Scientific Report CLIMMANI Short Visit Grant 2011

Project Title: “A natural temperature manipulation experiment on tree growth on geothermal vents in Iceland”

Applicant: Armando Lenz, Institute of Botany, University of Basel, Switzerland

Host: Prof. Dr. Bjarni D. Sigurdsson, Agricultural University of Iceland, Iceland

Purpose of the visit

Temperature is the driving factor behind natural high elevation treeline formation directly affecting growth. Thus, treelines around the globe experience similar thermal conditions and are found at a mean growing season temperature of around 6 °C. The question arises whether cold air temperatures alone are sufficient to limit tree growth. During the visit, we collected data to explore warm soil effects at geothermal active sites on carbohydrate charging and growth of the treeline species *Picea sitchensis* under otherwise cold climatic conditions. At natural high elevation treelines, trees experience simultaneously cold air and soil temperatures, while at the study site with natural soil warming trees experience cold air temperatures alone. This offers the unique opportunity to test the hypothesis that growth in cold climates needs a minimum of warmth, both, above and belowground, with root warming alone not facilitating better growth. The collected data during the short visit will lead to one joint publication.

Work carried out

During the exchange, data was collected to produce a joint scientific publication. During the first day, the study design was discussed and the study site was visited. At the following days, root zone temperature was measured with a thermistor at 10 cm below ground to choose trees along a soil warming gradient, with 0K, 2K, 4K, 7K and 10K warming along 5 blocks per temperature gradient with 2 replicates per block. Next, DBH (diameter above breast height) of the chosen trees was measured. In addition, each chosen tree was cored twice with a Suunto increment borer, once for chemical analysis and once for growth analysis. Than, height increment of the last 7 years was recorded with a 12m height pole. Further, DBH of all trees within a 3 m radius of the studied trees was measured, to get information about stand density. In addition, branch samples of each studied tree were collected for chemical analysis. Last, soil moisture was measured in each block and temperature loggers were distributed along the study site. During the last 3 days of the exchange, a treeline stand was searched, and tree cores of 12 treeline trees were collected to have a reference site with natural growth. All standard measurements were carried out at the treeline stand as well and data loggers were distributed. In addition, the scope of the planned publication and ideas for further collaborations were discussed.

Preliminary results

There is a strong soil warming gradient in the root zone at 10 cm soil depth from 0 K warming at the edge up to 50 K warming in the centre of the 2000 m^2 Reykir Sitka spruce forest, starting after an earthquake in spring 2008 (Fig. 1). From ca. 35 K warming towards higher temperatures all trees died. The temperature decline along the slope (vertical distance) is stronger, since there is more soil with increasing altitude between the geothermal vent and the trees.

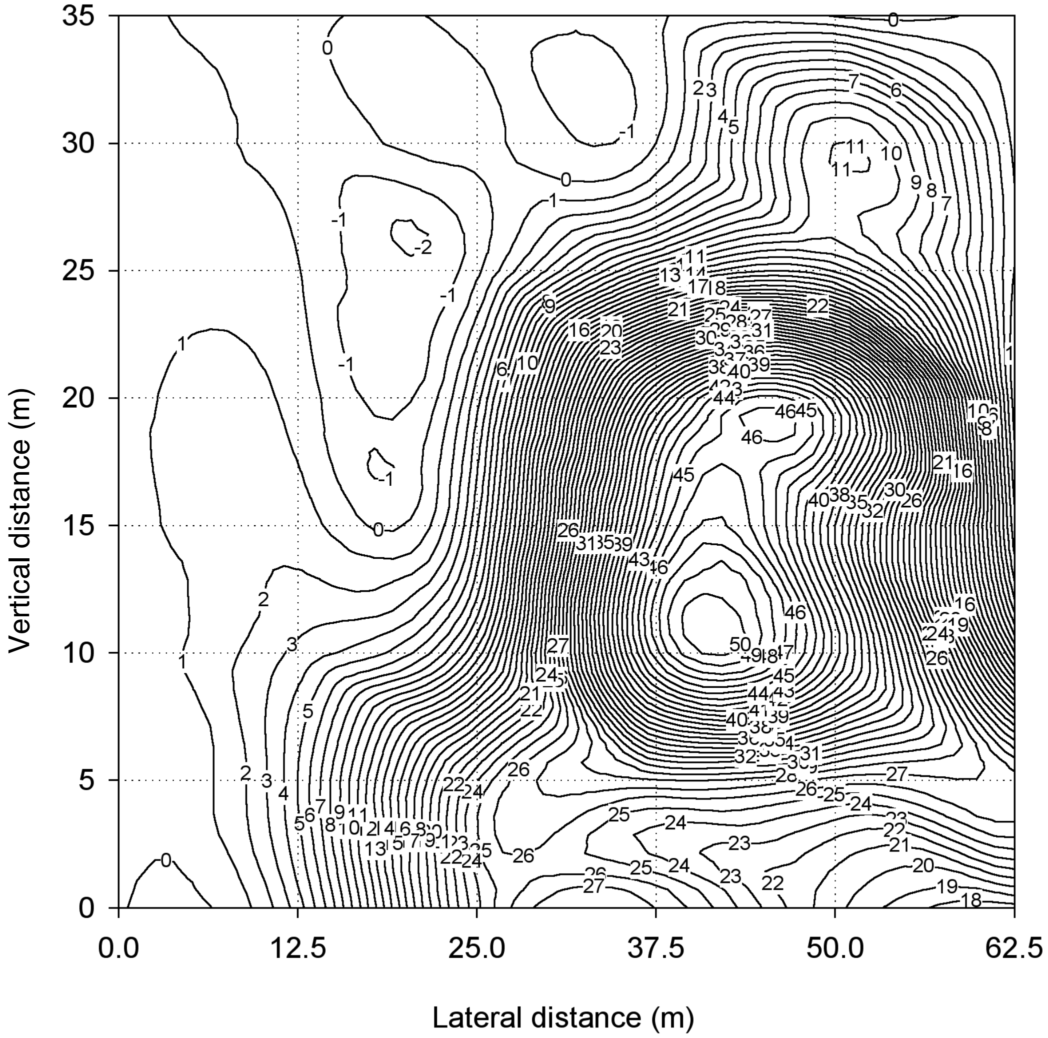

Fig. 1 Soil temperature elevation (K) compared to shaded references without warming outside the stand from the 27th of September to the 3rd of October 2011 in a 45 year old Sitka spruce stand at Reykir, S-Iceland. Note the difference in scale between the x and y axis.

In general, above ground trees parameters are rather similar along the soil temperature elevation gradient (Tab. 1). For instance, no decrease in tree height or DBH was detected. On the other hand, soil moisture seams to increase towards higher temperatures, especially above 10 K warming.

Tab. 1 Mean tree height, diameter above breast height (DBH) and soil moisture (± s.e.) along the temperature elevation gradient at the Reykir Sitka spruce stand.

Temperature elevation (K)	Tree height (m)	DBH (cm)	Soil moisture (%)
0	9.5 ± 0.6	15.3 ± 0.8	32.6 ± 0.9
2	10.1 ± 0.7	17.3 ± 1.4	35.3 ± 1.0
4	9.2 ± 0.7	14.0 ± 1.0	34.2 ± 0.8
7	9.2 ± 0.7	16.2 ± 1.2	34.9 ± 1.9
10	8.3 ± 0.7	13.8 ± 1.0	34.7 ± 3.3

Natural soil warming started after an earthquake in spring 2008. The first year after the warming treatments, no response of height increment could be seen (Fig. 2). Increasing soil temperatures could not induce an advanced growth in Sitka spruce, indicating that cold air temperatures alone are sufficient to suppress tree growth. Interestingly, a strong decrease in height growth towards warmer temperatures could be seen.

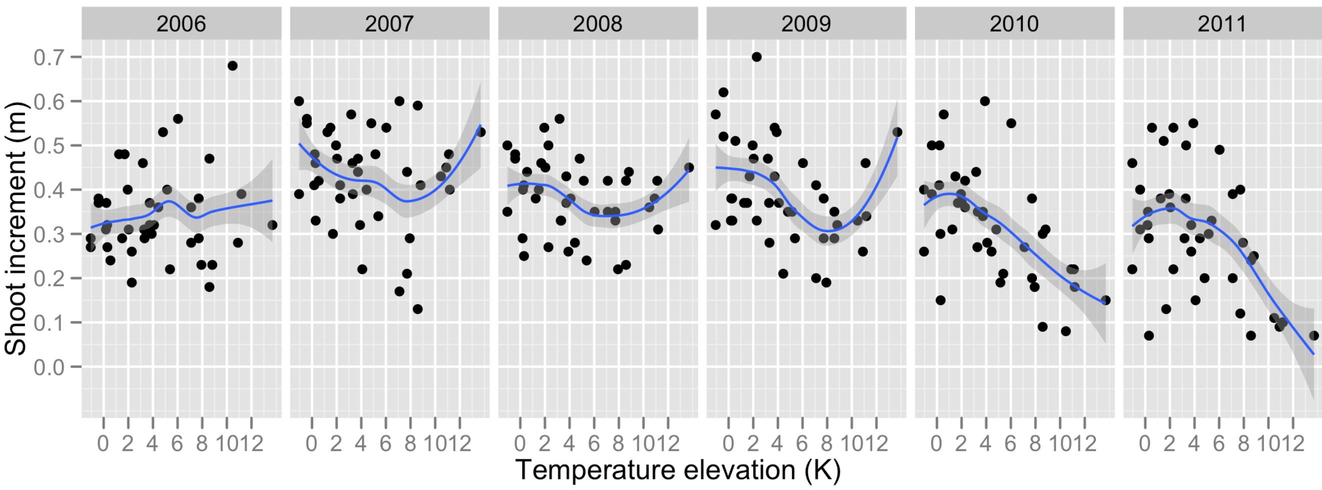

Fig. 2 The annual increment of the main shoot of Sitka spruce along a soil temperature gradient for each year from 2006 to 2011. Natural soil warming started in spring 2008.

Future collaborations

A joint master's project studying temperature effect on xylem development is planned for the year 2012.

Projected Publications

A. Lenz, B.D. Sigurdsson, Ch. Körner (2012) Effect of natural soil warming on growth of treeline trees. *In preparation*