Biogeography of Snow Algae Communities in the Pacific Northwest

Rachael Mallon
Western Washington University

Introduction:

Alpine environments are paradoxically both fragile and biodiverse ecosystems. In addition to megafauna such as mountain goats and marmots, lesser-known microorganisms inhabit snowpack both seasonally and year-round including arthropods, fungi, bacteria, and algae. Snow algae tend to grow in dense patches and can be colored pink due to a secondary pigment, which has led to the colloquial term, 'watermelon snow' (Figure 1). This pigment allows snow algae to withstand the intense UV rays that glacial ecosystems receive from the sun; however, the pigmentation absorbs the sunlight and increases snow melting. A snow algae 'bloom' is a massive increase in algae biomass, which visibly darkens the snow surface in spring and summer and can vastly exacerbate snow melt. Recent research found that snow algae can decrease the albedo (the proportion of the light or radiation that is reflected) of the snow by up to 13%[1]. This significant effect on melting suggests that snow algae populations should be integrated into climate change models. Similarly, climate projections indicate that these intricate microbial environments and their snowy habitat are increasingly at risk of shrinking, fragmenting, and disappearing.

Figure 1. Snow Algae covers seasonal snow in the Stewart Range of the Alpine Lakes Wilderness in Washington.

Previous research of snow algae communities has shown that watermelon snow harbors 2-40 species of algae. Although snow algae have been described on every continent, limited research has attempted to address the changes in these algal communities by geographic location. Previous research on continental glaciers in the European arctic has shown that algal community composition remains similar over geographic locations. In contrast to the continental glaciers of the European Arctic, alpine glaciers in Pacific Northwest (PNW) are characterized by natural gradients in latitude, elevation, and precipitation. This variation provides diverse and contrasting habitat for microorganisms, and an ideal location to study snow algae population dynamics. Recent glacial and climate analyses also suggest that the PNW—specifically the North Cascades—is experiencing faster than average snow and glacial melt. A decreased annual snowpack and earlier melting times place these unique environments at high risk in a continually warming climate.

Methods:
In the PNW, snow melts in a latitudinal and elevational gradient during onset of spring, such that both low elevation and southern latitudes melt earlier in the spring and higher elevation and northern latitudes melt later in the season. A heavier snowfall during the winter of 2016/2017 caused a later than usual start to our field season, as the snowpack melted later and the algae returned to the surface later in the spring/summer.

My advisor, Dr. Robin Kodner, and I began taking trips to our high-intensity permanent site (near the Mount Baker Ski Area) in May, and I began collecting samples on volcanoes in northern Oregon and southern Washington in late June. Depending on the destination, my field work consists of hiking, mountain biking, backcountry skiing, and/or mountaineering to reach alpine snow. In the field, pink snow is scooped into 50 ml Falcon tubes with a saline solution (RNA-later) used to preserve DNA (Figure 2). On each peak, I would collect 2-8 samples from different locations and record additional information like the latitude and longitude, quality of the snow, elevation, and aspect of the slope. Samples were stored on ice until they could be returned to a refrigerator at Western Washington University. In order to increase the efficiency of travel time spent collecting samples, I strategically planned to climb and collect on multiple peaks before returning samples to the lab.

Figure 2. Collecting snow algae on the Gerdine Glacier, Glacier Peak, WA.

In addition to the members of the Kodner Lab collecting snow algae samples this summer, we reached out to local outdoor enthusiasts to collect snow samples during their recreational outings as well. We created sampling kits for citizen scientists with self-addressed and pre-paid envelopes to return samples to our lab. This summer, citizen scientists collected 40 samples from locations that our small lab of two people would otherwise not have been able to collect (Figure 3). In addition to increasing our sampling efficiency and the total sampling area, we were able to connect with a diverse group of people and educate our volunteers about the snow ecosystem in their backyard.

Snow algae samples collected by both the Kodner Lab and citizen scientists are preserved in a refrigerator until they can be processed for molecular analysis. From the 120 samples I collected and over 40 collected by citizen scientists, I have extracted DNA from a select 60 samples thus far. I am currently in the process of using a technique called PCR (Polymerase Chain Reaction) to amplify a gene commonly used as a marker for species. In the next month, we will use a technology called high-throughput sequencing to determine the order of nucleotides in the gene we have amplified. Each snow algae sample is comprised of thousands of different microorganisms, and therefore thousands of sequences per sample.

Discussion:
Analysis of our samples collected during the summer of 2017 is contingent upon getting sequence data back, and subsequent bioinformatics analysis. I will use a powerful bioinformatics program, *pplacer*, designed to take lots of sequences and give them the best identification, or annotation, possible. Because each snow algae sample can contain thousands of different sequences, each sample has thousands of different annotations. Using a variety of statistical analyses, I will be able to use the annotations to describe how snow algae communities vary throughout the Pacific Northwest, including how snow algae communities change with respect to time and altitude. My research will also be the first comprehensive snow microbe biodiversity study across a whole mountain range, and may act as a platform for future climate modeling.

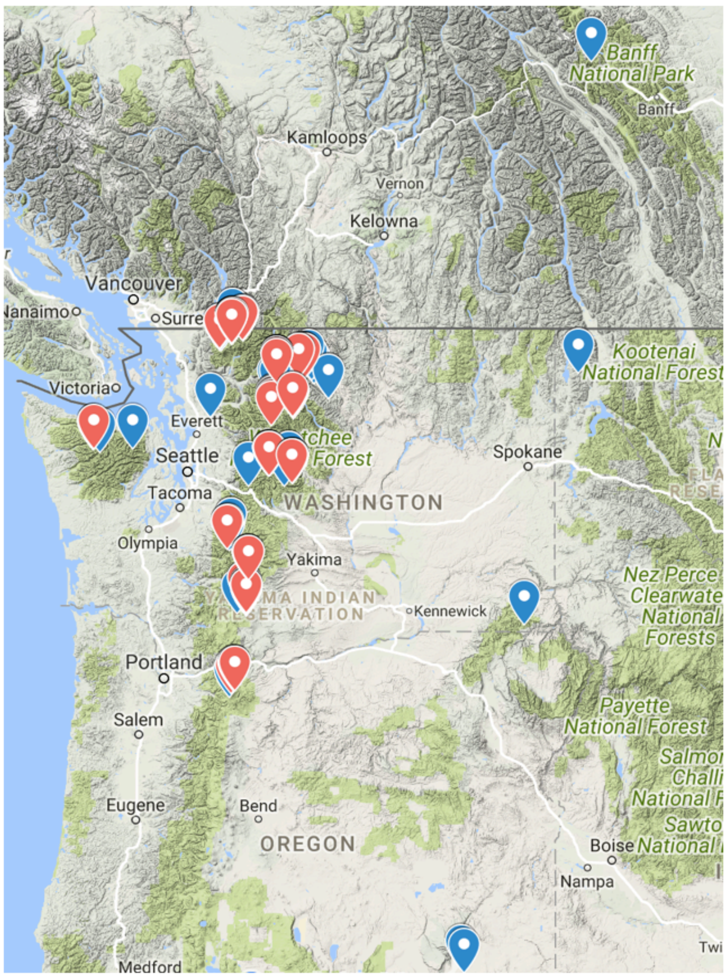

Figure 3. Samples collected by the Kodner Lab and citizen scientists during the summer of 2017. The red markers are locations where I collected samples this summer, and the blue markers show locations where citizen scientists collected samples this summer.

Future field work in the Kodner Lab would benefit from a better publicized citizen science initiative. We were able to reach a small number of recreationalists in the state of Washington via social media, lectures at the Bellingham Mountaineers, and reaching out to our friends in the outdoor and academic community. However, I believe we would be more successful if we were to seek out more publicity. This summer and fall, our citizen scientist efforts were recognized by The Seattle Times[2] and at the Northwest Avalanche Center's Northwest Snow and Avalanche Workshop (NSAW)[3], which has already led to an increase in interest in our citizen science program. In addition, we hope to reach many more potential citizen scientists in the coming summer by collaborating with local guiding services that frequent the North Cascades. We hope to continue to grow and improve this program to provide actionable science and climate change education for the public.

REFERENCES

1. Lutz, S., Anesio, A. M., Raiswell, R., Edwards, A., Newton, R. J., Gill, F., & Benning, L. G. (2016). The biogeography of red snow microbiomes and their role in melting arctic glaciers. *Nature Communications*. 7: 11968.

2. https://www.seattletimes.com/life/outdoors/citizen-scientists-track-effects-of-climate-change-in-the-northwest/

3. https://www.youtube.com/watch?v=FGH5kYkXHVc