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Norway spruce fine roots and seasonal drought – results of a field experiment in southern Finland

HH-S. Helmisaari[1], M. Kampouri[1], P. Nöjd[1], I. Lumme[1], K. Minkkinen[2] & T. Penttilä[1]

[1]Finnish Forest Research Institute, Vantaa Research Centre, P.O.Box 18, FFI-01301 Vantaa, Finland
hhelja-sisko.helmisaari@metla.fi
[2]2 University of Helsinki, DDepartment of Forest Ecology

Background

In the early 1990´s a reduction of growth of Norway spruce on fertile sites in southern Finland was detected in the National Forest Inventory.
Possible causes were widely discussed - early summer droughts?

In 2002 and 2003 hundreds of hectares of Scots pine and birch stands died because of drought in southern Finland on sites with a thin soil layer and on sites with a poor WHC.

Aims

to determine the effects of seasonal drought and elevated soil nitrogen levels on

- tree growth
- nutrient status and nutrient uptake
- fine roots and mycorrhiza
- soil and soil water nutrient status
- soil microbiology

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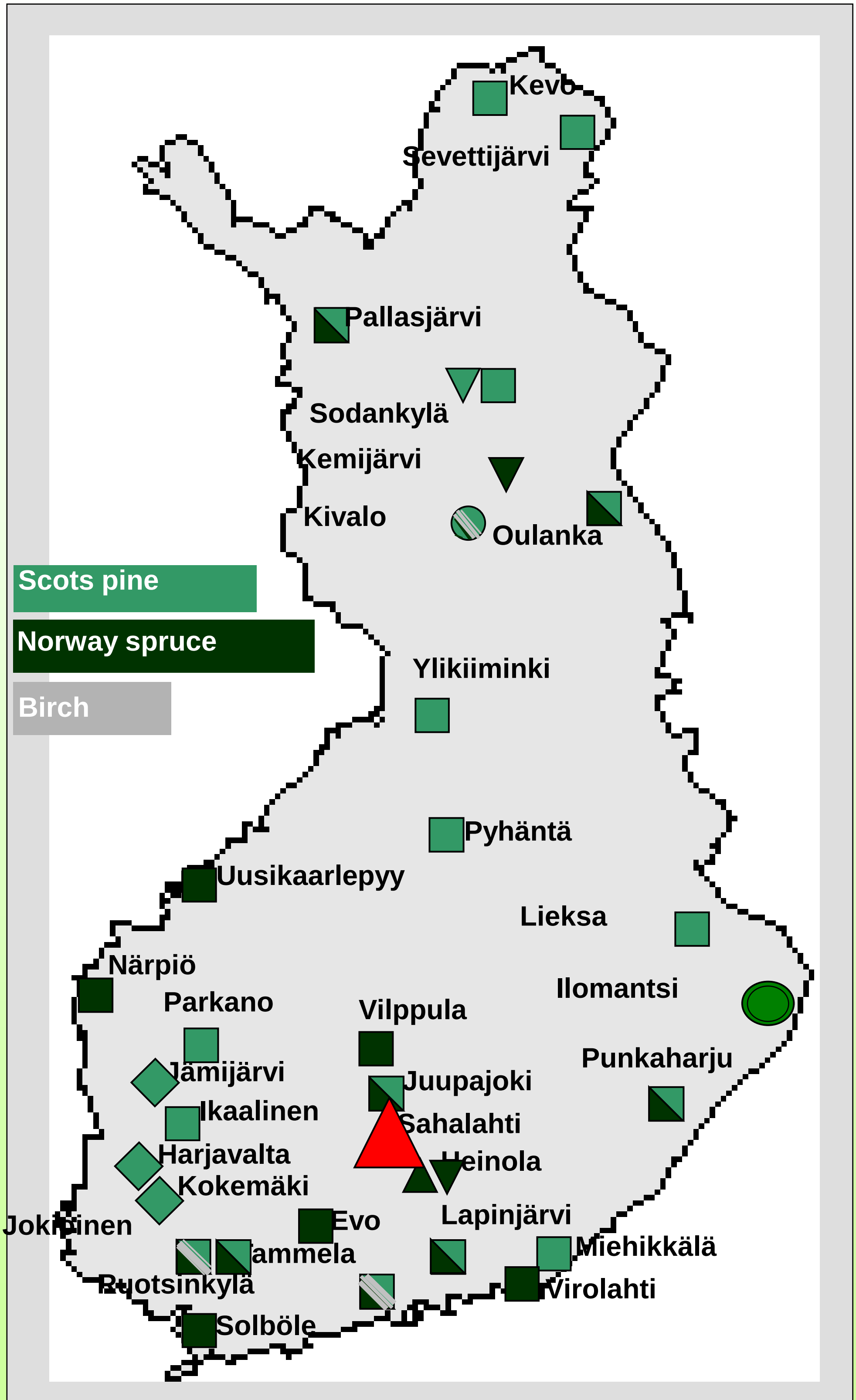
Location of Sahalahti



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Treatments

- control **(C)**

- N fertilization **(N)** 630**-**1000 kg/ha (80-150 kg N/ha given every 5 yrs) during 35 yrs

- drought **(D)** for three months (May-July during three summers 1998-2000)

- N fertilization combined with drought **(D+N)**

Drought-treatments

The drought treatments were carried out by covering the 900 m^2 D and D+N plots with a plastic roof 1-4 m above ground level.

Stand

Norway spruce stand,
age 67,
fertile site type
on fine sand till

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Hypotheses

We hypothesised that:

if the effects of drought on trees are not only caused by a decreased availability of water and nutrients but also due to damage to fine roots, then the recovery from drought may take longer.

A higher N status may be beneficial during drought but it may also change the pattern of carbon allocation in the trees favouring aboveground growth, thus increasing sensitivity to drought.

Studied processes

- Fine root dynamics
- Soil respiration
  - static chamber technique
- Tree diameter growth
  - automatic girth bands,
    recorded daily at 6 a.m.

- Litterfall
- Deposition, throughfall, soil water
- Nutrient status and uptake (^{15}N)
- Soil microbial respiration
- Ammonification, nitrification

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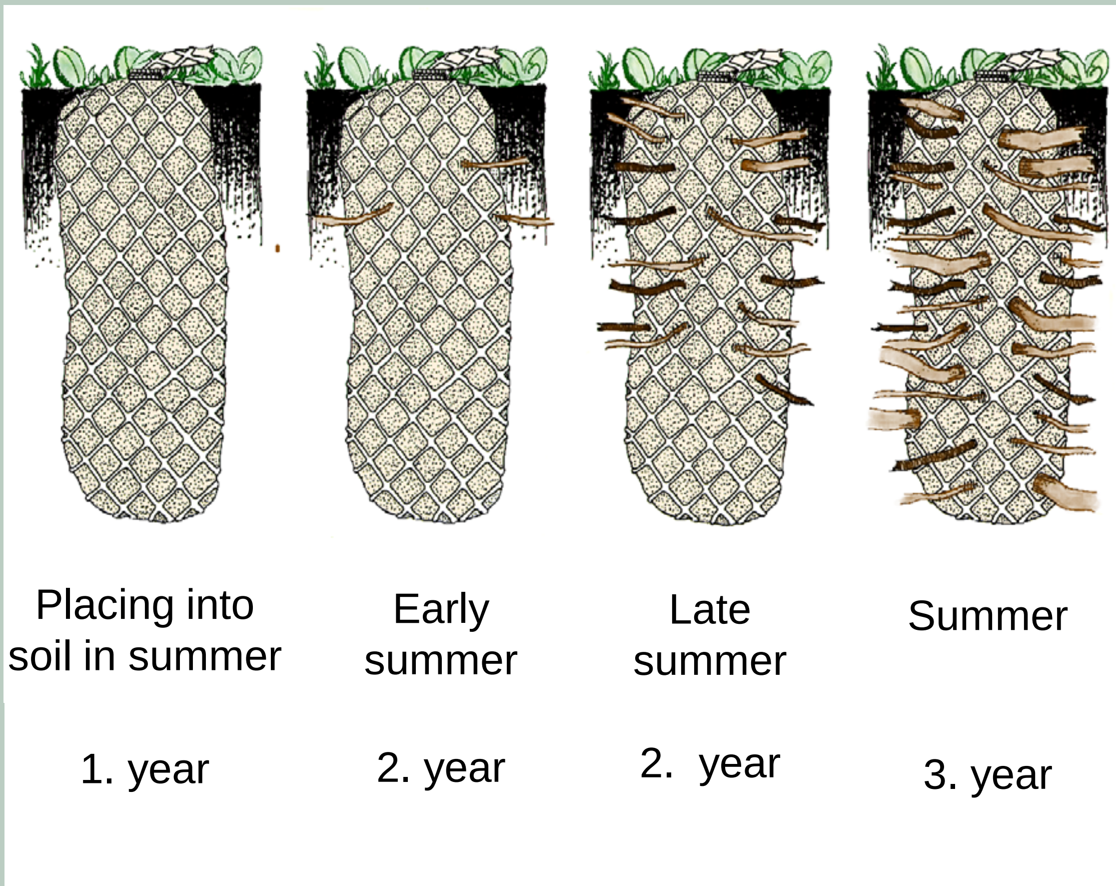
Field methods: ingrowth cores

Ingrowth cores



Picture by Jarmo Karvonen.

Field methods: ingrowth cores

- Placement in May 1998
- Samplings in 1999 & 2000

  1 = May/June (before drought)

  2 = August (just after drought)

  3 = October (after two months recovery)

Sorting of fine roots

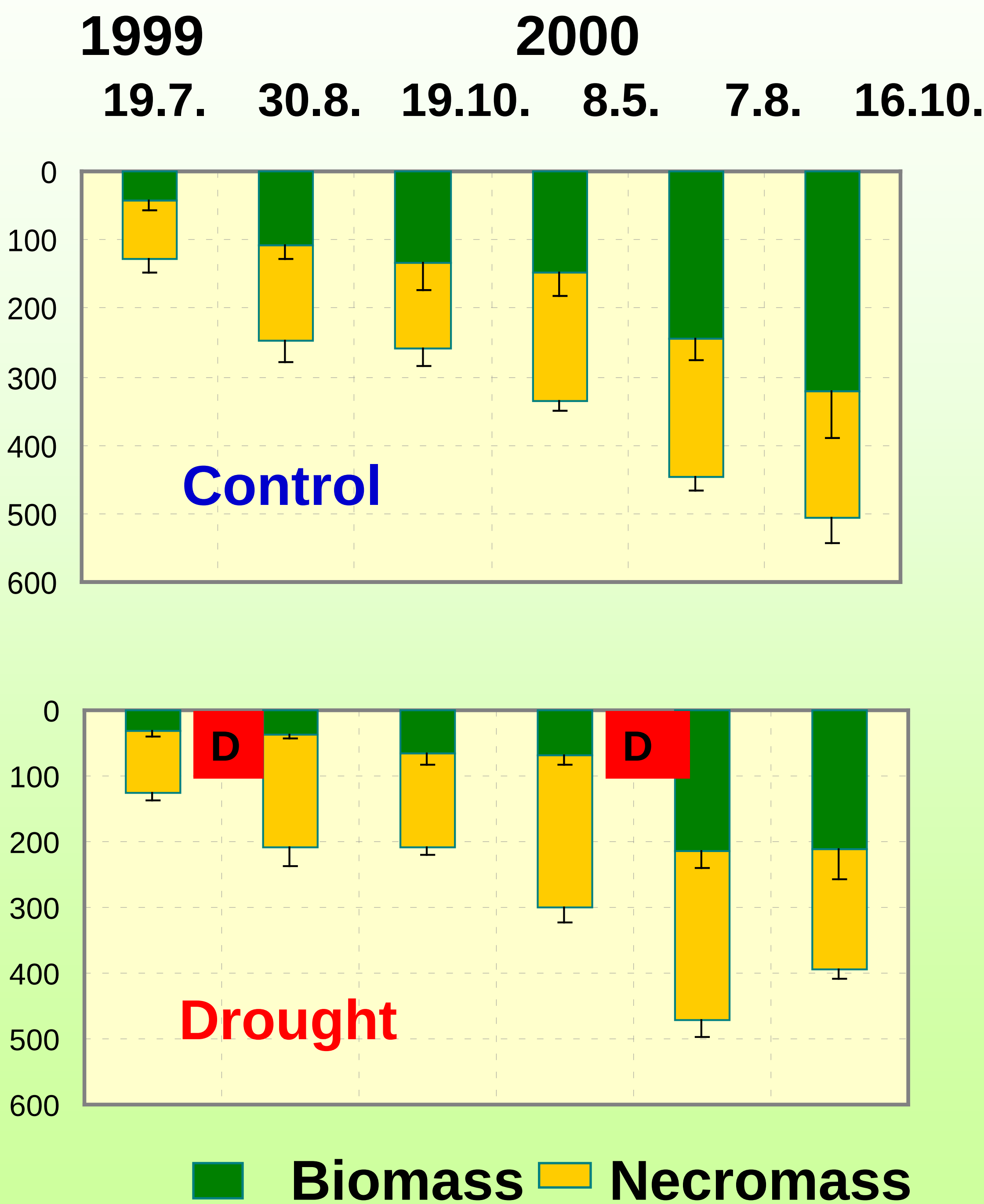
Fine root dry weights

- tree species, grasses and shrubs
- living and dead
- diameter classes

  < 1mm, 1-2 mm, > 2 mm

Numbers of mycorrhizal root tips

Fine root bio- and necromass in ingrowth cores



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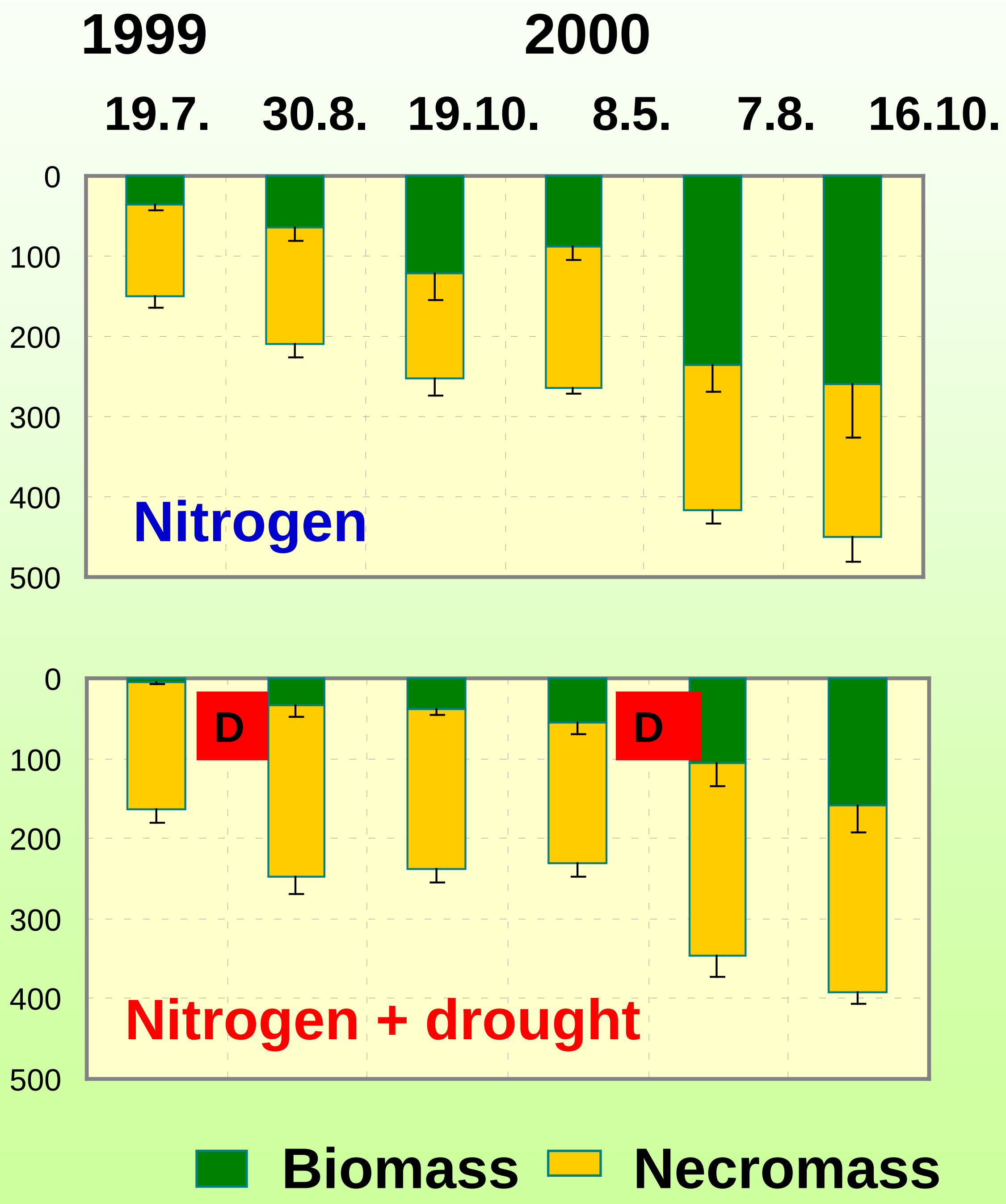
n = 8 cores

Fine root bio- and necromass in ingrowth cores



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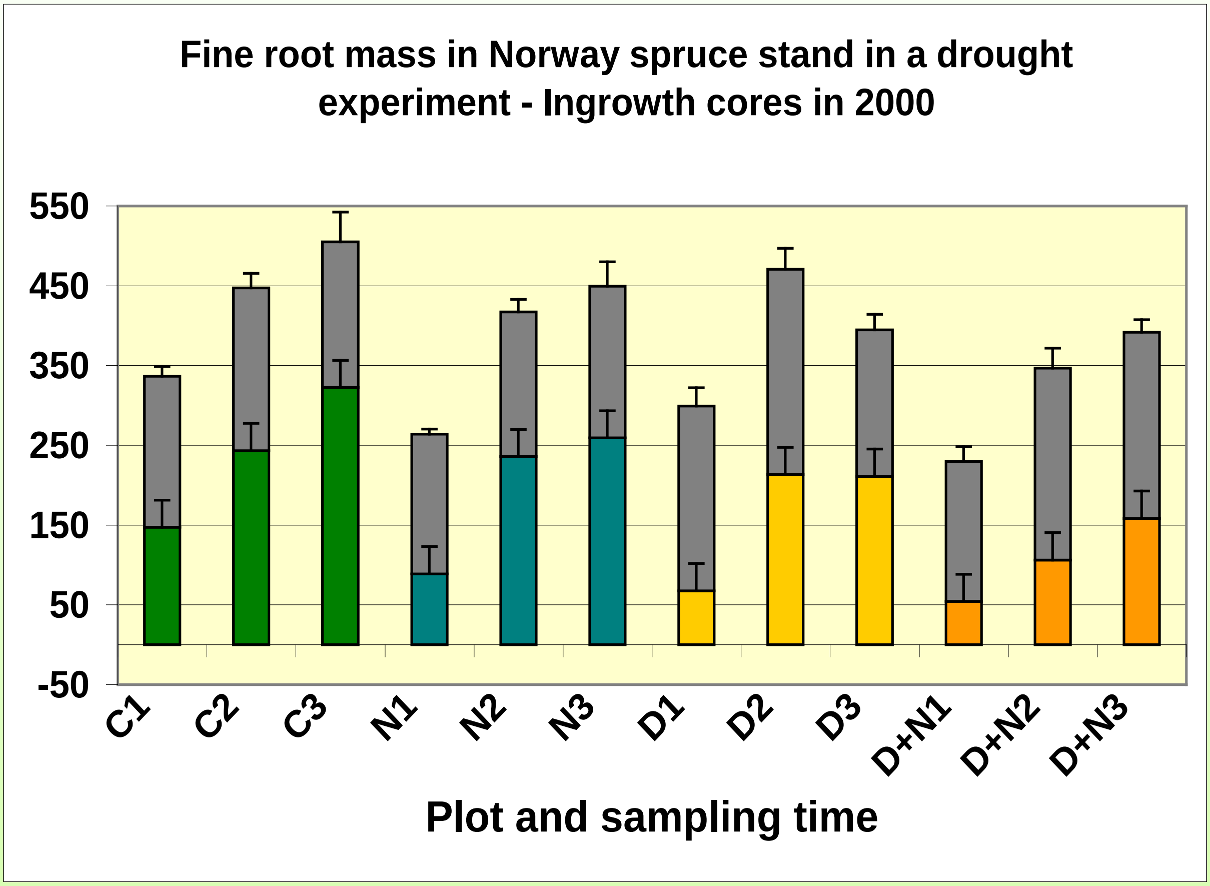
Fine root bio- and necromass in ingrowth cores



- Fine root mortality was higher on the D and D+N plots, no real recovery between treatments

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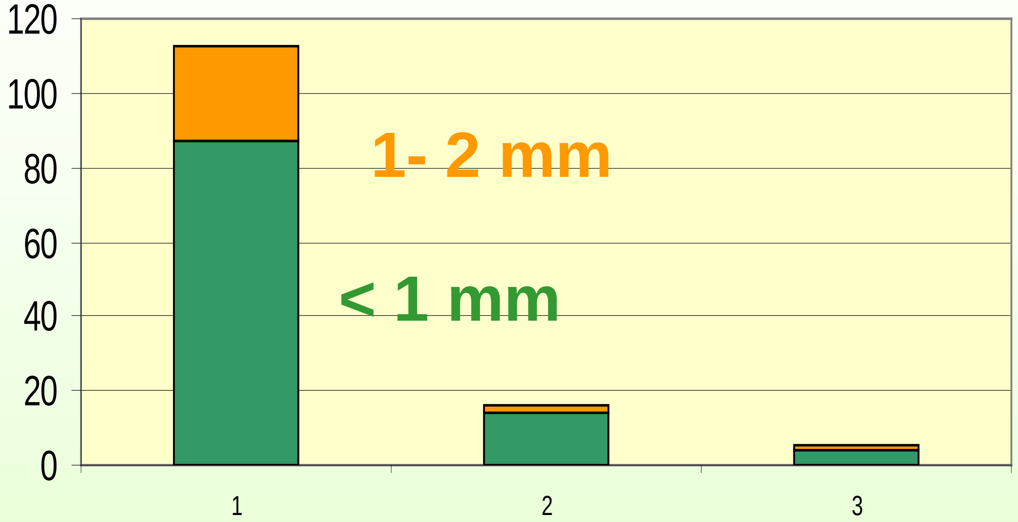
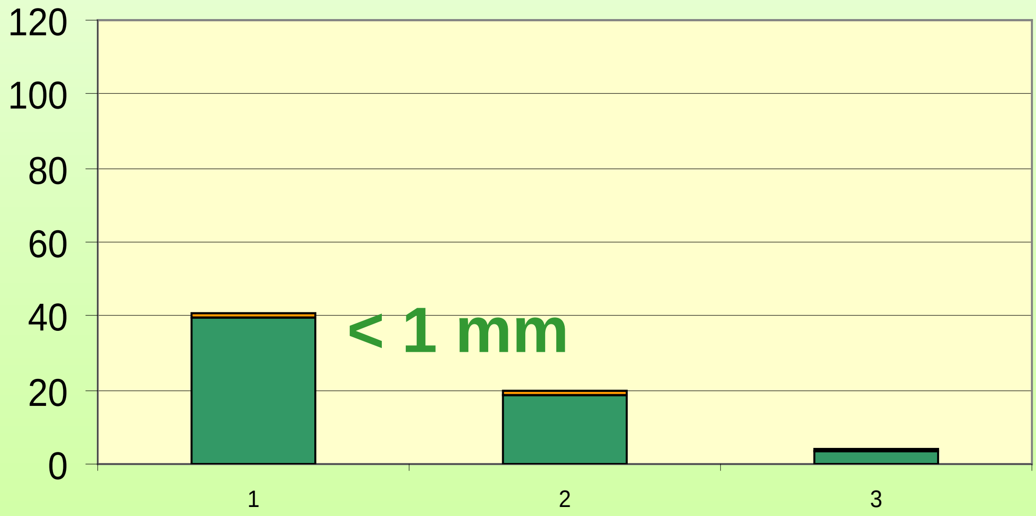
Diameter class distribution of living fine roots in the ingrowth cores in autumn 1999

Control



Depth 0-10 cm 10-20 cm 20-30 cm

Drought



Turnover higher on the D and D+N plots, ingrown roots died sooner, had no time to develope into thicker roots.

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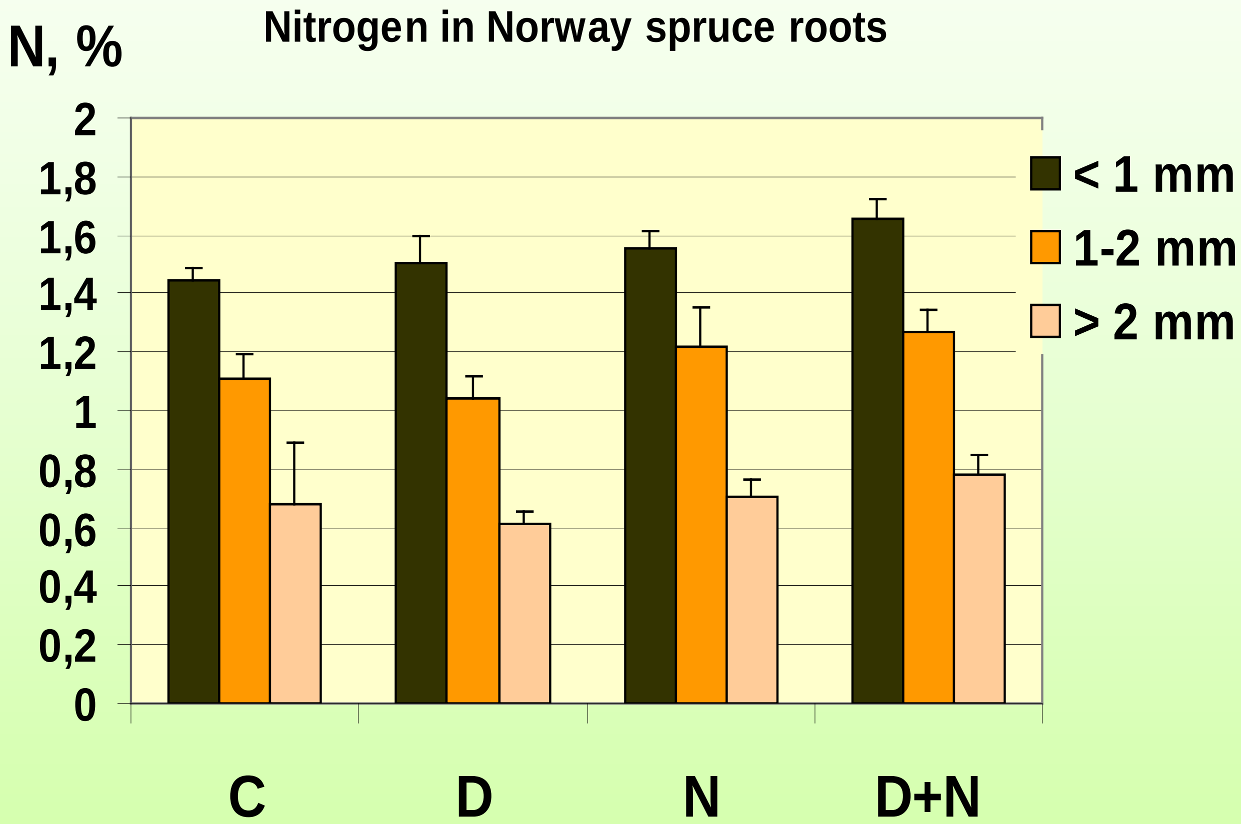
Nitrogen concentration in roots



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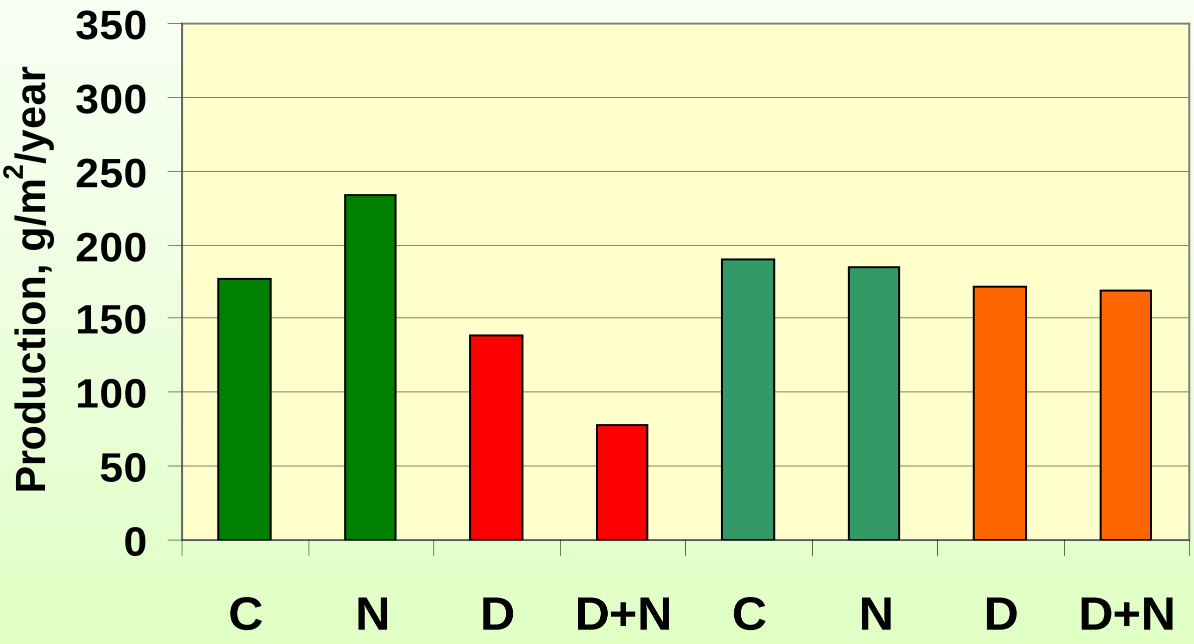
Annual fine root biomass production



Soil cores
three year means

Ingrowth cores
year 2000

➡ Fine root biomass production was lower on the D and D+N plots.

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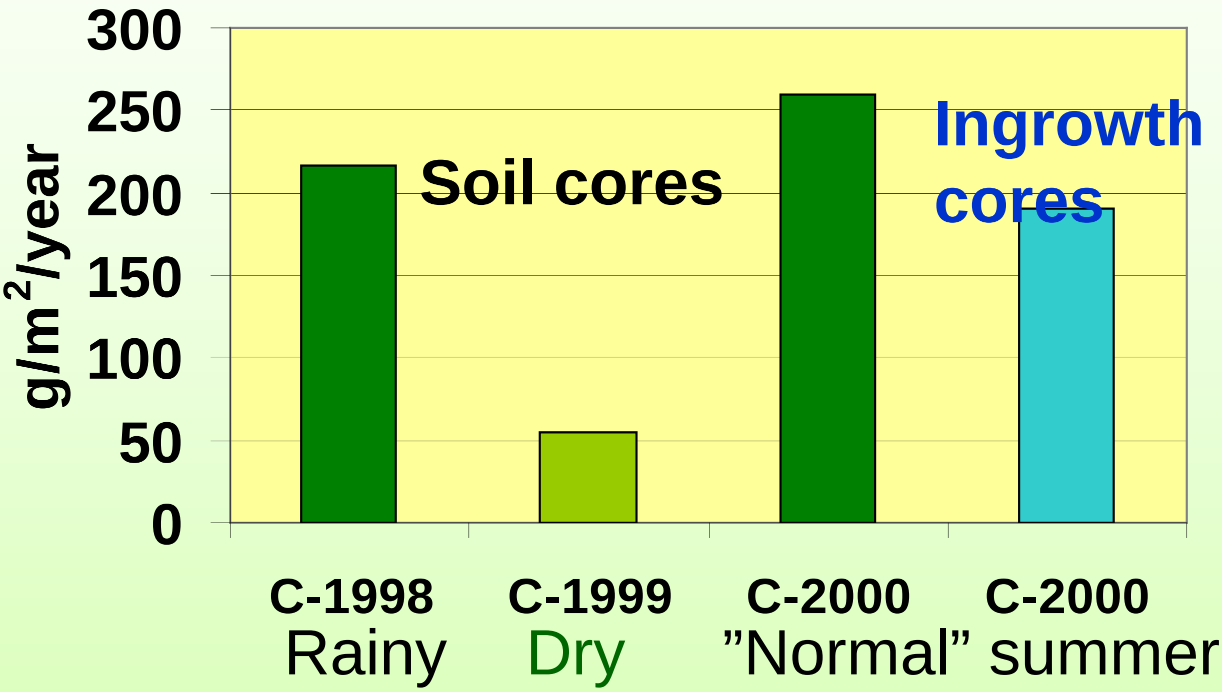
Fine root biomass production on the control plot determined with soil cores and ingrowth cores



Natural drought affected even the control plots in 1999!

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Turnover rate from ingrowth cores (annual production / biomass in 2000)

	Biomass production	Turnover rate
C	190 g/m^2/year	0.6
D	171 ”	0.7
N	185 ”	0.8
D + N	169 ”	1.1

➡ Higher turnover rate on drought treated plots.

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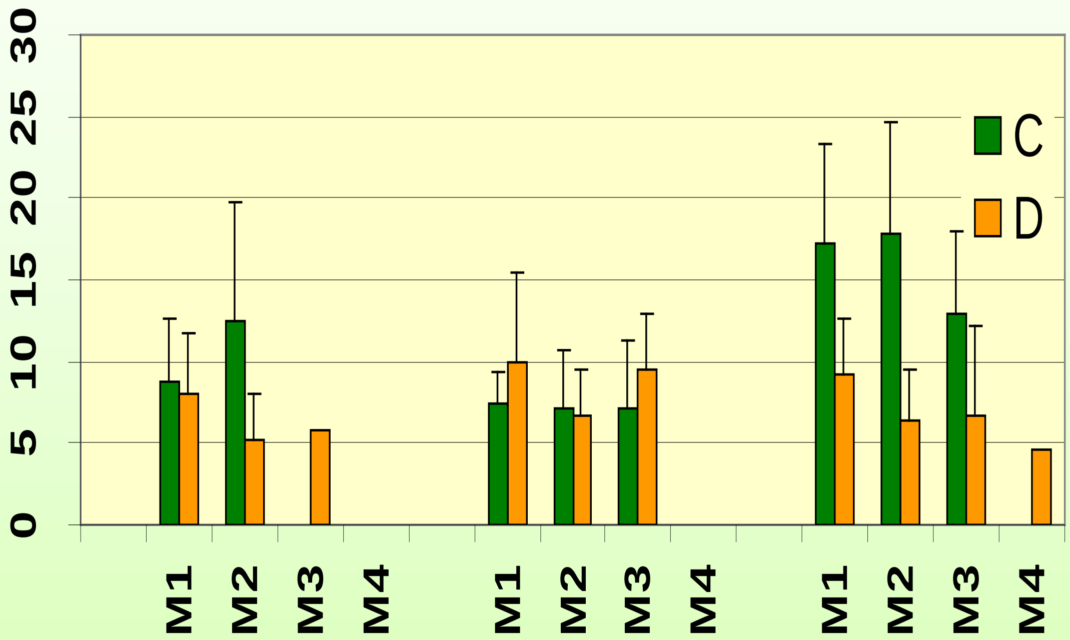
Living mycorrhizal root tips/mg of roots in the ingrowth cores in 1999



Soil layers M1=0-10 cm, M2=10-20 cm etc.

No significant differences – large variation.

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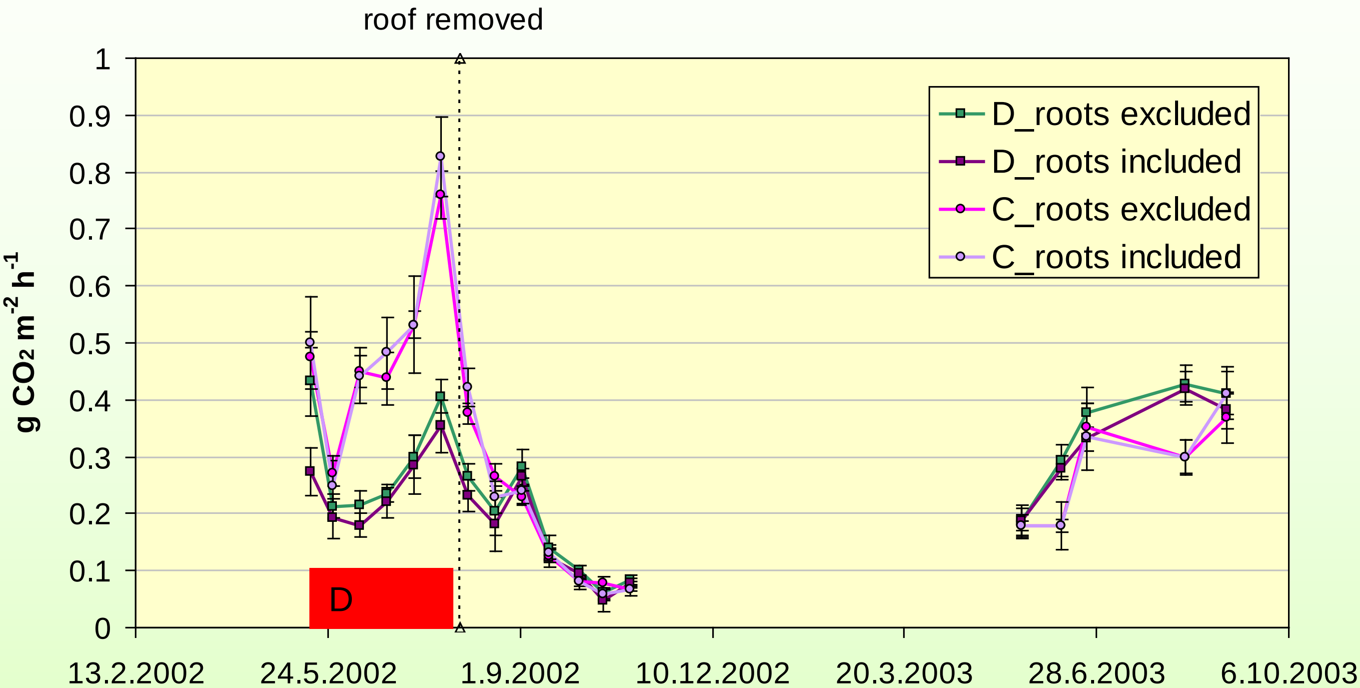
Soil respiration



- In 2002 soil respiration was clearly reduced by drought.

- Root exclusion did not affect soil respiration significantly.

- In 2003 a year after roof removal soil respiration was higher on the previously drought-treated plot.

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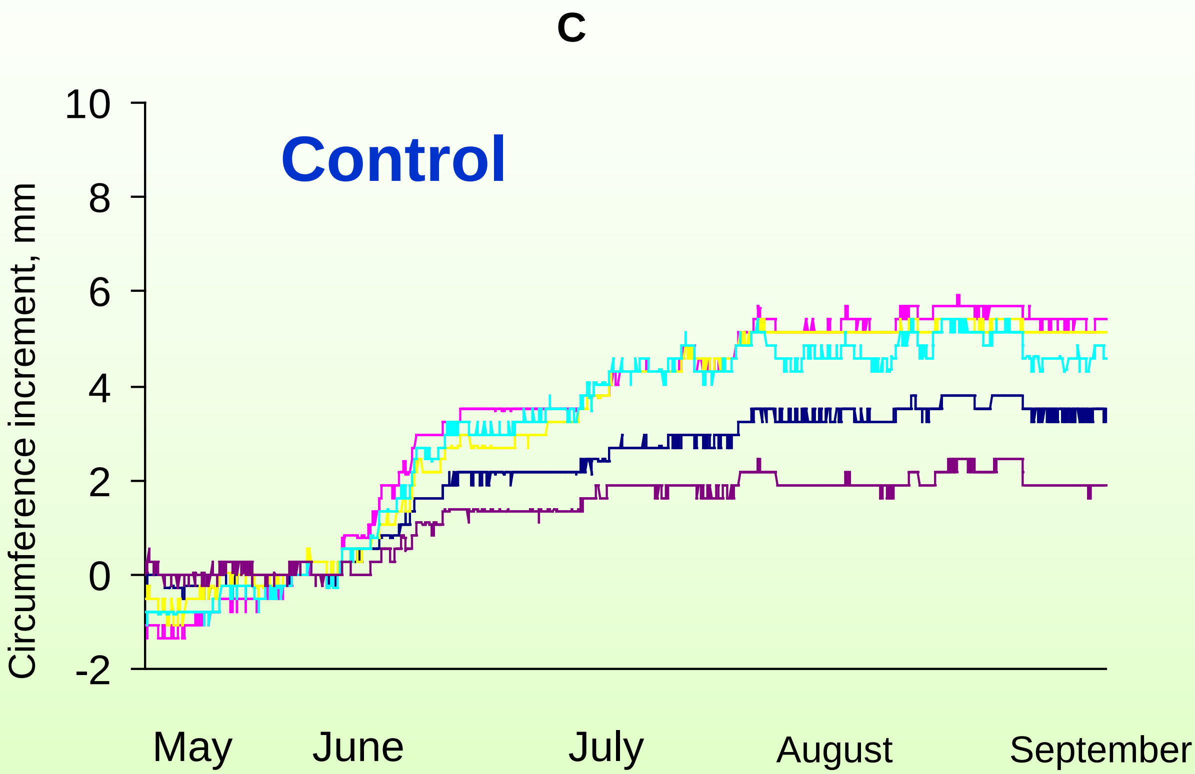
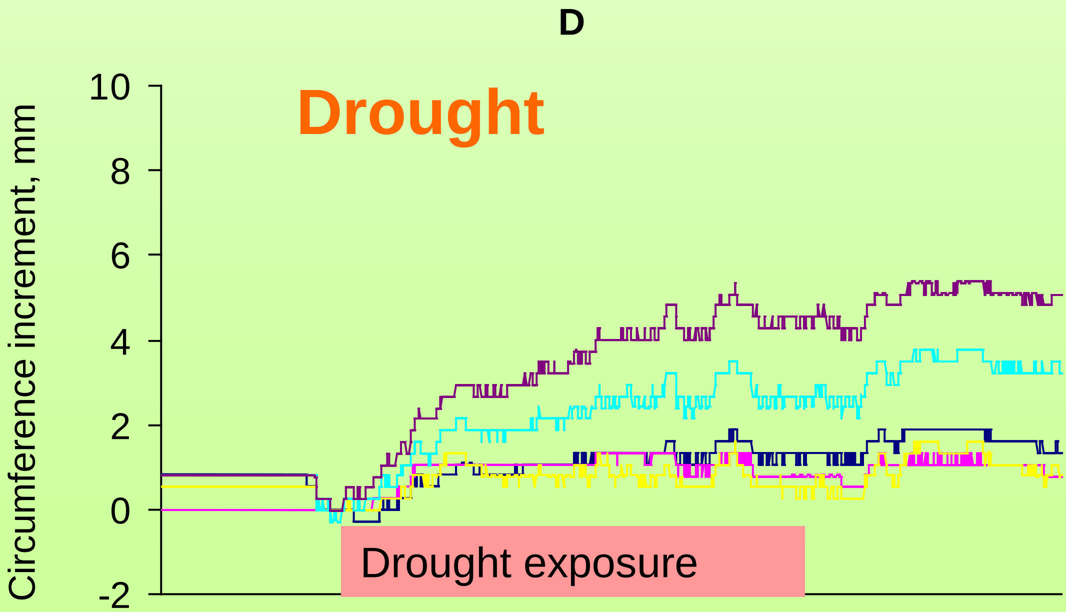
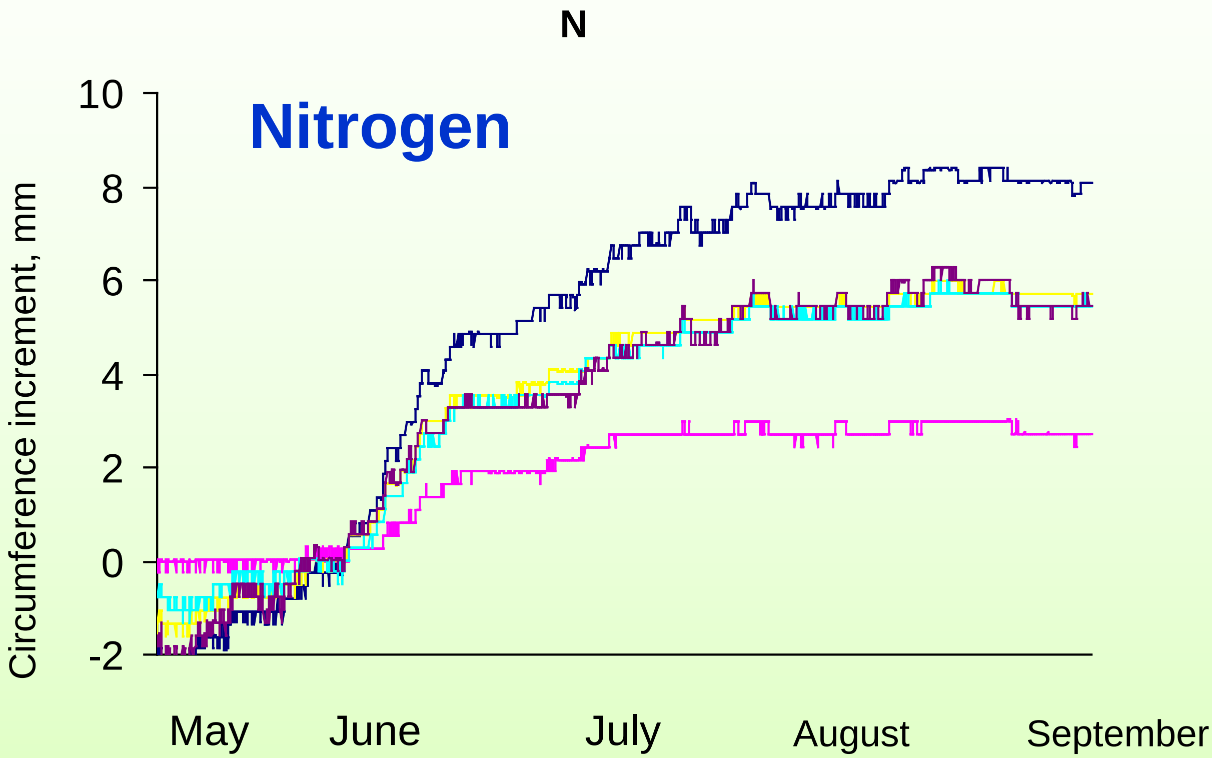
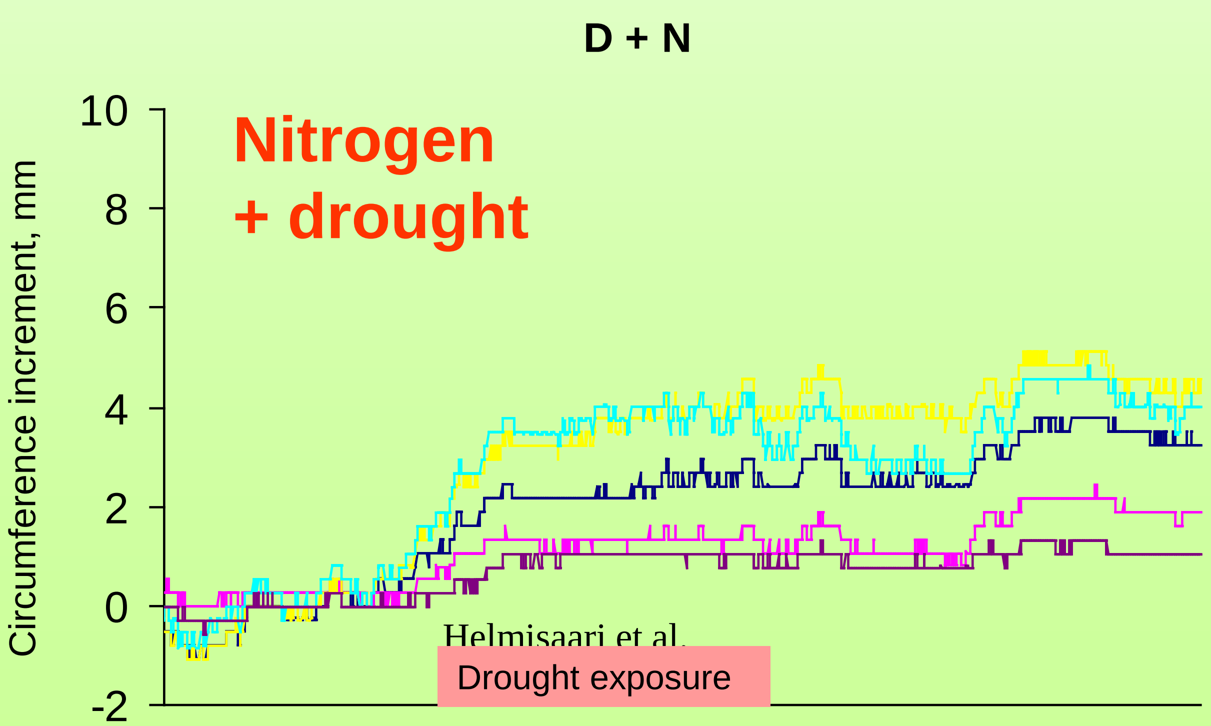
Tree diameter increment





Tree diameter increment





Tree diameter increment

- D + D+N trees had very little increment after the end of June.
- C and N trees grew normally untill the beginning of August.
- The mean diameter increment was considerably lower in drought-treated trees.
- Sample trees were felled in October 2004: diameter growth from disks is being analysed.

Conclusions

- Norway spruce fine roots and diameter growth reacted rapidly to water deficiency in the soil, and fine roots did not recover between drought events.

- The soil microflora is sensitive to the reduction of soil water content, but it also recovers rapidly after rewetting of the soil.

- The mean diameter increment was lower in drought-treated trees.

Conclusions

- The stand is not able to recover during the end of one growing season even if the soil water content would markedly increase.
- However, a temporal water stress occurring during 1 to 4 consecutive growing seasons did not cause death of Norway spruce on fertile site type.
- Long-term recovery results 2003 & 2004?

Thank you!