I. Introduction

Glaciers are important resources at Mount Rainier National Park (MORA) because of their direct influence on Park geology, geomorphology, biology, and hydrology. The glaciers provide water for the region, maintain aquatic ecosystems and major regional river systems. Many glaciers at Mount Rainier have been the source of damaging glacial flooding throughout the Park’s history. These floods are most often caused by periods of high temperatures or intense rainfall and can quickly mobilize materials from the area, such as talus blocks on marginal moraines into debris flows. These outburst floods and debris flows can have devastating impacts on Park infrastructure and have led to changes in Park management throughout MORA.

II. Methods

Mapping of 2015 glacial extents in this study was completed by hand digitizing features from aerial imagery at a 1:1,000 scale. Due to the difficulty in delineating debris cover on glaciers, lower resolution (15,000 images) were used to map debris cover. Manually digitizing glacial boundaries inherently introduces error into final measurements. For the purposes of this study, the horizontal accuracy of a point at 1:1,000 scale is 0.047 m (2.27 ft) and 1:5000 scale is 0.433 m (13.89 ft). To account for all other potential errors, a relatively high 5% value was used for potential variability error.

Glacier volumes were calculated using MORA glacier extents in combination with equations from previous studies:

\[ V_{\text{volume}} = 0.0255 \times A_{\text{area}}^{1.36} \]

\[ T_{\text{temperature}} = 45.1 \times A_{\text{area}}^{2} - 0.106 \]

\[ R_{\text{rhythm}} \times g \]

III. Results

Table 1: Changes in glacial extent at Mount Rainier National Park from 1896 to 2015.

<table>
<thead>
<tr>
<th>Glacier</th>
<th>Change from 1896 to 2015</th>
<th>Change from 2009 to 2015</th>
<th>Average Rates of Area Loss</th>
<th>Average Rates of Volume Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mowich Glacier</td>
<td>-1.46 km² (-0.09 mi²)</td>
<td>-0.24 km² (-0.16 mi²)</td>
<td>-0.021 km²/yr (-0.004 mi²/yr)</td>
<td>-0.56 mi³/yr (-0.16 mi³/yr)</td>
</tr>
<tr>
<td>South Mowich</td>
<td>-2.68 km² (-0.16 mi²)</td>
<td>-0.44 km² (-0.07 mi²)</td>
<td>-0.02 km²/yr (-0.003 mi²/yr)</td>
<td>-1.41 ± 0.26 mi³/yr (-0.44 ± 0.07 mi³/yr)</td>
</tr>
</tbody>
</table>

IV. Conclusions

- Analyzes of glacier extent and volume at Mount Rainier National Park show an overall loss of ice over the last century:
  - -0.56 mi³/yr (-0.16 mi³/yr) between 2009 and 2015
  - -0.004 mi³/yr (-0.001 mi³/yr) between 2009 and 2015

- Despite a relatively gradual decrease in glacier area, glacier volume loss is accelerating as glaciers thin. This is significant since glaciers at MORA represent a major source of fresh water for the region. If the regional climate continues to change in ways that shrink glacial extent, further volume loss park-wide is anticipated, as well as the complete loss of small, lower-elevation glaciers in the next few decades.

References Cited