

Title

Rock Glaciers to the Rescue? The Abundance, Distribution, and Resilience of Glaciers versus Rock Glaciers in the Greater Yellowstone Ecosystem

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Background and Questions

Glacier retreat is an iconic symbol of climate change. Glaciers are an important component of alpine environments, providing ecosystem services and modulating the timing and magnitude of the hydrologic system of mountain catchments. Meltwater from glaciers sustains streamflow in high elevation glacierized catchments during the otherwise dry late summer season. Glaciers thereby maintain cold temperatures in aquatic habitats which support species that are currently listed as threatened under the Endangered Species Act, e.g., *Zapada glacier*, the western glacier stonefly.

However, glaciers are not the only source of ice melt in mountain landscapes. Rock glaciers are another key Cryospheric feature. Rock glaciers can be identified as talus-mantled, lobate landforms that are connected to steep headwalls and have margins steeper than the angle of repose. The steep margins imply the presence of internal ice. Past research shows that melt water from rock glaciers can similarly sustain aquatic habitats for species adapted to cold meltwater input. Rock glaciers thereby serve as refugial settings in mountain ecosystems that are no longer favorable for sustaining traditional, ice-only glaciers, because the talus mantle of a rock glacier insulates the underlying ice.

New data on glacier and rock glacier outlines, derived from digitizing Cryospheric feature margins from satellite data, are now available. This analysis will address the following broad management questions:

- (1) How can new glacier and rock glacier datasets derived from remote sensing inform landscape management across the Greater Yellowstone Ecosystem?
- (2) How can these data be used to assess the impacts of climate change on mountain ecosystems?

Methods

To address these questions, currently available data on glacier and rock glacier distribution across the Greater Yellowstone Ecosystem will be synthesized and analyzed in conjunction with gridded climate model output (winter precipitation, summer temperature) from the

European Centre for Medium-Range Weather Forecasts Reanalysis v5 (ERA5) to quantify local microclimate controls and resilience:

Hypothesis. Rock glaciers are located at lower elevations, with warmer temperatures and drier precipitation regimes, and across a wider variety of aspects than ice-only glaciers within the Greater Yellowstone Ecosystem.

Conclusions

The results of this study will quantify the abundance and distribution of glaciers and rock glaciers across the Greater Yellowstone Ecosystem. The synthesis against summer temperature and winter precipitation will provide valuable insight into the potential for rock glaciers to provide refugial habitat services even after glaciers have retreated.