Vascular Flora of Nunataks in Southwest Alaska

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Abstract

Increased mean annual temperature and decreased precipitation over the last 50 years have resulted in measurable recession for many glaciers in southwest Alaska. Changes in ice cover are expected to impact nunatak communities, many of which are found in Kenai Fjords National Park (NP) and Lake Clark National Park and Preserve (NPP). A comparison of 1950s survey photography and 2005 IKONOS images from Kenai Fjords NP suggests that nunataks on the Harding Icefield and in the southern Kenai Mountains have increased in area by 30%, on average, over the past five decades. An inventory of the vascular flora at these sites yielded seven species of conservation concern and five collections that represented new range extensions. Several sites possessed unusual species assemblages, suggesting a relict flora from the Last Glacial Maximum.

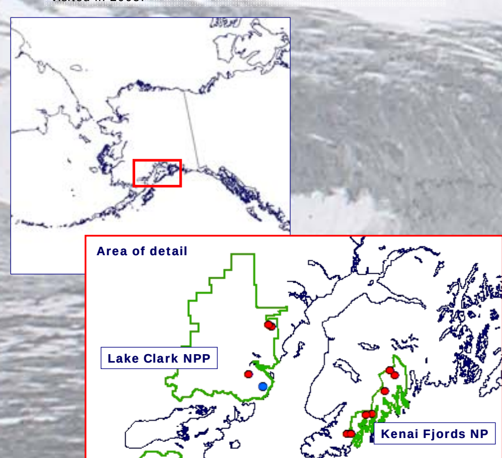
Introduction & Background

Multiple glacial advances over the past 100,000 years have shaped the landscape and communities of south-central and southwest Alaska, most of which was covered by ice during the Last Glacial Maximum (LGM), approximately 20,000 years bp (Manley 2002). Alternative views regarding the fate of alpine plants during the Quaternary glaciations suggest that (1) alpine populations were either entirely extirpated in glaciated areas and re-colonized only after the retreat of the glaciers, or (2) that they survived glaciation *in situ*, on ice-free ridges (nunataks), and re-colonized from there.

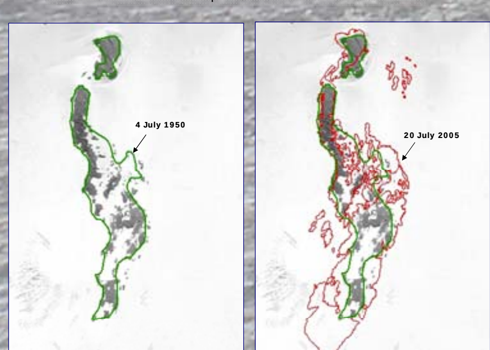
In southwest Alaska, local climate records indicate a warming of approximately 2 °C over the last 50 years (Driscoll et al. 2005). The Harding Icefield, largely contained within Kenai Fjords NP, has shown a net loss of approximately 5% of ice cover between 1950-1985, (Rice 1987). Surface elevation profiles conducted in the mid-1990s suggest that the total volume change since the 1950s has been equivalent to an average-area elevation loss of -21 m (Aðalgeirsdóttir et al. 1998).

In 2005, we conducted a vascular plant inventory on nunataks in Lake Clark NPP and Kenai Fjords NP, two National Park Service units in southwest Alaska. Nunataks were of interest because of their geographic isolation and because of their potential to support species that may have survived the LGM. We inventoried a total of eleven sites across the two parks (Fig. 1), and initiated baseline monitoring at eight. We also began an analysis of historic and recent imagery to quantify changes in nunatak extent on the Harding Icefield.

1 **Figure 1.** Nunatak sites, Lake Clark NPP and Kenai Fjords NP. Saddle Mt. (blue) is thought to have remained ice free during the Last Glacial Maximum and was the only non-glacial site visited in 2005.



2 **Figure 2.** Change in nunatak extent, Petrof Glacier, 1950-2005. Estimated increase is approximately 66%. Green line denotes 1950s USGS perimeter.



Methods

Study sites

We inventoried four sites in Lake Clark NPP: Double Glacier (north and south), Tuxedni Glacier, and Saddle Mountain (Fig. 1). The Saddle Mountain site is not currently surrounded by ice and is thought to have remained ice-free during the Wisconsin glaciation (Manley 2002).

In Kenai Fjords NP, we visited seven sites (Fig. 1), including five on the Harding Icefield (Bear, Skilak, Holgate-Northwest, Dinglestadt, and Split Glacier complexes), and two in the southern Kenai Mountains (Wosnesenski and Petrof Glacier complexes).

Sites ranged from 650-1420 m in elevation and from >2 to approximately 8 km from the edge of the ice. Parent material ranged from granodiorite to weathered shales and metasediments.

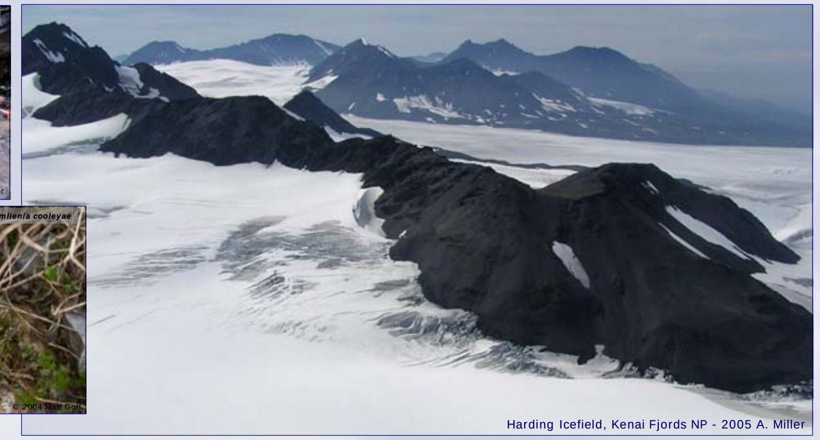
Collections

We inventoried the vascular flora at each site and collected nonvascular specimens (lichens, bryophytes) opportunistically. The University of Alaska-Fairbanks and University of British Columbia Herbariums provided final determinations.

Image analysis

Changes in nunatak area were estimated for the Harding Icefield (1800 km^2) and glacier complexes in the southern Kenai Mountains (400 km^2), Kenai Fjords NP. Using perimeters derived from 1950s USGS digital quads and georeferenced 2005 IKONOS imagery (n=20), we created GIS shape files that were then differenced to derive estimates of change.

Areas calculated from USGS quads approximate or exceed those digitized from rectified 1950s survey photography (1:40,000) (Fig. 2), and thus we consider our difference values conservative. Registration of the remaining 1950-1952 survey photography is in progress.



Results

Species of conservation concern

Vascular plant collections produced seven species of conservation concern, three of which were Alaska-Yukon endemics (Fig 3). The remaining four collections were of Rocky Mountain disjuncts (Fig 4), one of which (*Arabis lemmonii*) represents a dramatic range extension to the west.

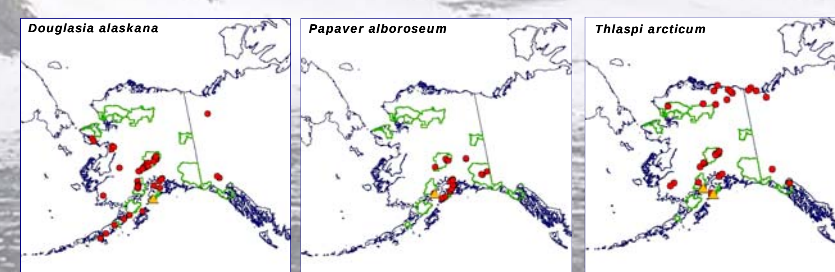
Alaska-Yukon endemics

Douglasia alaskana (Coville & Standl. ex Hultén) S. Kelso (Alaska Natural Heritage Program Rank: G3-S3) was found on the Wosnesenski Glacier, Kenai Fjords NP (59.4441 °N, 150.9458 °W). The species is known in Alaska from the Chugach and Wrangell Mountains. Estimated population size was <10 individuals.

Papaver alboroseum Hultén (G3G4-S3) occurred at Saddle Mountain, Lake Clark NPP (60.0091 °N, 152.8029 °W). It is known in Alaska from the Chugach, Kenai, and Wrangell Mountains, the western Alaska Range and the Alaska Peninsula. A second main population center is in Kamchatka. Estimated population size was 20-50 individuals.

Thlaspi arcticum Porsild (G3-S3) occurred at Saddle Mountain, Lake Clark NPP (60.1249 °N, 152.8089 °W) and on the Wosnesenski Glacier, Kenai Fjords NP (59.4441 °N, 150.9458 °W). It is known in Alaska from the Wrangell and Chugach Mountains. Estimated population size was 20-30 individuals.

3 **Figure 3.** Distribution of *D. alaskana*, *P. alboroseum*, and *T. arcticum* in Alaska and the surrounding region (Hultén 1968; ALA and NPS databases 2006). Our collections are indicated by yellow triangles.



Rocky Mountain disjuncts

The following taxa are widespread montane species found from California to Colorado and into British Columbia.

Arabis lemmonii Wats (G5-S1) was found on the Double Glacier (60.7126 °N, 152.6580 °W) and at Saddle Mountain, Lake Clark NPP (60.0019 °N, 152.8051 °W). It is known in Alaska only from the Wrangell Mountains. Estimated population size was 40-100 individuals per site. The population at Saddle Mountain appeared to be morphologically distinct, and further study genetic study may be warranted.

Arnica diversifolia Greene (G5-S1) was found at Saddle Mountain, Lake Clark NPP (60.0089 °N, 152.8107 °W). It is known in Alaska from the Chugach and Talkeetna Mountains, and from a site on Kodiak Island. Estimated population size was 50 individuals.

Carex phaeocephala Piper (G4-S1S2) was found on the Double Glacier (60.7126 °N, 152.6580 °W) and Saddle Mountain, Lake Clark NPP (60.0019 °N, 152.8051 °W), and on the Petrof Glacier, Kenai Fjords NP (59.4415 °N, 150.8558 °W). The species is known from the Coastal Mountains of southeast Alaska, Wrangell and Chugach Mountains, and the western Alaska Range. Estimated population size was 20-100 individuals per site.

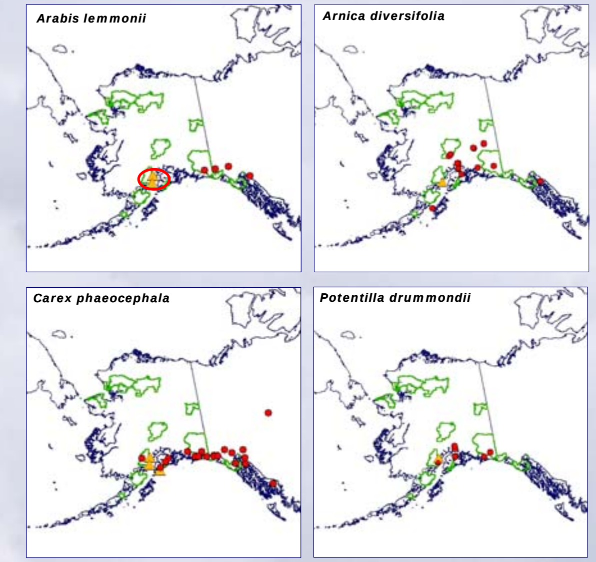
Potentilla drummondii Lehm (G5-S2) was found on the Double Glacier (60.7126 °N, 152.6580 °W). It is known in Alaska from the Chugach, Talkeetna, and St. Elias Mountains. Estimated population size was 100-200 individuals.

Range extensions

Collection location, distance and direction from the nearest population is given in parentheses:

- ***Erigeron compositus*** Pursh. (Double Glacier, Lake Clark NPP (60.7126 °N, 152.6580 °W); 110 km; west)
- ***Kumlienia cooleyae*** (Vasey & Rose) Greene (Double Glacier, Lake Clark NPP (60.7126 °N, 152.6580 °W); 260 km; west)
- ***Carex albonigra*** Mackenzie (Wosnesenski Glacier, Kenai Fjords NP (59.4441 °N, 150.9458 °W); 285 km; south)

4 **Figure 4.** Distribution of *A. lemmonii*, *A. diversifolia*, *C. phaeocephala*, and *P. drummondii* in Alaska (Hultén 1968; ALA and NPS databases 2006). Our collections are indicated by yellow triangles. The Lake Clark populations of *Arabis lemmonii* (circled) occurred approximately 555 km west of the closest known occurrence in the Wrangell Mountains.



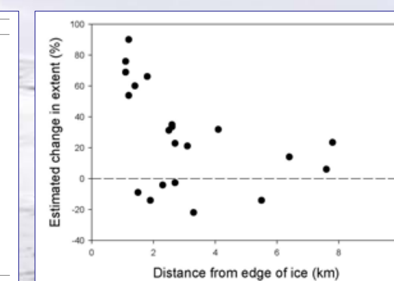
Changes in nunatak extent

Nunatak boundaries mapped from 1950s-era survey photography (USGS-EROS; 1:40,000) and 2005 IKONOS imagery indicate a mean increase in nunatak area of approximately 30% (n = 20) in Kenai Fjords NP (Table 1). The greatest increases in nunatak area appear to have occurred in the northern half of the Harding Icefield (45%; n = 8), and in the southern Kenai Mountains (34%; n = 6). Sites showing the greatest increase in area also tended to be closest to the ice margin (Fig. 5).

1 **Table 1.** Estimated change in nunatak area for selected sites in Kenai Fjords NP (1950-2005).

Region	Glacier complex	1950 ha	2005 ha	% change
North	Lowell	11.5	21.8	+ 89.8
North	Exit	19.6	26.5	+ 35.1
North	Bear	43.5	33.9	- 22.0
North	Bear	31.5	48.5	+ 53.9
North	Skilak	90.3	111.0	+ 22.9
North	Skilak	79.0	133.5	+ 69.0
North	Skilak	5.5	9.8	+ 75.9
North	Skilak	132.7	174.1	+ 31.3
Central	Holgate	39.8	45.4	+ 14.0
Central	Holgate	61.1	74.0	+ 21.2
Central	Holgate	44.2	46.8	+ 6.0
Central	Northwestern	25.9	22.3	- 13.9
Central	Northwestern	31.1	26.8	- 14.0
Central	Dinglestadt	28.6	37.7	+ 31.8
South	Nuka	7.3	9.8	+ 33.7
South	Petrof	54.7	90.9	+ 66.2
South	Wosnesenski	156.1	142.1	- 8.9
South	Wosnesenski	58.3	90.6	+ 55.4
South	Wosnesenski	29.9	29.2	- 2.6
South	Wosnesenski	14.1	22.6	+ 60.2
Total		**2383.8**	**2958.6**	+ **30.2**

5 **Figure 5.** Percent change in nunatak area (1950-2005) vs. minimum distance to edge of ice (2005). Sites showing the greatest increases in area were those closest to the ice margin.



Discussion

Three sites (Double Glacier, Saddle Mountain, Wosnesenski Glacier) supported 90% of the rare species collected in the parks. The additional occurrence of a number of cordilleran and amphiberingian disjuncts suggests that one or more of these sites may have been ice-free during the LGM. Similar levels of endemism in the Alps are consistent with molecular evidence for glacial refugia (Schönswetter et al. 2005). The rare species here are also found almost entirely on unglaciated terrain in Alaska and the Yukon. The collections of *Arabis lemmonii* from Lake Clark NPP are significant because of the rarity of this taxon in Alaska, and because the populations are so widely disjunct from the nearest known populations on the AK-Yukon border. The Saddle Mountain population is of particular interest, as it appears to be morphologically and perhaps genetically distinct from other populations in the region, possibly as the result of prolonged isolation.

Recent changes in nunatak extent are indicative of changing winter conditions in southwest Alaska. A general warming and decreased snowfall at lower elevations has the potential to increase the length of the snow-free season and facilitate the establishment of new species at these sites. Such a change in species composition has already been observed on the Petrof Glacier, Kenai Fjords NP, where loss of ice has resulted in an approximately 65% increase in nunatak area (Fig. 2) and the establishment of coastal species in former snowbed communities (A. Miller, unpublished data). It is unclear how once-isolated populations of rare plants will respond to increased opportunities for migration and the encroachment of more common species as nunataks expand and/or become contiguous with larger ice-free regions.

Literature Cited

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