



Institutionen för Skoglig Produktionsekologi  
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ANKOM

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Samnordisk Skogsforskning  
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**Ang. Slutredovisning av KLIMA-projektet 'The likely impact of rising CO<sub>2</sub> and temperature on Nordic forests at limiting and optimal nutrient supply'**

KLIMA-projektet 'The likely impact of rising CO<sub>2</sub> and temperature on Nordic forests at limiting and optimal nutrient supply' var ett samarbete mellan forskargrupper från samtliga nordiska länder. Projektets finansiering och löptid var mellan åren 1993 och 1997, men den en 'officiella' projektavslutning skedde vid en workshop i Reykjavik i juni 1998 (se bifogat program). Workshopen skulle enligt överenskommelse ersätta 'Status Report' för 1998 och samtliga forskningsgrupper var närvarande liksom projektets internationelle rådgivare Prof. Paul Jarvis samt den av SNS utsedde utvärderaren Sveinn Adalsteinsson.

Vid workshopen hölls ett antal föredrag som presenterade resultat från en mycket framgångsrik femårsperiod där ett stort antal vetenskapliga arbeten publicerats om nuvarande och framtida klimats inverkan på de nordiska skogarna (se bilagd publiceringslista). En viktig del av projektet var forskarutbildning och på workshopens sista dag försvarade Michael Freeman framgångsrikt sin avhandling 'Leaf gas exchange in mature beech (*Fagus sylvatica* L.) exposed to long-term elevated CO<sub>2</sub> in branch bags'. Två av de tre opponenterna kom från projektet (P.G. Jarvis & S. Linder) vilket visar på de goda kontakter som utvecklats och fördjupats under projektiden.

Vid utgången av 1998 hade fyra av projektets doktorander avlagt sina examina. Den isländske doktoranden, Bjarni Sigurdsson, som påbörjade sina studier under projektets tredje år, kommer att framlägga sin avhandling under det kommande året. Han har med stöd från NorFa och numera genom ett stipendium från EUs 'Marie Curie Research

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Training Grants' kunnat genomföra den teoretiska delen av sina doktorandstudier vid SLU i Uppsala. Detta innebär att trots att projektet redan avkastat fyra doktorer, och ett stort antal publikationer i internationell fackpress, så kommer efterdyningarna att pågå under ytterligare ett par år. Den sista gemensamma satsningen inom projektet är att publicera tre 'syntesartiklar' där resultat från samtliga projekt kommer att sammanställas (se bilaga). Den huvudsakliga databearbetningen och analysen har genomförts och 'uppsatserna' har under 1999 presenterats vid två internationella workshops i form av postrar och föredrag.

Förutom den 'interna' doktorandutbildningen har projektet, med stöd från NorFa, anordnat tre nordiska forskarkurser (1995, 1997 och 1998) med 20 nordiska deltagare per kurs. Som lärare vid kurserna har, förutom projektets egna krafter, medverkat ett stort antal internationellt framstående forskare. Kurserna har varit mycket uppskattade, av såväl elever som lärare, och kommer troligen att upprepas i framtiden.

Sammanfattningsvis kan sägas att det initiativ som togs av SNS/NKJ att skapa ett längre sammanhållet nordiskt program inom klimatområdet föll väl ut. Projektet har förutom vetenskapliga och utbildningsmässiga framgångar också varit inkörsporten till ett antal internationella forskningsprojekt och nätverk. Mycket lite av detta skulle ha varit möjligt utan den planering och 'seeding money' som erhöles från Nordiska Ministerrådet och SNS/NKJ. Det är bara att hoppas att detta inte var en engångsföreteelse utan att liknande initiativ kan tas i framtiden. Ett mycket lämpligt område vore att på gemensam nordisk basis penetrera de frågor som aktualiserats av 'Kyoto Protokoll'et.

Uppsala dag som ovan



Sune Linder

Projektkoordinator

### **Bilagor**

Program för workshop  
Publiceringslista  
Planerade syntesuppsatser

## PROGRAMME FOR NORDIC WORKSHOP IN ICELAND, 3 – 6 July, 1998

**Venue:** Hotel Loftleidir, Reykjavik

### Friday 3 July

Arrival and check-in

1800 *Ice-breaker with drinks and snacks*

### Saturday 4 July

0800 *Breakfast*

#### Session 1: *General overviews (Chairman Paul Jarvis)*

0900 Background to project and general achievements (Sune Linder)

0930 A review of 'Tree and forest functioning in an enriched CO<sub>2</sub> atmosphere' (Henrik Saxe)

1000 *Coffee*

1030 Political implications and agreements in relation to Global Change (Halldor Thorgeirsson)

1100 Discussion

1200 *Lunch*

#### Session 2: *Results from the Nordic project (Chairman Seppo Kellomäki)*

1330 The effect of nutrient availability and elevated CO<sub>2</sub> on foliar chemistry (Peter Roberntz)

1400 The effect of nutrient availability on gas exchange (Bjarni Sigurdsson)

1500 *Coffee*

1430 The effect of elevated CO<sub>2</sub> on gas exchange (Kaisa Laitinen)

1530 Use of the common data base for meta analysis of effects of elevated CO<sub>2</sub> on trees (Belinda Medlyn)

1600 Discussion

1900 *Dinner*

### Sunday 5 July

0800 *Breakfast*

#### Session 3: *The likely impacts of climatic change on Nordic forests (Chairman Sune Linder)*

0900 Influence of environment during sexual reproduction on physiological adaptations in trees (Øystein Johnsen)

0930 Modelling short-term effects of climatic change on Nordic forests (Johan Bergh)

1000 *Coffee*

1030 Modelling long-term effects of climatic change on Nordic forests (Seppo Kellomäki)

1100 The carbon balance of forests – current understanding and need for future research (Paul Jarvis)

1130 Discussion about future collaboration within the Nordic countries

1200 *Lunch*

Afternoon free

### Monday 6 July

0800 *Breakfast*

0900 Michael Freeman's PhD-defence  
Afternoon free

### Tuesday 7 July

0800 *Breakfast*

0830 Excursion

**PAPERS ON EFFECTS OF CLIMATE AND NUTRITION ON NORDIC FORESTS  
PUBLISHED OR SUBMITTED BY THE GROUP DURING THE YEARS 1994-1999**

1. Aradóttir, Á.L., H. Thorgeirsson, J.H. McCaughey, I.B. Strachan & A. Robertson. 1997. Establishment of a black cottonwood plantation on an exposed site in Iceland: plant growth and site energy balance. *Agriculture and Forest Meteorology* 84, 1-9.
2. Bergh, J. & Linder, S. 1999. Effects of soil warming during spring on photosynthetic recovery in boreal Norway spruce stands. *Global Change Biology* 5, 245-253.
3. Bergh, J., Linder, S., Lundmark, T. & Elfving, B. 1999. The effect of water and nutrient availability on the productivity of Norway spruce in northern and southern Sweden *Forest Ecology and Management* 119, 51-62.
4. Bergh, J., McMurtrie, R.E. & Linder, S. 1998. Climatic factors controlling the productivity of Norway spruce: a model-based analysis. *Forest Ecology and Management* 110, 125-139.
5. Beuker, E., Kolström, M. & Kellomäki, S. 1996. Changes in wood production of *Picea abies* and *Pinus sylvestris* under a warmer climate: comparison of field measurements and results of a mathematical model. *Silva Fennica* 30, 239-246.
6. Börjesson, P., Gustavsson, L., Christersson, L. & Linder, S. 1998. Future production and utilization of biomass in Sweden: Potentials and CO<sub>2</sub> mitigation. *Biomass and Bioenergy* 13, 399-412.
7. Friend, A., Kellomäki, S. & Kruijt, B. 1998. Modelling leaf, tree, and forest responses to increasing atmospheric CO<sub>2</sub> and temperature. In: P.G. Jarvis (ed.) *European Forests and Global Change*, pp. 293-346. Cambridge University Press.
8. Goudrian, J., Shugarth, H.H., Bugmann, H., Cramer, W., Bondeau, B., Gardner, R.H., Hunt, T., Lauenroth, W., Landsberg, J.J., Linder, S., Noble, I., Parton, W., Pitelka, L., Smith, M.S., Sutherst, B., Valentin, C. & Woodward, F.I. 1999. Use of models in global change studies. In: Walker, B.H., Steffen, W.L., Canadell, J. & Ingram, J.S.I. (eds). *The Terrestrial Biosphere and Global Change, Implications for Natural and Managed Ecosystems*, pp. 106-140. Cambridge University Press.
9. Gregory, P., Campbell, B., Goudriaan, J., Hunt, T., Ingram, J., Landsberg, J.J., Linder, S., Stafford Smith, M., Sutherst, B. & Valentin, C. 1999. Managed production systems. In: Walker, B.H., Steffen, W.L., Canadell, J. & Ingram, J.S.I. (eds). *The Terrestrial Biosphere and Global Change, Implications for Natural and Managed Ecosystems*, pp. 229-270. Cambridge University Press.
10. Hänninen, H., Leinonen, I., Repo, T. & Kellomäki, S. 1996. Overwintering and productivity of Scots pine in a changing climate. *Silva Fennica* 30, 229-237.
11. Ingram, J., Canadell, P., Elliot, T., Hunt, T., Linder, S., Murdiyarso, D., Stafford Smith, M. & Valentin, C. 1999. Networks and consortia. In: Walker, B.H., Steffen, W.L., Canadell, J. & Ingram, J.S.I. (eds). *The Terrestrial Biosphere and Global Change, Implications for Natural and Managed Ecosystems*, pp. 45-65. Cambridge University Press.
12. Karjalainen, T., Kellomäki, S. & Pussinen, A. 1995. Role of wood-based products in absorbing atmospheric carbon. - *Silva Fennica* 28, 67-80.
13. Karjalainen, T., Pussinen, A. & Kellomäki, S. 1999. Regional carbon budgets for forests and wood-based products under changing climatic conditions. *Biogeochemistry* (in press).
14. Karjalainen, T., Kellomäki, S. & Pussinen, A. 1994. Role of wood-based products in absorbing atmospheric carbon. *Silva Fennica* 28, 67-80.
15. Kaufmann, M.R. & Linder, S. 1996. Tree canopy process and physiology research in a changing world. *Tree Physiology*, 16: 1-5.
16. Kellomäki, S. & Kolström, M. 1994. The influence of climate change on the productivity of Scots pine, Norway spruce, pendula birch and pubescent birch in southern and northern Finland. *Forest Ecology and Management* 65: 201-217.
17. Kellomäki, S. & Strandman, H. 1995. A model for the structural growth of young Scots pine crowns based on light interception of shoots. *Ecological Modelling* 80, 237-250.
18. Kellomäki, S. & Väisänen, H. 1997. Modelling the dynamics of the boreal forest ecosystems for climate change studies in the boreal conditions. *Ecological Modelling* 97, 121-140.
19. Kellomäki, S. & Wang, K.-Y. 1996. Photosynthetic response to needle water potentials in Scots pine after four-year exposure to elevated CO<sub>2</sub> and temperature. *Tree Physiology* 16, 765-772.
20. Kellomäki, S. & Wang, K.-Y. 1997. Effects of elevated O<sub>3</sub> and CO<sub>2</sub> concentrations on photosynthesis and stomatal conductance in Scots pine. *Plant, Cell and Environment* 20, 995-1006.
21. Kellomäki, S. & Wang, K.-Y. 1997. Effects of high-soil-nitrogen supply on the response of photosynthesis and growth to elevated CO<sub>2</sub>: a result of a branch-in-bag experiment. *Tree Physiology* 17, 231-240.

22. Kellomäki, S. & Wang, K.-Y. 1997. Effects of long-term CO<sub>2</sub> and temperature elevation on crown nitrogen distribution and daily photosynthetic performance of Scots pine. *Forest Ecology and Management* 99, 309-326.
23. Kellomäki, S. & Wang, K.-Y. 1998. Daily and seasonal CO<sub>2</sub> in Scots pine grown under elevated O<sub>3</sub> and CO<sub>2</sub>: experiment and simulation. *Plant Ecology* 136, 229-248.
24. Kellomäki, S. & Wang, K.-Y. 1997. Effects of elevated O<sub>3</sub> and CO<sub>2</sub> on chlorophyll fluorescence and gas exchange in Scots pine during the third growing season. *Environmental Pollution* 97, 17-27.
25. Kellomäki, S. & Wang, K.-Y. 1996. Photosynthetic responses to needle water potentials in Scots pine after a four-year exposure to elevated CO<sub>2</sub> and temperature. *Tree Physiology* 16, 765-772.
26. Kellomäki, S. & Wang, K.-Y. 1998. Sap flow in Scots pines growing under conditions of year-round carbon dioxide enrichment and temperature elevation. *Plant, Cell and Environment* 21, 969-981.
27. Kellomäki, S. & Wang, K.-Y. 1999. Short-term environmental controls on the heat and water vapour fluxes above a boreal coniferous forest: model computation compared with measurements by an eddy correlation. *Ecological Modelling* (in press).
28. Kellomäki, S., Hänninen, H. & Kohlström, M. 1995. Computations on the effect of climatic warming on growth and development of Scots pine stands in boreal conditions; introducing frost damage of trees in a gap-type forest ecosystem model. *Ecological Applications* 5, 42-52.
29. Kellomäki, S., Karjalainen, T. & Väisänen, H. 1997. More timber from boreal forests under changing climate? *Forest Ecology and Management* 94, 195-208.
30. Kellomäki, S., Väisänen, H. and Kolström, T. 1997. Model computations on the effect of elevating temperature and atmospheric CO<sub>2</sub> on the regeneration of Scots pine at the timber line in Finland. *Climate Change* 37, 683-708.
31. Kellomäki, S. & Wang, K.-Y. 1998. Growth, respiration and nitrogen content in needles of Scots pine exposed to elevated ozone and carbon dioxide in the field. *Environmental Pollution* 99, 1-12.
32. Laitinen, K. Temperature response of photosynthesis on Scots pine after three years' exposure to elevated temperature and CO<sub>2</sub>. *Canadian Journal of Forest Research*. (Submitted)
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38. Lundmark, T., Bergh, J., Strand, M. & Koppel, A. 1998. Seasonal variation of maximum photochemical efficiency in boreal Norway spruce stands. *Trees* 13, 63-67.
39. Mäkipää, R., Karjalainen, T., Pussinen, A. & Kellomäki, S. 1999. Effect of climate change and nitrogen deposition on the carbon sequestration of a forest ecosystem in the boreal zone. *Canadian Journal of Forest Research* (in press).
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48. Roberntz, P. & Linder, S. 1999. Effects of long-term CO<sub>2</sub> enrichment and nutrient availability in Norway spruce II: Foliar chemistry. *Trees* 14, 17-27.
49. Roberntz, P. & Stockfors, J. 1998. Net photosynthesis, stomatal conductance and respiration of mature Norway spruce foliage under CO<sub>2</sub> enrichment and different nutrient regimes. *Tree Physiology* 18, 233-241.
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#### DISSERTATIONS

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- Laitinen, K. 1998. Photosynthesis and carbon accumulation in Scots pine needles exposed to elevated atmospheric CO<sub>2</sub> and O<sub>3</sub> concentrations and temperature in long-term experiments. D.Sc. Thesis, University of Joensuu.
- Roberntz, P. 1998. Effects of elevated CO<sub>2</sub> and nutrition on gas exchange and foliar chemistry in Norway spruce. *Acta Universitatis Agriculturae Sueciae, Silvestria* 67, 46 pp. Doctor's dissertation.

## SYNTESUPPSATSER UNDER BEARBETNING

Impact studies on Nordic forests I: Effects of elevated CO<sub>2</sub> and fertilisation on foliar chemistry (Peter Roberntz, M. Freeman, K. Laitinen, M. Næss, B.D. Sigurdsson and S. Linder)

Impact studies on Nordic forests II: Effects of elevated CO<sub>2</sub> and fertilisation on gas exchange (Bjarni D. Sigurdsson, P. Roberntz, M. Freeman, H. Saxe, M. Næss and H. Thorgeirsson)

Modelling the short-term effects of climate change on productivity of selected tree species in the Nordic countries. (Johan Bergh, Seppo Kellomäki, Michael Freeman, Øystein Johnsen, Kaisa Laitinen, Sune Linder, Sini Niinistö, Heli Peltola, Sabine Philippot, Peter Roberntz, Henrik Saxe, Bjarni Sigurdsson and Halldor Thorgeirsson)