Colorado Rock Glacier Inventory: Active, Inactive and Relict Rock Glaciers

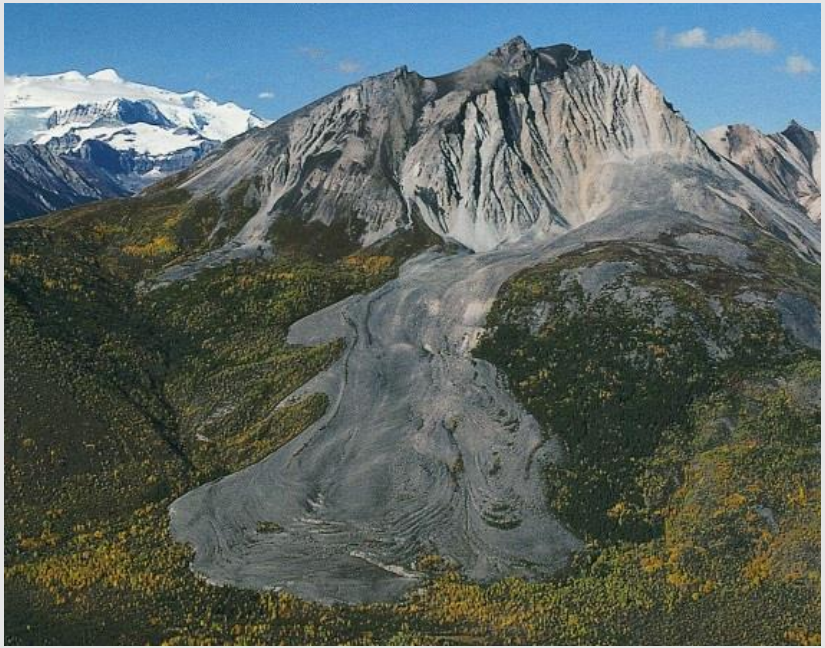

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Photo: National Park Service

Rock Glaciers

Mass of rock, sediment and perennial ice, all flowing downslope

- Methods of formation:
  - Periglacial: when ice fills the space between rock debris
  - Glacial: ice-core glacier is covered in rock debris
  - Combination of periglacial and glacial
- Supply of rock debris and snow is important

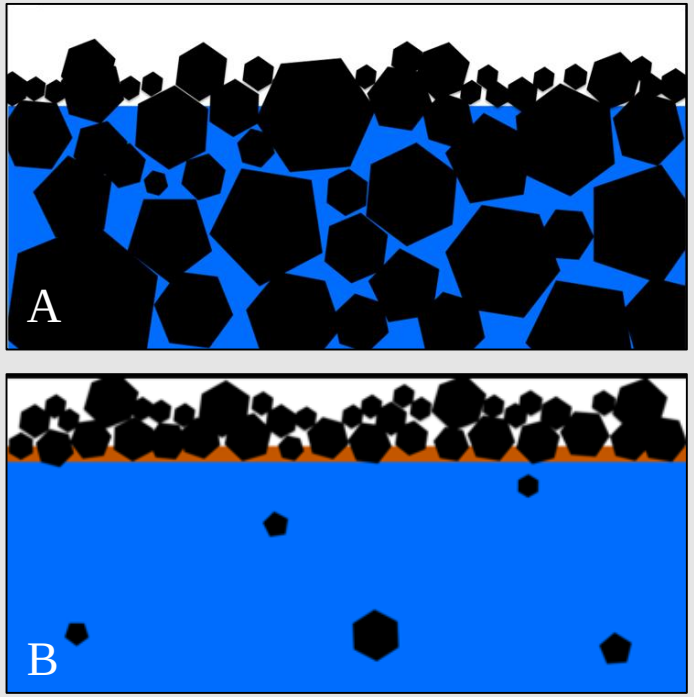


Figure 1: *Cross-sections of the formation of a rock glacier.*

Diagram: courtesy of Andrew Fountain

Significance

- More resilient against climate change than other glaciers because debris insulates ice
- Fresh water source for ecosystems, agriculture and human use
- Cool air creates microclimates for plants and animals

Figure 2: *Pikas are a kind of animal that benefits from rock glaciers as a habitat.*

Photo: Dulude-De Broin

Previous Inventories

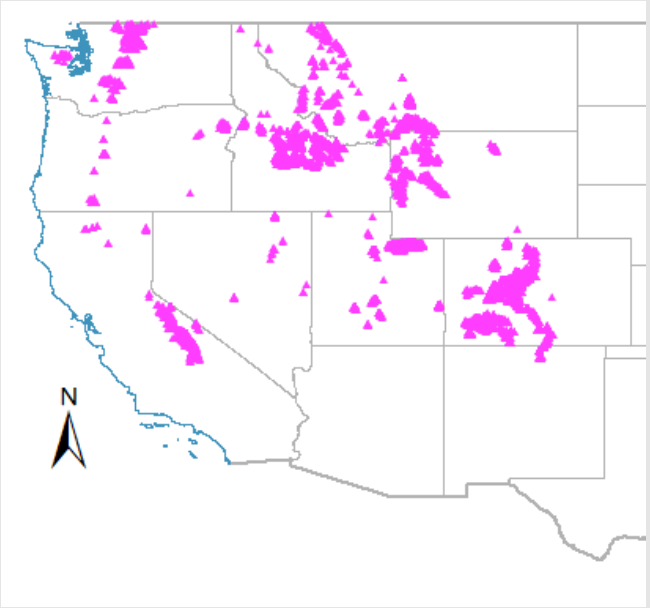


Figure 3: *Each rock glacier in the Johnson (2018) inventory of the western U.S. is marked with a pink triangle.*

Diagram: courtesy of Andrew Fountain

- Johnson (2018) provides a template for locating rock glaciers nationally
- Janke (2007) classified rock glaciers around Rocky Mountain National Park in Colorado

Issue that this study is addressing:

- Inconsistent classification of rock glaciers among studies
- Non-rock-glacier features are wronlgy being classified into rock glaciers

What I did

Located rock glaciers using Google Earth Pro

Categorized rock glaciers into one of three categories, also marking features similar to rock glaciers

Outlined rock glaciers on ArcMap

Repeated this process for more than two thousand rock glaciers and features!

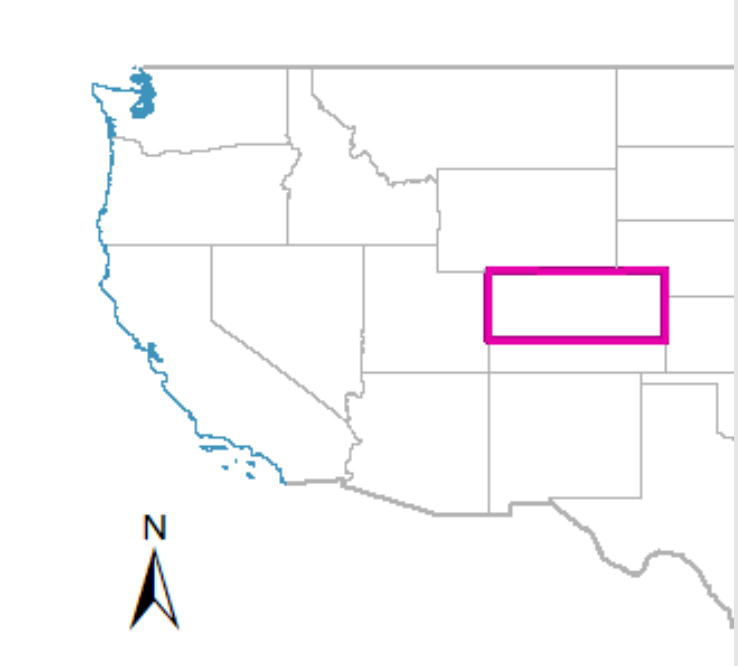


Figure 4: *The study area in Colorado is outlined in pink.*

Active Rock Glaciers

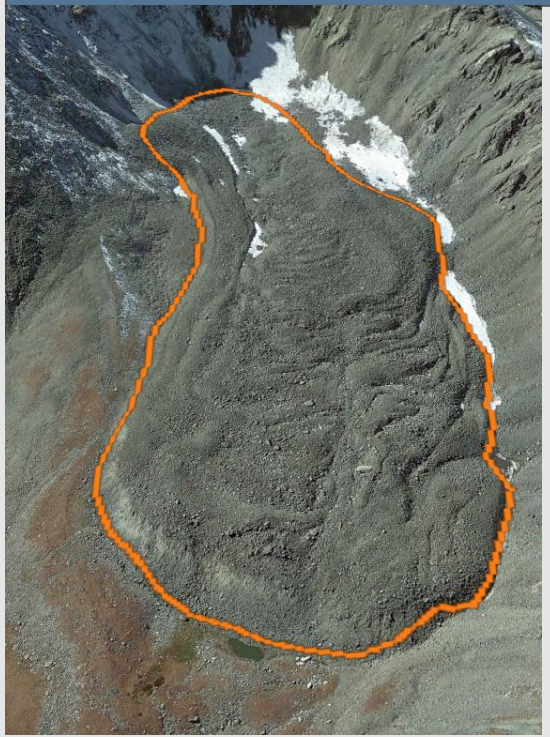


Figure 5: *Active rock glacier at Pacific Peak in Colorado, outlined on Google Earth Pro*

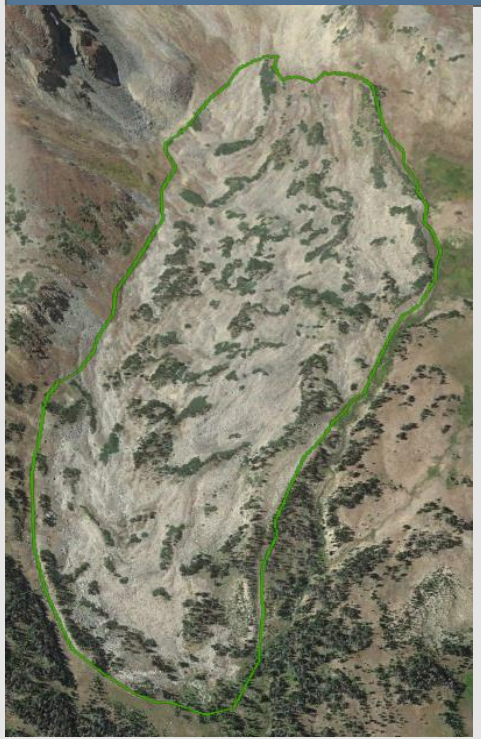
- Oversteepened front and side margins
  → contains ice
- Ridges and furrows often arcuate and convex downslope
  → currently moving
- Vegetation-free surface indicates ongoing movement
- Can completely occupy the axis of a valley

Inactive Rock Glaciers

- Steep front and side margins → contains ice
- Dominantly smooth surface indicates no internal deformation → no longer moving
- Minimal vegetation can be present on the surface, such as moss
- Surface erosion can also create gully-like features nearby

Figure 6: *Inactive rock glacier at Ice Mountain in Colorado, outlined on Google Earth Pro*

Relict Rock Glaciers



- Gentler terminal front and sides
  → lack of ice
- Subdued ridges and furrows or a flat surface
- Vegetation present
  → no longer moving
- Deflated surface and collapse structures
- Most variety

Figure 7: *Relict rock glacier near Clark Peak in Colorado, outlined on Google Earth Pro*

Features of Interest

Figure 8: *Feature of interest near Mt. Arkansas in Colorado on Google Earth Pro. This example does not flow downvalley and is therefore not a rock glacier.*

Features of interest are **not** rock glaciers but have similar characteristics

- Can be flat or have steep margins
- Usually stop at valley walls rather than flowing down the valley
- Various shapes: sometimes wider than long, ridge or series of ridges parallel to the valley wall
- Sometimes carved by rivers

Classification Comparison

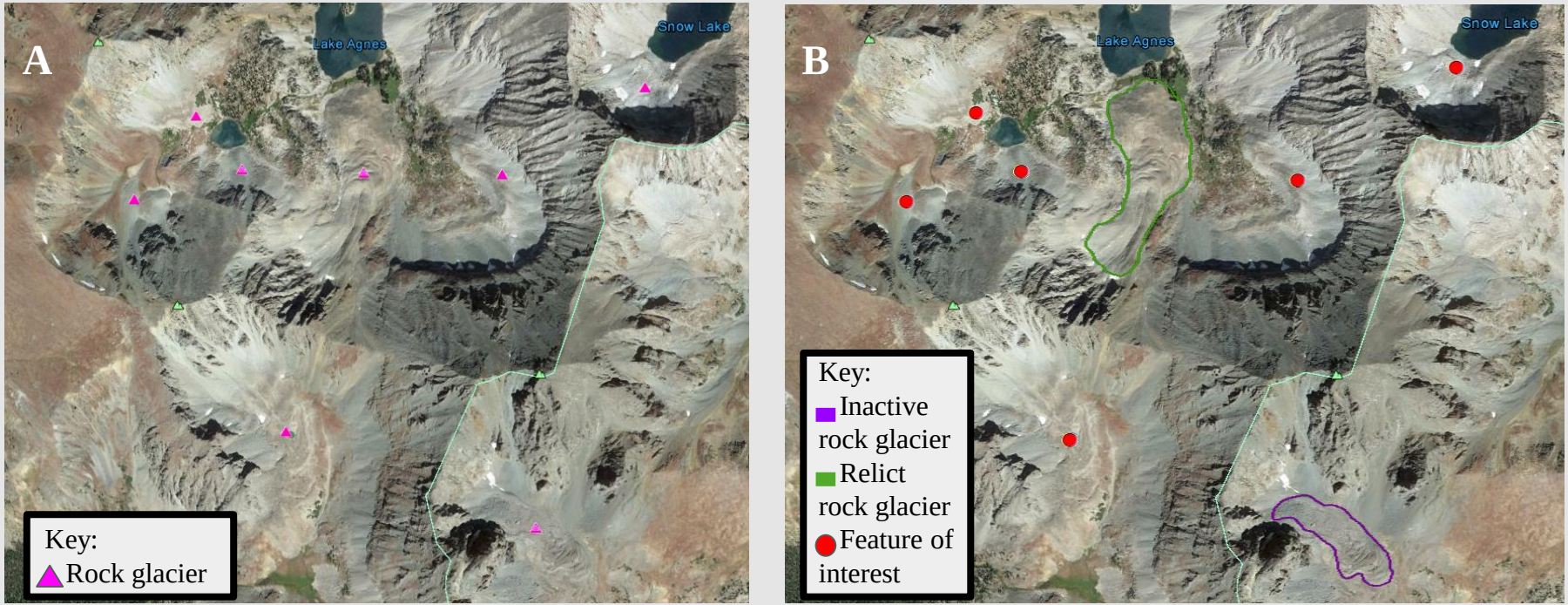


Figure 9: *Johnson's classification (left) and this study's classification (right) of same area near Mount Mahler and Mount Richthofen.*

- This study **re-classified many points as features of interest - not rock glaciers.**

Results: Rock Glaciers Located

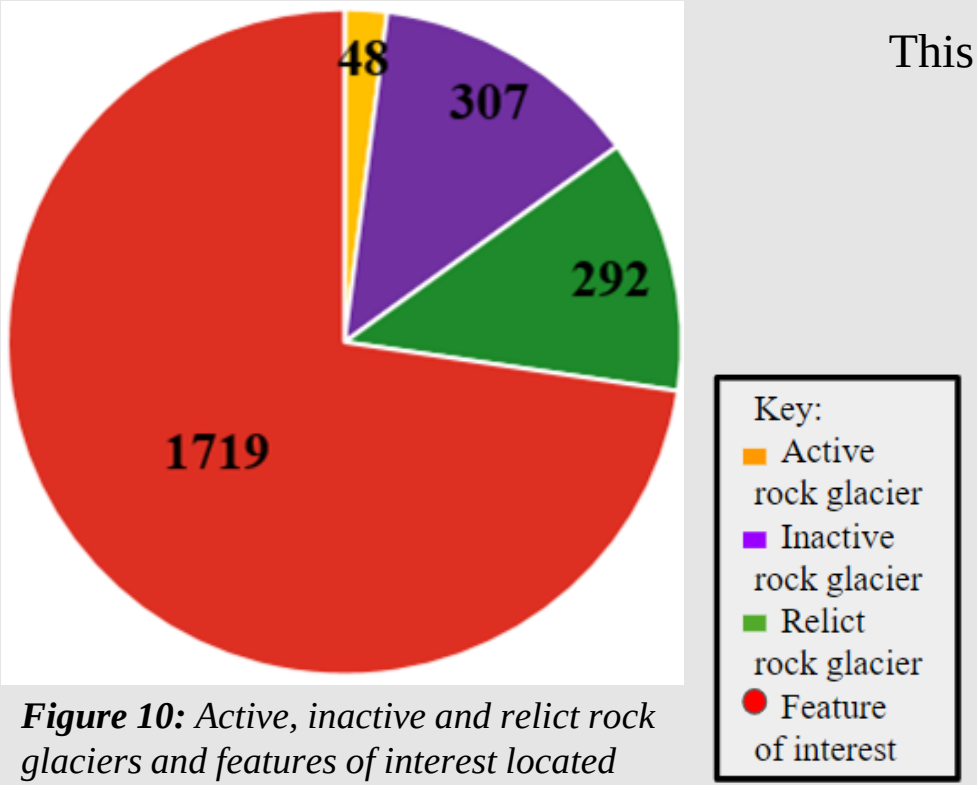
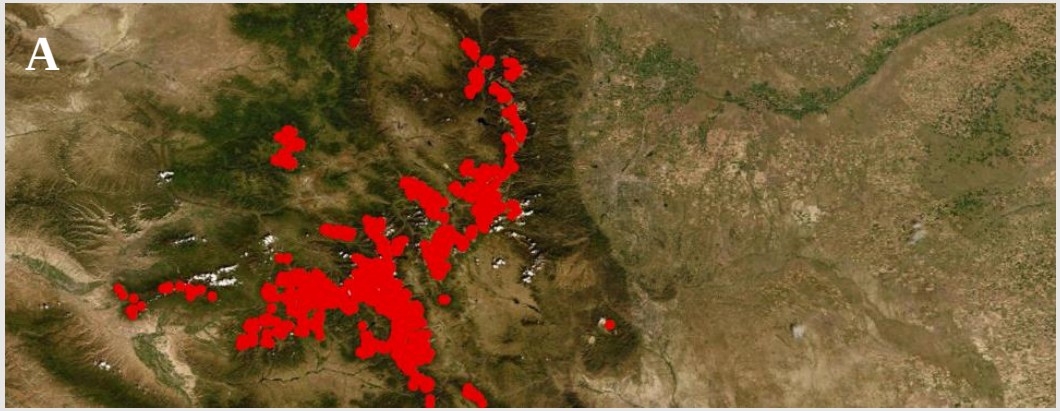


Figure 10: *Active, inactive and relict rock glaciers and features of interest located*

This study classified:

- 647 rock glaciers:
  - 48 (7.4%) active
  - 307 (47.4%) inactive
  - 292 (45.1%) relict
- 1,719 features of interest
- 74 non-rock-glacier points

Results: Rock Glaciers Located



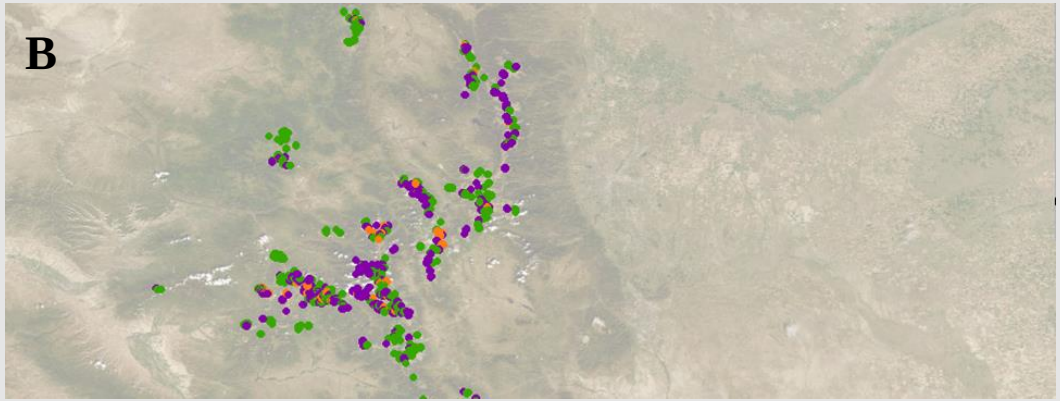
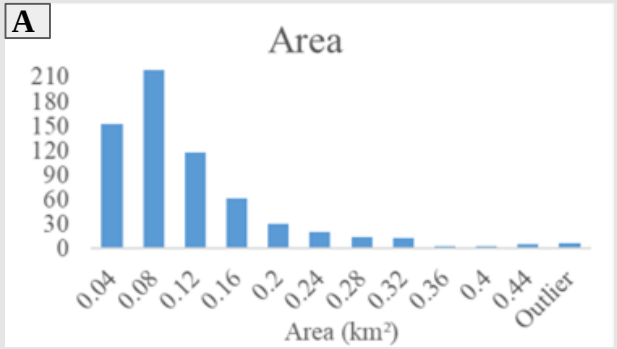
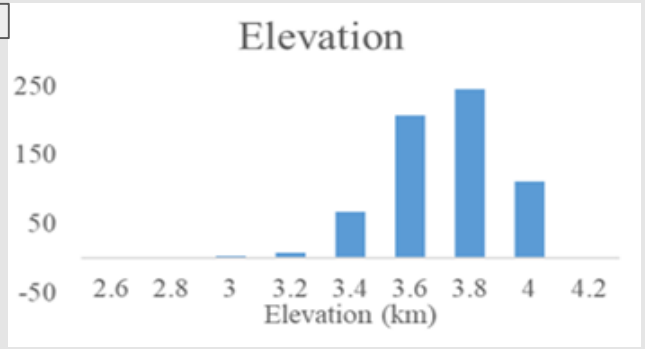
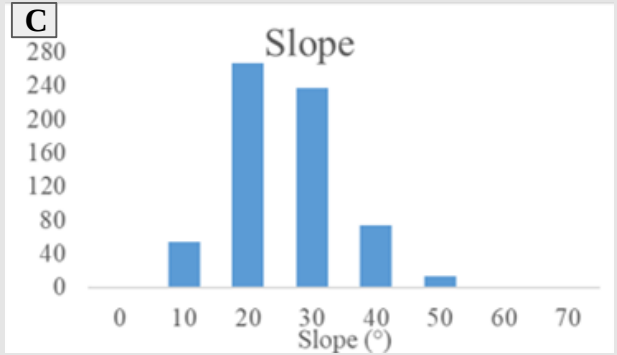


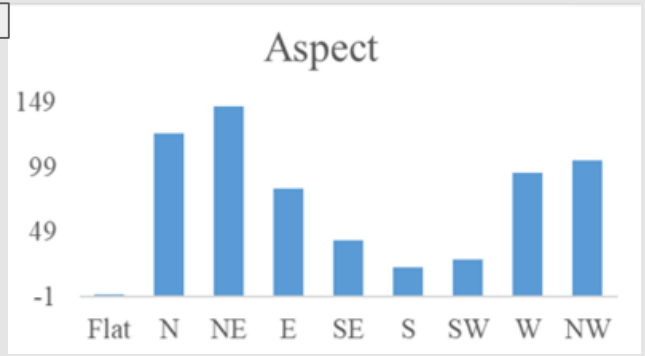
Figure 11: *Features of interest (A) and rock glaciers outlined (B) in the study area in Colorado .*

Results: Rock Glaciers Located









Average area: 0.005632 km²
Average elevation: 3.613 km
Average slope: 20.92°
Mean aspect: Northeast

Figure 12: *Area (A), elevation (B), slope (C) and aspect (D) for rock glaciers in the study area in Colorado.*

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Agave
(Julian's dog)

Photo credit: Bryce Glenn

Portland State
UNIVERSITY

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*Johnson (2018) was used as a reference for locating rock glaciers.