Geophysical Research Abstracts
Vol. 12, EGU2010-3917, 2010
EGU General Assembly 2010

Effects of drought and irrigation on ecosystem functioning in a mature Scots pine forest

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Climate change is expected to increase temperature and reduce summer precipitation in Switzerland. To study the expected effects of increased drought in mature forests two different approaches are in general possible: water can be partially or completely removed from the ecosystems via above- or below-canopy roofs or water can be added to already drought-prone ecosystems. Both methods have advantages and disadvantages. In our study water was added to a mature 90-year old Scots pine (Pinus sylvestris L.) forest with a few singe pubescent oaks (Quercus pubescens Willd.), located in the valley bottom of the driest region of Switzerland (Valais). In Valais, Scots pines are declining, usually with increased mortality rates following drought years. It was therefore of special interest to study here how water addition is changing forest ecosystem functioning.

The irrigation experiment started in the summer of 2003. Out of eight 0.1 ha experimental plots, four were randomly selected for irrigation, the other four left as a control. Irrigation occurred during rainless nights between April and October, doubling the annual rainfall amount from 650 to 1300 mm. Irrigation water, taken from a near-by irrigation channel, added some nutrients to the plots, but nutrients which were deficient on the site, e.g. nitrogen and phosphorus, were not altered.

Tree diameter, tree height and crown width were assessed before the start of the irrigation in winter 2002/2003 and after 7 years of the experiment in 2009/2010. Tree crown transparency (lack of foliage) and leaf area index (LAI) were annually assessed. Additionally, tree mortality was annually evaluated. Mycorrhizal fruit bodies were identified and counted at weekly intervals from 2003 until 2007. Root samples were taken in 2004 and 2005. In 2004 and 2005 wood formation of thirteen trees was analysed in weekly or biweekly intervals using the pinning method. These trees were felled in 2006 for stem, shoot and needle growth analysis.

Soil water content was significantly reduced during irrigation periods. Irrigation doubled tree stem growth, increased shoot growth and thus increased volume growth and crown dimensions. Annual tree mortality rates were reduced by 50% in irrigated plots. The growing period for stem growth was extended in pines as a result of irrigation. Altogether, increased growth and reduced mortality significantly increased tree stem basal area at breast height per ha. As irrigation also increased needle length, estimated mean foliage amount per tree and stand leaf area index significantly increased. However, the number of needle generations was not altered or even reduced due to irrigation. Root growth, was less affected by irrigation and only resulted in increased fine root length. Species richness and fruit body numbers of mycorrhizal fungi were several times higher on the irrigated plots.

Overall, it can be concluded that water availability was the main ecosystem limiting factor and that any changes in water availability will result in changes in ecosystem functioning.

References

Brunner I, Graf-Pannatier E, Frey B, Rigling A, Landolt W, Dobbertin M (2009) Morphological and physiological responses of Scots pine fine roots to water supply in a climatic dry area in Switzerland. Tree Physiology 29:541-550.

Dobbertin M, Eilmann B, Bleuler P, Giuggiola A, Graf Pannatier E, Landolt W, Schleppi P, Rigling A (2010) Effect of irrigation on needle, shoot and stem growth in natural drought-exposed Pinus sylvestris forests, Tree Physiology, doi:10.1093/treephys/tpp123.

Eilmann B, Zweifel R, Buchmann N, Fonti P, Rigling A (2009) Drought induced adaptation of the xylem in Pinus sylvestris and Quercus pubescens. Tree Physiology 29:1011-1020.