

**Twenty-sixth Session of the FAO/European Forestry Commission's
Working Party on the Management of Mountain Watersheds 19-22
August 2008, Oulu (Finland)**

NATIONAL REPORT

Potential Management of Forested Headwaters in Sweden

Harald Grip
SLU

(Surbrunnsgatan 4, SE-114 21 Stockholm, Sweden)

Summary

Predicted Global Climate Change will substantially influence growing conditions for many forest species, not least in mountainous areas and at northern latitudes within the coming century. It is therefore important to monitor changes in primary and secondary climate variables in an efficient network that allows trends in space and time to be calculated. But what is of even greater importance is urgently to develop and apply environmental management practices that help counteracting the increasing atmospheric carbon dioxide concentration.

An inventory of environmental monitoring in northern Sweden was conducted on behalf of the Swedish Committee for the International Polar Year (IPY) (Grip & Olsson, 2008) to find variables of potential relevance for arctic monitoring and to which degree this monitoring followed the recommendations from a US committee on designing an Arctic Observing Network (AON, 2006). Out of the 31 variables suggested by AON 18 were found to have an adequate monitoring program with stable funding, 10 had limited monitoring and / or unstable funding, for example through research groups. One variable did not have any regular monitoring program and two variables were not relevant to the Arctic but were monitored.

At the Rossby Center at the Swedish Meteorological and Hydrological Institute (SMHI) regional climate change scenarios have been calculated for the coming century starting from different global scenarios (SPRES A2 (business as usual) and SPRES B2 (decrease in population and economic growth)) (SMHI, 2008). It was found that for the SPRES A2 scenario in northern Sweden air temperature would increase by about 5 °C, precipitation would increase by 15 to 35 % and most in the north-western part. The duration of snow cover would decrease by 70 to 100 days and most along the coast and at medium latitudes. The growing season would increase by about 45 to 90 days and most in the southern part. In the SPRES B2 scenario the air temperature increase would be less, about 4 to 5 °C. It is obvious that such climate changes would have large influences on vegetation growth and species composition.

One means to sequester more carbon dioxide from the atmosphere would be to apply forestry management practices that increase forest productivity. A natural first step would be to find the potential forest productivity when different constraints are removed. In boreal and cold temperate forests production is mostly limited by nitrogen (Tamm et al., 1999), but the balance between nitrogen and other nutrients can also be important (Tamm, 1991, Linder,

1995). At the optimum nutrition experiments in young Norwegian spruce at Asa (southern Sweden) and Flakaliden (northern Sweden) started 1987 treatments include balanced nutrient addition based on foliage nutrient concentrations combined with or without irrigation (Linder, 1995). Taking production rate in such stands where nutrients and water are not limiting for growth as potential Bergh et al. (2005) calculated potential production in Swedish forests from climate data (PAR and humidity during the growing season). For northern Sweden there was hardly any humidity deficit and the attainable stem wood production without irrigation was estimated to 8 – 14 m³ ha⁻¹ a⁻¹. That can be compared with the actual production of 2 – 5 m³ ha⁻¹ a⁻¹. The large effect of balanced fertilisation on stem wood production is partly caused by a redistribution of carbo-hydrates from the photosynthesis from below-ground to above-ground parts of the trees since less resources are needed to extract nutrients from the soil. Another reason for the increased production is that the substantially increased leaf area is capturing more light.

When less carbo-hydrate are needed for growth and maintenances respiration of fine roots and attached mycorrhiza the result will be less soil respiration. This effect will be further increased by decreased root litter production and less saprophytic activity. To study these effects a large girdling experiment was conducted at the nutrient optimization experiment at Flakaliden (Olsson et al., 2005). By girdling 0.1 ha plots of fertilized and non-fertilized 40-year-old Norway spruce stands and measuring soil respiration the autotrophic and heterotrophic components could be identified. The result was that the total soil respiration on non-fertilized plots was double the respiration from the fertilized plots. While the autotrophic part of the soil respiration was substantially lower from the fertilized plots than from the non-fertilized plots (about 800 and 3500 kg C ha⁻¹ a⁻¹, respectively), the heterotrophic respiration was more equal (about 2600 and 3300 kg C ha⁻¹ a⁻¹, respectively). Consequently, balanced fertilization of Norway spruce not only increases carbon sequestration in above ground parts of the trees, it also decreases soil respiration.

According to the climate change scenarios referred above air temperature would increase by 4 to 5 °C in the coming century, which would also increase soil temperature. By heating cables the soil was kept at 5 °C above ambient during summer since 1995 on 100 m² plots of 40-year-old Norway spruce irrigated (I) and irrigated and liquid fertilized (IL) since 1986 at Flakaliden (Strömngren, 2001). Soil heating started in April and increased by 1 °C per week during five weeks and decreased by 1 °C per week when control soil temperature reached 0 °C. Six years of soil heating increased stem volume production by 5 (I) and 7 (IL) m³ ha⁻¹ a⁻¹. Even though IL plots had received totally 450 kg N ha⁻¹ fertilization during the six years the difference in accumulated N between heated and non-heated plots was equal between I and IL plots (totally 50 kg N ha⁻¹). The natural abundance of ¹⁵N in one-year-old spruce needles increased after soil heating, which indicates that the source for mineralized soil nitrogen was deeper in the soil profile after heating. It was not possible to assign increased production to growing season extension or to increased nutrient availability. When increased growth and soil CO₂ flux were compared it was concluded that the ecosystem CO₂ sink strength had increased due to soil heating.

This report focussed on regional climatic change scenarios, monitoring that may verify them and potential measures in the boreal forests to counteract atmospheric CO₂ increase. It was reported that present monitoring is mostly adequate, but in some cases unsecured. The potential of optimum nutrition in Norway spruce stands to increase carbon sequestration by increased wood production and decreased soil respiration was found promising and should be tested at larger scale. Finally a soil heating experiment was referred where deeper soil

nitrogen was mobilized and the growing season was prolonged giving increased stem wood production and the site a stronger CO₂ sink term.

References

- AON, Committee on Designing an Arctic Observing Network, National Research Council, USA, 2006. *Towards an Integrated Arctic Observing Network*. The National Academic Press, Washington, D.C., 128 pp.
- Bergh, J., Linder, S. and Bergström, J. 2005. Potential production of Norway spruce in Sweden. *For. Ecol. Manage.* 204, 1-10.
- Grip, H. and Olsson, H. Swedish environmental monitoring north of 60°N. Report from the Swedish Research Council (VR). In press 2008.
- Linder, S. 1995. Foliar analysis for detecting and correcting nutrient imbalances in Norway spruce. *Ecol. Bull (Copenhagen)* 44, 178-190.
- Olsson, P., Linder, S., Giesler, R. and Höggberg, P. 2005. Fertilization of boreal forest reduces both autotrophic and heterotrophic soil respiration. *Global Change Biol.* 11, 1745-1753.
- SMHI 2008. (<http://www.smhi.se>)
- Strömngren, M. 2001. *Soil-surface CO₂ flux and growth in a boreal Norway spruce stand – Effects of soil warming and nutrition*. PhD Thesis, SLU, Uppsala, Sweden, 44 pp. and 5 Appendix.
- Tamm, C.O. 1991. *Nitrogen in terrestrial ecosystems, Questions of productivity, vegetational change, and ecosystem stability*. Springer-Verlag, 115 pp., Ecol. Stud. 81.
- Tamm, C.O., Aronsson, A., Popovic', B., Flower-Ellis, J. 1999. Optimum nutrition and nitrogen saturation in Scots pine stands. *Stud. For. Suec.* 206, 126 pp.