Monitoring Global Change impacts on Páramo Ecosystems in Ecuador

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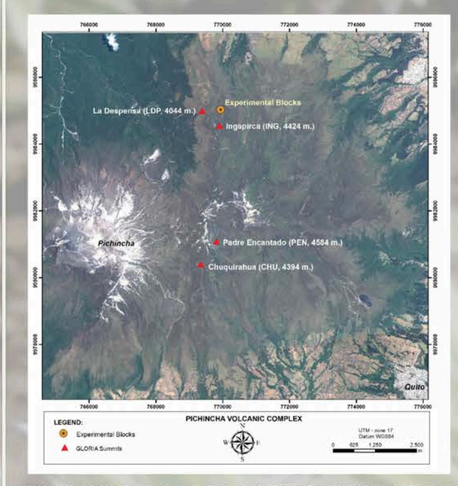
AIM OF THE STUDIES

Ecuadorian Páramos have been identified as a national priority region, due to their sensitivity and vulnerability to environmental changes and to their relevance for the survival of low-income communities settled here. However, scientific information derived from quantitative experiments and long-term biodiversity monitoring processes is essential to reinforce the development of adaptation guidelines for High Andean ecosystems in face of global changes. These studies have been designed to contribute to the understanding and documentation of climate change impacts on Páramo plant communities.

STUDY SITES AND EXPERIMENTAL DESIGN

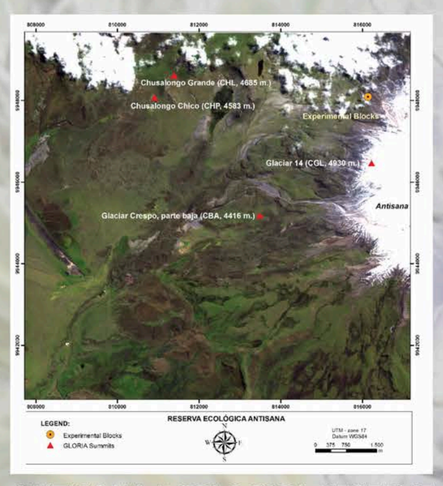
In order to determine specific climate warming effects on physiological adaptations present on Páramo plants, two monitoring sites have been established in the Ecuadorian High Andes: the Pichincha Volcanic Complex (2012) and the Antisana Ecological Reserve (2013).

Changes on Páramo diversity and community structure will be studied through the establishment of vegetation monitoring regions following the protocol of the Global Observation Research Initiative in Alpine Environments (GLORIA), each associated with a complementary research site based on an experimental design that supports the future incorporation of other modules, if new research questions arise.



PICHINCHA VOLCANIC COMPLEX

Location of both sites in the country

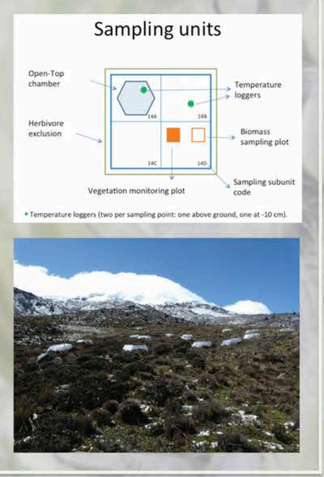


ANTISANA ECOLOGICA RESERVE

SITE COMPONENTS

1. **GLORIA Target region, composed by 4 summits**
2. **Complementary research site:**

- Module 2.1. Long-term monitoring on vegetation permanent plots
- Module 2.2. Experimental warming and its effects on Páramo plants
- Module 2.3. Effects of changes on soil nutrient availability and herbivore exclusion on diversity and community structure



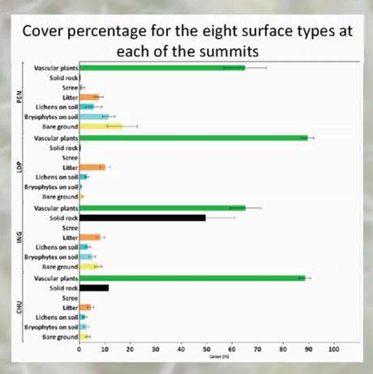
ESTABLISHMENT AND PRELIMINARY RESULTS

1. GLORIA target regions

Two target regions were established, following the protocole of the Global Observation Research Initiative in Alpine Environments Network, and are part of the GLORIA-Andes chapter:

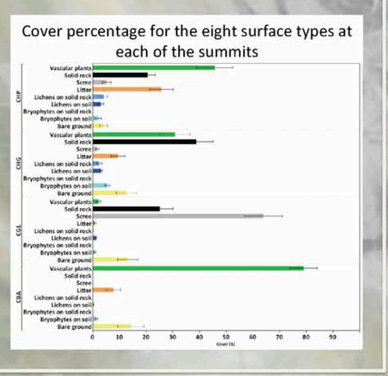
PICHINCHA VOLCANIC COMPLEX (ECPIC)

- 152 flowering plant species (in 37 families)
- 2 Pteridophytes
- 18 Bryophyte species



ANTISANA ECOLOGICAL RESERVE (ECANT)

- 78 flowering plant species (in 26 families)
- 7 Pteridophytes (in 3 families)
- 8 Bryophyte species



2.1 Long-term monitoring on vegetation permanent plots

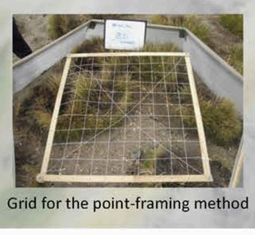
The vegetation monitoring process is based on the continuous sampling of all experimental 6 x 6 m units (four 1 x 1 m permanent plots per samplin unit), in order to answer the following questions:

1. What is the diverstity, composition, and structure of vascular plant communities on High-Andean ecosystems?
2. Will changes occur on the diverstity, composition, and structure of vascular plant communities on a short (2 years) and long (>2 years) term?
3. What is the amount of aereal biomass present, according to the following categories: living vascular plants, dead vascular plants, and dead biomass in general?

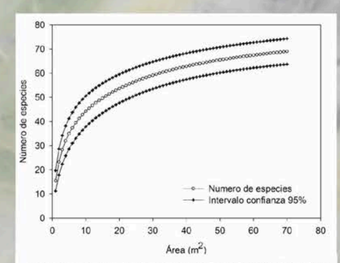
Ideally, each plot will be resurveryed every six months, during the periods of maximum gowth for the vegetation.
On each survey, the composition and structure of the communities are recorded using three different methodologies:

1. Visual estimation of cover percentage on the 1 x 1 m plots,
2. Point-frame recording of species, using a divided frame,
3. Photographic documentation.

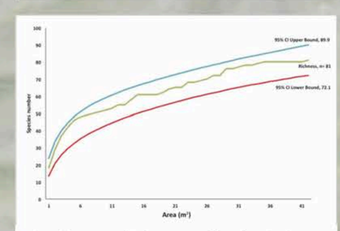
The figures at the right show the cumulative curves for the experimental units that have been already processed at both sites



Grid for the point-framing method



Species cumulative curve for the Pichincha Volcanic Complex site



Species cumulative curve for the Antisana Ecological Reserve

2.2 Experimental warming and its effects on Páramo plants: Open-Top Chambers

45 polycarbonate hexagonal Open-Top Chambers, following the International Tundra Experiment –ITEX– guidelines, have been set up on both sites (20 OTC´s in ECPIC and 25 OTC´s in ECANT).
The first phase of the project aims to determine the effects of experimental warming on the functional types of Páramo plant communities:

1. Effects of the experimental warming on plant growth form, foccusing on selected Páramo species (see pictures),
2. Effect of the experimental warming on the freezing point observed on selected Páramo studies:
   1. *Permanent inner-temperature monitoring (at site)*
   2. *Experimental determination of freezing temperature*

Above: Open-Top Chamber at the Antisana site. Right: Analysis of the recorded temperatures inside and outside the OTC, above and below ground

2.3 Effects of changes on soil nutrient availability and herbivore exclusion on diversity and community structure

Both experiments follow the protocole of the Global Nutrient Network (see http://www.nutnet.umn.edu):

Experimental units (6 x 6 m)	Treatment			
	N	P	K + micronutrients	Herbivore exclusions
1	0	0	0	0
2	0	0	1	0
3	0	1	0	0
4	1	0	0	0
5	0	1	1	0
6	1	0	1	0
7	1	1	0	0
8	1	1	1	0
9	0	0	0	1
10	1	1	1	1

1. *Determination of the effects of soil nutrient limitation:* three nutrient treatments (1: Nitrogen —N—, 2: Phosphorous —P—, and 3: Potasium plus other micronutrients —K+ micronutrients—) on 1 x 1 m experimental plots, each at two levels (control; nutrient added), on a factorial desing for a total of 8 different treatment combinations (see table). The nutrients are applied only after the first year, at a relatively high yearly rate (10 g/m^2).

2. *Determination of the effects of native animals (camelids and small mammals) on the diversity and dynamics of the plant communities:* 1–2 m high fences (herbivore exclusions) are built around the 6 x 6 m units (see experimental design).