



High elevation phenology in mountain forests and alpine botanical gardens

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Within the joint research project KLIMAGRAD, the phenological response of alpine species to climate change is investigated. Therefore, on the one hand, the phenological response of mountain forest trees to altitude and temperature has been observed to investigate possible future developments in species and habitat shifts. On the other hand, the Alpine Botanical Garden Schachen has initiated a new network of arctic-alpine botanical gardens including a new phenological observation key.

In the Werdenfelser Land (Bavaria, Germany), at 42 sites along four altitudinal gradients ranging from 700 to 1800 m elevation, weekly phenological observations of eight different tree species (*Abies alba*, *Acer pseudoplatanus*, *Fagus sylvatica*, *Larix decidua*, *Picea abies*, *Pinus cembra*, *Pinus mugo*, *Pinus sylvestris*) were taken from April to July 2010, according to a modified BBCH Code. All tree species showed a clear response to altitude in their phenological development. Onset dates revealed a high variation within species and within observed specific phenological phase. There are clear differences in phenological behaviour of young vs. adult trees or north vs. south exposed sites. Leaf unfolding period decreased with increasing altitude. Temperature thresholds, species dependant reaction and adaption to high elevated habitats were studied.

One of the gradients includes the site of the Alpine Botanical Garden Schachen at 1850 m altitude. Botanical Gardens are an important source for long-term phenological observation. Although mountain ecosystems in Europe are the most threatened biome by climate change, there have not been any long-term phenological observations in these high elevated areas so far. This lack of information will be filled by establishing a new phenological monitoring program within an European network of arctic-alpine botanical gardens (Alpengarten auf dem Schachen (D), Giardino Botanico Alpino "Viotte" (I), Jardin Botanique Alpin du Lautaret (F), Jardin d'Altitude du Haut Chitlet (F), Tromsø Arctic-Alpine Botanic Garden (N), Reykjavik Botanic Garden (IS)).

According to a list of several important characteristics, following indicator species were selected for the program: *Allium senescens*, *Alnus viridis*, *Arnica montana*, *Dianthus alpinus*, *Dryas octopetala*, *Geum reptans*, *Helianthemum alpestre*, *Lonicera alpigena*, *Potentilla nitida*, *Rhodiola rosea*, *Rhododendron ferrugineum*, *Ribes alpinum*, *Salix reticulata* and *Saxifraga paniculata*. For these species, useful phenological attributes were determined and an observation key for the new long-term observation program was developed. At the same time, a collection of mother plants for the selected species was set up to provide vegetative reproduced clones. On these, observations will start in 2011.