Arctic LCC Progress Report

1. PROJECT INFORMATION

Title:	Long-term monitoring of the impacts of climate change on the glaciers and rivers in the Arctic National Wildlife Refuge
Report period	15 June 11 - 15 December 11
Report submission date	25 January 12
Author of Report	Dr. Matt Nolan

Principal Investigator(s), Co-Principal Investigators and Recipient Organization(s):
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2. PROJECT OVERVIEW

a. Briefly (4-5 sentences) describe both the research purpose and the underlying need for this research.

We are investigating glacier-climate interactions within the Arctic National Wildlife Refuge, including the impacts of glacier change on the downstream aquatic and terrestrial ecosystems, using McCall Glacier as the primary research glacier and the Hulahula River as the primary research watershed. McCall Glacier has been under intensive study since 1957 primarily by academic researchers, and we hope that this project will facilitate USFWS and the ALCC in their management and scientific goals in this region.

b. List the objective(s) of the project, exactly as described in your Statement of Work.

- Installation of a temporary weather station and mass balance stake on Esetuk Glacier and delivery of any data recorded there.

- Measurements of glacier ice thickness for the purpose of estimating the total volume of glacier ice draining into the Jago, Okpilak, and Hulahula Rivers. These measurements will be made at about 6 glaciers of varying size, including McCall and Esetuk Glaciers.

- Acquisition of vertical photo mosaics of the Hulahula and Jago Rivers at about 20 cm ground sample distance. The imagery will be made available at full resolution, subsampled to web resolution, in a KML file with flight track, and as a seamless mosaic available to the public over the internet.

- LIDAR-derived DEMs of the Hulahula, Jago, and Okpilak river channels will be made available for gradient mapping.

3. PROGRESS SUMMARY

Describe report period progress.

Installation of weather station and mass balance program on Esetuk Glacier and delivery any data recorded there. The weather station and mass balance pole were installed in August 2010, with enough memory and power for at least two years of recording without intervention. We scheduled four attempts by fixed wing to access Esetuk Glacier in 2011, but were unfortunately thwarted by weather and conditions. We were unable to mobilize a helicopter to venture into this remote region.

Aerial photography of Jago and Hulahula Rivers. We completed transects of both rivers on June 22-23 and September 13. These dates recorded the peak flood and near the minimum low water for the season, respectively. I posted large thumbnails and KMLs on-line within several days of acquisitions, along with complete mission notes, www.drmattnolan.org/photography/2011_index.htm . We attempted to fly a similar mission in April and October, but were on standby for 2 weeks each without success; in April I had also rented a FLIR camera for simultaneous IR measurements, but testing while on standby showed that the complications of using it were not warranted at this stage, so I did not rent it again. In December I posted some mosaics online, demonstrating the accuracy levels of the DEMs and orthoimages that can be created from these data. I distributed full resolution images to several scientists, but have not delivered them to ALCC at their request pending completion of their data archival system.

Measurement of ice thickness on McCall and Esetuk Glaciers and several smaller glaciers. In August 2010, we brought two independent radar systems to McCall Glacier, along with experts from Belgium, Canada and Germany to run them. We completed a substantial amount of work on McCall Glacier, and one long longitudinal transect on Esetuk Glacier. Weather conditions thwarted our continued use of the helicopter for several days before releasing it. I purchased one of these radar units and tested it thoroughly on McCall Glacier in May 2011; unfortunately due to weather and other logistical reasons we were unable to reach Esetuk or any other glaciers that summer. I spent a considerable amount of time modifying this system for use behind a snow machine, rather than use on foot, increasing our acquisition speeds by a factor of 100.

LiDAR measurements of Jago and Hulahula Rivers. To be honest, I had thought this was only mentioned as a possibility for a deliverable, as USFWS or ALCC had nothing to do with acquisition of these data, but in any case I still have not received the final deliverables from the vendor so I cannot pass these on. As of January 2012, we are very close to finalizing this contract and I do intend to freely share the data once I validate it fully.

a. Describe preliminary results.

The primary results from the past year are related to the radar and aerial photography work.

Our work with the 10Mhz monopulse ice radar was especially rewarding, despite not measuring as many glaciers as we had hoped. We found that with this system we could measure not only ice thickness at high resolution but also ice temperature. We then used this ice temperature information to back-calculate the upwards migration of the late-summer snow line over the past 50 years, as this line largely controls ice temperature here, and validated these results with our long-term field records, temperature measurements in deep boreholes, and further modeling. This technique is brand new, and can now be utilized at other glaciers. Our radar work on Esetuk Glacier also records the temperature, for example. The ability to use this radar behind a snow machine now will also allow us to make much more comprehensive maps on McCall Glacier.

The aerial photography work has demonstrated that this technique is viable logistically and useful scientifically. Our last mission on September 13 was done in a day trip from Fairbanks, opening up the options for rapid response to capture events of interest. We also demonstrated that we are able to fly at a

nearly constant height above ground while simultaneously following the twisting thalweg, which is no minor feat and improves data quality by maintaining a consistent spatial scale and providing full river coverage. I also demonstrated that these data are quite useful photogrammetrically, creating DEMs at submeter spatial resolution and vertical noise on the order of 20-40cm, and virtually seamless orthomosaics.

b. Publications, conference papers, and presentations.

Two peer-reviewed publications were supported by this work:

Nolan, M., R. Churchwell, J. M. Adams, J. McClelland, K. Tape, S. Kendall, A. Powell, K. H. Dunton, D. Payer , and P. D. Martin, 2011, "Predicting the impact of glacier loss on fish, birds, floodplains, and estuaries in the Arctic National Wildlife Refuge", Proceedings of the Fourth Interagency Conference on Research in the Watersheds: Observing, Studying and Managing for Change, U.S. Geological Survey Scientific Investigations Report 2011-5169, Page 49-54.

Charlotte Delcourt, Brice Van Liefferinge, Frank Pattyn and Matt Nolan, "The climate memory of an Arctic polythermal glacier", Geophysical Research Letters, submitted.

c. Education and outreach.

I maintain a comprehensive blog about our field activities which can be found at www.drmattnolan.org/photography/2011_index.htm I also regularly discuss our activities and findings with residents of Kaktovik.

d. Other products resulting from the project.

This project also supported in part our efforts to understand how loss of glacier ice here will impact downstream acquatic ecosystems, largely through supplies and logistics supporting Greta Burkart, an acquatic ecologist now employed by USFWS' Arctic Refuge.

This project also supported in part the filming of a documentary about our research. Clips of this footage can be found on my 2011 photography page above near the bottom. We are still seeking funding to edit this footage into a feature length documentary.

e. Describe any concerns you may have about your project's progress.

The primary obstacle to success and deliverable timelines is simply remote arctic logistics. These complications were expected and our level of trouble is no higher than any other year. The only thing that I can think might improve the situation for our ice radar work is if USFWS could charter a helicopter, to both spread costs between projects and get one in the area, or insert me into the AMD line up in some way.

4. PROGRESS STATUS

Progress seems on track to me. Our overall goals of maintaining long-term time-series of measurements on McCall Glacier, extrapolating these to the surrounding glaciers, and understanding how these glaciers are related to the ecological networks downstream of them are all progressing nicely. I think we have identified a nice climate-glacier-ecology driver-response linkage and have a nice story to tell about it that many people are taking an interest in.

I'm planning two more vertical photography missions, one in early spring just as the snow is melting and one in late-September once the aufeis begins to form but before the snow falls. The first is to capture the extent and volume of aufeis, both to identify springs and estimate their winter flow. The second is to pinpoint the location of springs. I'm planning two trips to McCall Glacier, for about 2 weeks in May and August. I plan to gage discharge on the Jago River in early June, mid-July, and early and late August. I also plan to make photogrammetric measurements of glacier surfaces in mid-July.

Part 2: Detailed report on progress made towards deliverables specified in Statement of Work

List **each** deliverable specified in the Statement of Work and estimate the progress made towards completion of that deliverable. If no progress has been made on a deliverable, record that as '0'. Please limit entries into the "Progress (% completed)" column to integers only, it is not necessary to include text or symbols.

The information you provide in the table is for use by LCC staff and will not be posted on arcticlcc.org.

Deliverable	Progress (% completed)
Installation of weather station and mass balance program on Esetuk Glacier	100%
Download of data from Esetuk Glacier weather station	0%
Aerial photography of Jago and Hulahula Rivers	50%
Measurement of ice thickness on McCall and Esetuk Glaciers	85%
Measurement of ice thickness on several smaller glaciers	0%
LiDAR measurements of Jago and Hulahula Rivers	95%