

## **Vulnerability of European shrublands to climate change**

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Shrublands are considered for a vulnerability assessment since they are often vulnerable and changes in climate affect key biological processes, the ecosystem functioning and ecosystem services derived from shrublands. To understand or know what will happen to shrublands under climate change manipulation experiments are needed. These manipulations are experimental challenging since 3 factors are involved: CO<sub>2</sub>, the temperature regime and water supply.

One example for a manipulating experiment is the EU project VULCAN that was carried out at for three years at six different sites across Europe; it was a gradient approach, involving different hydrological conditions (East to West Europe), as well as different temperature regimes (North to South Europe). Manipulations included a nocturnal warming and a summer drought. The results includes:

- A rise in growing degree-days for all sites except Spain (temperature threshold!)
- An increase in Nitrogen deposition for warming treatments that lead to high Nitrogen leaching- this effect depends on the Nitrogen status of the ecosystem!
- A species specific response to warming in plant growth (indications for biodiversity) and also a season specific response - climate change can change the phenology and timing of species and this is also species specific!
- An increase in herbivory due to warming (often species specific attacks)
- A loss of species with warming and drought (biodiversity is changing)
- An effect on carbon balance, whereby the response differed among the gradient; this affected soil structure
- An overall negative effect of drought.

For this short term experiment the biomass production reacted most sensitive. More carbon was gained than lost; however, the response was stronger than expected. There were indications for the spanish site that under warming and drought conditions the risk of fire and erosion will increase due to a reduced plant cover.

Next generation experiments on climate change will focus on a multifactor problem, i.e., combinations of altered conditions will be analyzed. So far there was conducted an experiment on net primary production affected by elevated CO<sub>2</sub> plus a rise in temperature plus altered precipitation at Jasper Ridge. Interestingly, the effects of changes in the single factors are not additive. Putting together all the single factors for modelling purposes does not yield a better understanding. Very recently a new project called CLIMAITE was started, which is a multifactor project. It includes an elevated CO<sub>2</sub> concentration of 519 ppm, an increase in temperature of 2 °C and summer drought and all combination of these factors. It is designed to simulate the climate in Denmark predicted for the year 2075.

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