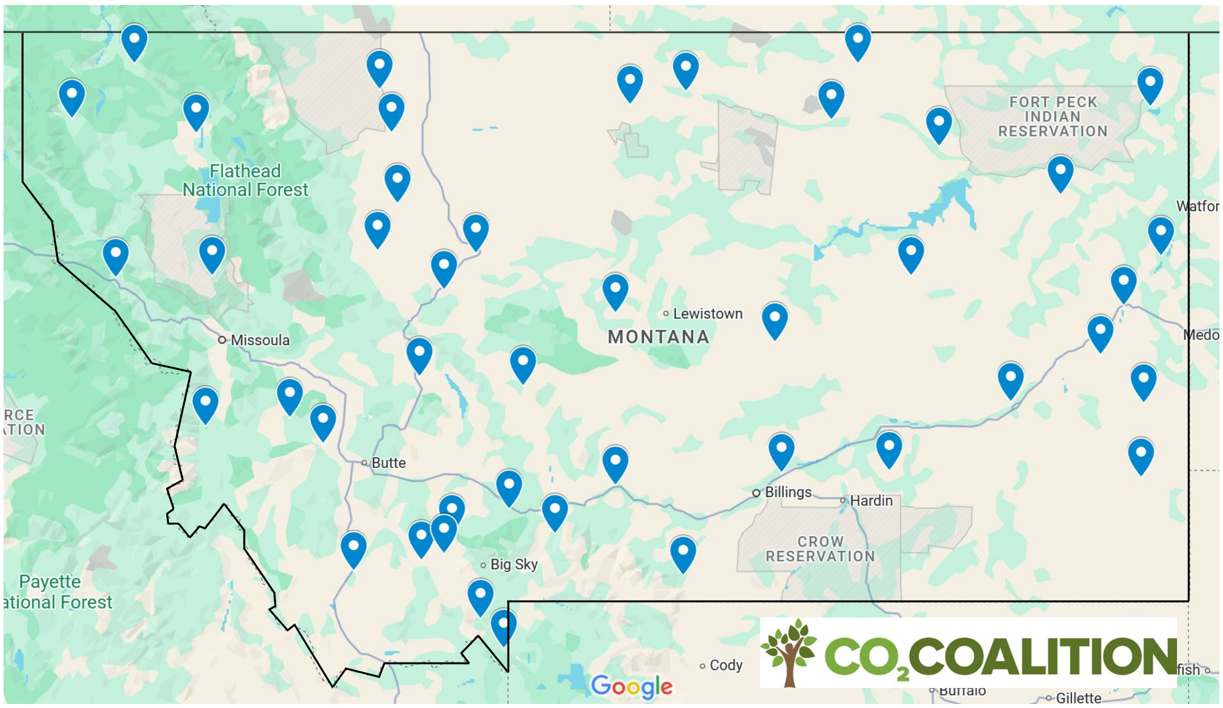


**Figure 7:** *The locations of the 44 USHCN temperature and precipitation stations in Montana. NOAA NCEI (2025e)*

## AVERAGE TEMPERATURES IN MONTANA

The annual average temperature data from Montana (Figure 8) show that the state has had a modest warming since the late 1800s of about 1.9 °F (1.1 °C), based on the five-year average temperatures.

The highest annual average temperature was recorded in 1934, during a time when the atmospheric $CO_2$ concentration was more than 100 ppm lower than the current level (Keeling et al., 2025; Lan and Keeling, 2026). If $CO_2$ were primarily responsible for the warming in Montana, the peak value for the average temperature would have been observed closer to the present, rather than nearly a century ago at very low $CO_2$ levels. Clearly, $CO_2$ is not the only factor affecting Montana's temperatures.

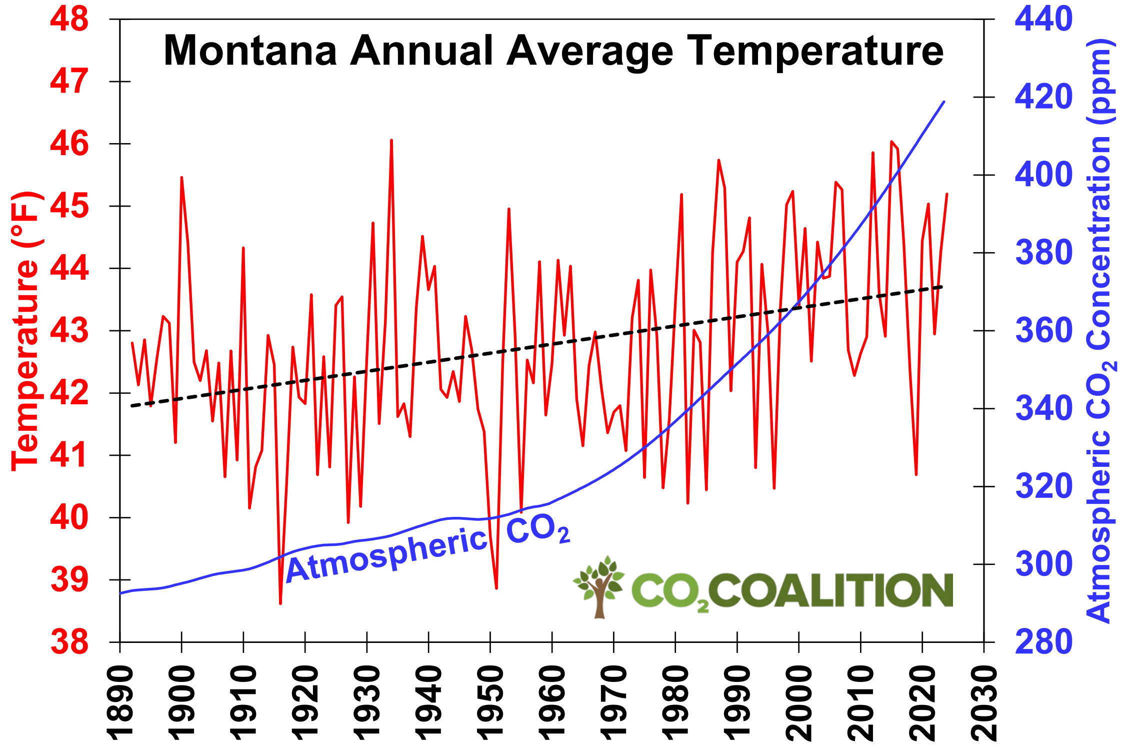


**Figure 8:** *Annual average temperature in Montana vs. atmospheric $CO_2$ concentration. Temperature: NOAA NCEI (2025e), $CO_2$: Keeling et al. (2025)*

Based on a linear trend for the annual average temperature, the average rate of warming in Montana since 1892 is 0.015 °F/year (0.0081 °C/year), which translates to a predicted warming of about 1.1 °F (0.61 °C) from 2025 to 2100. In contrast, the *Findings of Fact* predicts much higher warming:

> *"Projections indicate a high-emission scenario results in 9.8°F of warming in Montana by 2100, relative to temperatures in 1971–2000. An intermediate emission scenario projects an increase of 5.6°F in Montana by 2100, relative to temperatures in 1971–2000."*

How can this be?

The answer is simple: The *Findings of Fact* relies on computer models:

> *"Computer models used by scientists are an important tool for predicting climate change and are reasonably relied upon by members of the scientific community."*

However, these climate models have been proven to be unreliable. The models are based on assessments of climate sensitivity, which is the estimated temperature response to a doubling of atmospheric $CO_2$ concentrations. In other words, if our current ~ 430 ppm $CO_2$ level doubled to 860 ppm, what increase in temperature could we expect?

On top of this greenhouse-induced warming, these models assume that the direct warming effect of $CO_2$ is multiplied by a large and positive “feedback factor” from $CO_2$-induced changes in water vapor and clouds, which contribute much more to the greenhouse warming of the Earth than $CO_2$. But there is observational evidence that the feedback factor is small and may even be negative (Lindzen, 2022).

> **Note:** The Held v. Montana ruling relied on several climate modeling scenarios to predict warming from future emissions of $CO_2$. One of these scenarios, the high-emission scenario (Shared Socioeconomic Pathway 5-8.5, SSP5-8.5, and its “precursor,” Representative Concentration Pathway 8.5, RCP8.5), was recently determined to “have become implausible” by its developers (Van Vuuren et al., 2026).

A detailed examination by Dr. John R. Christy, Distinguished Professor of Atmospheric Science and Director of the Earth System Science Center at The University of Alabama in Huntsville, provides a stark assessment of the validity of the climate models (Figure 9). For instance, this chart shows that the average of the modeled temperatures predicts a warming rate of 0.42 °C per decade, while the measured temperature shows an increase of 0.17 °C per decade. That means that the models are overpredicting temperature increase by about 2.5 times.

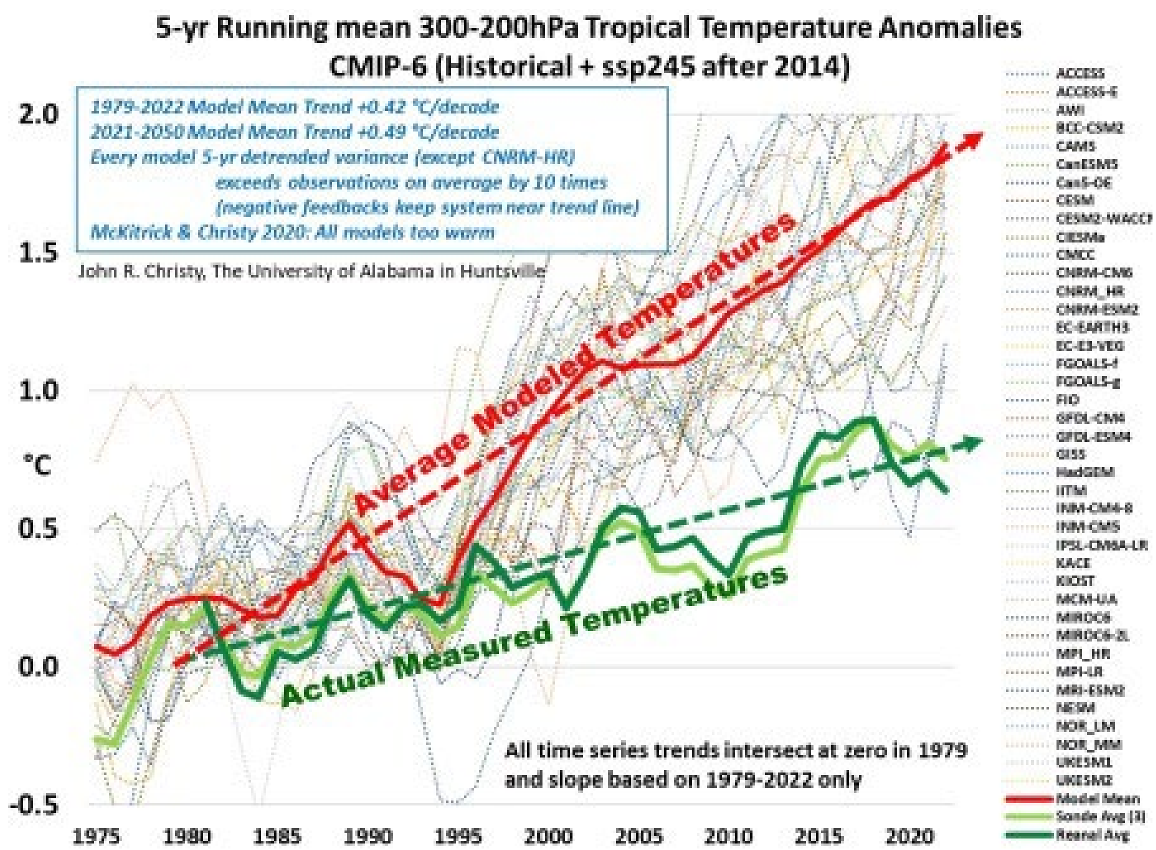


**Figure 9:** *Average of modeled tropical temperature anomalies vs. real-world temperatures. Christy (2023) (modified)*

A report published in the journal *Nature* (Hausfather et al., 2022) by climate modelers from NASA, Columbia University, Texas A&M University, and Lawrence Livermore National Laboratory confirms that many of the CMIP6 models (Coupled Model Intercomparison Project, 2026), on which the Held v. Montana case relied, significantly overpredict warming.

Given that we cannot accurately predict the temperature just days into the future, it is not surprising that climate models cannot predict the temperature decades into the future. The models relied on by the *Findings of Fact* vary by more than a factor of three, indicating that Earth's climate system is not well understood. Therefore, climate models should not be used to make claims regarding the climate, let alone formulate climate policies.

Should Montanans be concerned regarding the modest increase in temperature? After all, the *Findings of Fact* asserted that rising temperatures are detrimental to children's health:

> *"Children who have pre-existing respiratory conditions, including asthma, are especially vulnerable to climate impacts, including … rising temperatures."*

Data suggest the contrary. Based on a recent international study concerning temperature-related mortality (Zhao et al., 2021), many more people worldwide die from cold than from heat (Figure 10), with the cold killing nine times more people than heat. Therefore, there is no need to fear the modest warming that Montana is experiencing. If anything, Montanans should be worried if the temperature were to cool at a significant rate.

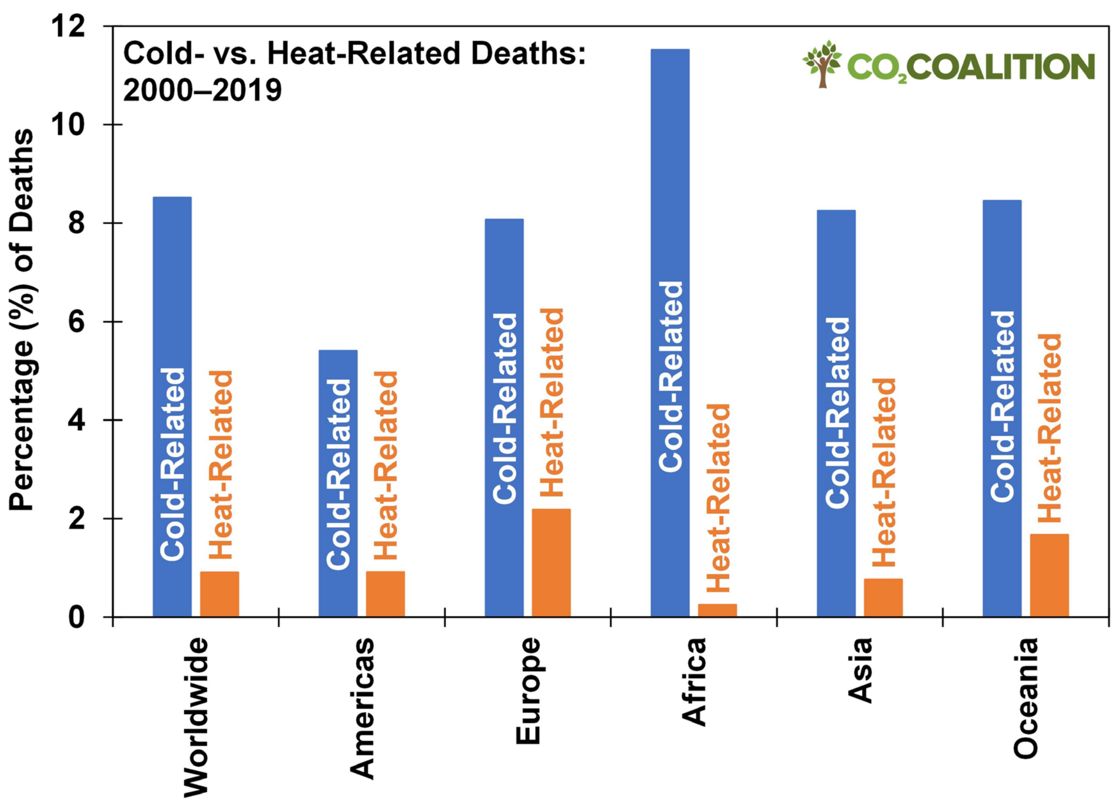


**Figure 10:** *Global proportion of deaths due to cold and heat. Zhao et al. (2021)*

In addition to benefiting humans by reducing the number of cold-related deaths, the warming benefits plants. The U.S. EPA (2025b) lists temperature, frost days, precipitation, and daylight hours as factors that affect the length of the growing season of crops. Here, the growing season becomes longer as the temperature increases and as killing frosts end earlier in the spring and arrive later in the fall.

The *Findings of Fact* confirmed the reduction in “the number of freeze-free days” that contribute to the lengthening of the growing season of crops:

> *“Rising temperatures will increase the number of freeze-free days in Montana …”*

Rather than being detrimental to Montana’s ecosystems and agricultural productivity, rising temperatures are highly beneficial, as they have caused the length of the growing season to increase.

As shown in Figure 11, the growing season length in the western United States, which encompasses the State of Montana, has increased by more than three weeks since 1895. This development provides farmers more time for planting and harvesting, which helps boost agricultural production. Further discussions regarding the thriving agricultural sector in Montana are provided in a later section.

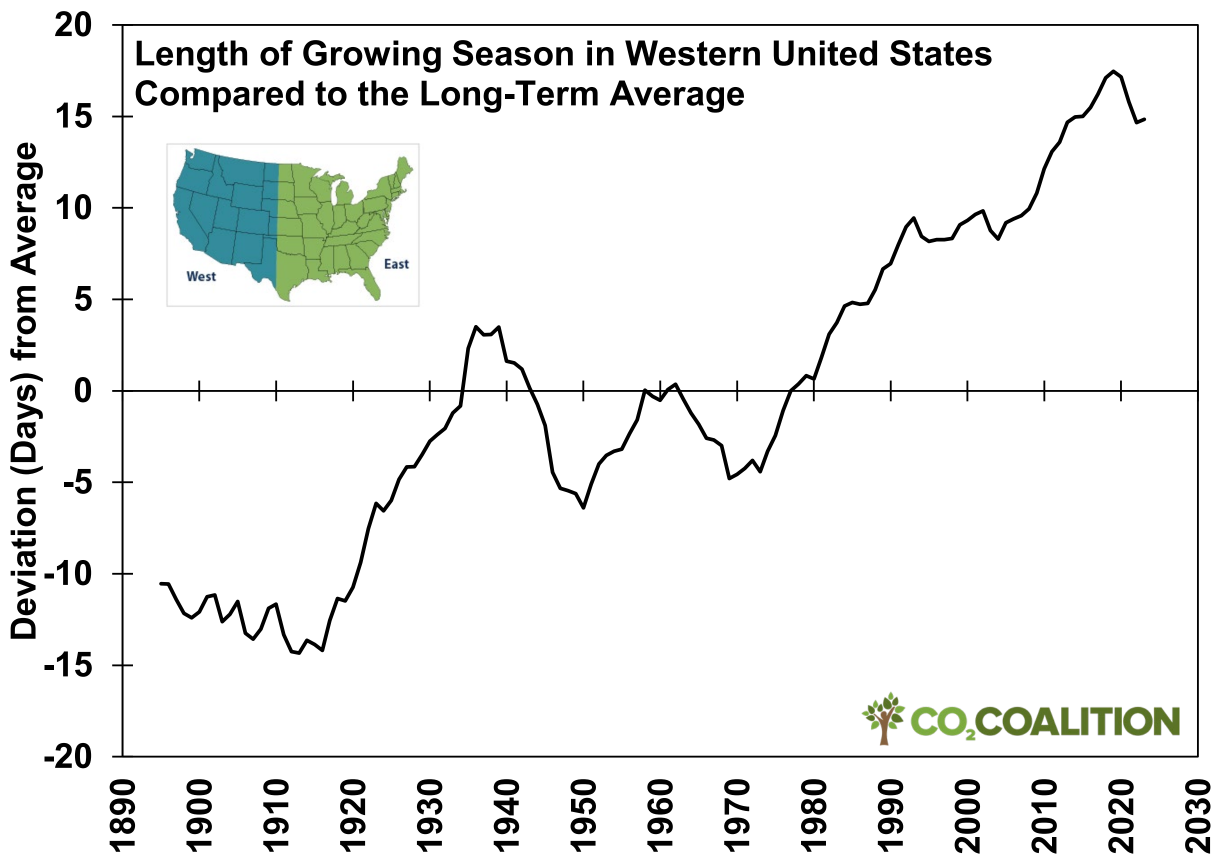


**Figure 11:** Length of *growing season of crops in the western United States. U.S. EPA (2025b)*

## COLD TEMPERATURES IN MONTANA

The *Findings of Fact* claims that winter seasons are under threat due to rising temperatures.

What do the data tell us?

Based on the temperature records from the USHCN stations, Montana has had a modest increase in its annual average minimum temperature (Figure 12).

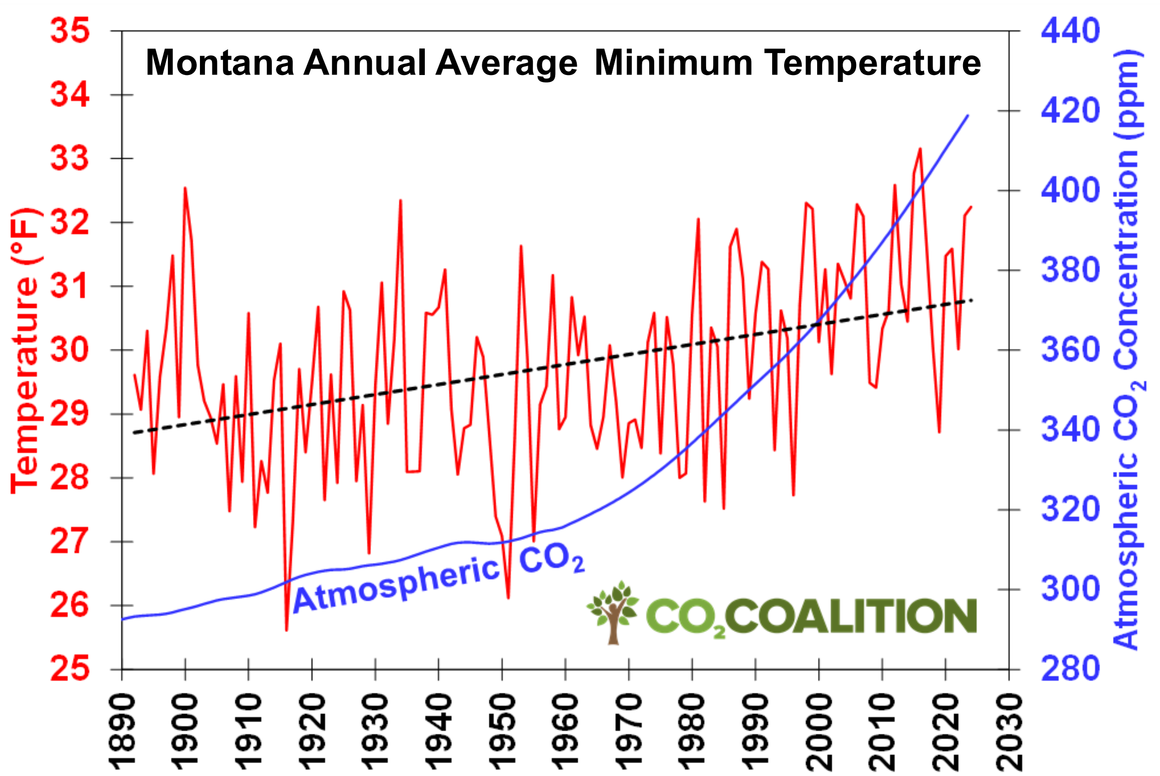


**Figure 12:** *Annual average minimum temperature in Montana vs. atmospheric $CO_2$ concentration. Temperature: NOAA NCEI (2025e), $CO_2$: Keeling et al. (2025)*

According to the *Findings of Fact*:

> *"The current decline in Montana snowpack and snow accumulation is projected to continue."*

We find no evidence to support this claim. For instance, based on the data from Montana State University (Figure 13), while the annual snowfall has fluctuated significantly since 1980, there is no evidence of a decline in annual snowfall despite increasing atmospheric $CO_2$ concentration and modest warming in Montana (Figures 8 and 12). This refutes the claim from the *Findings of Fact* that "the decline in snowpack is directly attributed to elevated temperatures due to high levels of GHG emissions" (Held v. Montana, 2023). That snows are not disappearing in Montana is good news for ski enthusiasts.

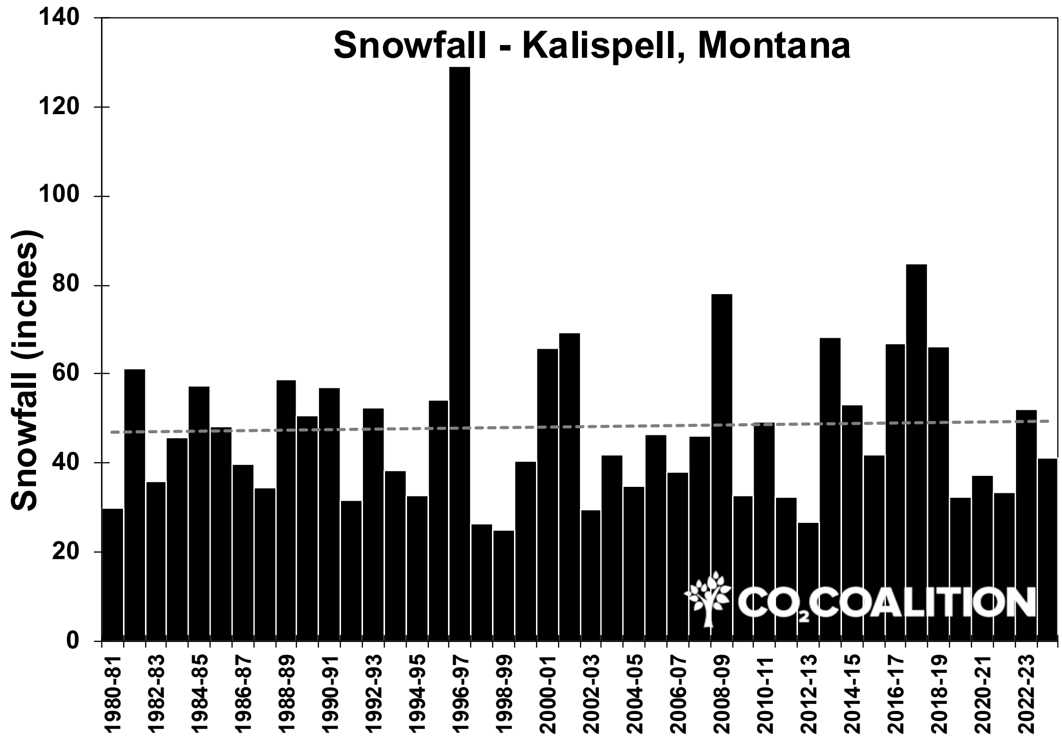


**Figure 13:** *Annual snowfall at Kalispell, Montana since 1980. Montana State University (2025)*

> *"The scientific consensus is that the retreat of Glacier Park's glaciers over the past century is due to human GHG emissions (mainly $CO_2$ from fossil fuel burning)."* (Held v. Montana, 2023)

Claims that glacial retreat is linked to increasing $CO_2$ is refuted by long-term data. Cochrane et al. (2012) show that the glacial retreat at Alaska's Glacier Bay began before 1800, long before there was a significant increase in atmospheric $CO_2$ (Figure 14). This observation suggests that increasing $CO_2$ cannot be solely blamed for the warming responsible for causing glacial retreats. The comparison in Figure 15 of the total worldwide glacial extent, based on 169 records, compared to the global $CO_2$ emissions from fossil fuel combustion and cement production confirms that glaciers began retreating in the early 1800s at very low $CO_2$ levels.

## HOT TEMPERATURES IN MONTANA

The *Findings of Fact* claims that heat waves are becoming more frequent in Montana:

> *"The yearly days in Montana with extreme heat, meaning temperatures over 90 degrees, is expected to increase by 11 – 30 days by midcentury, and by as much as two months by the end of the century."*

Figure 16 shows that the annual average maximum temperature in Montana has been increasing at a rate of about 1.3 °F per century since the late 1800s. Furthermore, just as with the annual average temperature, the highest annual average maximum temperature of 59.8 °F

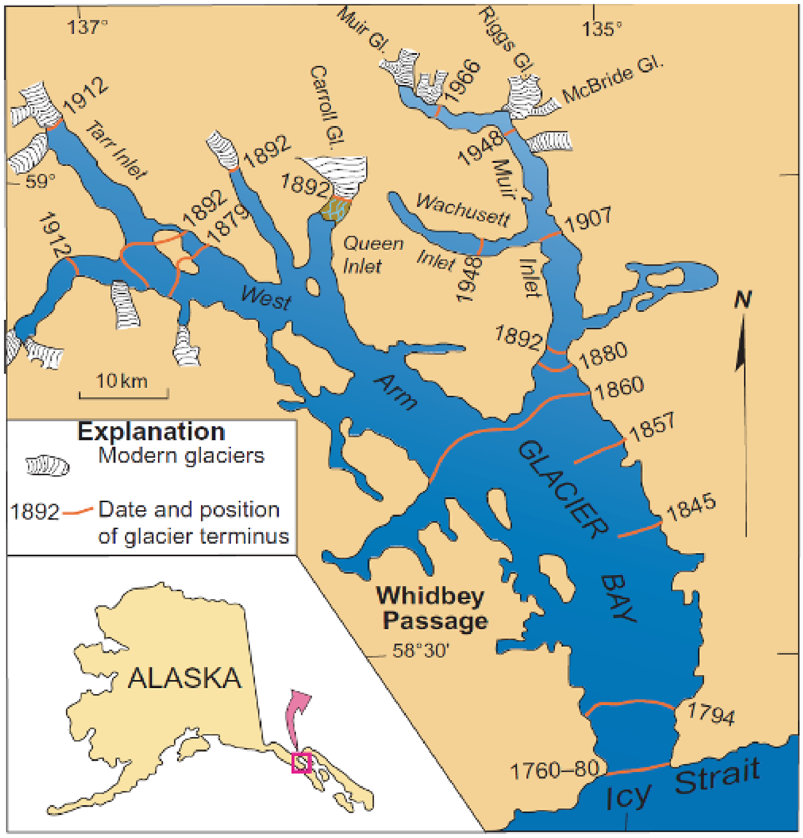


**Figure 14:** *Glacial retreat of Glacier Bay, Alaska, since the late 1700s. Image source: Cochrane et al. (2012)*

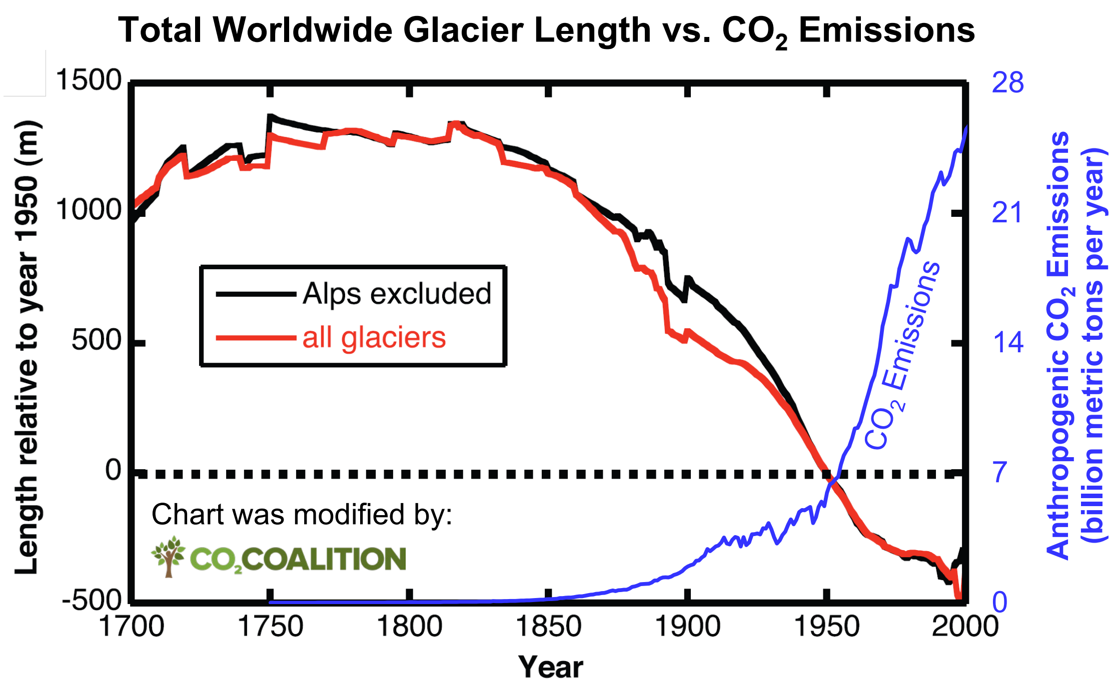


**Figure 15:** *Total worldwide glacial extent, based on 169 glacier records vs. $CO_2$ emissions. Glacier chart and data: Oerlemans (2005), $CO_2$ emission: Global Carbon Budget (2025)*

was recorded in 1934. To reiterate, this took place when the atmospheric $CO_2$ concentration was more than 100 ppm *lower* than recent values (Keeling et al., 2025; Lan and Keeling, 2026).

The fact that Montana's hottest summer occurred about nine decades ago, when $CO_2$ levels were much lower than today, shows that $CO_2$ is not the only factor affecting temperatures. Moreover, the observed upward trend in Montana's summer high temperatures is modest and benign, whatever its causes.

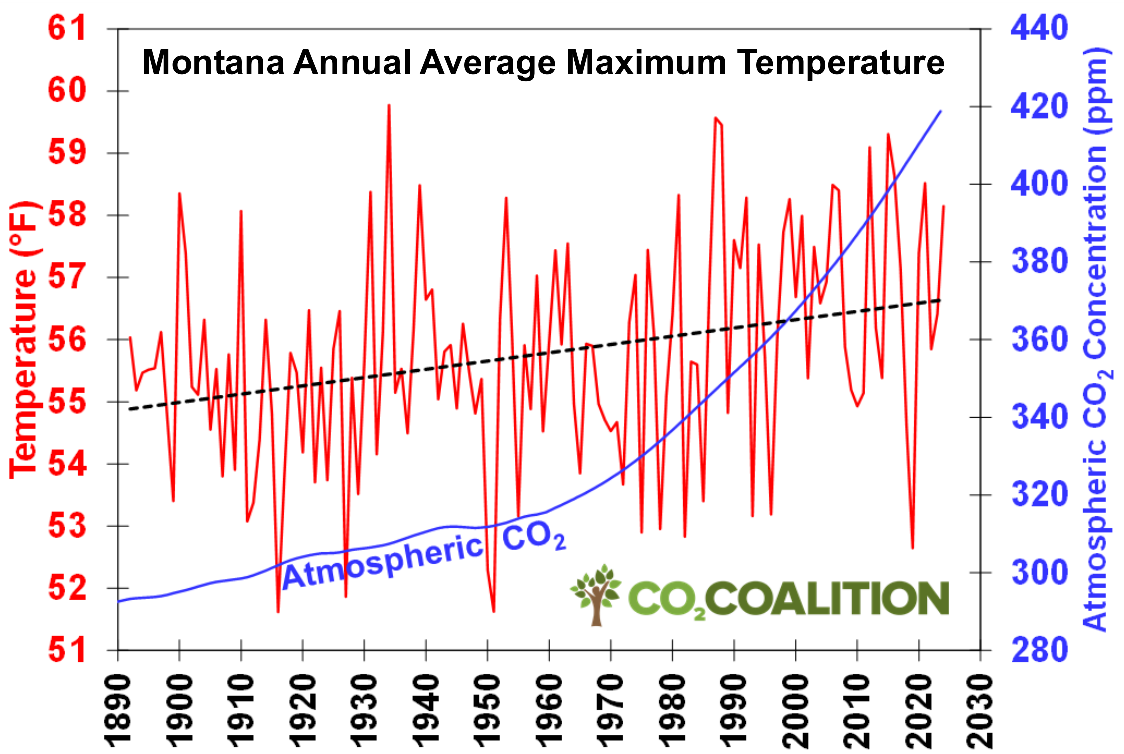


**Figure 16:** *Annual average maximum temperature in Montana vs. atmospheric $CO_2$ concentration. Temperature: NOAA NCEI (2025e), $CO_2$: Keeling et al. (2025)*

Claims in the *Findings of Fact* that the number of days over 90 °F (32.2 °C) will increase by 11–30 days by 2050, and as much as 60 days by the end of the century, are not supported by the actual data. Figure 17 plots the annual percentage of days in Montana with temperatures above 90 °F. We find that since 1895, the annual number days with temperatures above 90 °F (32.2 °C) has increased at a rate of about 7 days/century. At this rate, additional days over 90 °F would only increase by about 2 days from 2025 to 2050 and by about 5 days from 2025 to 2100, far smaller than the alarming claims made in the *Findings of Fact*.

Looking at the bigger picture, Figure 18 shows that the heat wave index in the contiguous United States peaked in the 1930s (during a time of much lower atmospheric $CO_2$ concentration), during the "Dust Bowl" era (U.S. EPA, 2025a). Since then, despite increasing atmospheric $CO_2$ concentrations, the annual heat wave index has remained well below those experienced during the "Dust Bowl" era. Clearly, $CO_2$ is not the sole factor affecting heat waves.

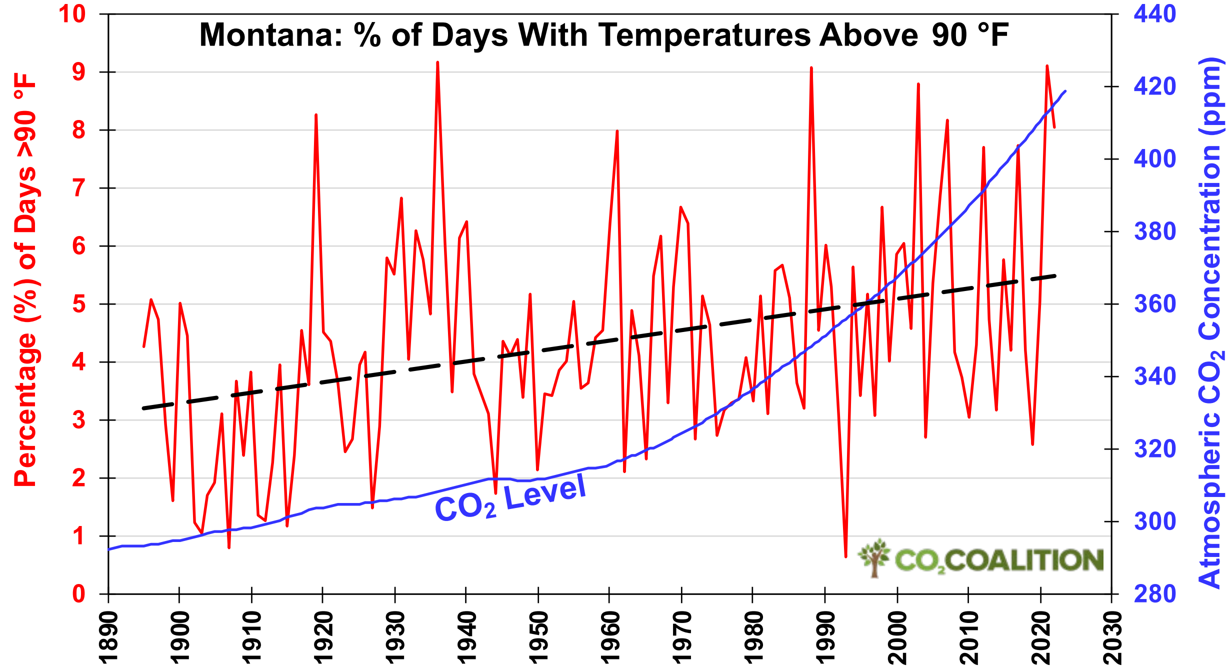


**Figure 17:** *Percentage of days with temperatures above 90 °F in Montana vs. atmospheric $CO_2$ concentration. Temperature: NOAA NCEI (2025c, 2025e) via Heller (2023), $CO_2$: Keeling et al. (2025)*

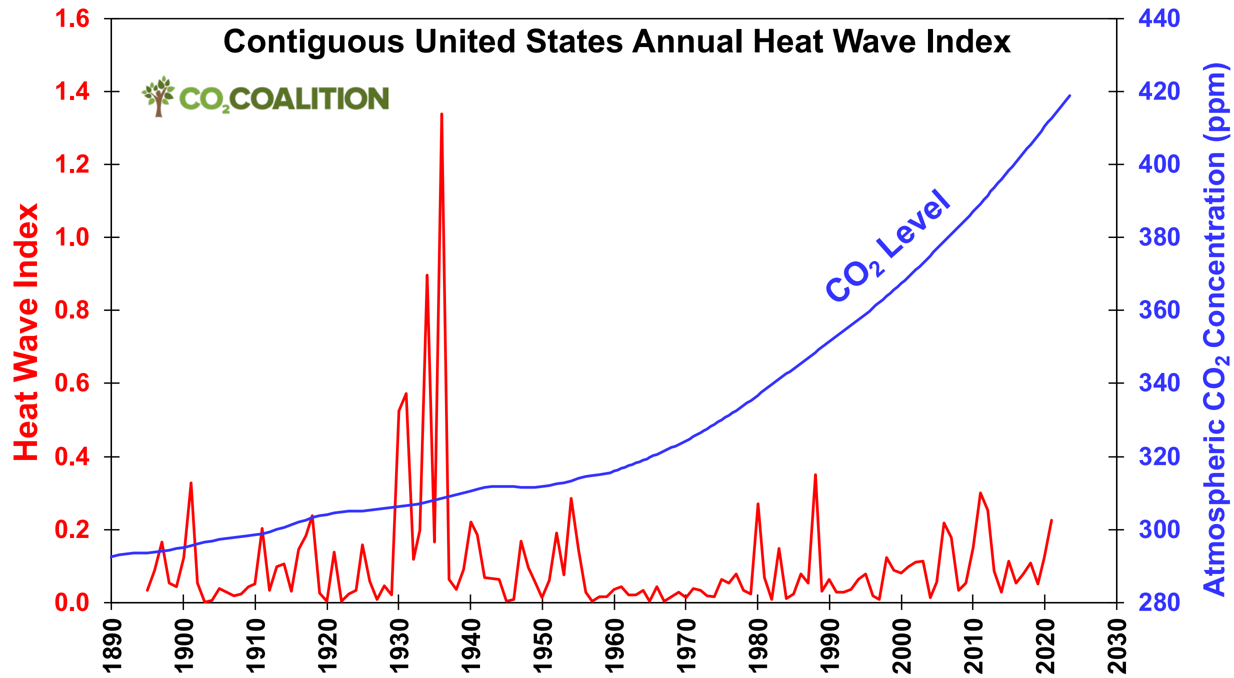


**Figure 18:** *Contiguous United States annual heat wave index vs. atmospheric $CO_2$ concentration. Heat wave index: U.S. EPA (2025a), $CO_2$: Keeling et al. (2025)*

## EXTREME WEATHER EVENTS

### DROUGHT

Droughts, and the famines associated with them, were the leading cause of death during 1970–2019, making them the world's worst natural disasters over the last 50 years (WMO, 2021). Drought is also the single greatest threat to the agricultural sector around the world. In fact, according to the United Nations' Food and Agriculture Organization (FAO), drought "has been established as the single greatest culprit of agricultural production loss" (FAO, 2021). While drought can make life difficult for the general population, it is agriculture that bears 82% of the impacts.

Since the economic and human toll from sustained droughts are enormous, in this section, we will review the data to determine if droughts are increasing, as claimed by the *Findings of Fact*:

> *"The western United States, including Montana, has experienced a trend of increased drought and heat stress from climate change …"*

In the previous section, we have shown that the observed upward trend in Montana's summer high temperatures is modest and benign, and the worst heat waves occurred in the 1930s, when $CO_2$ levels were nearly 120 ppm lower.

Once again, we find that claims of increasing drought are not supported by the data. Figure 19 shows the annual precipitation in Montana. The data indicate that the annual precipitation can fluctuate greatly from year to year, but there has been no long-term decrease recently or over the last 140+ years.

In addition to precipitation, another measure of the severity of drought is the Palmer Drought Severity Index (PDSI). This metric estimates the relative soil moisture conditions using simplified soil water balance (NOAA NIDIS, 2025). Positive and negative PDSI values indicate wet and dry conditions, respectively, with PDSI > 4 indicating "very wet conditions," and PDSI < -4 indicating "extreme drought."

Figure 20 shows the PDSI values for Montana. Since 1895, Montana's condition has been alternating between dry and wet periods. Despite that, there is no indication that droughts are worsening in Montana. The most severe drought occurred in the 1930s, during a time when the atmospheric $CO_2$ concentration was much lower. These observations indicate that the rising $CO_2$ concentration does not make droughts more frequent or severe.

In fact, elevated $CO_2$ mitigates drought impacts through reduced transpiration and improved water-use efficiency of crops (Taylor and Schlenker, 2025).

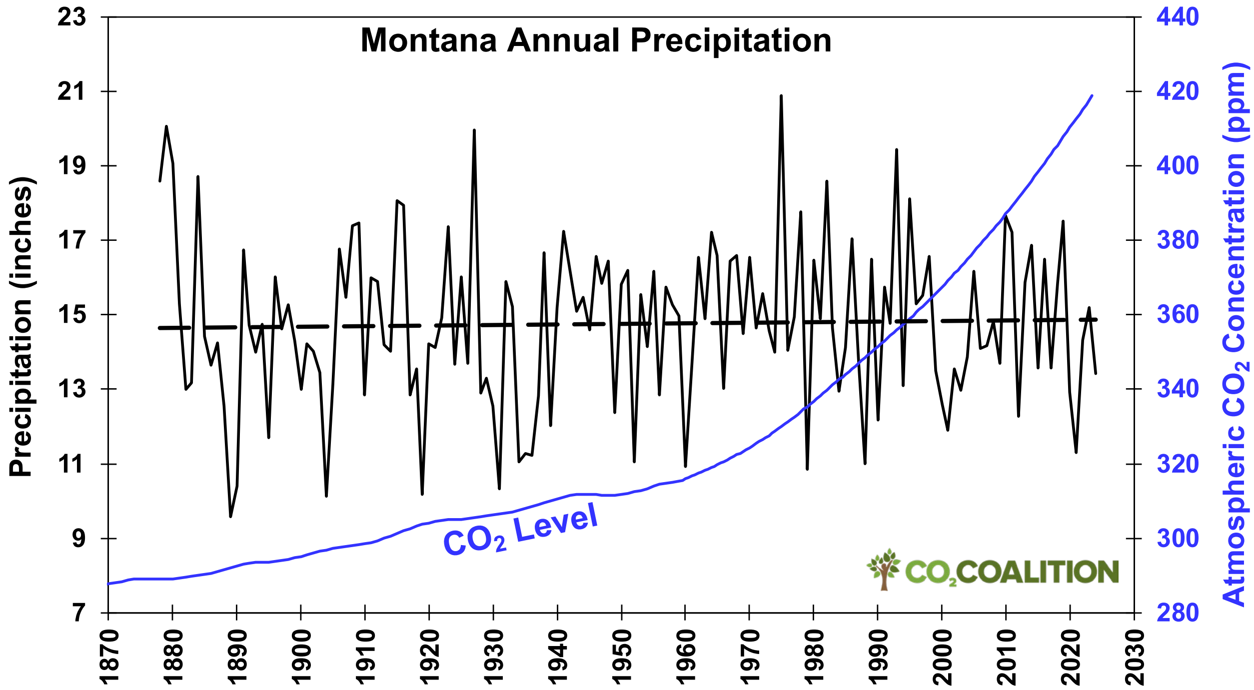


**Figure 19:** *Annual precipitation in Montana vs. atmospheric $CO_2$ concentration. Precipitation: NOAA NCEI (2025e), $CO_2$: Keeling et al. (2025)*

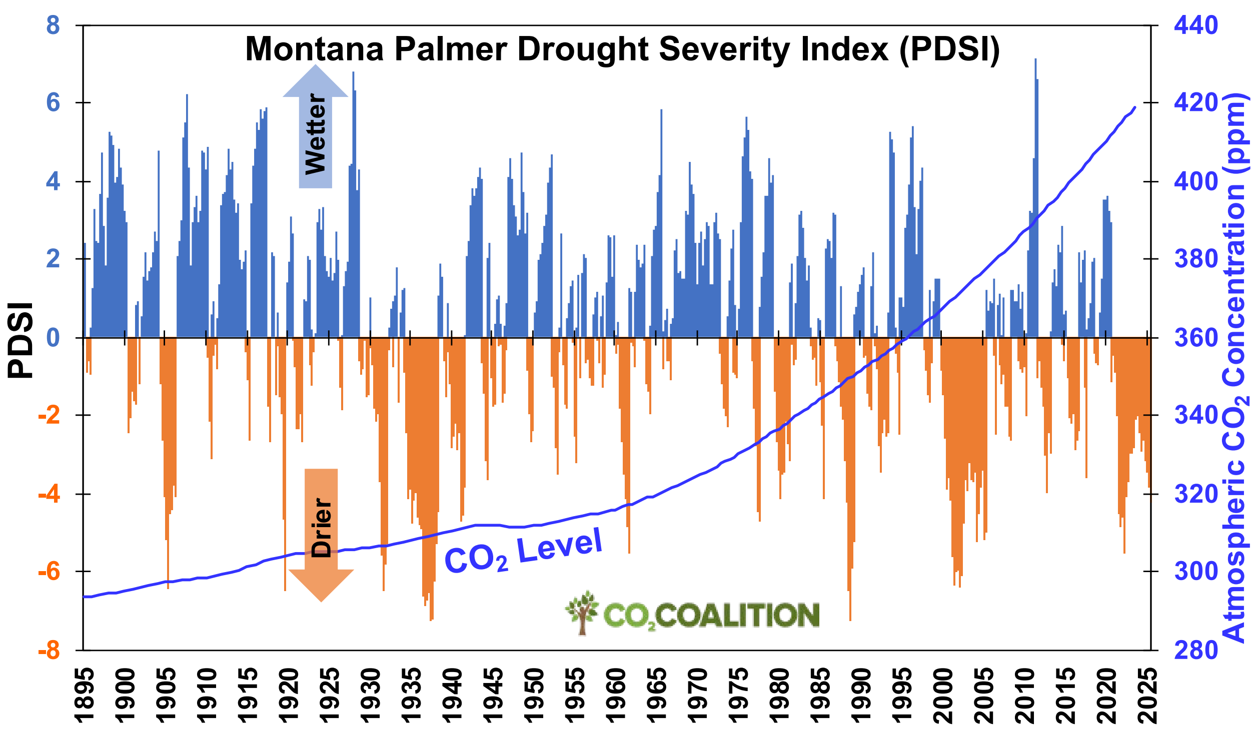


**Figure 20:** *Palmer Drought Severity Index (PDSI) of Montana vs. atmospheric $CO_2$ concentration. PDSI: NOAA NCEI (2025b), $CO_2$: Keeling et al. (2025)*

## WILDFIRES

The *Findings of Fact* claims that the combination of increasing temperatures and drought is causing wildfires to become more frequent and severe and that an imagined worsening of wildfires is somehow linked to GHG emissions:

> *"Climate scientists have long known that increasing temperatures intensify drought conditions, and the combination of drier and hotter weather leads to larger, more frequent, and severe wildfires."*
>
> *"The extent of area burned in the U.S. each year has increased since the 1980s. According to National Interagency Fire Center data, of the ten years with the largest acreage burned, all have occurred since 2004, including the peak year of 2021."*
>
> *"Wildfires in Montana are expected to become significantly worse in the coming years without immediate steps to reduce GHG emissions."*

As discussed in the previous section, the data from NOAA show that droughts in Montana are not worsening. As for wildfires, Figure 21 shows the data regarding the number of wildfires and acreage burned in the United States. The claim that the acreage burned has increased since the 1980s is correct, but it ignores the entire data set available that begins in 1926. In fact, the area burned by wildfires has dropped by more than 80% since its peak in 1930, and the number of wildfires has dropped by more than 70% since its peak in 1981.

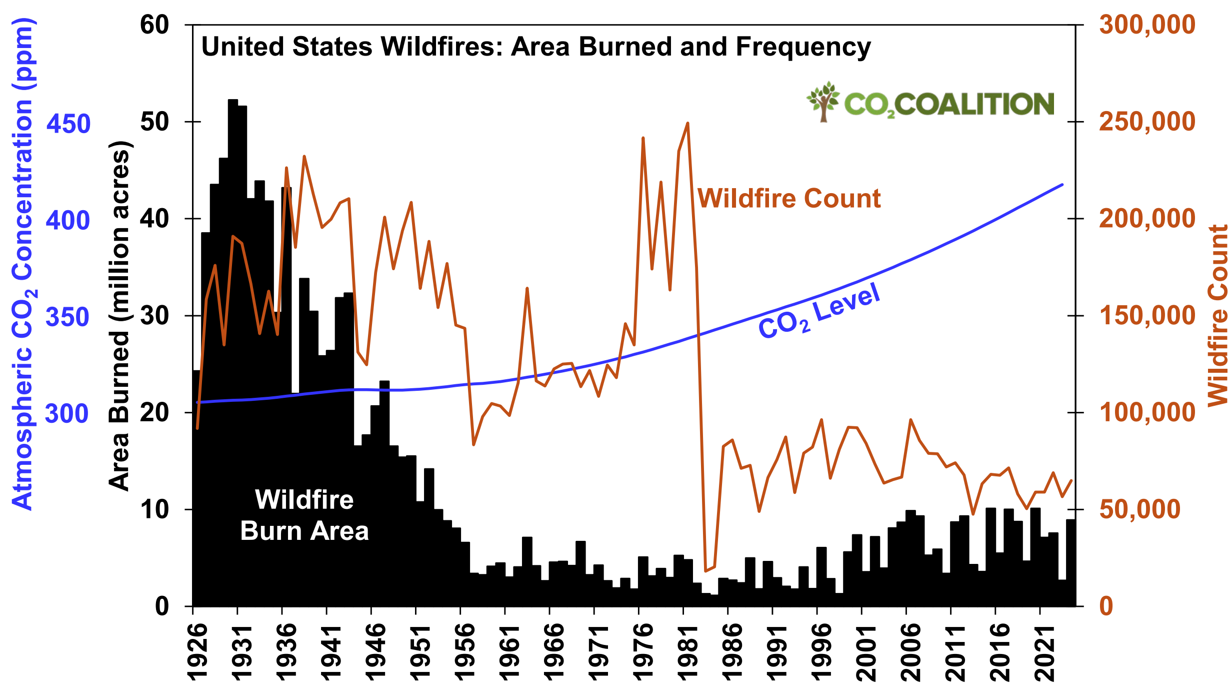


**Figure 21:** *Annual area burned and frequency of wildfires in the United States vs. atmospheric $CO_2$ concentration. Wildfires: NIFC (2020, 2025), $CO_2$: Keeling et al. (2025)*

The claims of $CO_2$-linked increases in wildfires are contradicted by the data. In fact, the increasing atmospheric $CO_2$ concentration can be credited for its contribution to this decrease in wildfires.

Wildfires require dry conditions, fuel, and ignition. As discussed in the previous section, the annual precipitation in Montana is not decreasing and droughts are not worsening. As for the role of $CO_2$, plants have pores in their leaves, called stomata, that they open to "inhale" $CO_2$ and "exhale" oxygen and water vapor. When the stomata are open, water vapor escapes from the stomata through transpiration. This phenomenon is the second largest contributor to water loss in plants. But the good news is that increasing $CO_2$ concentration allows plants to keep their stomata open for a shorter duration, thus reducing the amount of water vapor lost. As a result, plants need less water and more water remains in the soil. This increase in soil moisture plays a major role in reducing wildfires.

It is worth noting that the slight increase in the area burned by wildfires since the 1980s is not caused by climate change. Rather, it is because of public agencies reacting to wildfires rather than proactively preventing fires from starting due to pressure from environmental groups.

## FLOODS

While claiming that droughts are increasing in Montana, the *Findings of Fact* also claims that floods are becoming more of a problem in Montana:

> *"Extreme spring flooding events are consistent with climate change, including more spring precipitation, which can cause flash flooding when rain falls on snow. … Spring flooding is expected to increase in frequency with increased climate change."*
>
> *"Climate change results in water levels in Montana's rivers and lakes that are routinely well below normal levels in summer and fall months and water temperatures that are well above historical levels."*
>
> *"The 2018 Shields River flooding and the 2022 Yellowstone River flooding event are examples of rain on snow and heavy precipitation events that will be more frequent with climate change."*

What's going on with the rivers in Montana?

To answer this question, we turn to the data from the U.S. EPA. Figure 22 shows that there is no significant change in the number of days with low stream and river flows in Montana since 1940. This observation indicates that rivers in Montana are in no danger of drying, which is good news for fishing, boating, and kayaking enthusiasts.

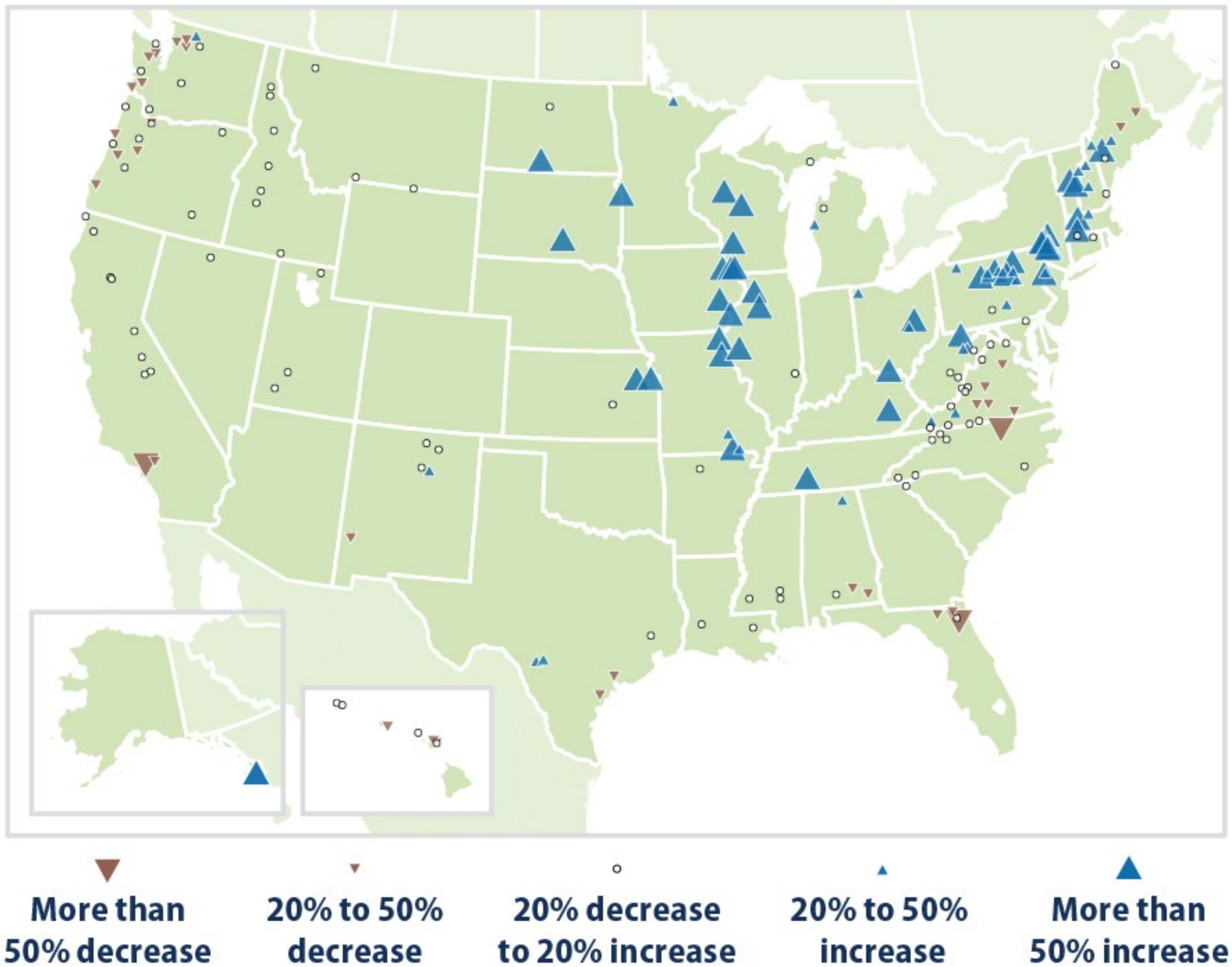


**Figure 22:** *Percentage change in the annual amount of low stream and river flows in the United States, from 1940 to 2022, based on the number of consecutive seven-day periods with the lowest average flow during the year. U.S. EPA (2025c)*

Similar to the case of low stream and river flows, Figure 23 shows that there is no significant change in the number of days with high stream and river flows in Montana since 1940. Confirming that there has not been a dangerous increase in flooding, Figure 24 shows that, based on their historic crest heights, the rivers listed in the *Findings of Fact* have not experienced an increase in flooding. Therefore, just as rivers in Montana are in no danger of drying, the flooding risks of these rivers are not increasing, which is good news for those in Montana with homes located within flood plains.

Moving from river floods to floods in general, the data from NOAA indicate that since 1996, floods (Figure 25) and flash floods (Figure 26) in Montana are not becoming more frequent, despite the rising atmospheric $CO_2$ concentration. Therefore, any claims linking rising atmospheric $CO_2$ concentration with more flooding are false.

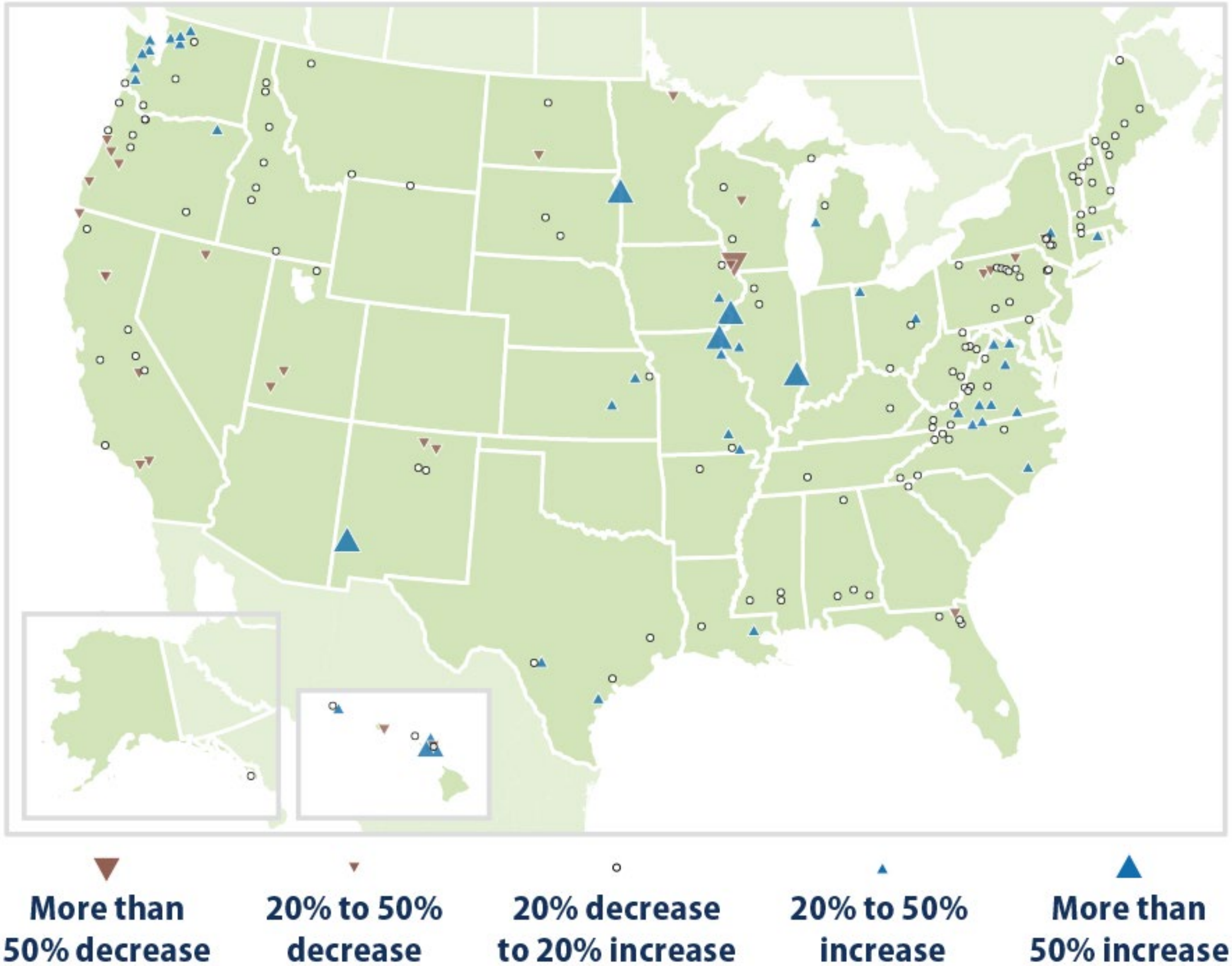


**Figure 23:** *Percentage change in the annual amount of high stream and river flows in the United States, from 1940 to 2022, based on the number of consecutive three-day periods with the highest average flow during the year. U.S. EPA (2025c)*

## TORNADOES

Given that "severe storms" were mentioned in the *Findings of Fact*, we will discuss tornadoes in our report. Unfortunately, reporting tornadoes can be challenging, as observations are needed:

> *"One of the main difficulties with tornado records is that a tornado, or evidence of a tornado must have been observed. … If a tornado occurs in a place with few or no people, it is not likely to be documented."* (NOAA NCEI, 2025f)

There have been improvements in the reporting of these tornadoes thanks to Doppler radar and an increase in population, which increases the likelihood of a tornado being spotted:

> "*With increased National Doppler radar coverage, increasing population, and greater attention to tornado reporting, there has been an increase in the number of tornado reports over the past several decades.*" (NOAA NCEI, 2025f)

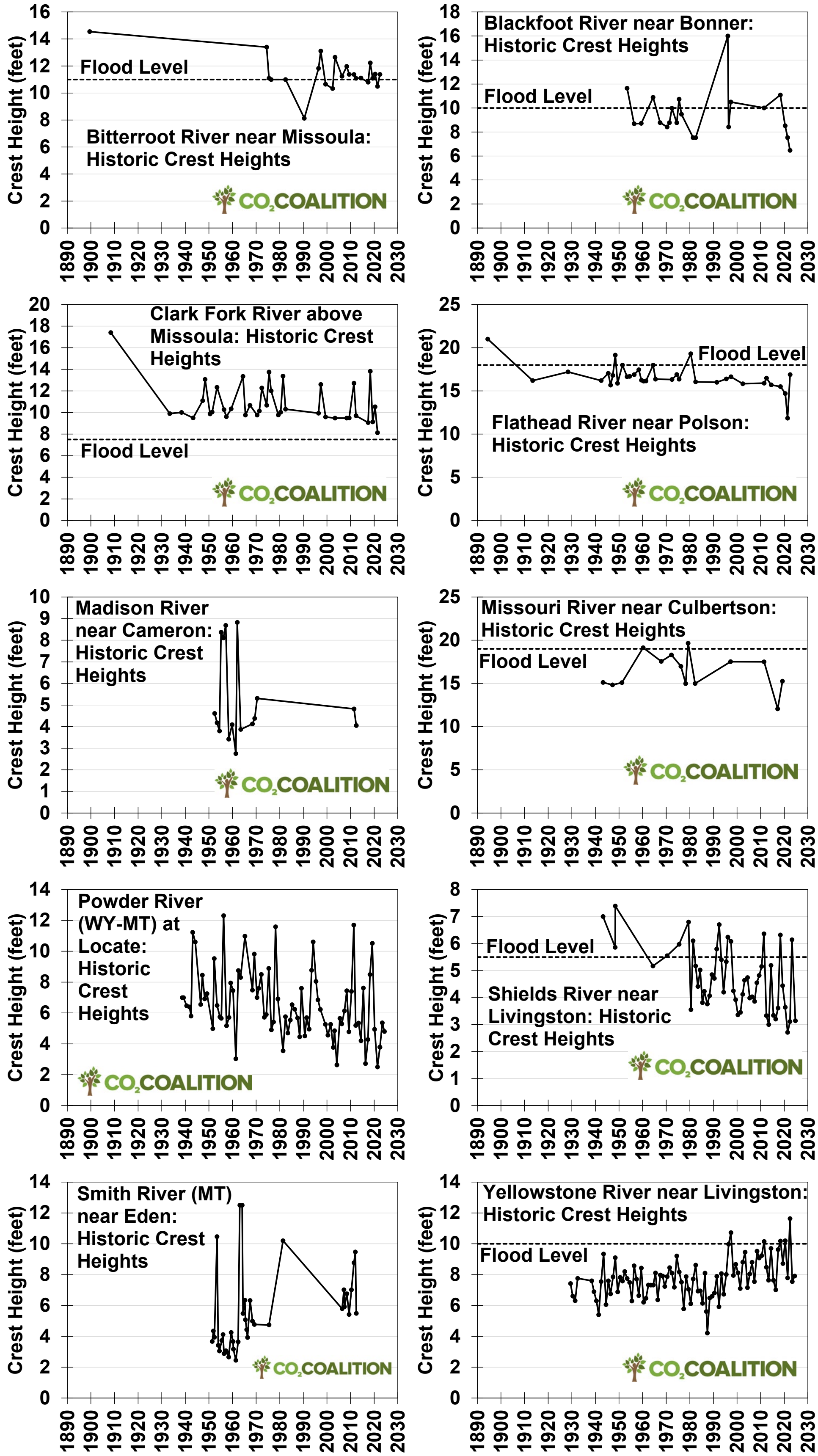


**Figure 24:** *Historic crest heights of the rivers listed in the Findings of Fact. NOAA NWPS (2025)*

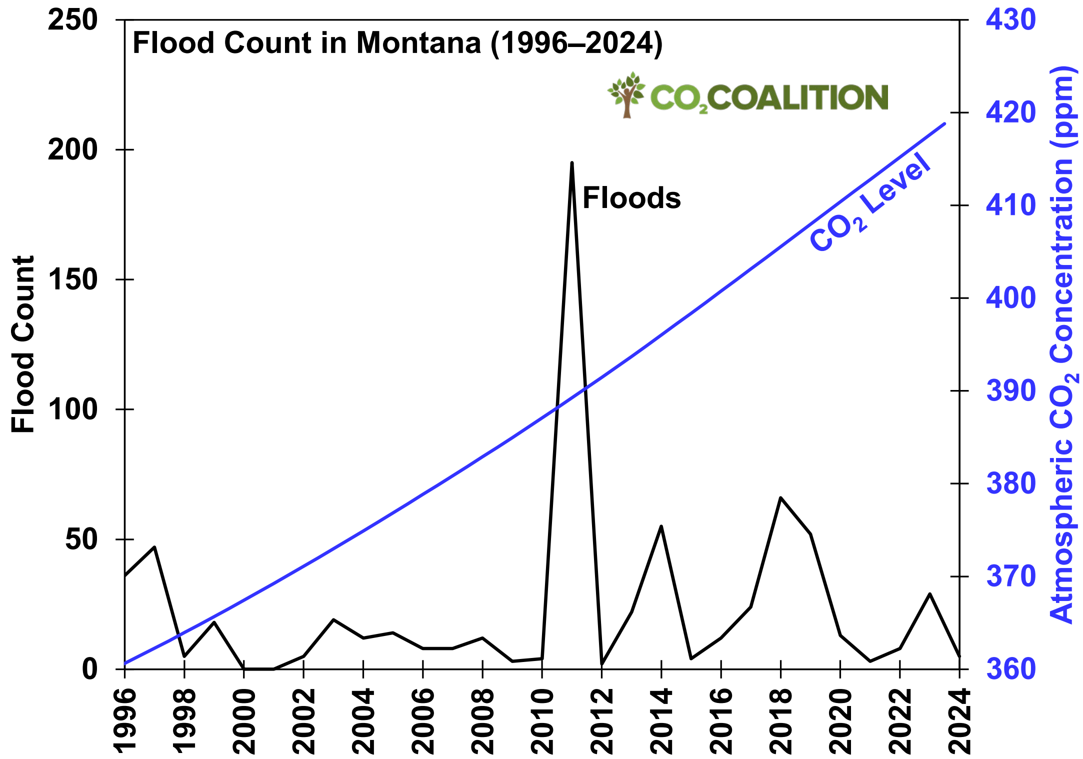


**Figure 25:** *Annual frequency of floods in Montana vs. atmospheric $CO_2$ concentration. Floods: NOAA NCEI (2025d), $CO_2$: Keeling et al. (2025)*

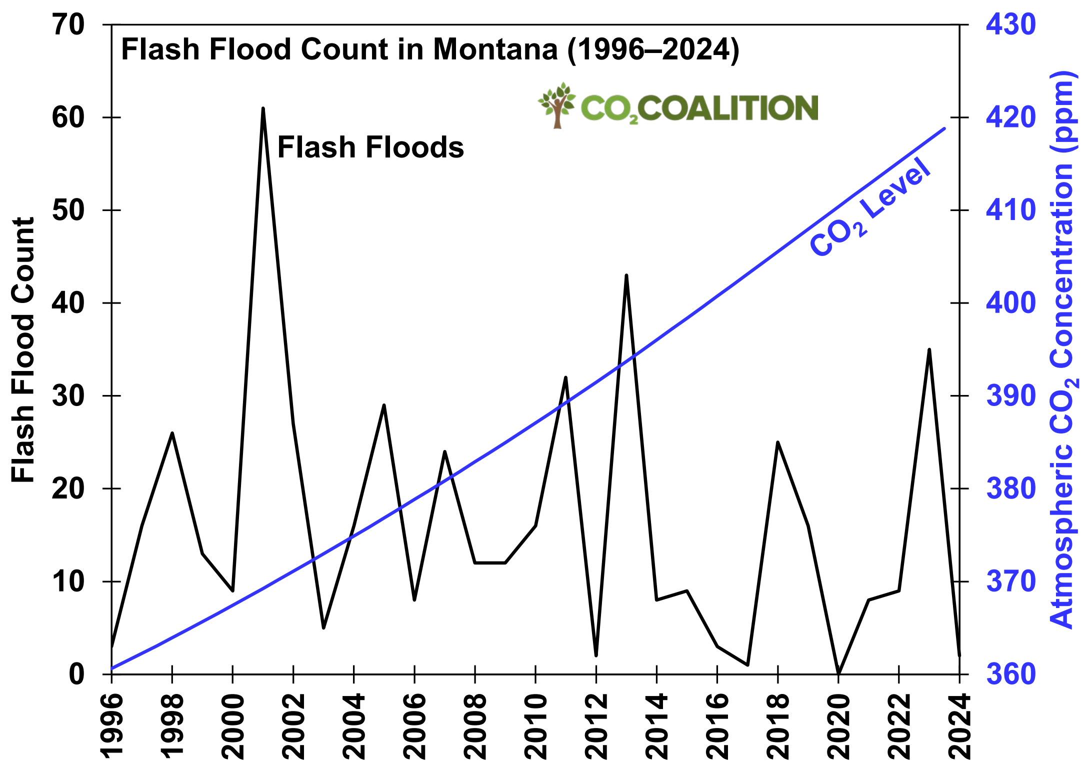


**Figure 26:** *Annual frequency of flash floods in Montana vs. atmospheric $CO_2$ concentration. Flash floods: NOAA NCEI (2025d), $CO_2$: Keeling et al. (2025)*

Notice that NOAA acknowledged that a *better reporting of tornadoes resulted in more tornadoes being reported over the past decades*. This pattern is noticeable in Montana, as shown in Figure 27, where the annual reported number of tornadoes increased until 1991; and from 1991 onward, the annual tornado count has dropped significantly.

Given these observations, the claim that these severe storms are becoming more frequent is false.

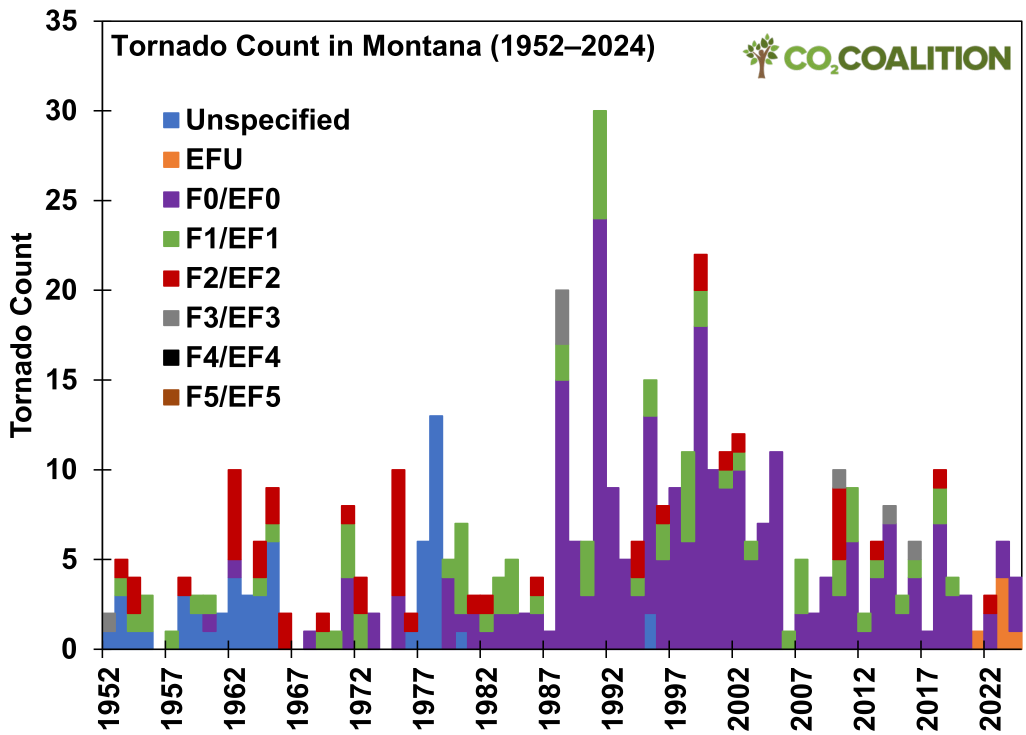


**Figure 27:** *Annual frequency of tornadoes in Montana. NOAA NCEI (2025d)*

For the interested reader, Table 1 lists the wind speeds associated with each tornado classification on the Fujita Scale (F-Scale, used prior to February 1, 2007) and the Enhanced Fujita Scale (EF-Scale, used from February 1, 2007, onward to "align wind speeds more closely with associated storm damage") (NOAA NWS, 2016, 2026). In Table 1, the EFU rating is given for those tornadoes that are detected but caused no damage, those that cannot be surveyed because they occur in remote settings, or those with nonstandard damage indicators (Dolce, 2025).

## AIR QUALITY

The *Findings of Fact* claims that air quality is deteriorating due to smoke from wildfires and climate change:

> *"The air quality where Plaintiffs live has been negatively impacted by smoke from wildfires contributed to by climate change."*

**Table 1:** *Tornado classifications based on wind speeds in the Fujita Scale and Enhanced Fujita Scale.*

| Fujita Scale (F-Scale) (used prior to February 1, 2007) | | Enhanced Fujita Scale (EF-Scale) (used from February 1, 2007, onward) | |
|---|---|---|---|
| **F-Scale Number** | **Wind Speed (mph)** | **EF Rating** | **3 Second Gust (mph)** |
| | | EFU (Enhanced Fujita Unknown) | Unknown |
| F0 | 40–72 | EF0 | 65–85 |
| F1 | 73–112 | EF1 | 86–110 |
| F2 | 113–157 | EF2 | 111–135 |
| F3 | 158–206 | EF3 | 136–165 |
| F4 | 207–260 | EF4 | 166–200 |
| F5 | 261–318 | EF5 | Over 200 |

*Sources: Dolce (2025); NOAA NWS (2016, 2026)*

As discussed in the previous section on wildfires, over the past century, the annual number and severity of wildfires in the United States have dropped significantly, as the $CO_2$ concentration increases (Figure 21). Therefore, any claims that air quality is deteriorating due to more frequent or intense wildfires are false.

Furthermore, the data from the U.S. EPA (Figures 28 and 29) indicate that the concentrations and emissions of various pollutants in the United States have been *decreasing*. Figure 28 also shows that the 2023 concentrations of the major pollutants were below the limits set by the National

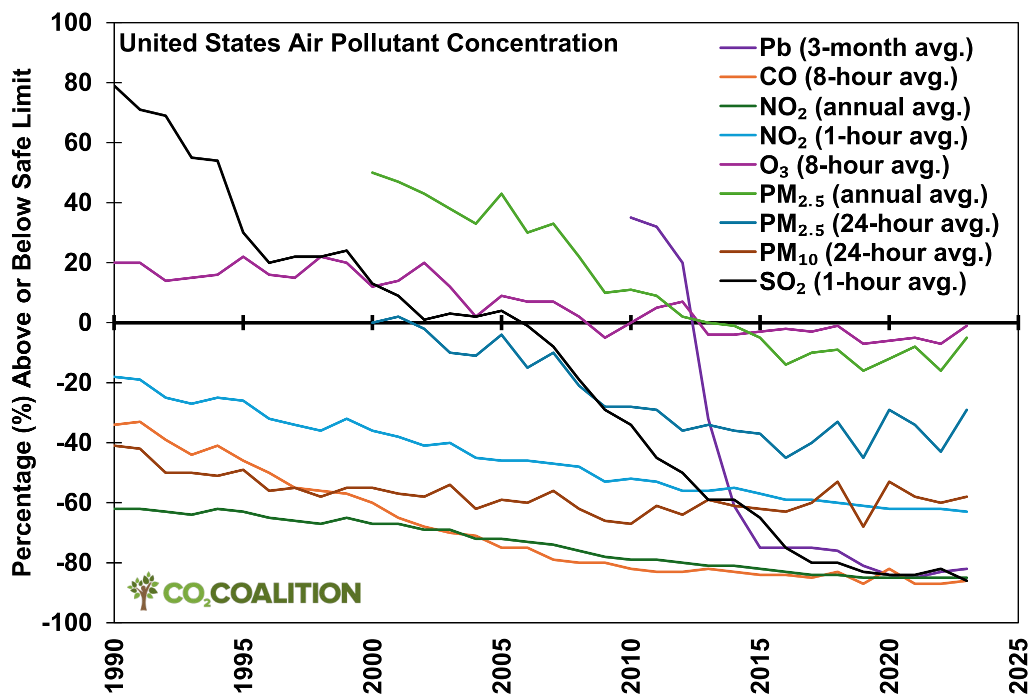


**Figure 28:** *Concentrations of various pollutants in the United States. U.S. EPA (2024)*

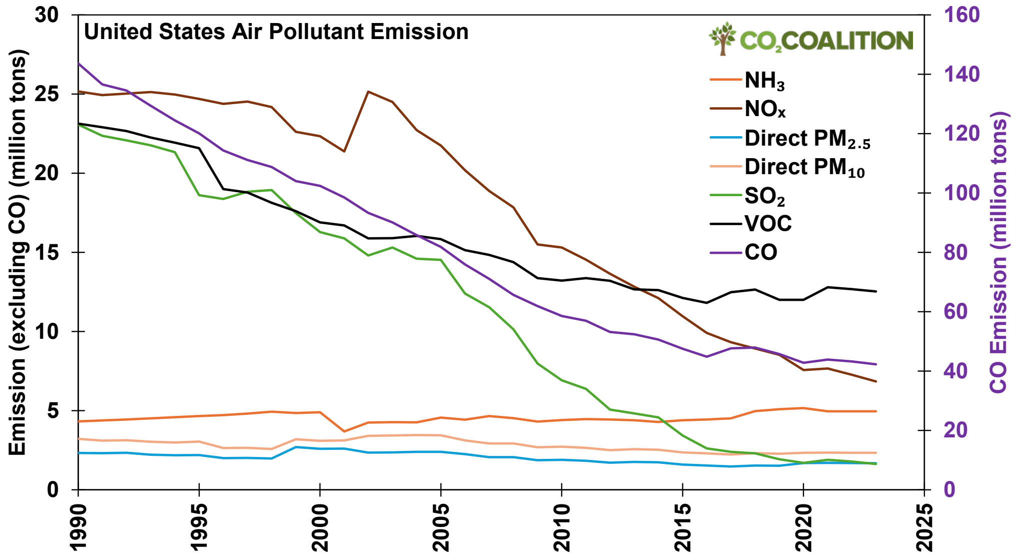


**Figure 29:** *Emissions of various pollutants in the United States. U.S. EPA (2024)*

Ambient Air Quality Standards (NAAQS). Given the decrease in the concentrations and emissions of the major pollutants in the United States, any claims regarding a decline in air quality are false. Air quality in the United States is likely the cleanest since the beginning of the Industrial Revolution.

## PLANTS LOVE $CO_2$

### THE GREENING OF EARTH AND MONTANA

The *Findings of Fact* claims that western forests are dying:

> *"There is already evidence of accelerating forest mortality in western forests, and this acceleration is clearly tied to increasing temperatures and plant water stress."*

However, satellite data from NASA and NOAA prove otherwise. For instance, a study funded by NASA and supported by the U.S. Department of Energy (Zhu et al., 2016) used satellite data to measure the amount of leaf cover across Earth (Hille, 2016). Leaf cover is expressed using the leaf area index (Hille, 2016), which quantifies the leaf area in square meters ($m^2$) of ground area (NASA Earth Observations, 2025). Because vegetation grows in layers, it is possible for the leaf area index to have values greater than one square meter of leaf area per square meter of ground area (NASA Earth Observations, 2026).

From these satellite data, Figure 30 shows the greening of Earth during 1982–2015. During 1982–2009, about 25% to 50% of the vegetated area on Earth experienced an increased in vegetation (i.e., greening), while less than 4% experienced a decrease in vegetation (i.e., browning) (Zhu et al., 2016). $CO_2$ fertilization contributed about 70% of the greening, as confirmed by NASA (Hille, 2016; Zhu et al., 2016).

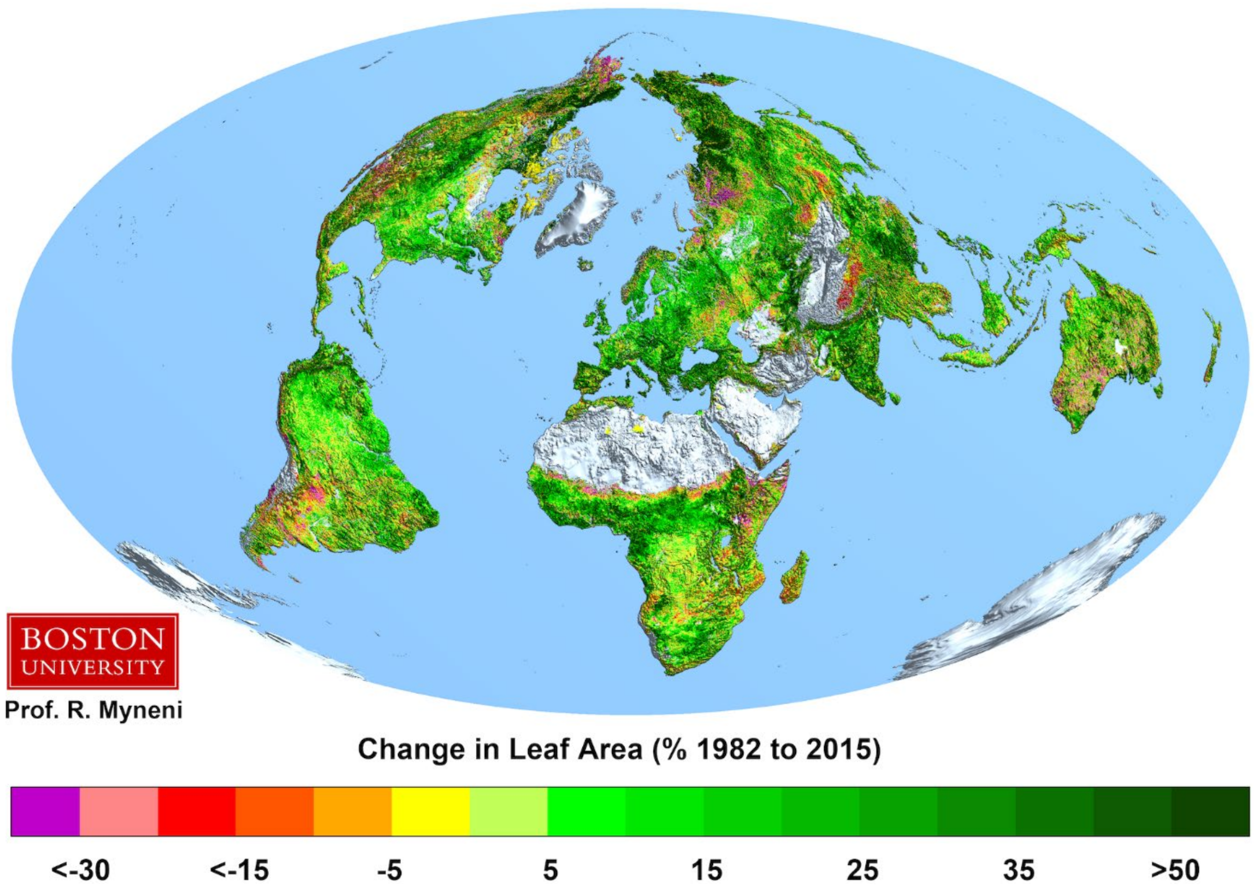


**Figure 30:** *Greening of Earth during 1982–2015. Myneni (2017) (used with permission)*

Also contributing to this greening has been the modest warming since the Little Ice Age and the greater availability of reactive nitrogen—a plant nutrient—released primarily from the combustion of fossil fuels (Trepel et al., 2026).

The greening trend shown in Figure 30 continued into the 21st century (Figure 31), as confirmed by NASA (NASA Earth Observations, 2026). In fact, during 2001–2020, 55% of Earth experienced greening and only 7% of Earth experienced browning (Chen et al., 2024).

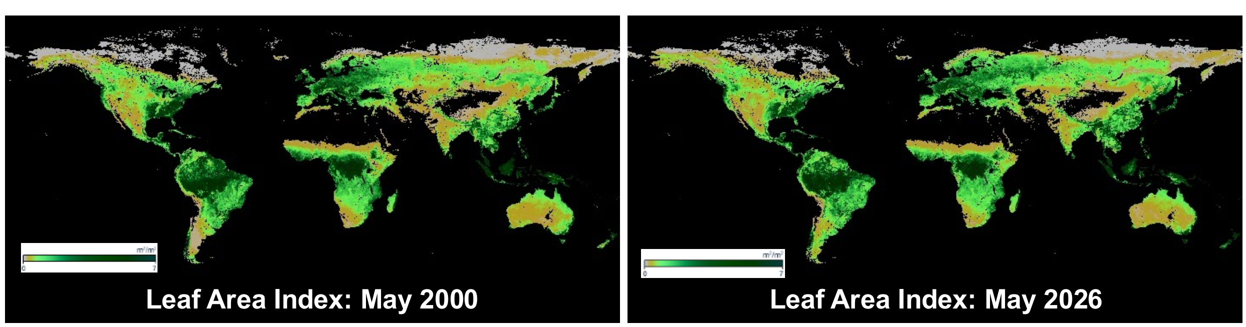


**Figure 31:** *Comparison of the leaf area index in May 2000 and May 2026.*
*NASA Earth Observations (2026)*

Moving from the 21st century to the overall trend, based on data from NOAA's Advanced Very High-Resolution Radiometer (Gutiérrez-Hernández and García, 2025), during 1982–2023 (Figure 32), about 38% of Earth's land surface had statistically significant trends in increased vegetation. Among these lands, about 76% experienced greening and about 24% experienced browning.

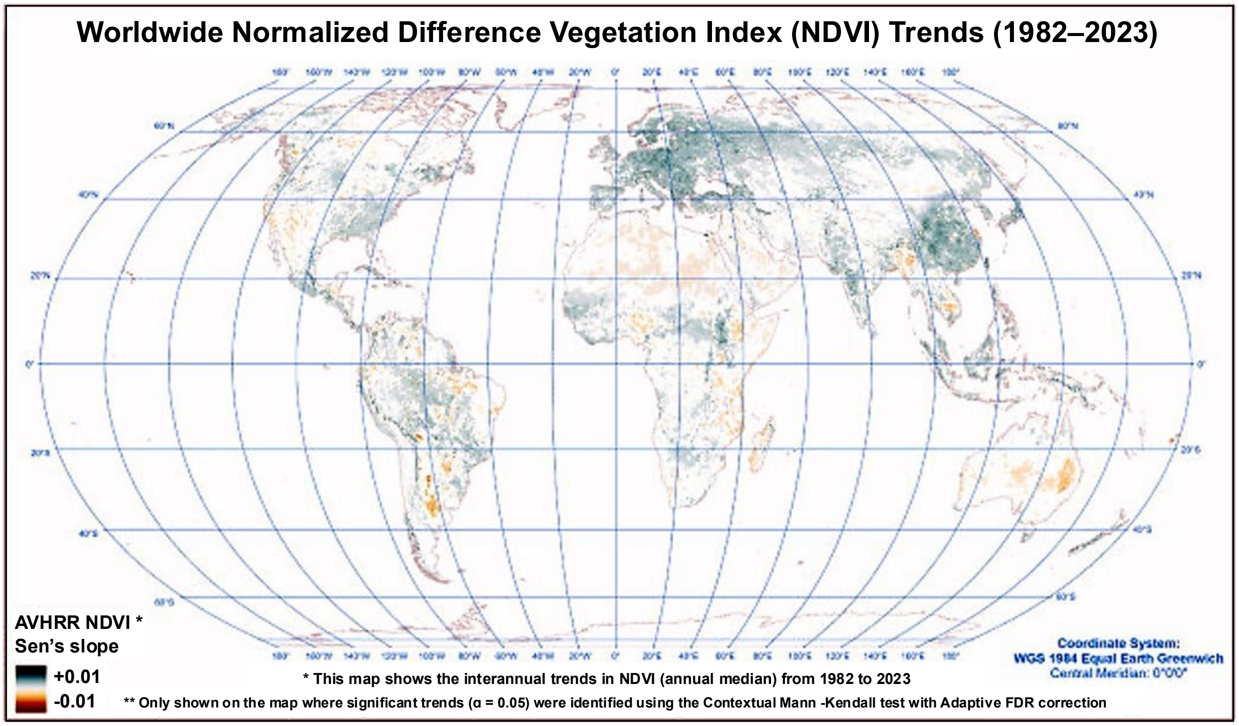


**Figure 32:** *The greening of Earth during 1982–2023. Gutiérrez-Hernández and García (2025)*

These statistics translate to about 29% of the land on Earth greening and about 9% of the land on Earth browning during 1982–2023. As NASA's and NOAA's satellite data show that Earth is greening, Montana is no exception to this positive trend, as shown in Figure 33, with the eastward expansion of forests. These observations contradict claims of deteriorating ecosystems and wildlife habitats.

## THE BENEFITS OF CARBON DIOXIDE ($CO_2$)

The contribution of $CO_2$ to the greening of Earth can be explained by the benefits of $CO_2$ for plants. As noted previously, $CO_2$ is plant food. Plants need $CO_2$, water, sunlight, and nutrients from the soil, to produce oxygen and food through photosynthesis (Happer et al., 2023). Without $CO_2$, plants could produce no oxygen and food and there would be no life on Earth.

Increases in atmospheric $CO_2$ have proven to be beneficial for plants; they grow bigger, produce more food, and use water more efficiently when exposed to higher $CO_2$ concentrations. These benefits have been confirmed by thousands of agronomy studies. For instance, Idso and

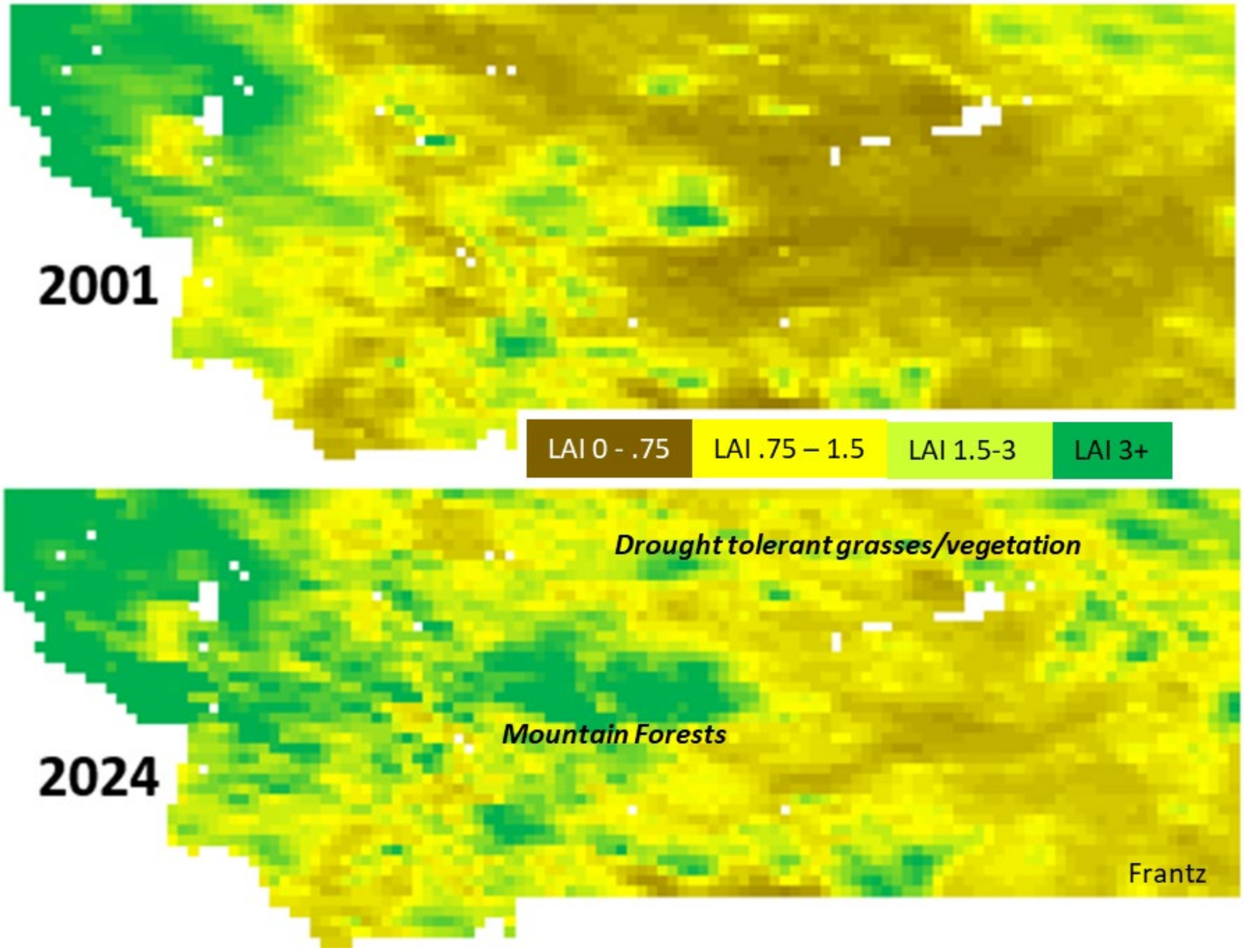


**Figure 33:** *Leaf area index in Montana on February 25, 2001, vs. March 4, 2024. Image source: Climate Intel (2024), data source: NASA Earth Observations (2026)*

Kimball (1993, 1997, 2001) and Leavitt et al. (2003) studied sour orange tree seedlings that were exposed to air enriched with $CO_2$ at about 700-ppm concentration in clear, open-top enclosures, and found that they grew larger, produced more fruits, and used water 80% more efficiently compared to trees that were exposed to ambient air at about 400 ppm $CO_2$.

Figure 34 compares the growth of 21-day-old rice seedlings exposed to different $CO_2$ concentrations. Notice that as the $CO_2$ concentration increases, the rice plants grow bigger, while rice plants exposed to the lower $CO_2$ concentrations look sickly.

## AGRICULTURE

Given that the *Findings of Fact* falsely claims that forests are dying, it is no surprise that it says agriculture is in danger:

> *"The effects of anthropogenic climate change, including rising temperatures, changing precipitation patterns, and drought conditions, create challenges and uncertainty for farmers."*

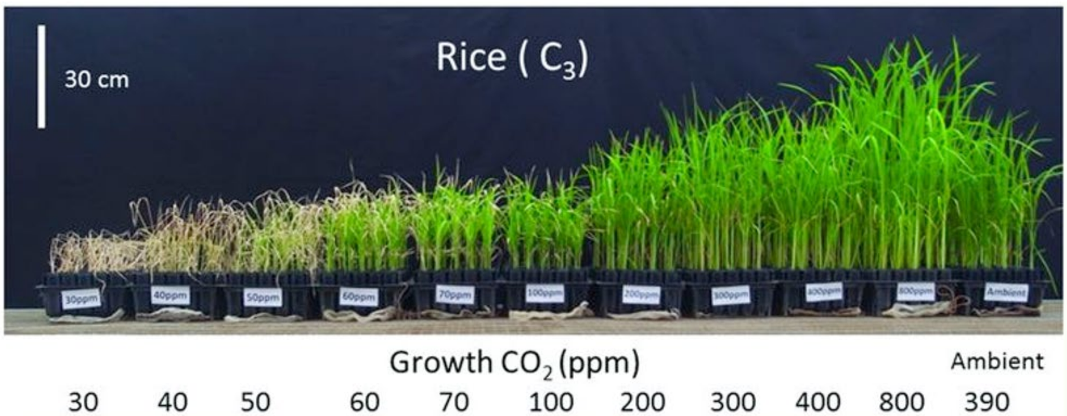


**Figure 34:** *Growth of 21-day-old rice seedlings exposed to different $CO_2$ concentrations. Image source: von Caemmerer et al. (2012)*

However, Figure 35 shows that global agriculture is thriving, such that agricultural production is outpacing population growth, despite the area of agricultural land remaining essentially the same since 1960.

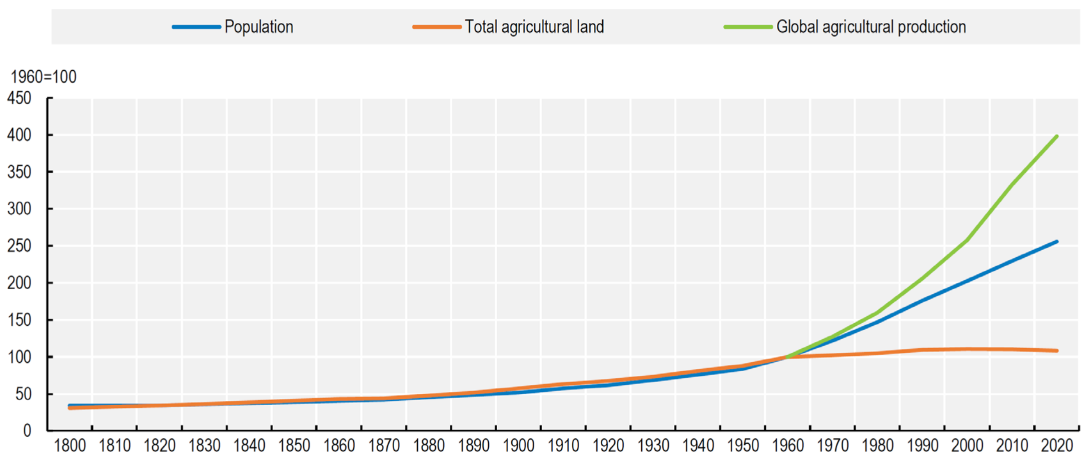


**Figure 35:** *Comparison of the global population, agricultural production, and agricultural land use. Image source: OECD (2021)*

This increase in global agricultural production can be attributed to agricultural innovation, $CO_2$ fertilization, increased $CO_2$-driven drought resistance of plants, warmer weather, the lengthening of the growing season, and the use of fossil fuel-based fertilizers and pesticides (Wrightstone, 2023).

The increase in global agricultural yield has been mirrored in Montana. Figure 36 shows the agricultural yield of the crops in Montana with the highest production values in 2024, where long-term data are available (USDA-NASS, 2025a, 2025b, 2025c). Figure 36 shows that overall, the yields of these crops have increased over the years. Claims of deteriorating agricultural productivity are false.

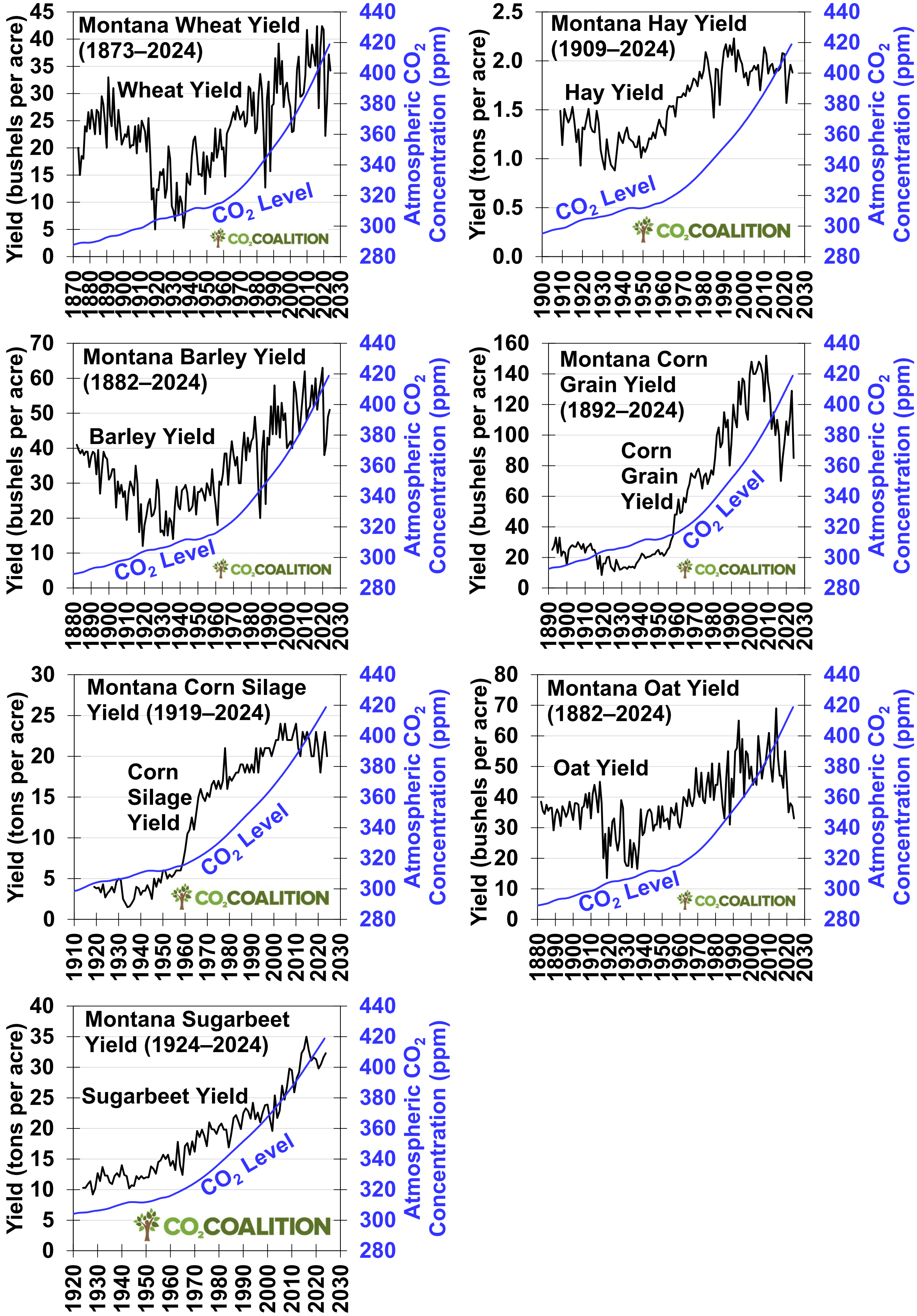


**Figure 36:** *Agricultural yields of the top crops in Montana vs. atmospheric $CO_2$ concentration. Crop yield: USDA-NASS (2025b), $CO_2$: Keeling et al. (2025)*

## MONTANA'S CARBON DIOXIDE EMISSIONS

The *Findings of Fact* estimated that Montana emits significant amounts of $CO_2$ into the atmosphere:

> *"… emissions from Montana's fossil fuel consumption, extraction, and infrastructure are globally significant quantities."*

> *"In 2019, … the total $CO_2$ emissions due to Montana's fossil fuel-based economy is about 166 million tons $CO_2$."*

The above estimate presented by the *Findings of Fact* is erroneous. According to the U.S. Energy Information Administration (U.S. EIA, 2025), Montana's total energy-related $CO_2$ emissions, which include those from the residential, commercial, industrial, transportation, and electric power sectors, averaged about 31 million metric tons per year during the period 2010–2023 (Figure 37), which is much lower than the value of 166 million tons presented by the *Findings of Fact*. Furthermore, since 1960, Montana's annual energy-related $CO_2$ emissions have been consistently below 40 million metric tons per year (Figure 35).

Montana's $CO_2$ emissions are significantly less than claimed by the *Findings of Fact*, amounting to only 0.6% of total U.S. emissions in 2023 (U.S. EIA, 2025). In order to assess the warming potential, we turn to the Model for the Assessment of Greenhouse Gas Induced Climate Change (MAGICC) (MAGICC IP Co, Inc., 2022). Using the results from previous works (Cato Institute,

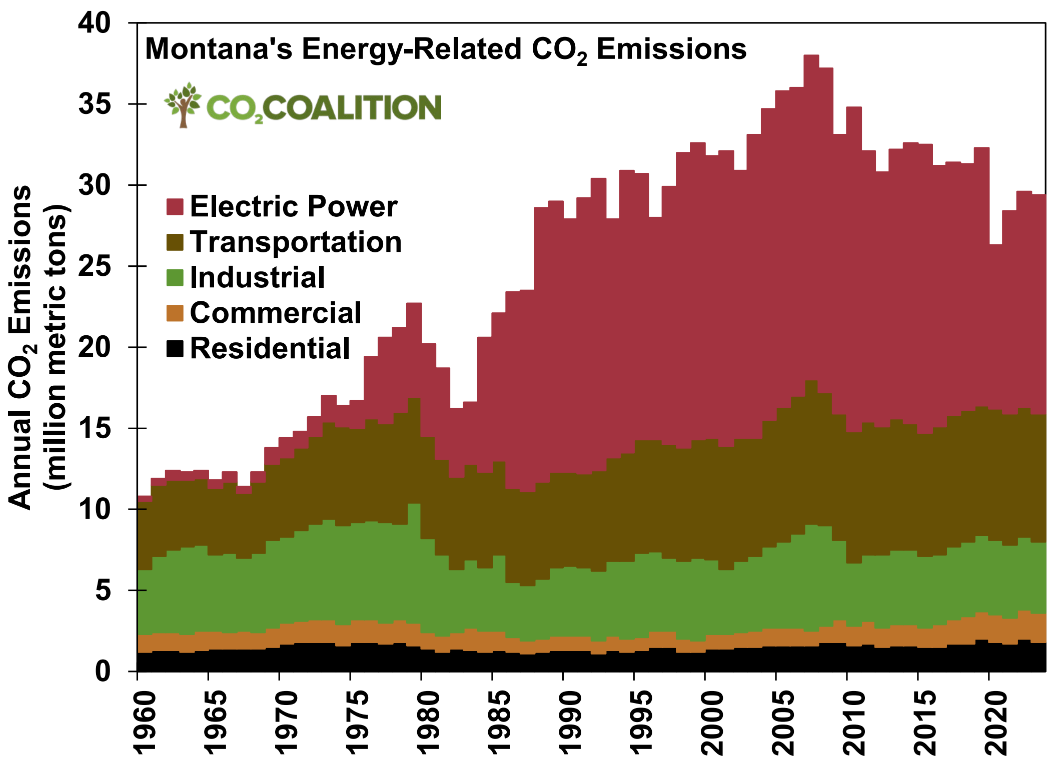


**Figure 37:** *Montana's annual energy-related $CO_2$ emissions. U.S. EIA (2025)*

2016; Michaels et al., 2023), we estimated the amount of warming that would have been prevented if Montana had stopped emitting $CO_2$ starting in 2010 (granting, for the sake of argument, MAGICC's assumption that $CO_2$ is the primary driver of global temperatures). Here, a climate sensitivity, or a warming due to the doubling of the atmospheric $CO_2$ concentration, of 2.0 °C (3.6 °F) was assumed, which is more than double the warming determined by Lindzen and Happer (2025).

Table 2 shows that if Montana had stopped emitting $CO_2$ from 2010 onward, the temperature rise that would have been prevented by 2050 and 2100 would amount to 0.0004 °F and 0.0011 °F, respectively. These temperature differences are negligible and impossible to be measured or felt. Therefore, efforts by Montana to achieve net zero $CO_2$ emissions would have no measurable effect on temperature.

**Table 2:** *Amount of temperature increase prevented by stopping all $CO_2$ emissions by 2010.*

| **Model for the Assessment of Greenhouse Gas Induced Climate Change (MAGICC)** | | | | | | |
|---|---|---|---|---|---|---|
| **How much temperature rise would be averted by 100% reduction in $CO_2$ emissions?** | | | | | | |
| **Jurisdiction** | **$CO_2$ emissions (2016) (million metric tons)** | **Percentage (%) of U.S. $CO_2$ emissions** | **Temperature rise averted by decreasing $CO_2$ by 100% (Climate sensitivity of 2.0 °C)** | | | |
| | | | **by 2050 (°C)** | **by 2050 (°F)** | **by 2100 (°C)** | **by 2100 (°F)** |
| United States | 5,161.00 | 100.0% | **0.041** | **0.0738** | **0.1040** | **0.1872** |
| *Montana* | *30.5* | *0.6%* | ***0.0002*** | ***0.0004*** | ***0.0006*** | ***0.0011*** |

*Sources: Cato Institute (2016); MAGICC IP Co, Inc. (2022); Michaels et al. (2023)*

As a further comparison of Montana's $CO_2$ emissions, in 2023, Montana's total energy-related $CO_2$ emissions amounted to 29.4 million metric tons (U.S. EIA, 2025), while China's $CO_2$ emissions from fossil fuel combustion and oxidation and cement production amounted to about 11.9 billion metric tons (Global Carbon Budget, 2025). This means that in 2023, Montana's annual $CO_2$ emissions were equivalent to 22 hours of China's $CO_2$ emissions.

In other words, if Montana were to succeed in achieving net zero $CO_2$ emissions, China's continued $CO_2$ emissions would render this effort useless. Montana's minuscule $CO_2$ emissions compared to those of other countries, as well as the energy policies of countries such as China and India that will further increase fossil fuel-related $CO_2$ emissions (Global Carbon Budget, 2025), render efforts to reduce $CO_2$ emissions in Montana meaningless.

## SUMMARY AND CONCLUSIONS

Based on the data presented in this report, Montana's ecosystems are thriving, and its citizens are benefitting from the increasing atmospheric $CO_2$ concentration. In summary:

- Agriculture is thriving in Montana partly because of modest warming, which has brought longer growing seasons, higher levels of atmospheric $CO_2$, and increased nitrogen.
- Most climate models overpredict warming, many by more than twice the observed rate.
- Annual snowfall in Montana is not declining.
- Glacial retreat began long before there was a significant increase in anthropogenic $CO_2$ emissions.
- Heat waves in the United States peaked in the 1930s and have been consistently more moderate since then.
- Annual precipitation in Montana shows no trend of either increase or decrease.
- Droughts and their impacts in Montana are decreasing, thanks, in part, to rising $CO_2$ levels.
- The area burned by wildfires in the United States has dropped by more than 80% since its peak in the 1930s.
- Floods are not becoming more frequent in Montana.
- The frequency of tornadoes in Montana has been declining since 1991.
- Air quality in the United States has been improving since 1990.
- $CO_2$ does not cause dangerous warming.
- Compared to the geological past, today's atmospheric $CO_2$ concentration is low.
- $CO_2$ is beneficial, as more of it allows plants to grow bigger, produce more food, and better resist drought, thus greening the Earth.

In conclusion, there is no climate crisis in Montana, and $CO_2$ is not only beneficial but necessary for life on Earth. Therefore, any measures for combating a purported climate crisis by reducing $CO_2$ emissions would place unnecessary financial burdens on the citizens of Montana and do more harm than good.

## ACKNOWLEDGMENTS

The current report is based principally on the work of the following:

- Frits Byron Soepyan, Ph.D., Chemical Engineering; $CO_2$ Coalition Science and Research Associate
- Gregory Wrightstone, M.S., Geology; $CO_2$ Coalition Senior Fellow
- David Burton, M.A., Computer Sciences, $CO_2$ Coalition Senior Science Advisor
- William Happer, Ph.D., Physics; $CO_2$ Coalition Chair; Professor Emeritus, Department of Physics, Princeton University

The authors gratefully acknowledge Professor Jessica A. Torrion and Charlene Kazmier from Montana State University's Northwestern Agricultural Research Center for assisting the authors with their data on snowfall.

These and other contributors to this evaluation represent the fields of climatology, meteorology, physics, geology, agronomy, engineering, and more.

This report is part of a series of state and regional studies by the $CO_2$ Coalition on the effects of the changing climate on various parts of the United States of America.

### About the $CO_2$ Coalition

The $CO_2$ Coalition was established in 2015 as a non-partisan educational foundation operating under Section 501(c)(3) of the IRS code for the purpose of educating thought leaders, policy makers, and the public about the important contribution made by carbon dioxide ($CO_2$) to our lives and economy. The $CO_2$ Coalition seeks to engage in an informed and dispassionate discussion of climate change, humans' role in the climate system, the limitations of climate models, and the consequences of mandated reductions in $CO_2$ emissions.

## REFERENCES


Andrew RM, Peters GP (2025): *The Global Carbon Project's Fossil $CO_2$ Emissions Dataset (Version 2025v15)*. Zenodo. https://doi.org/10.5281/zenodo.5569234

Benson T, Watts A (2022): *Research & Commentary: New Heartland Study Shows 96 Percent of NOAA Surface Temperature Station Data Is Corrupted*. The Heartland Institute, Schaumburg, IL, USA. https://heartland.org/publications/research-commentary-new-heartland-study-shows-96-percent-of-noaa-surface-temperature-station-data-is-corrupted/

Berner RA, Kothavala Z (2001a): *GEOCARB III: A Revised Model of Atmospheric $CO_2$ Over Phanerozoic Time*. American Journal of Science 301, 182–204. https://doi.org/10.2475/ajs.301.2.182

Berner RA, Kothavala Z (2001b): *NOAA/WDS Paleoclimatology – GEOCARB III: A Revised Model of Atmospheric $CO_2$ Over Phanerozoic Time*. IGBP PAGES/World Data Center for Paleoclimatology, Data Contribution Series # 2002-051, NOAA/NGDC Paleoclimatology Program, Boulder, CO, USA. https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=noaa-forcing-5778

Cato Institute (2016): *Carbon Tax Temperature-Savings Calculator*. Cato Institute, Washington, DC, USA. https://www.cato.org/carbon-tax-temperature-savings-calculator

Chen X, et al. (2024): *The Global Greening Continues Despite Increased Drought Stress Since 2000*. Global Ecology and Conservation 49, e02791. https://doi.org/10.1016/j.gecco.2023.e02791

Christy J (2023): *Scientific Facts of the Global Climate*. Advocates for Balance at Chautauqua, Chautauqua, NY, USA, 17 July 2023. https://www.abcatchq.com/past-lectures.html

Climate Intel (2024): Montana 2001-02-25, Map Index, Montana 2024-03-04, Map Index.

Cochrane GR, et al. (2012): *18 - Habitats and Benthos of an Evolving Fjord, Glacier Bay, Alaska*. In: *Seafloor Geomorphology as Benthic Habitat*, Harris PT, Baker EK (Eds.), Elsevier, pp. 299–308. https://doi.org/10.1016/B978-0-12-385140-6.00018-9

Coupled Model Intercomparison Project (2026): *CMIP Phase 6 (CMIP6)*. Coupled Model Intercomparison Project (CMIP). https://wcrp-cmip.org/cmip-phases/cmip6/

Dolce C (2025): *A Recent Plains Tornado Was Rated EFU. You Read That Right – Here's What It Means*. The Weather Channel, The Weather Company, LLC. https://weather.com/storms/tornado/news/2025-02-26-tornado-efu-rating-unknown-damage-fujita-scale

Engelbeen F (2023): Personal Communication.

Engelbeen F, et al. (2024): *The Human Contribution to Atmospheric Carbon Dioxide: How Human Emissions Are Restoring Vital Atmospheric $CO_2$*. The $CO_2$ Coalition, Fairfax, VA, USA. https://co2coalition.org/wp-content/uploads/2024/12/Human-Contribution-to-Atmospheric-CO2-digital-compressed.pdf

Etheridge DM, et al. (1996): Natural and Anthropogenic Changes in Atmospheric $CO_2$ Over the Last 1000 Years from Air in Antarctic Ice and Firn. Journal of Geophysical Research 101 (D2), 4115–4128.
https://doi.org/10.1029/95JD03410, https://depts.washington.edu/fish437/resources/Week%2010/Etheridge%20et%20al.%201996.pdf

FAO (2021): *Damage and Loss: Drought*. Food and Agriculture Organization of the United Nations, Rome, Italy. https://www.fao.org/interactive/disasters-in-agriculture/en/

Friedlingstein P, et al. (2025): *Global Carbon Budget 2024*. Earth System Science Data 17, 965–1039. https://doi.org/10.5194/essd-2024-519

Global Carbon Budget (2025): *GCB 2024*. Global Carbon Budget Office (GCBO), University of Exeter. https://globalcarbonbudget.org/gcb-2024/. Additional details regarding these data are provided in Andrew and Peters (2025) and Friedlingstein et al. (2025).

Gutiérrez-Hernández O, García LV (2025): *Uncovering True Significant Trends in Global Greening*. Remote Sensing Applications: Society and Environment 37, 101377. https://doi.org/10.1016/j.rsase.2024.101377

Happer W, et al. (2023): *Challenging "Net Zero" with Science*. $CO_2$ Coalition, Fairfax, VA, USA. https://co2coalition.org/wp-content/uploads/2023/02/Challenging-Net-Zero-with-Science-digital-CO2-Coalition.pdf. This reference was also used to determine the minimum $CO_2$ concentration for plant life in Figure 3.

Hausfather Z, et al. (2022): *Climate Simulations: Recognize the 'Hot Model' Problem*. Nature 605, 26–29. https://doi.org/10.1038/d41586-022-01192-2

Held v. Montana (2023): *Cause No. CDV-2020-307: Findings of Fact, Conclusions of Law, and Order*. Montana First Judicial District Court, Lewis and Clark County, Helena, MT, USA. https://heldvmontana.ourchildrenstrust.org/wp-content/uploads/2024/05/Doc-405_2023.08.14-Findings-of-Fact-Conclusions-of-Law-and-Order.pdf

Heller T (2022): *A Mountain Of Lies*. Real Climate Science. https://realclimatescience.com/2022/02/a-mountain-of-lies/#gsc.tab=0

Heller T (2023): *Unhiding The Decline 4.0 For Windows*. Real Climate Science. https://realclimatescience.com/2023/02/unhiding-the-decline-4-0-for-windows/#gsc.tab=0

Hille KB (2016): *Carbon Dioxide Fertilization Greening Earth, Study Finds*. National Aeronautics and Space Administration, Washington, DC, USA. https://www.nasa.gov/technology/carbon-dioxide-fertilization-greening-earth-study-finds/

Idso SB, Kimball BA (1993): *Tree Growth in Carbon Dioxide Enriched Air and Its Implications for Global Carbon Cycling and Maximum Levels of Atmospheric $CO_2$*. Global Biogeochemical Cycles 7 (3), 537–555. https://doi.org/10.1029/93GB01164

Idso SB, Kimball BA (1997): *Effects of Long-Term Atmospheric $CO_2$ Enrichment on the Growth and Fruit Production of Sour Orange Trees*. Global Change Biology 3 (2), 89–96. https://doi.org/10.1046/j.1365-2486.1997.00053.x

Idso SB, Kimball BA (2001): *$CO_2$ Enrichment of Sour Orange Trees: 13 Years and Counting*. Environmental and Experimental Botany 46, 147–153. https://doi.org/10.1016/S0098-8472(01)00093-4

Keeling CD, et al. (2001): *Exchanges of Atmospheric $CO_2$ and $^{13}CO_2$ with the Terrestrial Biosphere and Oceans from 1978 to 2000*. I. Global Aspects. SIO Reference No. 01-06, Scripps Institution of Oceanography, San Diego, CA, USA. https://scrippsco2.ucsd.edu/assets/publications/keeling_sio_ref_series_exchanges_of_co2_ref_no_01-06_2001.pdf

Keeling RF, et al. (2025): *Atmospheric $CO_2$ Data: Ice-Core Merged Products*. Scripps $CO_2$ Program, Scripps Institution of Oceanography (SIO), University of California, La Jolla, CA, USA. https://web.archive.org/web/20260124184307/https://scrippsco2.ucsd.edu/data/atmospheric_co2/icecore_merged_products.html. Additional details regarding these data are provided in Keeling et al. (2001) and Rubino et al. (2019).

Keeling RF, et al. (2026): Ice-Core Merged Products. Scripps $CO_2$ Program, Scripps Institution of Oceanography (SIO), University of California, La Jolla, CA, USA. https://scrippsco2.ucsd.edu/data/atmospheric-co2-data/ice-core-merged-products/. More details regarding the atmospheric $CO_2$ concentration data from before 1959, used in Figure 3, are provided in Etheridge et al. (1996) and MacFarling Meure et al. (2006).

Lan X, Keeling R (2026): *Trends in $CO_2$, $CH_4$, $N_2O$, $SF_6$: Trends in Atmospheric Carbon Dioxide ($CO_2$)*. NOAA Global Monitoring Laboratory, Boulder, CO, USA. https://gml.noaa.gov/ccgg/trends/data.html

Leavitt SW, et al. (2003): *The Effect of Long-Term Atmospheric $CO_2$ Enrichment on the Intrinsic Water-Use Efficiency of Sour Orange Trees*. Chemosphere 50 (2), 217–222. https://doi.org/10.1016/S0045-6535(02)00378-8

Lee J-Y, et al. (2021): *Future Global Climate: Scenario-Based Projections and Near-Term Information*. In: *Climate Change 2021: The Physical Science Basis*. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Masson-Delmotte V, et al. (Eds.), Cambridge University Press, Cambridge, United Kingdom, and

New York, NY, USA. https://doi.org/10.1017/9781009157896.006, https://www.ipcc.ch/report/ar6/wg1/

Legg T, et al. (2025): *An Update to the Central England Temperature Series—HadCET v2.1*. Geoscience Data Journal 12, e284. https://doi.org/10.1002/gdj3.284

Lindzen R (2022): *An Assessment of the Conventional Global Warming Narrative*. The Global Warming Policy Foundation. https://www.thegwpf.org/content/uploads/2022/09/Lindzen-global-warming-narrative.pdf

Lindzen R, Happer W (2025): *Re: Reconsideration of 2009 Endangerment Finding and Greenhouse Gas Vehicle Standards; Extension of Comment Period ("Proposed Rule")*. The $CO_2$ Coalition, Fairfax, VA, USA. https://co2coalition.org/publications/co2-coalition-comment-2-on-epa-endangerment-finding/

MacFarling Meure C, et al. (2006): Law Dome $CO_2$, $CH_4$ and $N_2O$ Ice Core Records Extended to 2000 Years BP. Geophysical Research Letters 33, L14810. https://doi.org/10.1029/2006GL026152

MAGICC IP Co, Inc. (2022): *MAGICC*. Climate Resource. https://magicc.org/. Additional details regarding this model are provided in Meinshausen et al. (2009, 2011, 2020) and Nicholls et al. (in prep.).

Meinshausen M, et al. (2009): *Greenhouse-Gas Emission Targets for Limiting Global Warming to 2°C*. Nature 458 (7242), 1158–1162. https://doi.org/10.1038/nature08017

Meinshausen M, et al. (2011): *Emulating Coupled Atmosphere-Ocean and Carbon Cycle Models with a Simpler Model, MAGICC6 – Part 1: Model Description and Calibration*. Atmospheric Chemistry and Physics 11 (4), 1417–1456. https://doi.org/10.5194/acp-11-1417-2011

Meinshausen M, et al. (2020): *The Shared Socio-Economic Pathway (SSP) Greenhouse Gas Concentrations and Their Extensions to 2500*. Geoscientific Model Development 13 (8), 3571–3605. https://doi.org/10.5194/gmd-13-3571-2020

Menne MJ, et al. (2009): *The U.S. Historical Climatology Network Monthly Temperature Data, Version 2*. Bulletin of American Meteorological Society 90 (7), 993–1008. https://doi.org/10.1175/2008BAMS2613.1

Met Office Hadley Centre (2026): *Met Office Hadley Centre Observations Datasets: HadCRUT.5.1.0.0 Data Download*. Met Office, Exeter, Devon, United Kingdom. https://www.metoffice.gov.uk/hadobs/hadcrut5/data/HadCRUT.5.1.0.0/download.html. Additional details regarding these data are provided in Morice et al. (2021).

Met Office Hadley Centre for Climate Change (2026): *Met Office Hadley Centre Central England Temperature*. Met Office, Exeter, Devon, United Kingdom.

https://www.metoffice.gov.uk/hadobs/hadcet/data/download.html. Additional details regarding these data are provided in Legg et al. (2025) and Parker et al. (1992).

Michaels PJ, et al. (2023): *The American Midwest and Climate Change: Life in America's Breadbasket is Good and Getting Better*. The $CO_2$ Coalition, Fairfax, VA, USA. https://co2coalition.org/wp-content/uploads/2023/07/American-Midwest-and-Climate-Change-digital.pdf

Montana State University (2025): *Snowfall: Snowfall Totals at NWARC Since 1980 (inches)*. Montana State University, Northwestern Agricultural Research Center (NWARC), Kalispell, MT, USA. https://agresearch.montana.edu/nwarc/weather/SnowfallCY.html

Morice CP, et al. (2021): *An Updated Assessment of Near-Surface Temperature Change from 1850: The HadCRUT5 Data Set*. Journal of Geophysical Research: Atmospheres 126 (3), e2019JD032361. https://doi.org/10.1029/2019JD032361

Myneni RB (2017): *Vegetation Remote Sensing & Climate Research*. Boston University, Department of Earth and Environment, Boston, MA, USA. https://sites.bu.edu/cliveg/people/professors/prof-ranga-b-myneni/

NASA Earth Observations (2026): *Leaf Area Index (1 Month – TERRA/MODIS)*. NASA Earth Observations, EOS Project Science Office, NASA Goddard Space Flight Center, Greenbelt, MD, USA. https://neo.gsfc.nasa.gov/view.php?datasetId=MOD15A2_M_LAI

National Park Service (2021): *Geologic Time Scale*. National Park Service, U.S. Department of the Interior. https://www.nps.gov/subjects/geology/time-scale.htm. This reference was used to determine the start and end years of the geological periods in Figure 3.

Nicholls ZRJ, et al. (in prep.): *Capturing Climate Science Assessments with Probabilistic Distributions for Reduced Complexity Climate Models*. Geoscientific Model Development Discussions.

NIFC (2020): *Total Wildland Fires and Acres (1926-2019)*. National Interagency Fire Center (NIFC), Boise, ID, USA. https://web.archive.org/web/20201224043154/https:/www.nifc.gov/fireInfo/fireInfo_stats_totalFires.html

NIFC (2025): *Wildfires and Acres*. National Interagency Fire Center (NIFC), Boise, ID, USA. https://www.nifc.gov/fire-information/statistics/wildfires

NOAA NCEI (2025a): *Climate at a Glance: Regional Mapping*. NOAA National Centers for Environmental Information (NOAA NCEI). https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/regional/mapping

NOAA NCEI (2025b): *Climate at a Glance: Statewide Time Series*. NOAA National Centers for Environmental Information (NOAA NCEI). https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/statewide/time-series

NOAA NCEI (2025c): *Global Historical Climatology Network daily (GHCNd)*. NOAA National Centers for Environmental Information (NOAA NCEI). https://www.ncei.noaa.gov/products/land-based-station/global-historical-climatology-network-daily

NOAA NCEI (2025d): *Storm Events Database*. NOAA National Centers for Environmental Information (NOAA NCEI). https://www.ncei.noaa.gov/stormevents/choosedates.jsp?statefips=30%2CMONTANA#

NOAA NCEI (2025e): *U.S. Historical Climatology Network (USHCN), Version 2.5*. NOAA National Centers for Environmental Information (NOAA NCEI). https://www.ncei.noaa.gov/products/land-based-station/us-historical-climatology-network. Additional details regarding these data are provided in Menne et al. (2009).

NOAA NCEI (2025f): *U.S. Tornadoes: Historical Records and Patterns*. NOAA National Centers for Environmental Information (NOAA NCEI). https://www.ncei.noaa.gov/access/monitoring/tornadoes/patterns/

NOAA NIDIS (2025): *U.S. Gridded Palmer Drought Severity Index (PDSI) from gridMET*. National Integrated Drought Information System (NIDIS) U.S. Drought Portal, National Centers for Environmental Information, Asheville, NC, USA. https://www.drought.gov/data-maps-tools/us-gridded-palmer-drought-severity-index-pdsi-gridmet

NOAA NWPS (2025): *National Water Prediction Service – NOAA*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service (NWS), National Water Prediction Service (NWPS). https://water.noaa.gov/

NOAA NWS (2016): *The Enhanced Fujita Scale (EF Scale)*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service (NWS), Norman, OK, USA. https://www.weather.gov/oun/efscale?os=lekshmi&ref=app

NOAA NWS (2026): *The Fujita Scale*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service (NWS), Atlanta/Peachtree City, GA, USA. https://www.weather.gov/ffc/fujita

OECD (2021): *Making Better Policies for Food Systems*. OECD Publishing, Paris, France. https://doi.org/10.1787/ddfba4de-en. Note: OECD = Organisation for Economic Co-operation and Development.

Oerlemans J (2005): *Extracting a Climate Signal from 169 Glacier Records*. Science 308, 675–677. https://doi.org/10.1126/science.1107046, https://ruby.fgcu.edu/courses/twimberley/EnviroPhilo/extracting.pdf

Our Children's Trust (2024): *Montana Youth Win*. Our Children's Trust, Eugene, OR, USA. https://heldvmontana.ourchildrenstrust.org/

Parker DE, et al. (1992): *A New Daily Central England Temperature Series, 1772–1991*. International Journal of Climatology 12, 317–342. https://doi.org/10.1002/joc.3370120402

Rubino M, et al. (2019): *Law Dome Ice Core 2000-Year $CO_2$, $CH_4$, $N_2O$ and d13C-$CO_2$, Version 3*. CSIRO Data Access Portal, CSIRO, Canberra, Australia. https://doi.org/10.25919/5bfe29ff807fb

Spencer RW, et al. (2025): *Urban Heat Island Effects in U.S. Summer Surface Temperature Data, 1895–2023*. Journal of Applied Meteorology and Climatology 64 (7), 717–728. https://doi.org/10.1175/JAMC-D-23-0199.1

Taylor CA, Schlenker W (2025): *Environmental Drivers of Agricultural Productivity Growth: $CO_2$ Fertilization of US Field Crops*. Working Paper 29320, National Bureau of Economic Research, Cambridge, MA, USA. https://doi.org/10.3386/w29320, https://www.nber.org/system/files/working_papers/w29320/w29320.pdf

Trepel J, et al. (2026): *Global Analysis Suggests Nitrogen Deposition as an Underestimated Driver of Vegetation Greening*. Ecography e08631. https://doi.org/10.1002/ecog.08631

U.S. EPA (2024): *Our Nation's Air: Trends Through 2023*. United States Environmental Protection Agency (U.S. EPA), Washington, DC, USA. https://gispub.epa.gov/air/trendsreport/2024/#air_trends

U.S. EPA (2025a): *Climate Change Indicators: Heat Waves*. United States Environmental Protection Agency (U.S. EPA), Washington, DC, USA. https://web.archive.org/web/20251011070447/https://www.epa.gov/climate-indicators/climate-change-indicators-heat-waves

U.S. EPA (2025b): *Climate Change Indicators: Length of Growing Season*. United States Environmental Protection Agency (U.S. EPA), Washington, DC, USA. https://web.archive.org/web/20251204001628/https://www.epa.gov/climate-indicators/climate-change-indicators-length-growing-season

U.S. EPA (2025c): *Climate Change Indicators: Streamflow*. United States Environmental Protection Agency (U.S. EPA), Washington, DC, USA. https://web.archive.org/web/20251201234317/https://www.epa.gov/climate-indicators/climate-change-indicators-streamflow

USDA-NASS (2025a): *News Release: Annual Crop Summary – 2024: Montana Highlights*. United States Department of Agriculture, National Agricultural Statistics Service (USDA-NASS), Montana Field Office, Lakewood, CO, USA, Cooperating with the Montana Department of Agriculture. https://www.nass.usda.gov/Statistics_by_State/Montana/Publications/News_Releases/2025/MT-Crop-Production-01102025.pdf

USDA-NASS (2025b): *Quick Stats*. United States Department of Agriculture, National Agricultural Statistics Service (USDA-NASS), Washington, DC, USA. https://quickstats.nass.usda.gov/

USDA-NASS (2025c): *2024 State Agriculture Overview: Montana*. United States Department of Agriculture, National Agricultural Statistics Service (USDA-NASS), Washington, DC, USA. https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=MONTANA

U.S. EIA (2025): *Environment: Energy-Related $CO_2$ Emission Data Tables*. U.S. Energy Information Administration (U.S. EIA), Washington, DC, USA. https://www.eia.gov/environment/emissions/state/

Van Vuuren DP, et al. (2026): *The Scenario Model Intercomparison Project for CMIP7 (ScenarioMIP-CMIP7)*. Geoscience Model Development 19, 2627–2656. https://doi.org/10.5194/gmd-19-2627-2026

von Caemmerer S, et al. (2012): *The Development of $C_4$ Rice: Current Progress and Future Challenges*. Science 336, 1671–1672. https://doi.org/10.1126/science.1220177

Watts A (2022): *Corrupted Climate Stations: The Official U.S. Temperature Record Remains Fatally Flawed*. The Heartland Institute, Schaumburg, IL, USA. https://heartland.org/wp-content/uploads/documents/2022_Surface_Station_Report.pdf

Watts A (2026): *GOATS (Global Open Atmospheric Temperature System): What Was Accomplished in Reno*. The Heartland Institute, Schaumburg, IL, USA. https://heartland.org/publications/goats-global-open-atmospheric-temperature-system-what-was-accomplished-in-reno/

WMO (2021): *WMO Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2019)*. WMO-No. 1267, World Meteorological Organization (WMO), Geneva, Switzerland. https://sidsport-climateadapt.unctad.org/wp-content/uploads/2022/06/WMO-ATLAS-OF-MORTALITY-AND-ECONOMIC-LOSSES-FROM-WEATHER-CLIMATE-AND-WATER-EXTREMES-1970%E2%80%932019.pdf

Wrightstone G (2023): *A Very Convenient Warming: How Modest Warming and More $CO_2$ are Benefiting Humanity*. Silver Crown Productions, LLC, Allison Park, PA, USA. https://convenientwarming.com/. This reference was also used to determine the minimum $CO_2$ concentration for plant life in Figure 3.

Zhao Q, et al. (2021): *Global, Regional, and National Burden of Mortality Associated with Non-Optimal Ambient Temperatures from 2000 to 2019: A Three-Stage Modelling Study*. The Lancet 5 (7), e415–e425. https://doi.org/10.1016/S2542-5196(21)00081-4

Zhu Z, et al. (2016): *Greening of the Earth and Its Drivers*. Nature Climate Change 6, 791–795. https://doi.org/10.1038/nclimate3004

# APPENDIX

## TEMPERATURE ADJUSTMENTS AND FABRICATION OF DATA

As summarized in the body of the report, the temperature data provided by NOAA's USHCN stations are influenced by factors that affect the temperatures recorded by these stations, including:

- Urban heat island effect that raises temperature readings (Spencer et al., 2025; Watts, 2022, 2026).
- Adjustments to raw temperature readings (Menne et al., 2009; NOAA NCEI, 2025e).
- Fabricated data for stations that no longer exist or are no longer reporting temperatures (Heller, 2022).

### Urban Heat Island Effect

This phenomenon refers to heat sources and sinks that are located near USHCN stations that raise the temperature readings at these stations (Michaels et al., 2023). A study conducted by Watts (2022) during April and May 2022 found that among the 128 temperature stations across the contiguous United States that were surveyed, 96% of these stations "are sited unacceptably," as these stations were located near heat sources and sinks, such as buildings, asphalt, etc. Based on his observations, Mr. Watts noted:

> *"Data from the stations that have not been corrupted by faulty placement show a rate of warming in the United States reduced by almost half compared to all stations."*
> (Benson and Watts, 2022)

Based on a study conducted on the raw temperatures measured by the Global Historical Climatology Network from 1895 to 2023 for the contiguous United States, Spencer et al. (2025) found that the contribution of the urban heat island effect to the observed increase in the raw average temperature ranges from 8%, in the case of rural stations, to 65%, in the case of suburban and urban stations.

### Adjustments of Data

Over the years, the raw temperature measurements (i.e., raw temperatures) recorded by the USHCN stations have been adjusted to correct for "systematic" and "nonclimatic" biases (Menne et al., 2009). Examples of such biases are changes in the time of day when the temperatures were recorded (referred to as the time of observation bias, or TOB), changing station locations, changes in measuring instruments, and changes to the surroundings around the measuring instruments. For instance, since around the mid-1900s, hundreds of USHCN stations have been shifting towards recording temperatures in the morning, rather than in the afternoon.

For these stations, temperature records taken during afternoons have slight warming biases, whereas temperature measurements taken during early mornings saw reductions in temperatures due to the earlier time these measurements were taken. To correct for these biases, temperature measurements taken during the afternoon were cooled, while early morning measurements were warmed. These temperatures that were corrected for the time of observation bias (TOB) are referred to as the TOB-corrected temperatures in this report.

## Fabrication of Data

Figure A-1 shows that despite the significant reduction in the number of USHCN stations that report the raw temperatures since ~ 1990, temperatures are somehow still being reported by most, if not all, of the 1,218 USHCN stations across the contiguous United States (referred to as the final temperatures in this report). For instance, in December 2024, only 746 stations were actually collecting raw data, yet final temperatures were being reported for 1,217 stations.

Where do these final temperatures come from? These final temperatures were generated by a computer model, instead of thermometers, to fill the gaps, such that temperatures are reported by most, if not all, of the USHCN stations, regardless of whether or not these stations actually capture any temperature data (Heller, 2022).

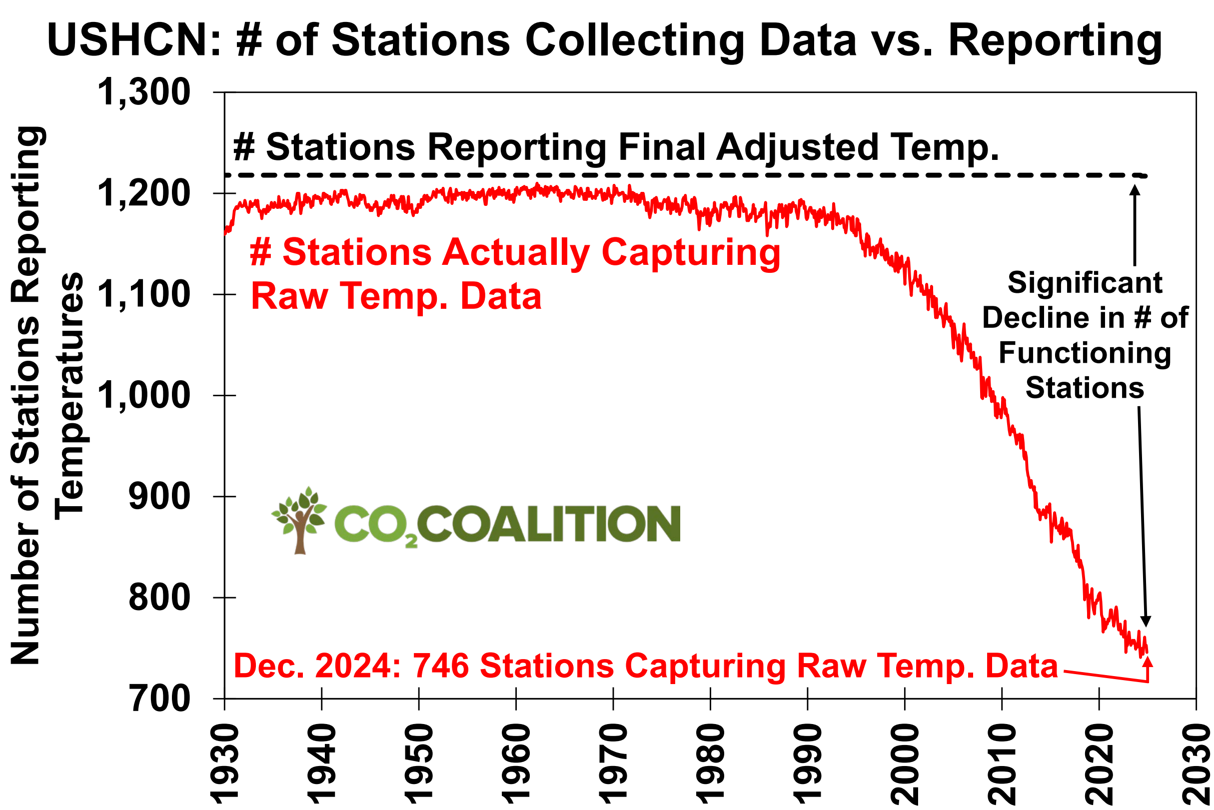


**Figure A-1:** *The number of USHCN stations reporting monthly average temperatures in the contiguous United States: Raw temperatures vs. final temperatures. NOAA NCEI (2025e)*

## WHAT DO THESE ADJUSTMENTS AND FABRICATIONS OF TEMPERATURE DATA MEAN FOR MONTANA?

In the case of Montana, correcting for the time of observation bias resulted in a cooling of the raw temperatures (Figure A-2). This observation suggests that USHCN stations in Montana have been recording temperatures during afternoons. However, the corrections for the time of observation bias vary from year to year (NOAA NCEI, 2025e). Therefore, the correction that has been applied for the time of observation bias allows for a fairer comparison of the temperature across different years, which is the reason we have opted to report the TOB-corrected temperatures, instead of the raw temperatures, in this report.

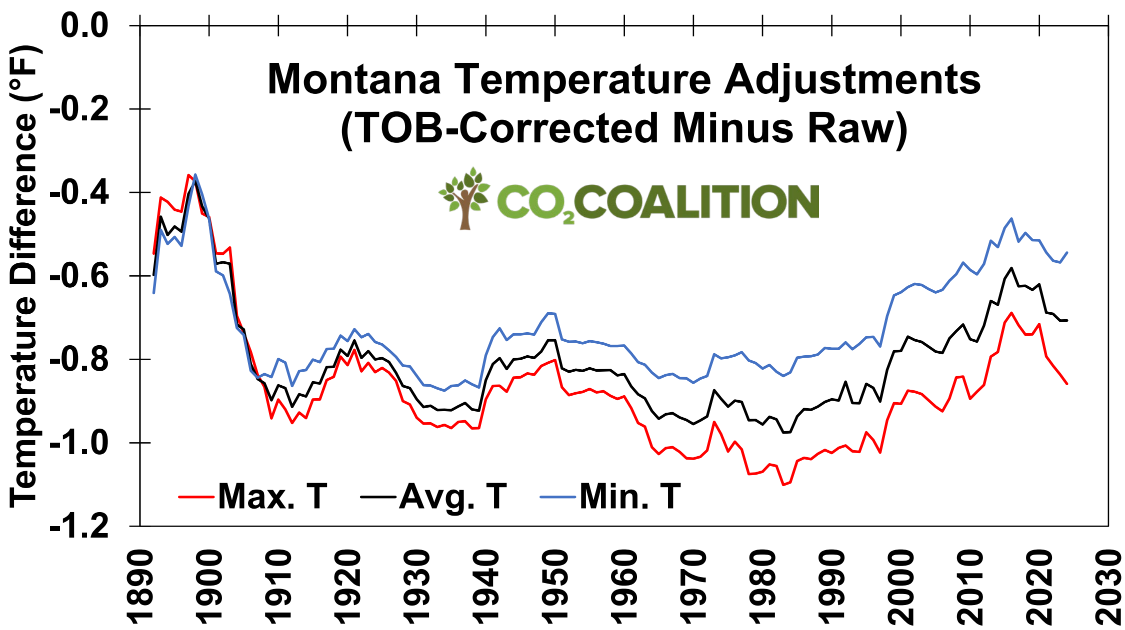


**Figure A-2:** *TOB-corrected minus raw temperature difference in Montana. NOAA NCEI (2025e)*

As for NOAA's "final" temperatures, we opted not to use these temperature data because these data include temperatures that were produced using computer models, instead of thermometers, for those stations that did not report the temperature. This alteration resulted in increased rate of warming for the final temperatures compared to the raw temperatures.

In Montana, the final temperature records have been adjusted downward by NOAA to reflect a cooling of the raw data. The older records prior to 1990 had significantly higher downward adjustments compared to the more recent modern records. Adjustments to the average and maximum temperature data had 0.4 °F and 0.7 °F cooler temperatures, respectively, prior to 1990 compared to the more recent records. The end result was to exaggerate any warming trend by NOAA's manipulation of the data (Figure A-3).

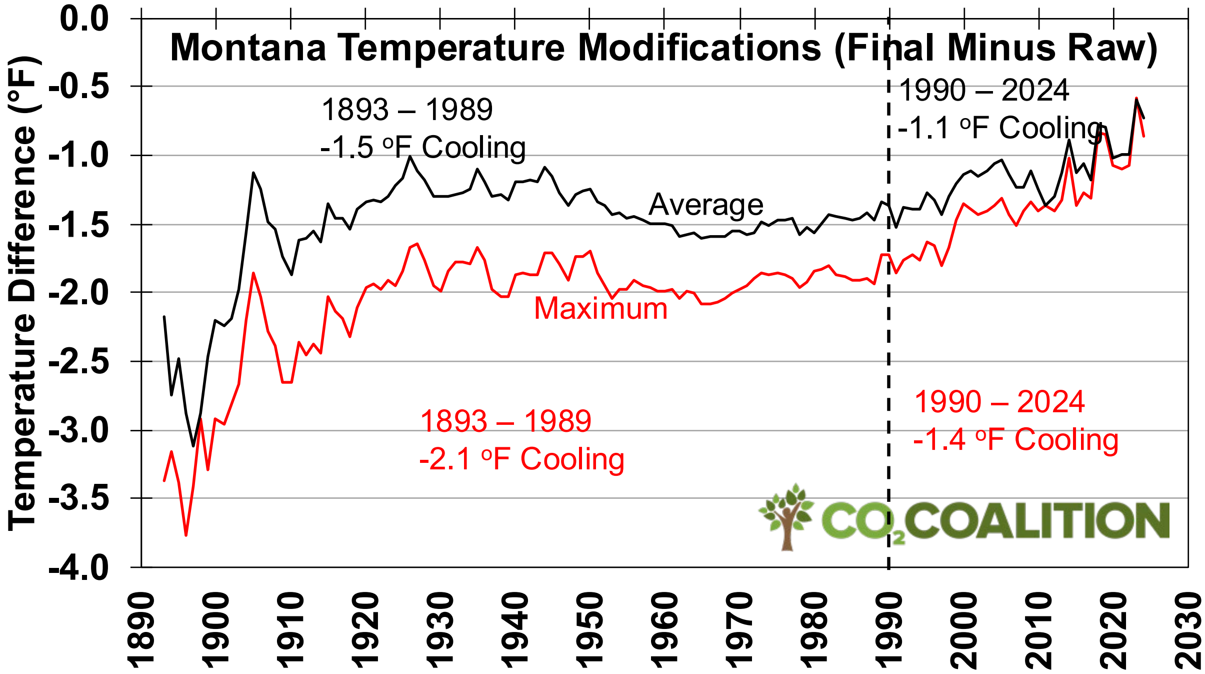


**Figure A-3:** *Final minus raw temperature difference in Montana. NOAA NCEI (2025e)*