Climate Change Monitoring and Installation of GLORIA at Great Basin National Park

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Introduction

One of the areas where climate change impacts are most likely to be detected quickly is on mountain tops due to the restricted area, harsh climate, and short growing season. To detect these high elevation changes, a consortium of universities and agencies initiated talks in Europe in 1996. The Global Observation Research Initiative in Alpine Environments (GLORIA) program was born and quickly spread to other continents, with the goal of using a standardized approach so that data from different regions can be compared. The GLORIA project collects quantitative information, including species richness, species composition, vegetation cover, soil temperature, and length of snow cover period. It also assesses the potential risks of biodiversity losses due to climate change by comparing the current distribution patterns of species, vegetation, and environmental factors along vertical and horizontal gradients. At present, forty seven target regions have been established in mountain ranges around the world, with nine in the western USA.

Study area

Great Basin National Park is located in east-central Nevada (Figure1) and contains four of the ten highest peaks in Nevada. Its location in the Great Basin makes it an ideal place to study climate change, and in 2008 it became part of the GLORIA network.

Methods

Mountain peaks in the area were evaluated with the goal of selecting four summits of different elevations ranging from timberline to the region's highest elevation. The peaks needed to have the same climatic conditions, the same bedrock type, cone-shaped peaks, sufficient vegetation to measure, and little to no human land use.

The sampling design followed the GLORIA field manual (Pauli et al. 2004):

1. Sixteen 1 m x 1 m permanent quadrats, with four in each main cardinal direction.
2. Four 10 m x 10 m permanent quadrats.
3. Summit area sections, with four sections in the upper summit area (from 0 to 5 m from the summit) and four sections in the lower summit area (between 5 and 10 m from the summit)—the size of the summit area section was not fixed but depended on the physical structure and slope of the peak.

In addition, a datalogger programmed to record temperature every two hours for the next five years was buried on each side of the mountain. All grid points and datalogger loca-

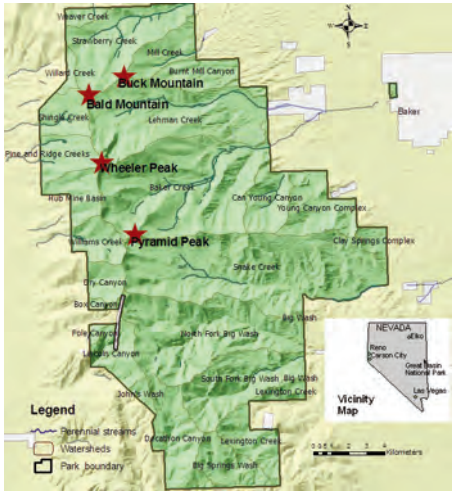


Figure 1. Buck, Bald, Wheeler, and Pyramid Peaks were chosen as part of the GLORIA project in Great Basin National Park, located in east-central Nevada.

tions were photographed to assist in the rereading of the plots and retrieval of data-loggers in five years.

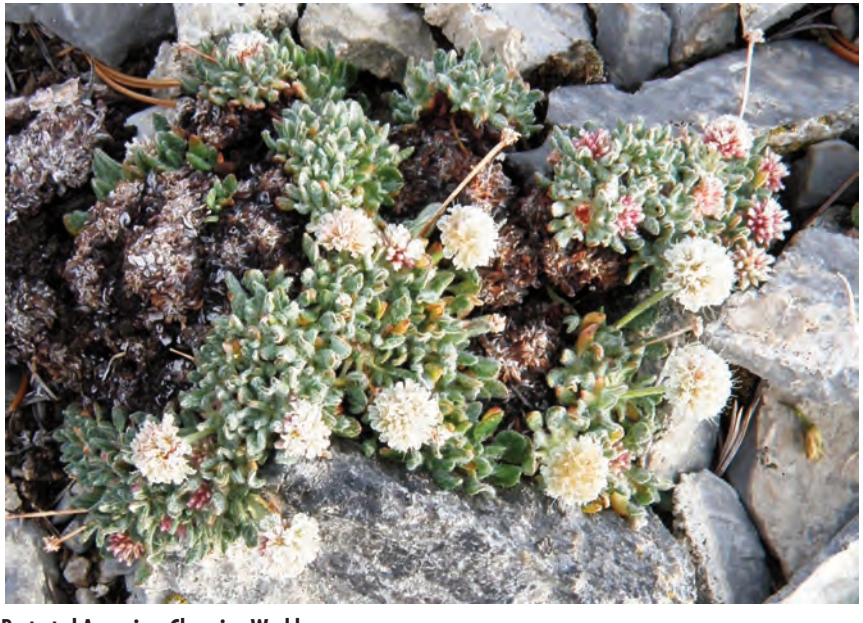
Results

It took six days to complete the setup, plant identification, and data gathering on four peaks (Wheeler, Pyramid, Bald, and Buck), ranging in elevation from 3,347 m to 3,981 m. Sixty-seven plant species from 22 families were found within the plots. The Gramineae and Rosaceae families had the most species, 12 and 7, respectively. Although many species were similar to those found in the Sierra Nevada mountains, one species was endemic to the Snake Range, *Eriogonum holmgrenii* (Figure 2).

Out of 64 quadrats across the four summits, only 20 had vascular plants, and only 10 had 3 or more species present. The number of quadrats with vegetation present ranged from 0 (Pyramid) to 7 (Bald) quadrats.

Wheeler Peak had the least plant diversity, with just 11 species, while Bald Mountain had the most, with 42 species. Flora found on all four peaks included *Poa secunda, Trisetum*

Figure 2. Close-up of *Eriogonum holmgrenii.*



spicatum, Polemonium viscosum, and *Selaginella watsonii*. *Phlox pulvinata* was found on the three higher peaks, but not on Buck Mountain. A number of species were found on the three lower mountaintops but not on Wheeler: *Arenaria congesta, Minuartia obtusiloba, Erigeron leiomerus, Potentilla ovina, and Castilleja nana*.

Twenty-five plant species were found on Buck Mountain, elevation 3347 m, the peak with the most woody vegetation. Species found only on this peak were: *Mertensia ciliata, Pseudostellaria jamesiana, Juniperus communis, Carex pelocarpa, Piptatherum exiguum, Picea engelmanii, Aquilegia caerulea, Rubus ideaus, Penstemon humilis,* and *Penstemon leiophyllus.*

Bald Mountain, elevation 3524 m, had the most diversity, with 42 species. Species found only on this peak were: *Antennaria corymbosa, Sedum lanceolatum, Draba albertina, Poa fendleriana, Luzula spicata, Astragalus platytropis, Lewisia pygmaea, Ranunculus adoneus, Sibbaldia procumbens,* and *Heuchera parvifolia.*

Pyramid Peak, elevation 3633 m, hosts 30 plant species, including the endemic *Eriogonum holmgrenii*. Other species found only on this peak: *Rhodiola integrifolia, Arabis lemmonii, Draba reibata, Calamagrostis purpurescens*, and *Cymopterus nivalis.*

As expected, the highest peak in the study and in the park, Wheeler Peak at 3981 m (Figure 3), is home to the fewest (11) species. Three species were found only on this peak: *Oxyria digyna, Primula parryi,* and *Ranunculus eschscholtzii*.Additional data analysis is ongoing. Data has been entered into the GLORIA database, a common data archive that will allow comparisons of different regions.

Conclusions

Despite a large number of peaks in Great Basin National Park, finding four peaks for the GLORIA project was more difficult than anticipated. Differences in bedrock excluded some peaks, while others had virtually no vegetation on them. In the end, three ideal peaks were selected, along with one, Buck Mountain, that had more woody vegetation on it, which made it more difficult to lay out transects.

Modifications of the GLORIA protocol proposed for the re-sampling in 2013 include adding supplemental quadrats. These additional quadrats will help detect trends in species abundance and patterns of change. Due to the large amount of tree cover on Buck Mountain, we rec-

Figure 3. View of Wheeler Peak from Buck Mountain..

ommend adding 'stem count by size class' and 'tree canopy top cover' as additional data fields for the 1 m x 1 m quadrat and 10 m x 10 m quadrats.

The GLORIA project is long-term, requiring people who are familiar with the protocols, and who have excellent botanical skills. It is especially important for an area implementing this project to reach out to numerous agencies to find the expertise needed, and to help foster a wider appreciation of the GLORIA site so that the project will continue long into the future.

Reference

Pauli, H., M. Gottfried, D. Hohenwallner, K. Reiter, R. Casale, and G. Grabherr, eds. 2004. *The GLORIA Field Manual—Multi-summit Approach*. Luxembourg: Office for Official Publications of the European Communities. On-line at www.gloria.ac.at/downloads/GLORIA_MS4_Web_english.pdf.