# Temporal Trends in the receding glaciers in Glacier National Park, Montana, 1904 to 2020

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## Introduction

Glacier National Park (GNP) is located within the Rocky Mountains in western Montana, which is in the western United States. It is connected to Waterton Lakes National Park, located across the Canadian border. It is made up of 1583 square mi (4101 square km) (Glacier National Park, n.d.). It was made a National State Park in 1910, as seen in Figure 1 (National Park Foundation, n.d.). GNP was comprised of approximately 80 glaciers following the Little Ice Age. During this time, the glaciers hit their peak and were the largest size they have ever been (as seen in Figure 2). Over the years, these glaciers have significantly decreased in size and many of these glaciers no longer meet the required criteria to be considered a glacier. As of 2015, only 26 of these glaciers are considered an "active glacier" since they are larger than 0.1 km² as they move around as a result of thawing and melting (Overview of Glacier National Park's Glaciers, n.d. & National Park Foundation, n.d.). The purpose of this research is to analyze temporal trends in the receding active glaciers from 1904 to 2020.

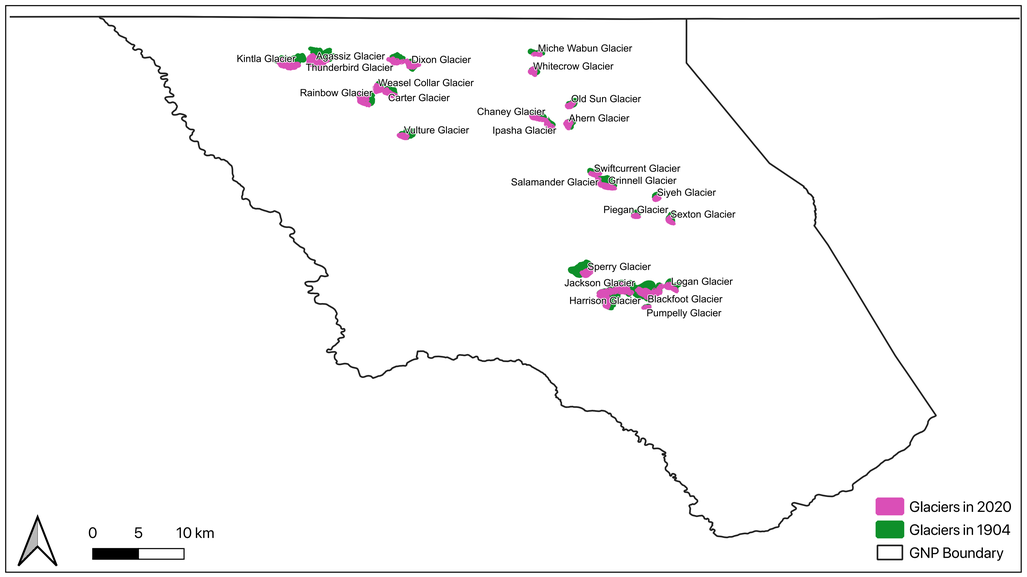
## Data and methods

There have been previous studies performed in which the glacial areas have been analyzed, however, these specific years have not been analyzed.

Data for this study was obtained from multiple topographic maps from TopoView including a topographic map of Chief Mountain (1904), Kintla Lakes (1904), Ahern Pass (2020), Many Glacier (2020), Logan Pass (2020), Mount Jackson (2020), Mount Stimson (2020), Mount Cleveland (2020), Mount Cannon (2020), Kintla Peak (2020), Vulture Peak (2020) and Mount Carter (2020) (TopoView, n.d.). A dataset of climate patterns (average annual temperature and the annual precipitation) for Glacier County was also collected (NOAA National Centers for Environmental information, 2020). Shapefiles, which outlined the boundary of GNP and the state of Montana, were downloaded from the Montana State Library (Administrative Boundaries 2015).

To prepare the data for analysis, the maps were loaded into QGIS and then a shapefile layer was created to map out the glaciers using a polygon layer. Blackfoot Glacier spilt into two separate glaciers, Blackfoot and Jackson Glacier; however, these values were calculated together and treated as one single glacier for the purpose of this analysis. The area, calculated by using the field calculator, was transferred into an Excel spreadsheet to create various graphs. A bar graph (Figure 3) was created to visualize the loss in glacial area between the time periods analyzed along with a histogram to show the percent change of glacial area lost (Figure 4).

## Receding Glaciers in Glacier National Park, Montana, 1904 to 2020




Data Source: TopoView, Administrative Boundaries 2015 (base layer)
Project Coordinate System: NAD 83/ Montana

Created: December 2020
Cartographer: Emily Keenan

Figure 1 shows a glacier in GNP
Source: Overview of Glacier National Park's Glaciers, n.d.

Figure 2 depicts the extent of the Logan Glacier before it began to recede (approximately at 1850 A.D., as seen by the large moraines at the base.
Source: Retreat of Glaciers in Glacier National Park, n.d.

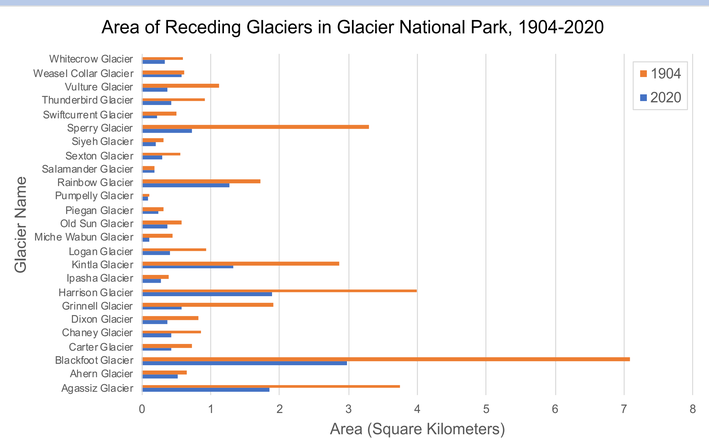



Figure 3 shows the glacial area from the glaciers in the study in 1904 and 2020.

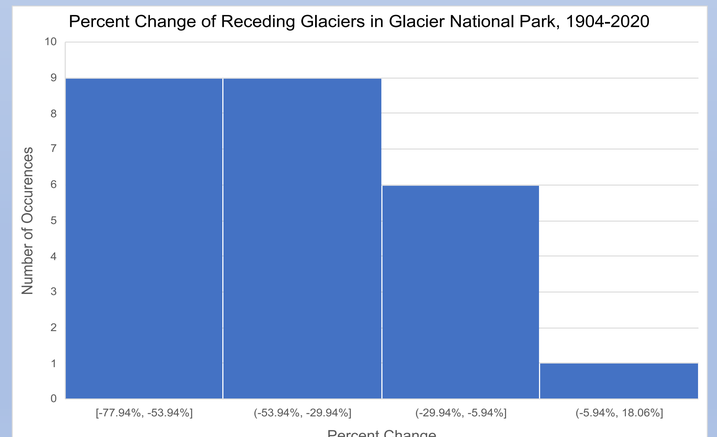



Figure 4 shows the percent change of glacial area from the glaciers studied in 1904 and 2020.

## Sources

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## Results

The area of the glaciers in GNP decreased significantly over time from 1904 to 2020. In 1904, the average of the glacial areas of the glaciers was 1.41 square km (0.54 square mi); the glacier with the smallest area was Pumpelly Glacier (0.09 square km (0.03 square mi)) and the glacier with the largest area was Blackfoot Glacier (2.97 square km (or 1.15 square mi)). In 2020, the average of the glacial area for the active glaciers was 1.41 square km (or 0.54 square mi); the glacier with the smallest area was Miche Wabun Glacier (0.44 square km (0.17 square mi)) and the glacier with the largest area was Blackfoot Glacier (7.08 square km (2.7 square mi)). The average percent change from 1904 to 2020 was -44.43%. The smallest percent change was seen in Weasel Collar Glacier (-5.14%) while the largest percentage change was seen in Sperry Glacier (-77.94%). There was an overall decrease in not only the glacial area in Glacier National Park from 1904 to 2020, but also in the number of active glaciers. As of 2015, 11 of the total glaciers in GNP were found to be no longer "active" as they did not meet the minimum size requirement.

## Discussion and Conclusion

Looking at the overall trend of this analysis, the relationship between the year and the glacial area is important in determining the future trend in the receding glaciers. As the weather becomes warmer and fluctuates more, there has been an increase in precipitation along with a decrease in snowfall, leading to snow melt occurring earlier in the spring (National Park Service, 2020). The area of the remaining glaciers is shrinking, and the number of "active" glaciers is decreasing more each year, which is shown by the data. According to the World Wildlife Fund, the phenomenon of the glaciers rapidly melting is a result of human activities. Carbon dioxide and other greenhouse gas emissions are making the air temperature higher and thus melting the glaciers (Hancock, n.d.). The United States Geological Survey and Portland State University published a study which goes on to explain that the warmer than usual temperatures are decreasing the area of the glaciers. According to their data, the glaciers have decreased in size by 39%, on average, and the number of active glaciers has decreased to only 26 glaciers, as of 2017 (Glaciers Rapidly Shrinking and Disappearing: 50 Years of Glacier Change in Montana2017). Many people believe that the glaciers will continue to decrease drastically and there will be no more glaciers left in GNP by 2030 (Overview of Glacier National Park's Glaciers, n.d.). This study seems to be generally accurate in terms of the trends, as many other sources agreed with the same findings and relationships, however, it does have its limitations. For example, the polygon layers in QGIS (depicting the glaciers) could be drawn more precisely, making the area of the glaciers much more accurate.