

*Jim Bishop wrote this article for a recent newsletter of the White Mountain Research Center, and I thought it would interest the broader CIRMOUNT community. With slight changes and support from WMRC newsletter editor, Denise Waterbury, I include Jim's piece here. —Editor*

## Monitoring White Mountain Alpine Plants for Impacts of Climate Change; A Page from the California GLORIA Field Notes

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**Figure 1.** Raspberry buckwheat on dolomite, White Mtn. in the distance. Photo: Stu Weiss

A group of determined investigators trudges upward above the last of the bristlecone pines, climbing toward a summit that will be their workplace for the day. Cold wind urges closed zippers and upturned collars. At their feet are hardy and beautiful alpine plants, living in a world of less wind and greater warmth than the hikers (and trees) feel. On the peak they'll outline plots with string and spend the day identifying the plants, characterizing

their abundance and distribution, taking photos, and burying temperature loggers...much of the day spent staring at the ground or hunched over windblown data sheets. If thunderstorms don't shorten the field day too much, they should complete the summit by day's end and return to Crooked Creek Station with priceless data on dozens of sheets.

The upper limit that trees reach is imposed by the average temperature of their environment. Above that point there is insufficient warmth during the growing season to allow them to persist...basic processes of cell construction and growth being too retarded by the low temperatures. A very plausible low-temperature effect on cell development is on the slowing of "molecular motors" that convey materials throughout the cell on the cytoskeletal framework, because they are critically dependent on thermal energy for their motion.

Yet alpine plants do grow above the trees. Their main trick is to remain low-stature, taking advantage of solar heating and minimizing airflow-induced cooling to achieve sufficient warmth for growth. Many alpine plants avoid the worst of winter's bitter cold under the snowpack. The alpine flora prevails in

microclimates of sufficient warmth and shelter, where cold air and lack of soil keep trees at bay. It is a very climate-sensitive ecosystem, vulnerable to the ascent of trees, the loss of habitat with upward migration, and dependent on the snowpack. For the most part they are undisturbed by human influence. Worldwide, alpine zones span latitudes from polar to tropical, elevations from a few hundred meters to over 5000 meters, and maritime as well as continental climates. It is an ideal place to look for effects of climate change on living things.



**Figure 2.** Alpine flowers found in the White Mountains. Photo: Catie & Jim Bishop

To best observe impacts of climate change on the alpine flora and its diversity, an international program was born at the University of Vienna, the GLobal Observation Research Initiative in Alpine Environments, 'GLORIA'. The North America chapter was initiated by Connie Millar (USFS) and Dan Fagre (USGS); the first sites being established in 2004 in the White Mountains and the central Sierra Nevada, CA, and at Glacier National Park, MT. The basic protocol involves carefully observing the plant species, their coverage and distribution, in the zone that occupies the top 10 meters of the peak. The survey also incorporates temperature sensors buried 10 cm deep that record for years, and extensive photo-documentation of the plants and the survey system. Presently seven summits in the White Mountains are systematically surveyed every 5 years.



**Figure 3.** Laying out the original survey system. Photo: Jim Bishop

The White Mountain Research Center is deemed a GLORIA “world master site”. Here related studies in alpine ecology, climate, forest ecology, mammalogy, and geomorphology supplement the GLORIA alpine plant surveys. Such studies include insects, a butterfly count, periglacial processes, detailed temperature observations over the terrain, mapping of upper treelines and shrublines, forest

demography, and studies on the effects of climate on mountain mammals (pika, marmot). The potential for mutually beneficial science catalyzed by that WMRC-GLORIA based collaboration is great.

Two important additions to the GLORIA methodology were developed in the White Mountains, and are now defined and available in the international protocol. It was realized early on that the estimates of plant cover in the large survey plots were too inaccurate, and that the quantitative measures in the quadrat plots covered too small an area. So a 10mX10m plot was developed that contains 400 survey points on a half-meter grid, and that plot gives good quantitative measures over a larger and more representative area. While the summit plots are important, it was essential to know more about the distribution of plants



**Figure 4.** Plant identification, data-taking, and documentation. Photos: Catie & Jim Bishop

below the summits to best interpret GLORIA observations, and desirable to be able to quantify shifts in plant-population distributions. A series of “downslope surveys” was done on 5 of the slopes in the White Mountains. At each 25-meter step below the summit a 100-meter belt transect is laid out along-contour, which duplicates the area and sample-point distribution of the 10mX10m plots. The set of downslope surveys spans the elevation range from the summit of White Mountain down into the bristlecone pine woodland and the sagebrush shrublands.

One set of White Mountain summits has now been resurveyed at 5 and 10 years, and the other set at 5 years (the 10-year resurvey there this summer). Physical aspects of climate-change trends emerge on decadal timescales, but even the short-term GLORIA results are interesting. For one thing they confirm the replicability of the survey protocol, with resurveys showing essentially the same species richness (to be expected with alpine plants being predominantly long-lived perennials). They reflect some of



**Figure 5.** GLORIA field team gets organized. Photo: Connie Millar

the short-term change that is imposed on long-term trends, such as fluctuations in annual plant occurrence and some shrub mortality in low-snow winters. And we may well get some ecological surprises with our 5-year resurveys.

The White Mountain Research Center is a key focus of this important international program. Additional information can be found on CIRMOUNT’s webpages on the North American chapter of GLORIA: [http://www.fs.fed.us/psw/cirmount/gloria/north\\_america/california.shtml](http://www.fs.fed.us/psw/cirmount/gloria/north_america/california.shtml).



**Figure 6.** Fieldwork done, the team heads down from White Mountain Peak. Photo: Connie Millar