Title: Inventory/Measure Climate Change Driven Impacts to Rare Arctic-Alpine Plants/Communities at the Edges of receding Permanent Snow Fields and Glaciers in Glacier National Park.

Authors, Principle Investigators: Joyce Lapp GNP, Jen AsebrookGNP, Dr. Cathy Zabinski MSU

Background: There is widespread agreement that increasing levels of atmospheric carbon dioxide and other "greenhouse gases" will result in global warming and widespread alteration of temperature regimes and rainfall patterns during the next 50 years. High mountain ecosystems may be the first ecosystems to be significantly altered. Arctic-alpine species at the southern limit of their range should be among the most sensitive indicators of global warming effects. Many arctic-alpine plants are at or near the southern limit of their range in Glacier National Park, and overall, these cold-adapted species will likely be driven out of their distribution range by warm-adapted species. Many of these plants grow in snowbed habitats and some of these are even restricted to these habitats. It has been proposed that grasses, sedges, and rushes will be most negatively impacted by global change. As snowbed plants have special growth conditions, their sensitivity and ability/inability to respond rapidly to changes in annual snowfall patterns make them particularly vulnerable in a warmer climate, and thereby sensitive indicators of global change.

Purpose/need: In Glacier National Park, glaciers have receded rapidly, primarily due to long-term changes in regional and global climate. These changes include warming daily minimum temperatures, and persistent droughts. The park's glaciers are predicted to disappear by 2030. While effects of the loss of these glaciers are being modeled, very few field studies are documenting the impacts of receding glaciers and snowfields to adjacent alpine vegetation. In Glacier National Park, there are several snowbed plants that are rare and/or endemic to the Northern Rocky Mountains with very narrow ranges and many at the southern extent of their range. As other studies have proposed, these peripheral snowbed plant communities are extremely sensitive indicators of climate change. In collaboration with the Climate Change in Mountain Ecosystems Program of the USGS Northern Rocky Mountain Science Center and Montana State University, we propose to initiate baseline inventory sites at the edges of several glacier and permanent snowfields to document impacts to these rare and endemic plants as indications of climate change. We will also collaborate with staff working on the currently funded Ice Patch study to evaluate potential cultural resources at these sites.

Methods: Sampling indicator species targeted for evaluation – most are endemic, rare, and often the only populations

in Montana are found in GNP; all are at the southern and/or eastern extent of their range:

- Pygmy poppy (*Papaver pygmaeum*), Timberline buttercup (*Ranunculus verecundus*), Arctic pearlwort (*Sagina nivalis*), Small tofieldia (*Tofieldia pusilla*), Lyall phacelia (*Phacelia lyallii*), Jones columbine (*Aquilegia jonesii*),
- Documentation will be made of other rare species present as well. This may include *Carex lenticularis var. dolia, Juncus albescens, Kobresia simpliciuscula, Euphrasia arctica*, species that are all at southern extent of ranges, are species of concern whose only locations in Montana are in GNP (mostly found in wet alpine turf).

B. Sample Locations: Approximately six to ten sites will be chosen for sampling. Ideally, study locations will be sites where ice/snow is retreating quickly over time and where soil development and new links to altered hydrology from the melting snow are occurring. As stated above, collaboration with the Climate Change in Mountain Ecosystems Program of the USGS has existing data on the trends of most glacier and permanent snowfields in Glacier National Park. Sites at the edge of existing glaciers could include Chaney Glacier, Sexton

Glacier, Blackfoot Glacier, and Swiftcurrent Glacier given their accessibility and the known presence of rare and endemic plants at these locations. Sites at the edge of permanent snow field could include Piegan Pass, Siyeh Pass, Logan Pass, above Feather Plume Falls, Spot Mountain, and Apikuni Mountain, also given their accessibility and the known presence of rare and endemic plants at these locations.

C. Inventory Methods: Work will be completed by GNP staff, MSU Research Assistant and others. The number of permanent transects will be determined by the area and the location of rare and endemic plants at each study site. Permanent transects will be stratified from the edge of snow to downslope areas where snow has melted and plants have colonized. Sampling methods will follow Lesica and Steele (1996), an established, effective methodology that has sampled rare plants in alpine wet tundra in Glacier. Repeated measures statistics will be applied to the data for analysis.

D. Total Grant Request: 3 year proposal at $36,000/yr = $108,000