FROM PHILADELPHIA TO PORTLAND: THE AMERICAN CLIMATE IN 1897

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ABSTRACT: *Prior to the 20th century, limited numerical data were available regarding the historical climate. Primary sources such as diaries can help researchers gain insight into this topic and fill this information gap. By expanding the body of knowledge about past climate phenomena, researchers can make comparisons with more modern data and determine climate change impacts. This study examined the 1897 diary 9000 Miles on a Pullman Train to obtain a deeper understanding of the historical climate including precipitation patterns, temperature, and agriculture through content analysis. The lack of quantitative data in the diary limited rigorous statistical analysis. However, the qualitative information was able to contribute to an expansion of knowledge regarding the historical climate. It was found that areas of higher and more consistent precipitation expanded further west than they do today. Moreover, qualitative analysis of the daily temperatures described suggested that the modern relationship between regional temperatures across the United States was similar in 1897. However, climatic features such as high elevation snow cover recorded in the diary was found to be greater than today, suggesting an increase in overall temperature. This was corroborated by observation of a shorter historical growing season. The diary also allowed for the examination of natural disasters and the population of individual towns.*

Keywords: *Historical climatology, content analysis*

INTRODUCTION

Following Svante Arrehnius' 1896 calculations predicting global warming (Arrhenius, 1896), multiple studies regarding the effects of greenhouse gas emissions on Earth's climate and weather patterns have been conducted. Though there is no consensus regarding the exact scale of temperature changes, studies have found that the average surface temperature of Earth has increased by over 1.5°C (or 2.7°F) since the beginning of the Second Industrial Revolution, primarily due to anthropogenic carbon emissions (IPCC, 2018). Techniques for tracking and assessing climate and weather data have improved in recent years, providing a vast amount of numerical data for the modern climate (Arnfield, 2003; National Climatic Data Center, 2020).

Primary sources are invaluable in assessing past weather occurrences and can contribute to the conclusions drawn about modern-day climate, as well as anticipated climate and weather patterns in the future. Individuals can gain insight into past weather and climate conditions through archival data such as ship logs (Küttel et al., 2010; Kubota et al., 2018) and diaries (Bernhardt, 2015). Moreover, direct observations of past climates are limited due to lack of data collection in the past, especially in less populated regions. Although some major cities in the U.S. operated weather stations in the 1800s, official weather stations did not reach more rural areas of the country until the 20th century (Fiebrich, 2009). In consequence, the records from most weather stations do not extend into the 19th century, necessitating climatologists to use alternative sources.

Diaries in particular are a useful source as they may provide Traditional Ecological Knowledge, or TEK (Bernhardt, 2020). Such information can be extracted using content analysis, which allows for the rigorous examination of text through the use of varying adjectives and verbs. Ultimately, those first-hand accounts permit historical climatologists to better understand local weather and climate patterns, and can also be analyzed to ascertain conditions experienced within that time period (Baron and Gordon, 1985; Bernhardt, 2015). Further, numerical data from sources such as weather stations can allow for a more objective measure of weather and climate. For example, microclimate and mesoclimate variations may exist between the setting of the diary and the nearest weather station, so a comparison of the two sources can be used to corroborate accounts in the diary (Orlanski, 1975) and investigate spatial variation. Closely reading the text to understand the strength of descriptive adjectives (i.e. warm vs hot vs scorching) can also allow for a semi-quantitative study by creating a ranking scale to rank climate features like temperature (Bernhardt, 2015; Allen and Seaman 2007). Thus, with the help of primary, textual sources, an individual can thoroughly interpret data of past conditions and make predictions on how the future climate may compare to the modern climate (Ingram, Underhill & Wigley, 1978). This study uses such techniques to analyze a firsthand account of the United States in 1897 and better understand changes in climate and weather patterns. It explores historical records from a personal diary published by Milton Shaw, a veteran railroad conductor for the Pennsylvania Railroad Company in 1897. He, along with numerous other employees of the company, traveled to the 26th session of the Grand Division of the Order of Railway Conductors that year. The conference was held in Los Angeles, and the Pennsylvania Railroad Company provided transportation for the trip (see Figure 1 for map of journey). Shaw took detailed notes each day because he was asked to create an unbiased record of all that happened throughout the journey by others on the voyage and at home in Philadelphia. Shaw declared that his goal was "to furnish interesting information relative to the party's whereabouts from day to day," (p. 3) and he included as much detail as possible. The party's request of Shaw, combined with the detailed nature of Shaw's work, suggests his meticulous nature.

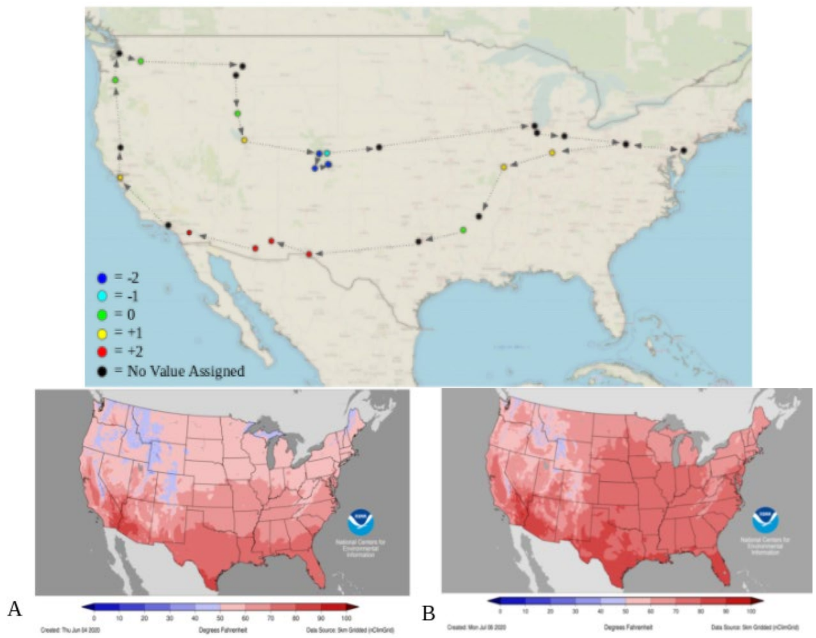

Figure 1: Temperature index rankings of locations Shaw passed

The details from his notes were ultimately consolidated in the book _Nine Thousand Miles On A Pullman Train: An Account of a Tour of Railroad Conductors From Philadelphia to the Pacific Coast and Return_. Named after the approximate distance traveled, the diary contained an entry for every day of the one month journey (May 8th, 1897-June 8th, 1897). Shaw was attentive throughout the trip, noting the numerous climatological features- from agriculture to temperature to mountain snow cover- and recorded these traits in the diary. Population, past climatic occurrences, and recreational activities were also reported. Although he quickly passed through most towns and cities, staying less than a week, he was able to provide additional information due to his discussions with local residents (Shaw, 1898). Using Shaw's info, this study sought to analyze the historical climate and weather conditions observed and compare them to those of the modern day. Specific focus was given to temperature, precipitation, agriculture, and snow cover.

METHODS

The weather patterns, terrain, and other relevant physical geographic information about the locations traveled through were recorded in the diary, indicating weather patterns in 1897 across the continental United States. Close assessment of the journal allowed the extraction of such data. Daily temperatures were ranked according to a temperature index ranging from -2 (extreme cold) to +2 (extreme heat), with 0 representing mild temperatures, based on the strength of descriptive adjectives. Shaw discussed his perception of the temperature most days in detail with careful wording choice, enabling relative temperature values to be assigned based on his diction and the creation of an index to rank the relative temperatures experienced by Shaw throughout his journey. This index allowed for a semi-quantitative analysis, compensating for the lack of numerical data present in the diary. To further minimize bias and increase the validity of this study, the diary was independently reviewed for geographic and climate data by the first two authors following the above procedures, and observations were compared at the end of each diary entry. Other primary sources such as weather maps were also read and examined for evidence corroborating the diary's description of major storm events.

Past weather and climate data were collected from the diary and urban weather stations in existence during the 1890s on Shaw's route and then compared to corresponding modern day conditions. Qualitative comparisons regarding temperature distribution, precipitation amounts, snowmelt, and agricultural timing were made based on government data from the modern day and accepted almanacs. Maps were also created using the Q-GIS mapping software to visually depict the encountered weather. Color coded points marked each location traveled through and described the temperature index ranking or the presence of precipitation. This allowed for a large-scale, macro-analysis of weather patterns during Shaw's journey which provide indications to the historic climate.

RESULTS AND DISCUSSION

Temperature

Exact temperature values were recorded less than five times over the course of the entire journey by Shaw. Locations with a temperature index ranking of +2 were confined to the southwest United States, while the temperature index ranking of +1 was generally concentrated in the mid-latitudes of the United States ranging from Salt Lake City to Oakland. Temperature rankings of 0 were distributed across latitudes, but generally focused on coastal regions. The only occurrences of negative temperature index rankings (-2 and -1) were in the high elevation mountain regions of Colorado (Figure 1). Shaw's descriptions of the clothes he and his party wore aided in the assignment of temperature index values, as did various adjectives and phrases that can be found in Table 1. In general, the temperature distribution was consistent with relative temperatures in the modern United States, but the past data suggested that the West coast experienced lower temperatures in 1897 than it experiences in the modern day (Figure 1a, 1b). Shaw's experience in the region appears consistent with the historical average temperatures for the region, demonstrated by the average June temperature of 60.1°F in Seattle (index rank of 0) during 1897 (National Centers for Environmental Information, 2021).

Table 1: Phrases that led to each temperature index assignment and the number of days the index value was assigned

Temperature Index Rank	Associated Phrases	Frequency (in days)
+2	"Burning sand" "Scorching desert plateau"	7
+1	"Lovely" "The sun shines very warm"	4
0	"[the climate] never goes to extremes" "air of coolness, comfort, and repose" "Blooming paradise [that] never freezes"	3
-1	"Cold and damp"	1
-2	"snow-bound, wind-swept" "Heavy wraps and overcoats" were needed	4

There were only a few instances in which numerical temperature data was recorded. For example, Shaw declared that "it [was] actually too hot in the sun to stand still" (p. 69) in Volcano Springs (now Mundo, California), and recorded a temperature of 101°F based on a thermometer reading. This provided context for Shaw's other descriptions of temperature, especially those yielding a +2 ranking. He also noted that the Great Salt Lake was "about 75 degrees [fahrenheit]" (p. 157) on May 30, 1897 (the day received a score of +1). The modern average temperature in May for the city lands between 60°F and 65°F while it reaches 70°F to 75°F in June (Figure 2a, 2b). Therefore, a temperature of 75°F would not be abnormal for the same date in modern times. Another exact temperature value was given on June 1 at Marshall Pass, Colorado and provided context for the negative temperature index scores. Shaw reported that the nighttime low was 11°F, and the temperature only reached 33°F during the day. On this day, the party braved a "wintry blast" while wearing "overcoats and wraps" (179).

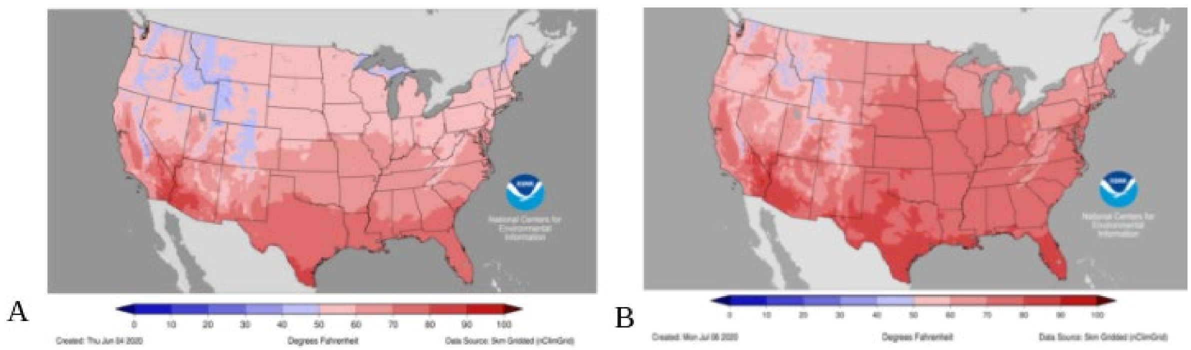

Figure 2: **a)** May's modern day average temperature in the United States (National Centers for Environmental Information, June 4, 2020) **b)** June's modern day average temperature in the United States (National Centers for Environmental Information, July 6, 2020)

Precipitation

In addition to rising temperatures across the globe, climate change models predict changing precipitation patterns. It is expected that coastal regions will experience a greater frequency of storms in the future, and these storms will be more powerful (Trenberth, 2011). However, droughts will also be longer and more severe in rain shadows (Braun et al, 2020). There is a distinct division in the United States between the wetter East and the drier West- the 100th meridian precipitation isohyet (Powell, 1878)- and this can be clearly seen on precipitation maps (Figure 3a, 3b). While the majority of precipitation Shaw encountered during his journey occurred east of the 100th Meridian (Figure 4), there was substantial rainfall in Denver which sits near the 105th Meridian. One day of precipitation during the journey while east of the demarcation line may be a random anomaly, but Shaw reported that rain fell for three straight days during his time in Denver (June 3-June 5, 1897). Furthermore, a "severe storm" (p. 174) was reported around Malta, Montana (May 31), and there was a "mean, commonplace shower of rain" (p. 182) just Southwest of Denver in Salida and Colorado Springs (June 1). Thus, these weather patterns likely conformed with the historic climate.

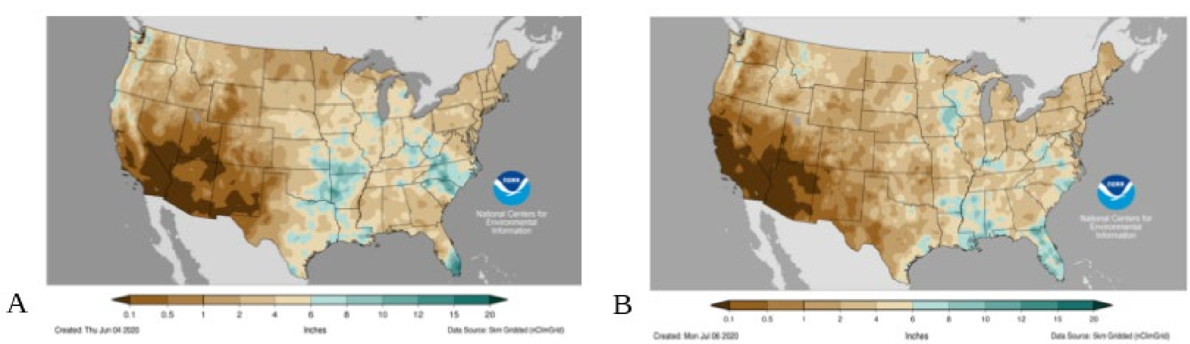

Figure 3: **a)** May's modern day precipitation in the United States (National Centers for Environmental Information, June 4, 2020) **b)** June's modern day precipitation in the United States (National Centers for Environmental Information, July 6, 2020).

Figure 4: Precipitation Shaw encountered during the journey. The dashed line marks the 100th Meridian.

As the diary examined in this study solely discussed a two month period and Shaw was in each location for no more than five days at a time, he may have experienced an abnormally wet year or experienced the majority of precipitation in the location for the month. However, corroborating studies on the historical location of the so-called 100th meridian precipitation isohyet (Bernhardt, 2020) and its modern eastward shift (Seager et al, 2018)- and the repeated occurrence of precipitation west of this meridian as recorded in *9,000 Miles on a Pullman Train* (Figure 4)- suggest that Shaw's observations are reflective of the historical climate. This indicates that the precipitation in May and June of 1897 extended further West than would be expected in the modern day. Thus, it is possible that the arid western rain shed of the United States is expanding and spreading eastward from its historical bounds, but limited data prevents a rigid comparison.

Agriculture

On Shaw's excursion across the country, he carefully observed agricultural activities. In 1897, the cultivation of plants and livestock was crucial in establishing a sufficient lifestyle for humans, in which livestock farming enabled individuals to live in cities with surpluses of food. Thus, numerous locations exhibited such farming techniques. However, due to the Industrial Revolution, urban sprawl, development of modern technology, and climate changes, agriculture has changed immensely. From the 20th century, there have been shifts in growing seasons, a decrease in livestock, and cohorts of crops grown in solely one area (Christiansen et al, 2011).

On May 8, 1897, Shaw embarked on his journey from his hometown of Philadelphia and reported that the growing season was beginning: men were "busily engaged in preparing the soil for the reception of seed" (p. 26), implying that the historical growing season began in early to mid-May. The growing season, a time period where plants and crops grow successfully, customarily begins near the end of April in present day Philadelphia and ends in early November, coinciding with the last frost of spring and first frost of fall (NCEI, 2020). This contrast of growing season dates in the region- beginning in May in the late 19th century and beginning in April in the 21st century- may indicate a gradual warming of temperature. With Philadelphia's current growing season commencing one month later than indicated by Shaw, a shorter duration of crop growth is to be expected. However, this is not consistent with Figure 5a, which portrays an overall lengthening of growing seasons in the United States (LaMonica, 2020). Thus, although the warming of Earth's temperatures is an implication of climate change, it cannot be assumed the variations in growing season depicted are directly caused by it. Rather, the lengthened duration seen throughout the country can be attributed to increasing greenhouse gas emissions into the atmosphere, in which more frost-free growing seasons are expected (Figure 5b).

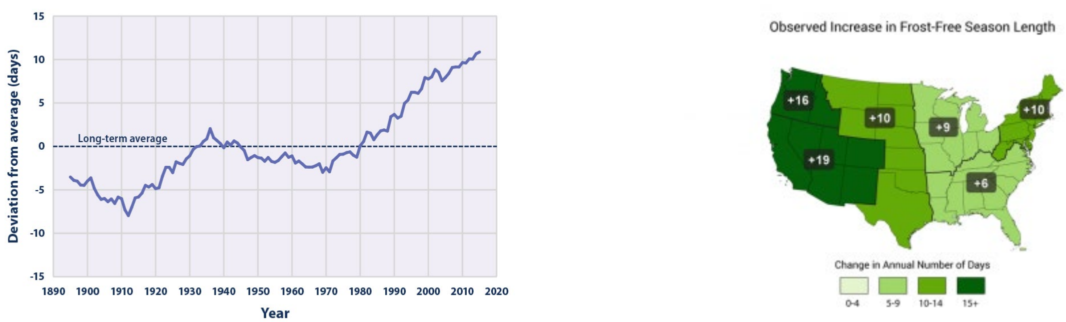

Figure 5: **a.)** Length of Growing Season by State (1895 - 2015) (Source: United States Environmental Protection Agency) **b.)** Observed Increase in Frost-Free Season Length (Source: U.S. Department of Agriculture; 2013).

On May 25, 1897, Shaw ventured into Portland, Oregon, where he recorded in his entries that streams surrounding the city were "abounding with" salmon (p. 124), with some species reaching 50 lbs. On the contrary, habitat loss and a decrease in water quality and watershed conditions have contributed to a decline in the salmon population in this region; the average weight of the fish now ranges from 8-10 lbs. Select salmon populations, such as the Coho salmon, are now also threatened and endangered (Stout et al., 2012). The decrease in the salmon population in Portland began shortly following World War I where numerous species were overfished; changes in the Northwest terrain led to the migration of salmon, also contributing to the population decline (Berwyn, 2019). Subsequently, salmon abundance dropped to 10 million pounds where 30 million pounds of salmon once frequented (Smith, 2014). The Columbia Basin in particular, which occupies most of eastern Oregon, has suffered from a dramatic decline (Figure 6). Natural factors are responsible for the downward trend of the salmon population, as well. Rising global atmospheric temperatures have warmed the temperatures of freshwater streams, luring predators and pathogenic parasites alike. This, coupled with the spawn of diseases and the depletion of nutrients, has further endangered salmon species. Ultimately, although salmon may be unrelated to agriculture, the act of salmon fishing can be deemed as a manipulation of nature for survival. It is important to acknowledge that impacts to salmon populations may directly interfere with one's lifestyle, so understanding its population changes is crucial.

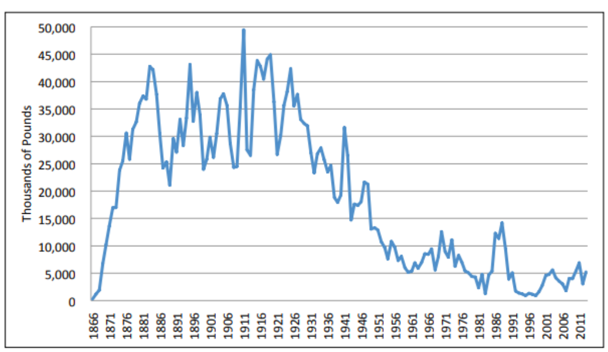

Figure 6: Sum of all species of salmon found in the Columbia basin (Sources: 1866–1936, Craig and Hacker [1940]; 1938–1970, Cleaver [1951]; 1970–2013, Oregon and Washington Department of Fish and Wildlife).

High Terrain Snow Cover

The Mount of the Holy Cross, a 14,000' peak in Colorado, was observed on May 31, 1897 when Shaw recorded a local conductor exclaiming that the cross was "filled with perpetual ice and snow" (p. 173). In the modern day, the summit experiences snowmelt throughout May, but retains a clear and distinct snow cover cross through July (Johnson, 2020). The view noted by Shaw in 1897 is likely similar to the modern view at the same time of the year. However, the local conductor's use of the word "perpetual" in his description suggests a slower rate of snowmelt allowing the snow cap to remain all year. The conductor's TEK allowed him to base his claim on many years of information, so it is not likely the result of one abnormally cold or snow heavy year. This is one potential indication of Earth's warming climate occurring throughout the 20th century.

Shaw traveled through Marshall Pass, a mountain pass with an elevation of 10,800' in Colorado, on June 1, 1897, the day after witnessing the Mount of the Holy Cross. He described "snowdrifts six feet deep" (p. 179) coating the pass and a strong gale. Quantitative data was also given in the form of temperature as Shaw recorded thermometer readings on Marshall Pass; the temperature ranged from a low of 11°F at night to a high of 33°F during the day. Today, no temperature recording weather stations exist on Marshall Pass, but a snowfall and precipitation tracking station is present. The data from this station reveals that over 23' of snow fall on Marshall Pass yearly. Snow continues to fall throughout all of May and into early June today (US Forestry Services). This resembles the situation described in the diary, so it appears that snowfall and snowmelt patterns for Marshall Pass in 1897 closely mirrored what could be expected in the modern day. However, weather stations capable of recording temperature data exist in nearby regions. Taylor Park, Colorado is about 50 miles north of Marshall Pass and has an altitude of 9,179'. The daily average temperature in May for this location today is 52.3°F with an average daily low of 36.9°F (National Oceanic & Atmospheric Administration, 2011). In June, these values increase to 57.3°F and 42.7°F respectively.

Natural Disasters

On Milton Shaw's journey, he visited numerous locations that were recently ravaged by natural disasters. The increase in greenhouse gas emissions today may contribute to a heightened risk of drought and the intensity of tropical storms, including cyclones with greater wind speeds.

On May 11, 1897, Shaw visited Fort Worth, Texas. Upon arrival, he learned that Fort Worth had been recovering from "...devastation and ruin, the effect we were told, of a recent cyclone" (p. 39). To corroborate this, a global summary was obtained from NCEI of Estelle, Texas, ~25 miles from Fort Worth. 7.5 inches of precipitation was recorded for the month of March, with 3.4 inches occurring on the 28th. Similarly, within a 32-mile radius is Dallas, Texas, which experienced a total of 8.13 inches of precipitation in March, the greatest accumulation of 2.45 inches observed on March 28th, as well. The precipitation in these regions was far greater than in the previous and following months, in which a maximum of 4.66 inches was recorded in January and a minimum of 0.15 inches in February. With the atypical amount of rain at the end of March and the lack thereof in other months, it is apparent that Fort Worth was affected by tropical weather in this allotted duration. However, the local's conclusion that Fort Worth suffered from a cyclone may be inaccurate this early in the cyclone season; the assumption that a thunderstorm occurred is probable.

CONCLUSION

Milton Shaw's account of his journey through the continental US in 1897 allowed for the analysis of the country's weather patterns in 1897, and comparisons between the historical and the modern climates were possible. Information gleaned from the diary seems to correspond to the overall historical climate as demonstrated by support from locals of each region visited and their TEK. The temperature distribution in 1897 closely mirrored modern temperature distributions. However, limited quantitative comparisons regarding temperature values were possible. Analysis of precipitation patterns provided additional support for climate change predictions as significant precipitation patterns extended further West during Shaw's 1897 journey than they do today. Modern-day agriculture has experienced changes as well. For instance, there have been shifts in growing seasons in which they commence at an earlier date and last longer. Snow on the peaks of mountains was demonstrated to melt at a faster and earlier rate in the modern day compared to the past, potentially due to climate change and an increase in mean global temperatures.

In the future, diaries from before the Second Industrial Revolution can be reviewed to further verify these findings and compare and contrast data from said accounts and Milton Shaw's entries. Primary sources such as diaries can be useful tools in constructing a picture of the historical climate, but many sources are required to obtain a complete understanding. Alone, the conclusions of a study analyzing a small number of sources must be limited, but the findings may be augmented via comparison to similar studies.

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