Protocol: Glacier Extent

Parks Where Protocol Will Be Implemented: KATM, KEFJ, LACL

Justification/Issues Being Addressed: Glaciers are highly sensitive, natural, large-scale, representative indicators of the energy balance of both mountains and lowlands within SWAN. Glaciers are often referred to as natural "water towers" because of their capacity to store water for extended periods and to exert control on the surface water cycle through timing of discharge, volume and variability, and delivery of sediments. Glaciers are a significant landscape feature in SWAN parks, especially KEFJ, KATM, and LACL, but they have been in widespread retreat and thinning since the Little Ice Age (1900). Although this ice loss has occurred at varying rates over time, it is generally understood to have significantly increased in the last few decades. This variation in glacial coverage is responsible for significant landscape change within these parks.

Glacier systems are primarily regulated by climate fluctuations and thus provide a record of long-term climate change. Glaciers act as huge ice reservoirs for freshwater storage in SWAN parks, and much of the freshwater flow systems in the network are currently of glacial origin. Glacial meltwater recharges valley lakes and regulates seasonal stream flows. Freshwater productivity is strongly influenced by glacially forced colder temperatures and limited light penetration due to light scattering from fine, suspended, glacial sediments. Key issues that need to be addressed in monitoring are changes to the extent of glacial ice and the direct effect of these changes on freshwater flow systems in KEFJ, KATM, and LACL.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:

Question:

- What are the changes and trends in glacier extent in KATM, KEFJ, and LACL?

Objectives:

- Document whether the surface area of glacier ice cover is growing or shrinking, the rate of any change, and where the greatest change is occurring.

Basic Approach: Photography, including the use of satellite imagery, is recognized as a simple and effective means for documenting change in glacier extent. Recently, this approach was used to examine change in glacial extent at KEFJ (Hall et al. 2005). Landsat satellite imagery is available from the 1970s to the present, and each scene encompasses large areas. This imagery will be used to monitor glacier extent on a decadal scale in SWAN parks, using a combination of supervised classification and manual methods. Icefields and outlying glaciers will be outlined using vector segments to produce shape files for geographic information system analysis. Changes in all the glaciers can be determined from analysis of the shape files and measurements for terminus-position change for selected glaciers. In areas where glacier boundaries cannot be clearly differentiated, such as moraine-covered ice, Landsat will be supplemented with higher resolution imagery (ASTER and air photos).

Although Landsat imagery can be used for retrospective studies, Landsat-program continuity is currently uncertain. In the future, the glacier extent protocol will be updated with changes in satellite technologies or with the advancements in classification methodologies. Protocol development will also be coordinated with the GLIMS (Global Land Ice Measurements from Space) working group, as they develop their protocols.

Repeat photography of the glacier terminus can provide a more long-term perspective on expansion or shrinkage of specific glaciers (Molnia and Sfraga 1999). The repeat photography makes use of photos taken during scientific expeditions into SWAN parks early in the last century. Repeat photography is conducted to duplicate to the greatest extent possible the location and orientation of historical photography,

using methods described by Hall (2002). In cases where the vantage point used in original photography no longer exists (e.g., a river cutbank), an alternative vantage point is selected to approximate the original as closely as possible. During field visits, the geographical coordinates for each photo-monitoring site are recorded using the GPS to facilitate repeated monitoring.

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Development Schedule, Budget, and Expected Interim Products:

2005 Draft protocol with SOPs, acquire imagery, and determine decadal glacial extent for KATM ($32,000).

2006 Test and finalize protocol, acquire imagery, and determine decadal glacial extent for LACL ($45,000).

2007 Implement ($ to be determined).

Literature Cited:

Hall, F. C. 2002. Photo-point monitoring handbook. Pacific Northwest Research Station, U.S. Forest Service, Portland, OR. PNW-GTR-526.

Hall, D. K., B. A. Giffen, and J. Y. L. Chien. 2005. Changes in the Harding Icefield and the Grewingk-Yalik glacier complex. 62nd Eastern Snow Conference. Waterloo, ON, 7-10 June 2005.

Molnia, B.F., and M. Sfraga. 1999. Measuring and monitoring changes in Alaska's glaciers with ground, aerial, and space photography: A history [abs.]. Program and Abstracts, 50th Arctic Science Conference, Science in the North: 50 Years of Change, Denali National Park and Preserve, Alaska, AAAS, Arctic Division, September 19-22, 1999:78-79.