METLA

# IMPACTS OF STUMP HARVESTING ON NITROGEN LEACHING AND CARBON FLOW IN THE BOREAL FOREST ENVIRONMENT

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# Content

1. **Boreal forest environment**
2. Increasing use of forest biomass
3. Research on environmental effects of stump harvesting
4. Conclusions

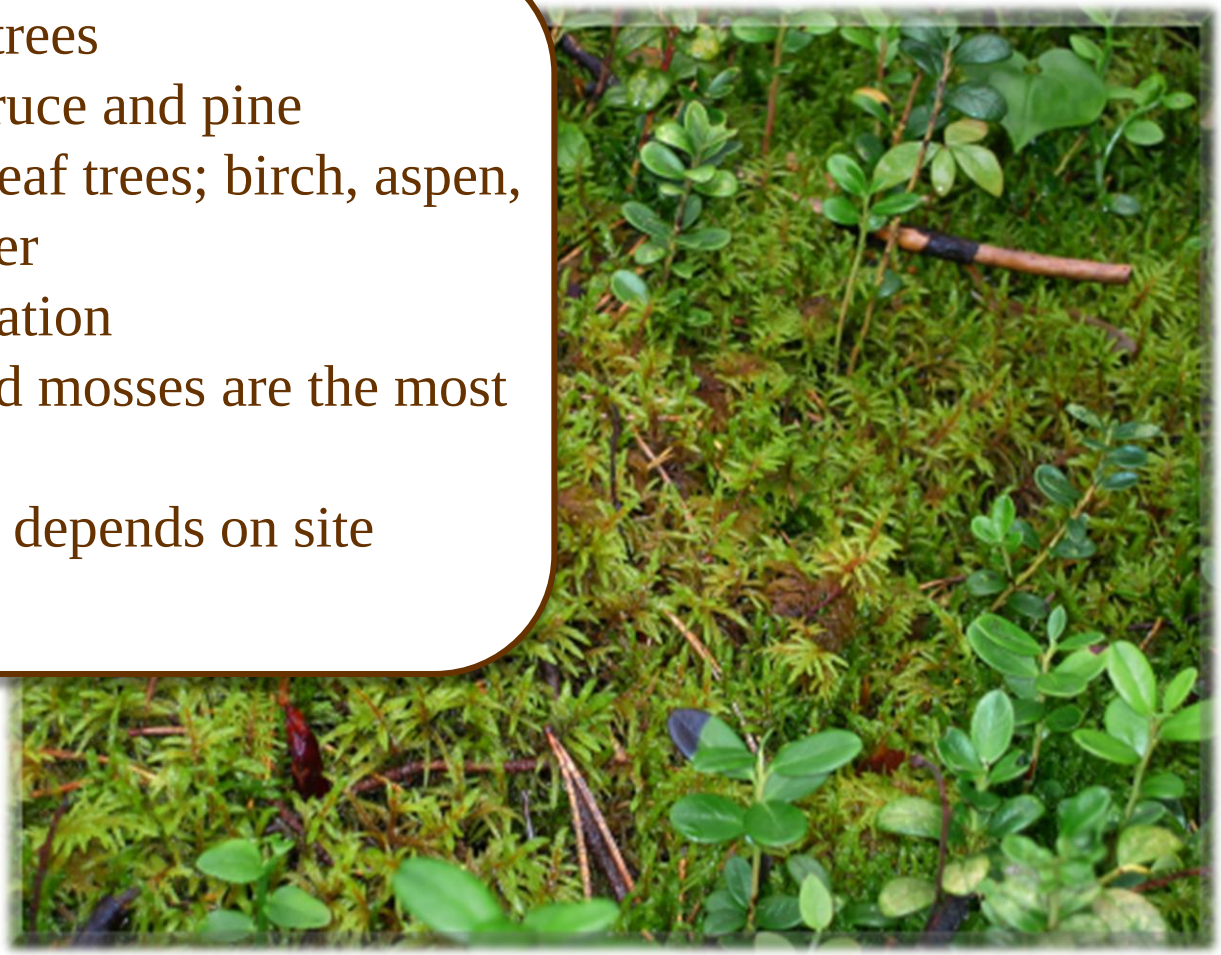
# Finnish forests, a part of boreal forest zone

Forests on mineral soils cover 17.2 million hectares

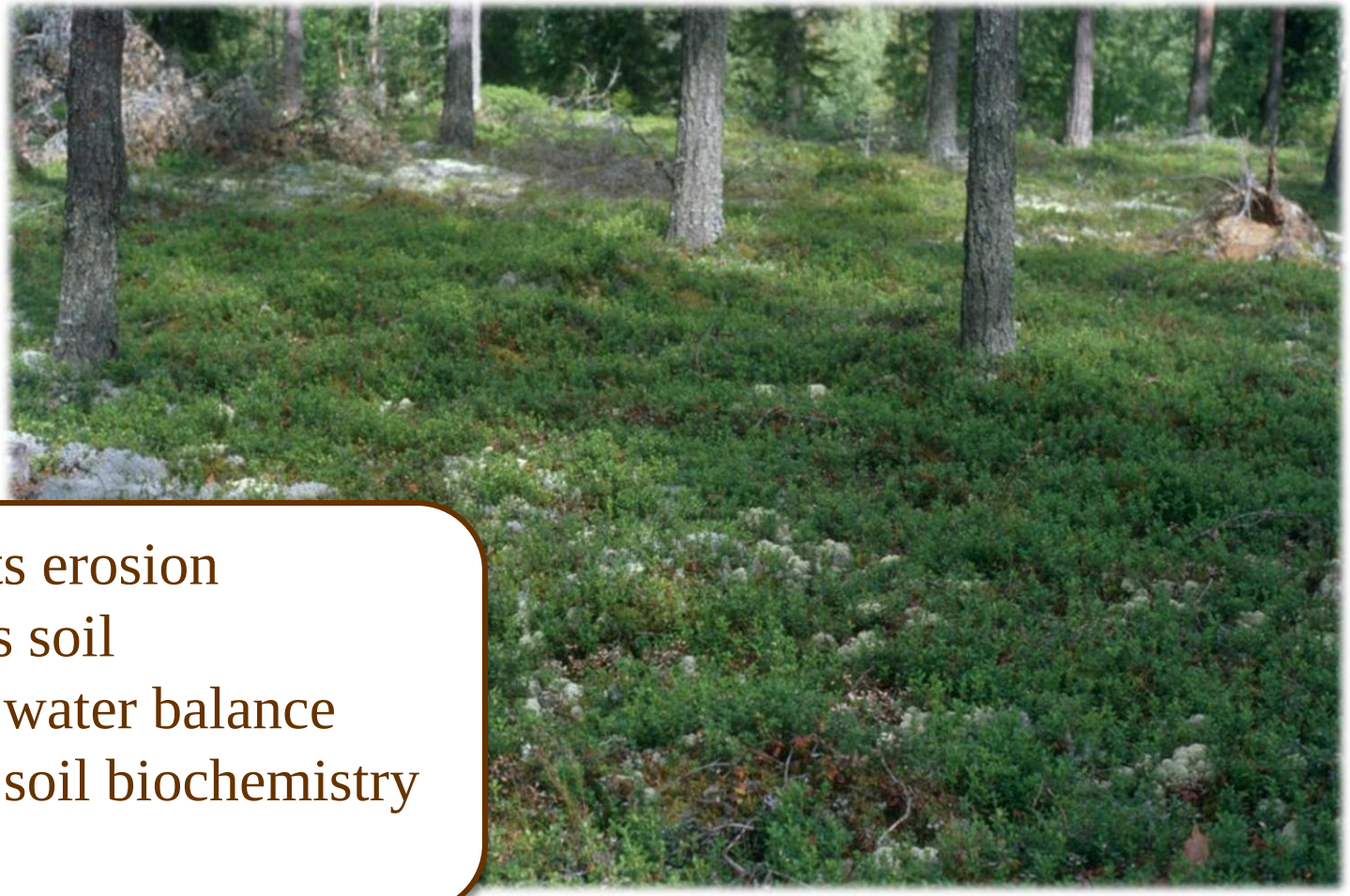
Forests on peatlands cover 8.9 million hectares (52 % is drainaged)

# Boreal forest vegetation

- ✓ Mainly coniferous trees
  - dominated by spruce and pine
  - also some broadleaf trees; birch, aspen, willow, rowan, alder
- ✓ Ground layer vegetation
  - dwarf shrubs and mosses are the most typical
  - other vegetation depends on site

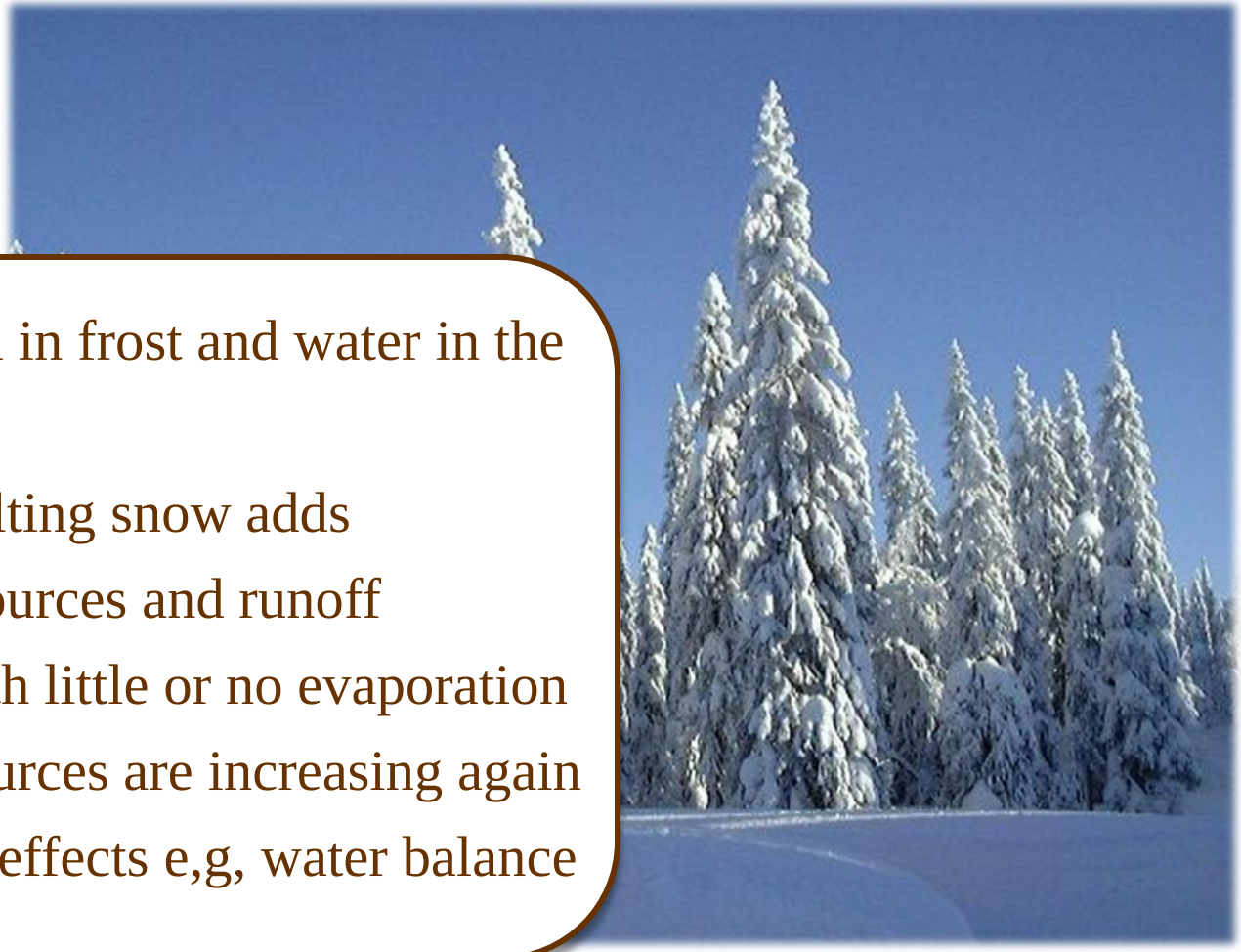


## In addition of trees ground layer has an important role



- ✓ Prevents erosion
- ✓ Protects soil
- ✓ Effects water balance
- ✓ Effects soil biochemistry
- ✓ Etc.

# Boreal forest hydrology



- ✓ Long winter; soil in frost and water in the form of snow
- ✓In the spring smelting snow adds groundwater resources and runoff
- ✓In the autumn with little or no evaporation groundwater resources are increasing again
- ✓Wood harvesting effects e,g, water balance

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1. Boreal forest environment
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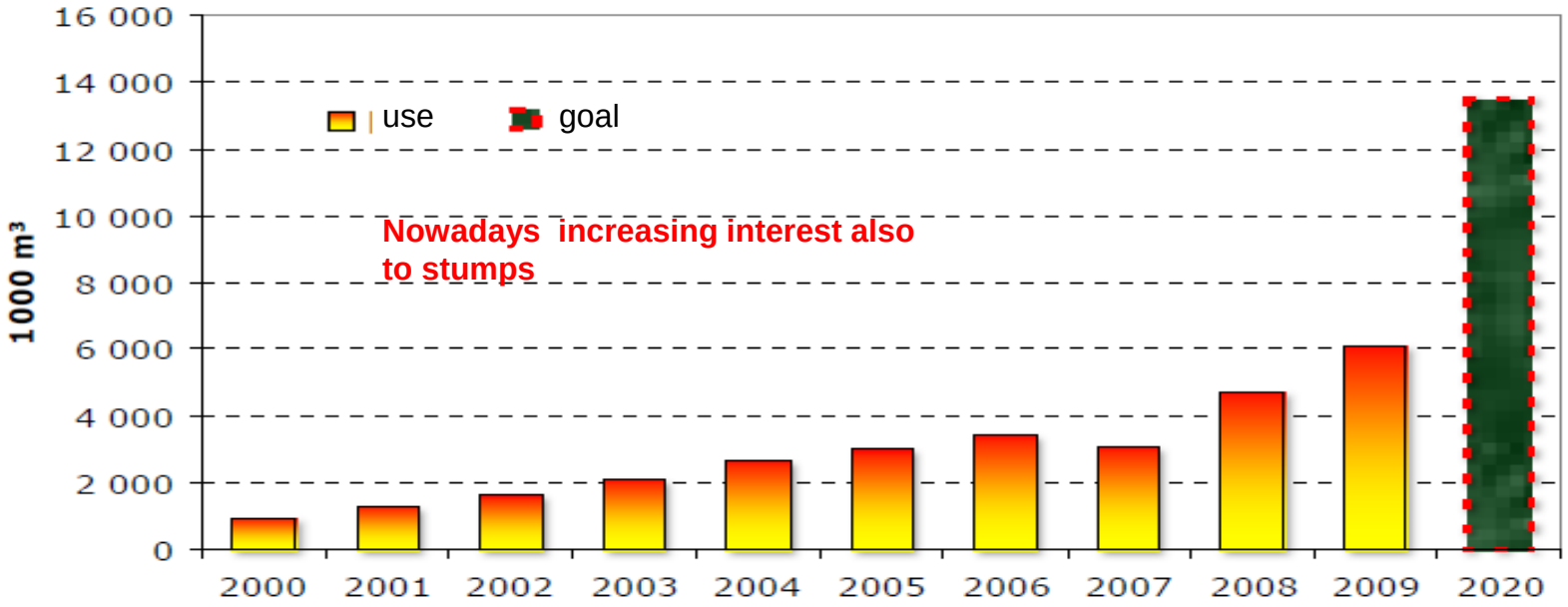
**In all European countries harvesting forest biomass from different sources and for different purposes is strongly increasing**

**In a country like Finland we have good raw wood resources → good possibilities to increase forest biomass use also for energy**

**The total use of forest chips 2000 – 2009 and the goal of use by 2020 (Finland)**




Source: Metla, Forest Statistics Information Service 2010

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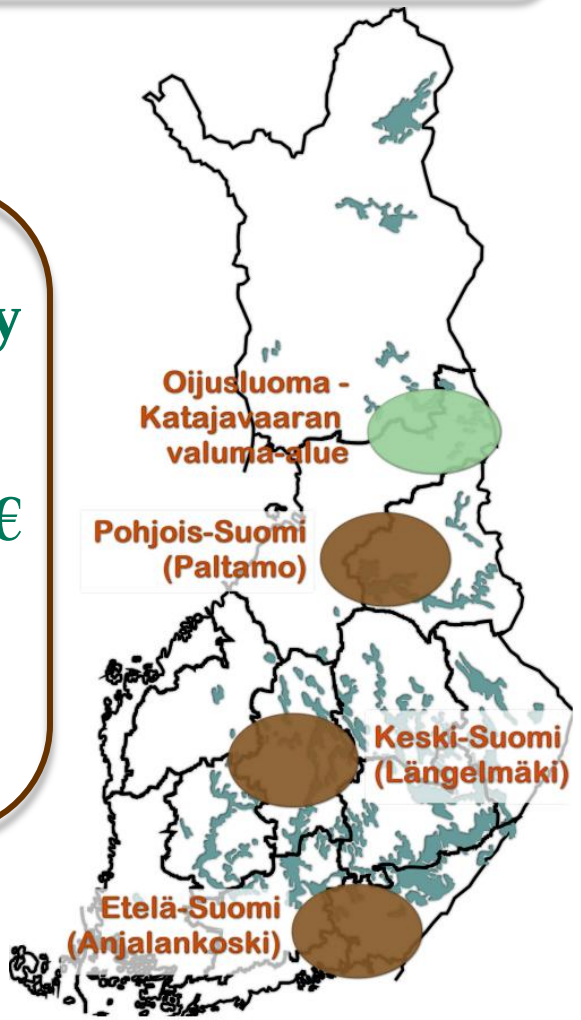
# New project on stump harvesting in Metla (Finnish Forest Research Institute) 2007-2013

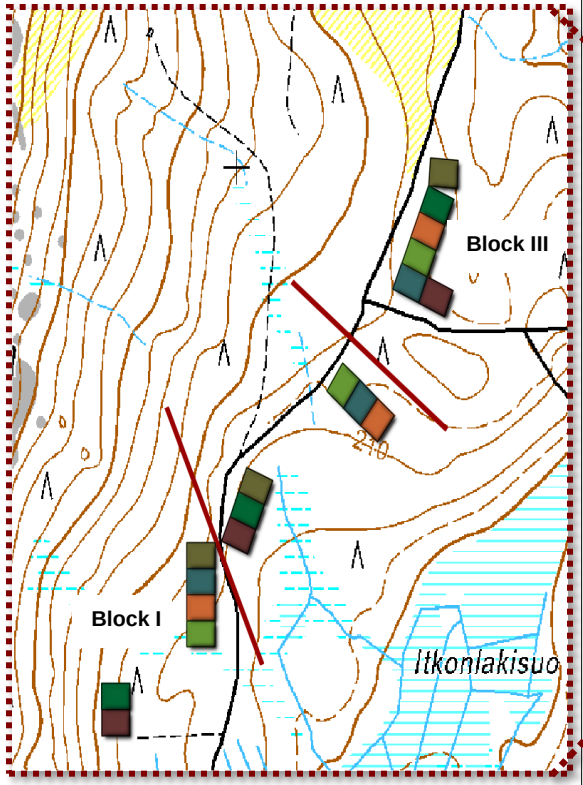
- ✓ **Objective: New information for forestry practice and policy makers**
- ✓ **Annual budget about 160 000 – 210 000 €**
- ✓ **Financed by the Ministry of Agriculture and Forestry and Metla**

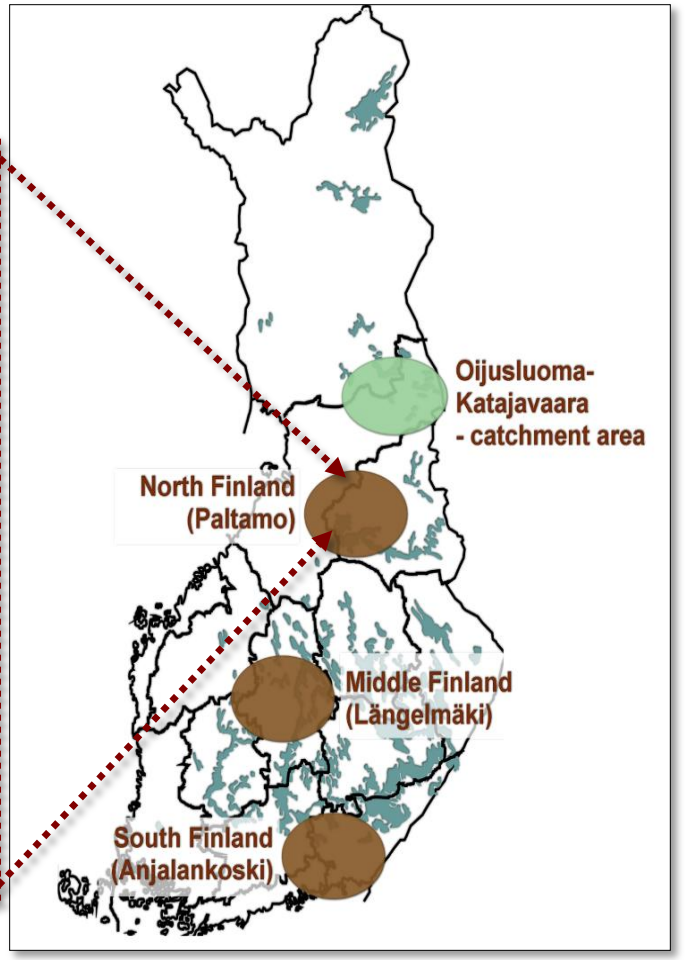


Stumps for transport to heat power plant

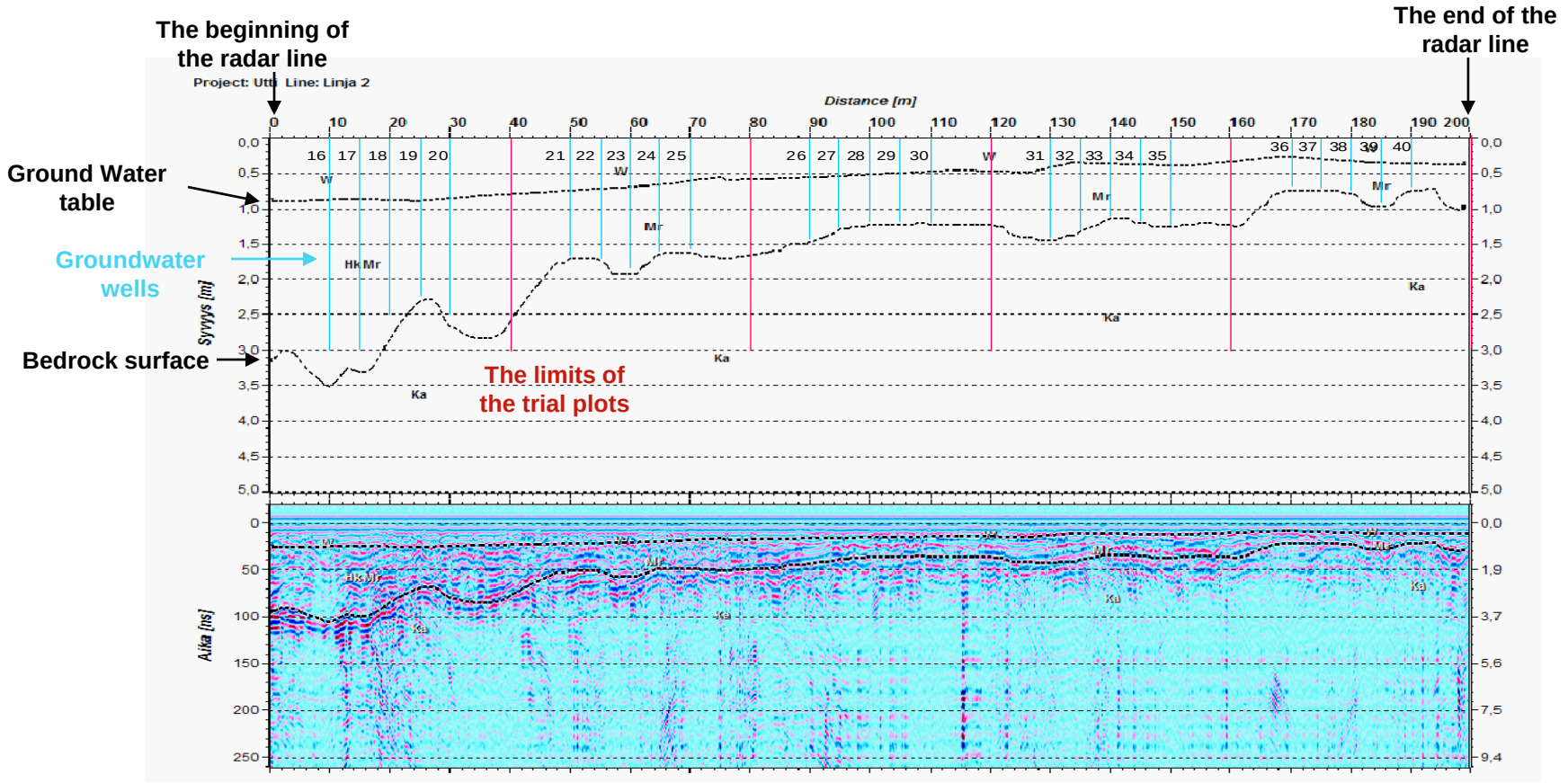
# Project layout

- Uncut forest
- Clearcutting
- Clearcutting + scalp mounding + spruce planting
- Clearcutting + scalp mounding + collected 70 % of logging residue + spruce planting
- Clearcutting + scalp mounding + collected 70 % of logging residue + stump removal, left 25 stump/ha + spruce planting
- Clearcutting + scalp mounding + collected 100 % of logging residure + stump removal, 100 % + spruce planting

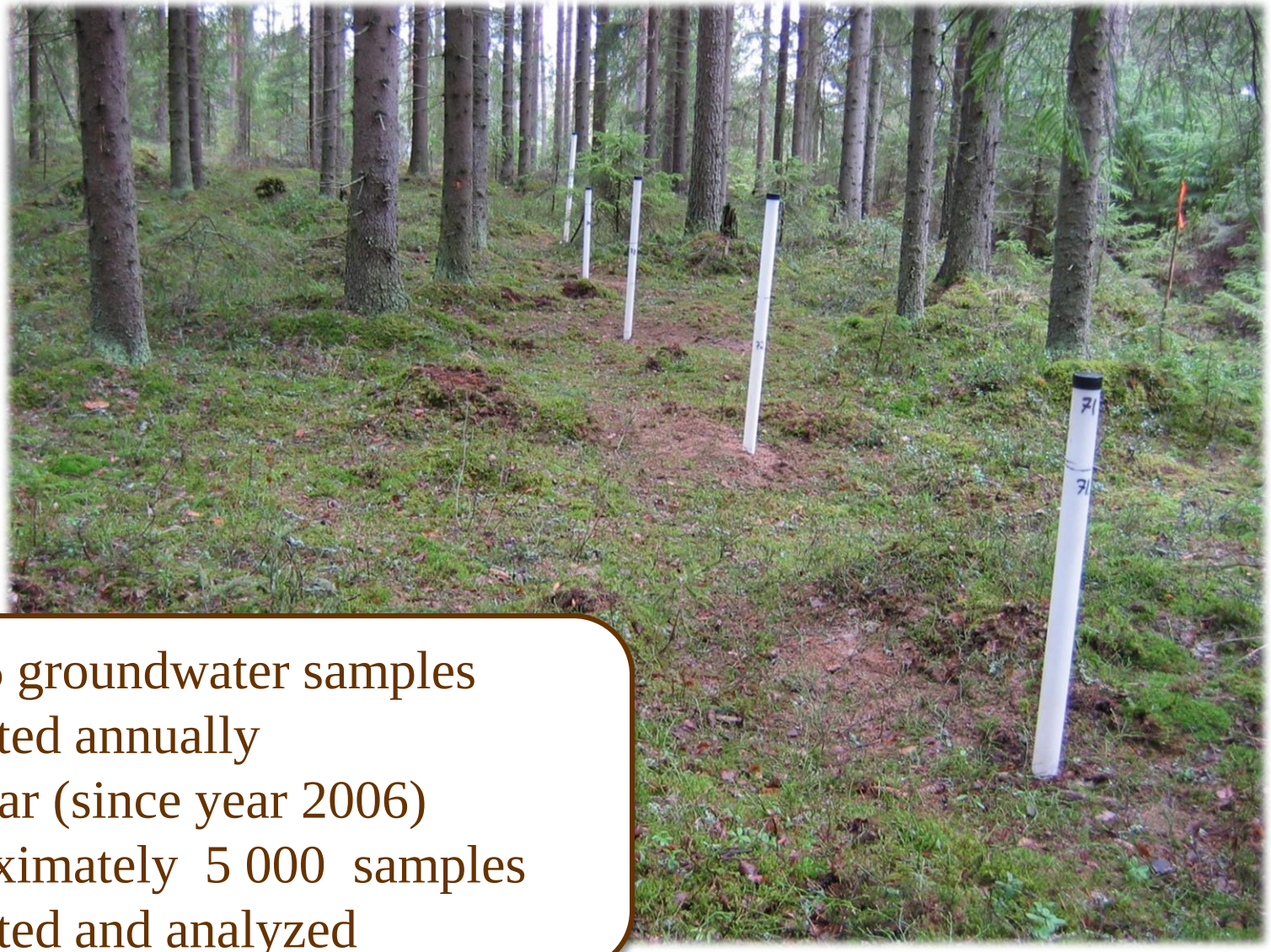


# At firts research areas were selected after scanning of groundwater table with radar




Radar makes possible to distinguish different layers of soil, the level of water table, the segmentation of the material in the area, the roughness of the soil type and often also the bedrock surface.



- ✓ 996 groundwater samples collected annually
- ✓So far (since year 2006) approximately 5 000 samples collected and analyzed

# Field work in stump harvesting study areas

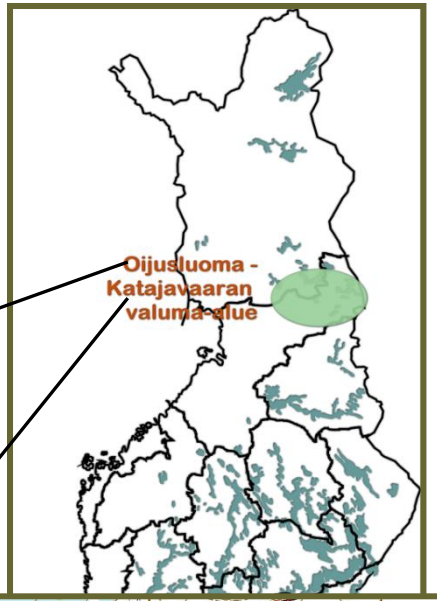
Uncut forest

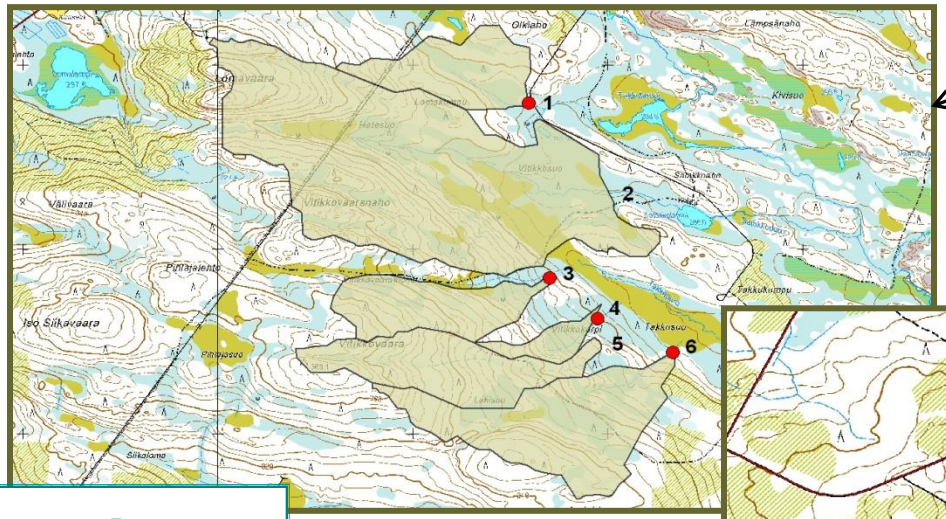
Clear-cutting

Harvesting of logging residue

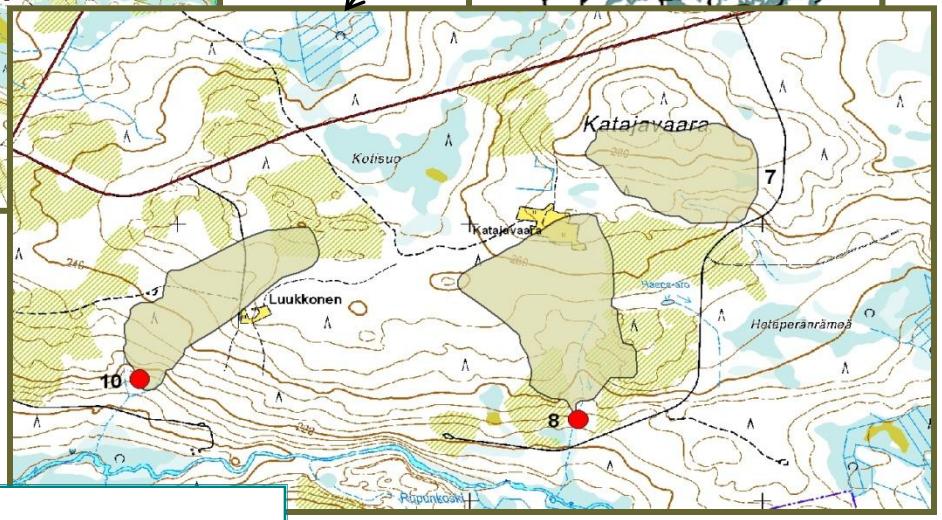
Stump removal

# Catchment areas




Oijusluoma




Katajavaara

# Researh group

## Reseach

- Project leader Eero Kubin, groundwater
- Professor, Dr Anne Tolvanen, plant succession
- Professor, Dr Hannu Ilvesniemi, carbon flow
- Senior scientist, Dr Eila Tillman-Sutela, seed and restocking
- Researcher, Dr Oili Tarvainen, mycorrhiza
- Senior scientist Dr Juha Piispanen, chemical analyses
- Senior researcher Dr Pekka Tamminen, soil water
- Assistant researcher, MSc (For.) student, Tanja Murto, carbon flow, restocking

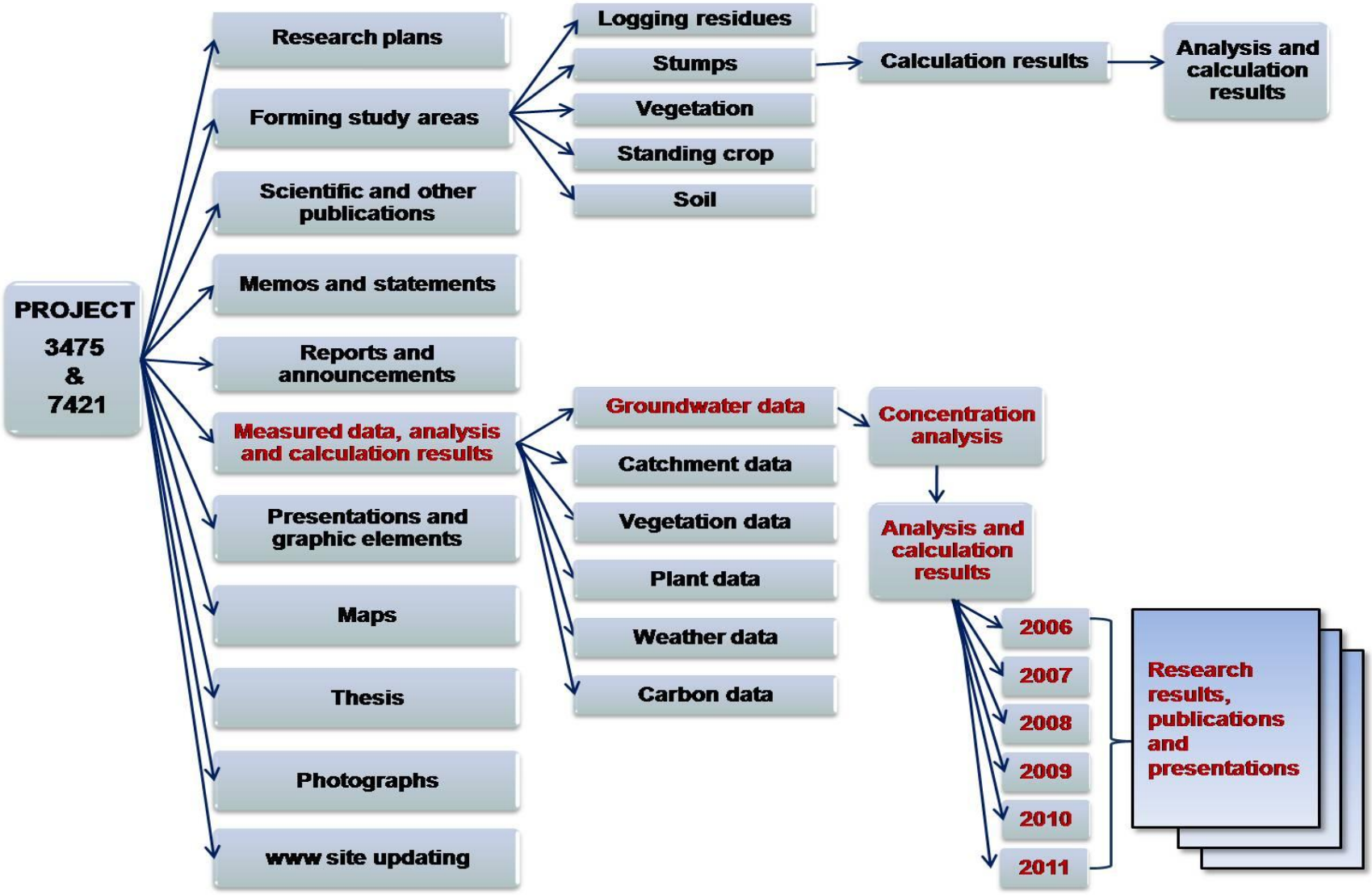
## Other staff

- Forestry engineer Jorma Pasanen
- Co-ordinator Ari Kokko
- Research assistant Reijo Seppänen
- Laboratory employees of Muhos Research Unit

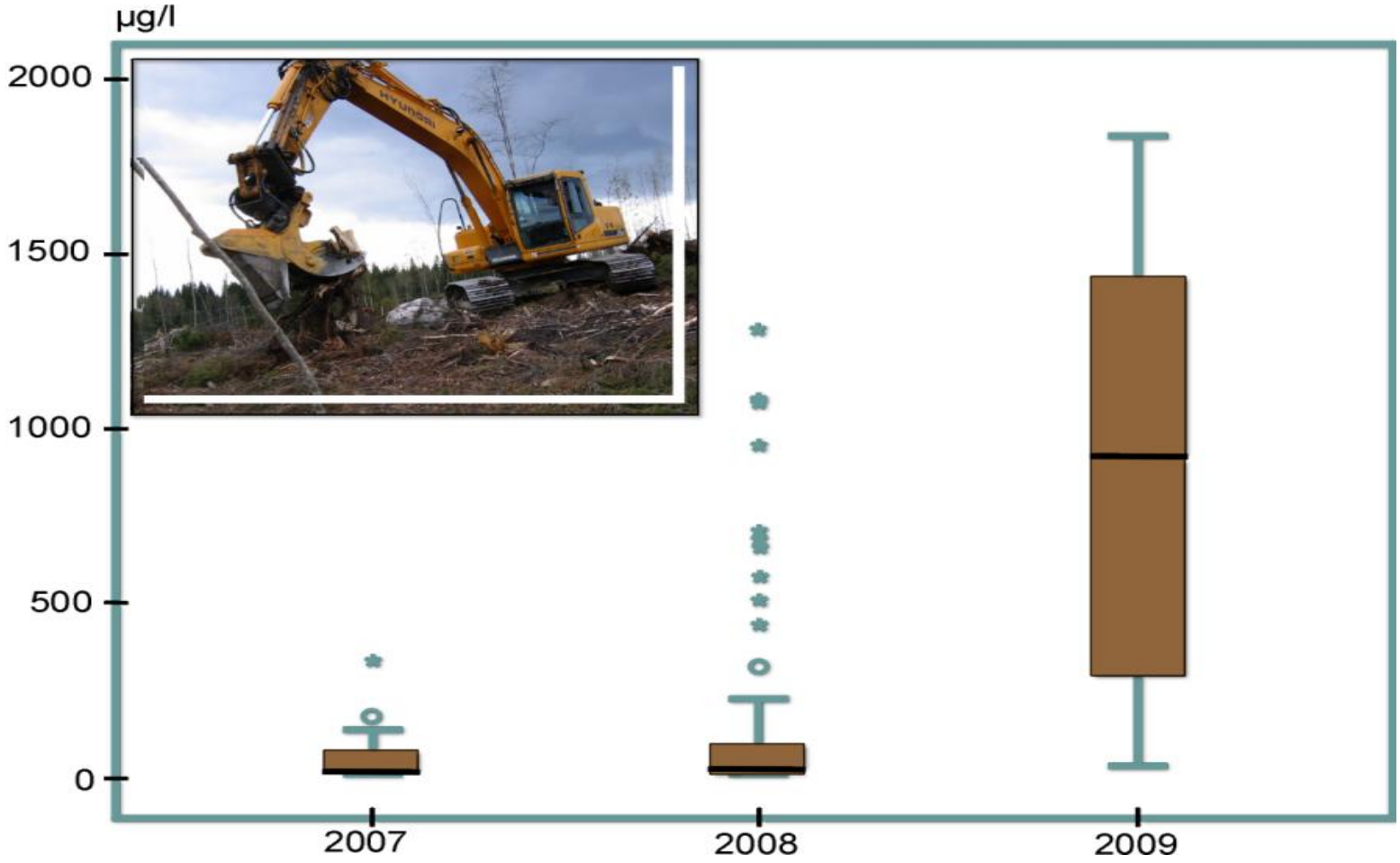
# Research in focus

- ✓ Nutrient cycle: groundwater, surface water, soil water
- ✓ Vegetation succession - plant species, abundance and recovery after disturbance
- ✓ Effect of whole tree and stumpharvesting on soil $CO_2$ respiration and carbon balance
- ✓ The stand development
- ✓ Microbiology

# Organization of data and metadata

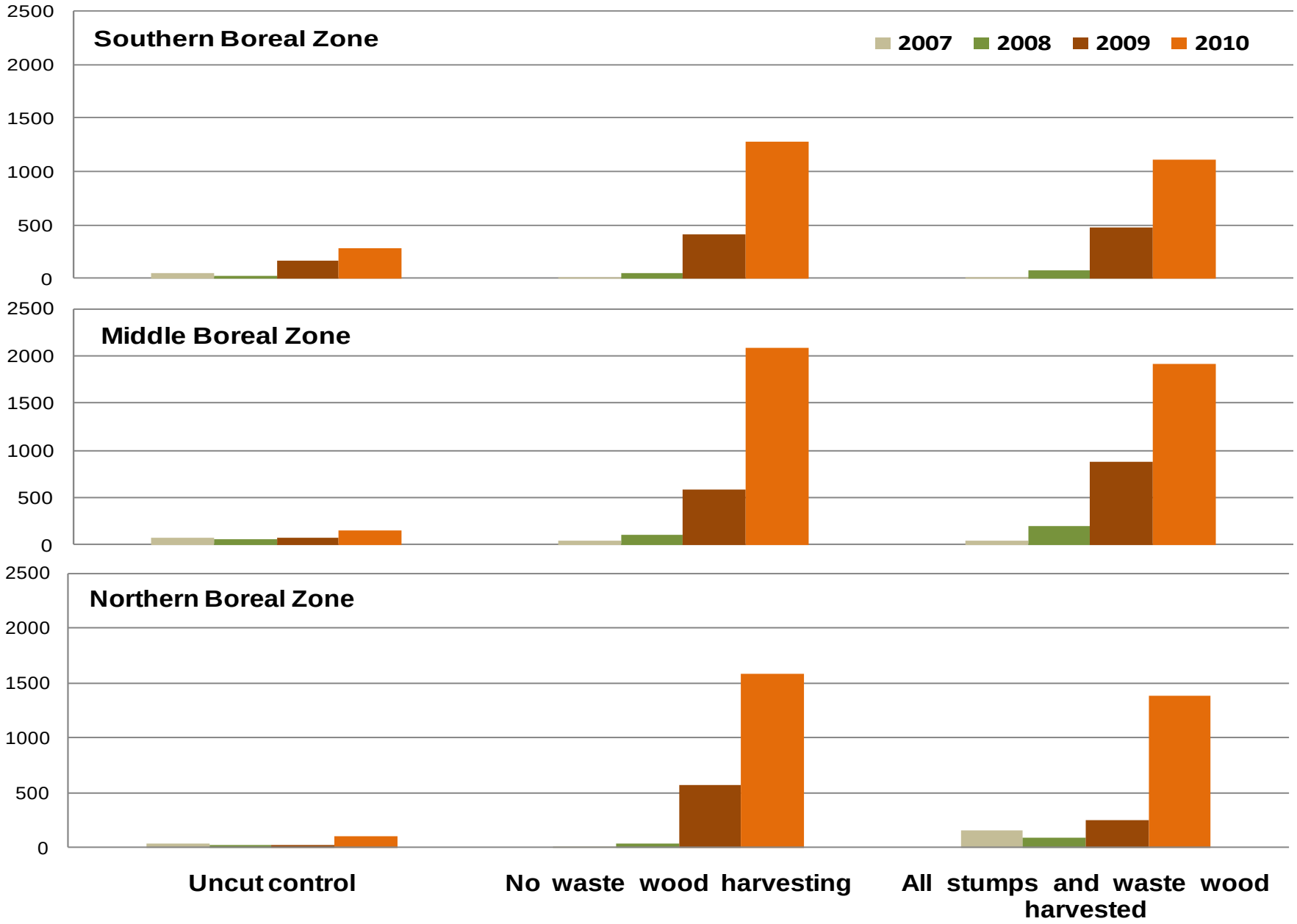


# Nitrate nitrogen is the most essential nutrient among studied 17 elements: Example from the Middle Boreal Zone

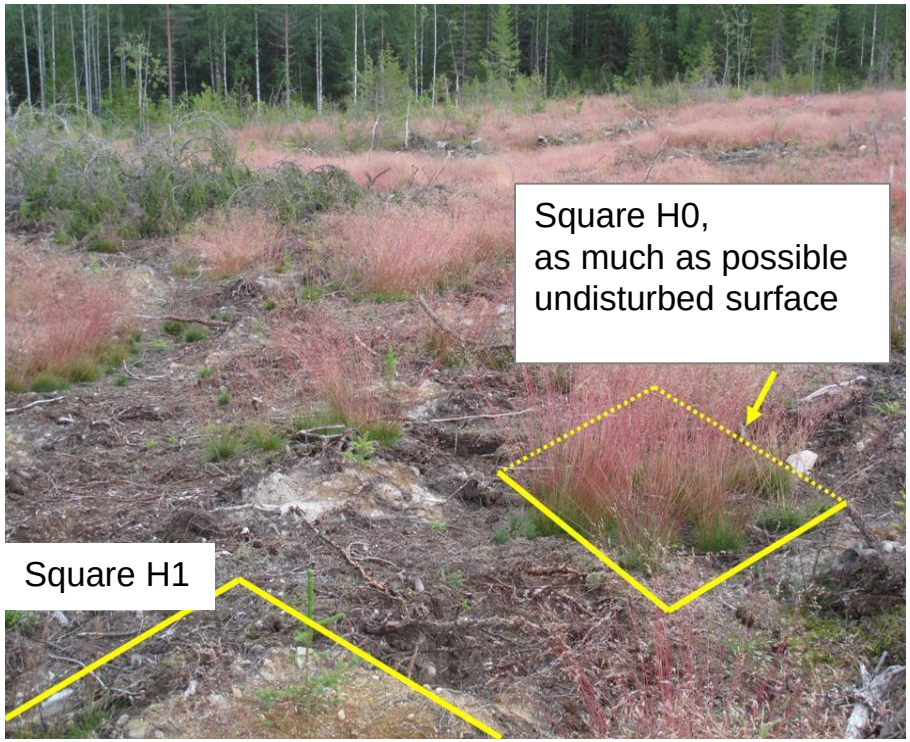


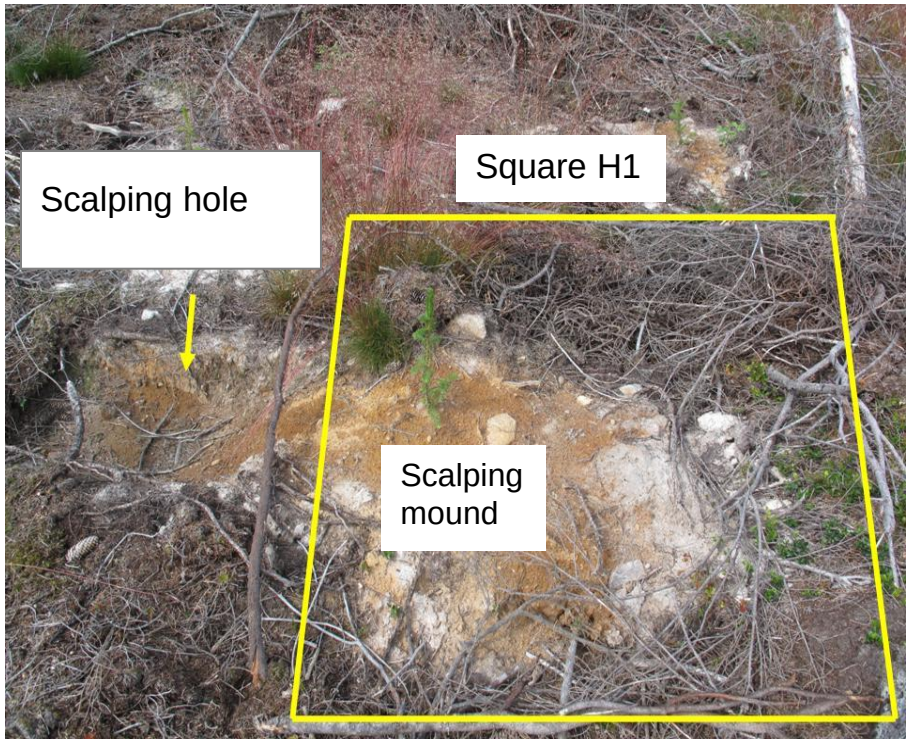

**All stumps and logging residues were harvested**

# Nitrate µg/l


Southern Boreal Zone
2007
2008
2009
2010
2500
2000
1500
1000
500
0
Middle Boreal Zone
Northern Boreal Zone
Uncut control
No waste wood harvesting
All stumps and waste wood harvested

# Recovery of ground vegetation is the first step to prevent leaching and protect groundwater quality

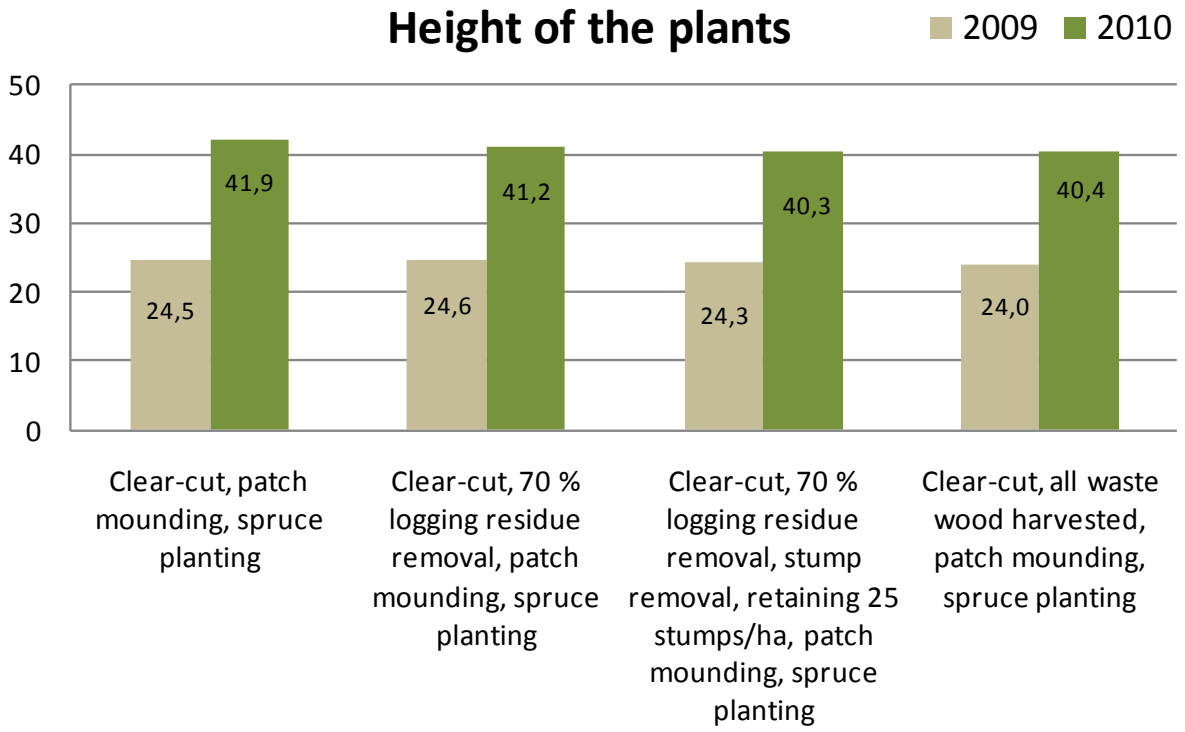



Experimental plots of vegetation inventory

# Research area three years after stump harvesting, Southern Boreal Zone

# Rapid reforestation prevents also leaching and is important step back to forest ecosystem



## Example from earlier study

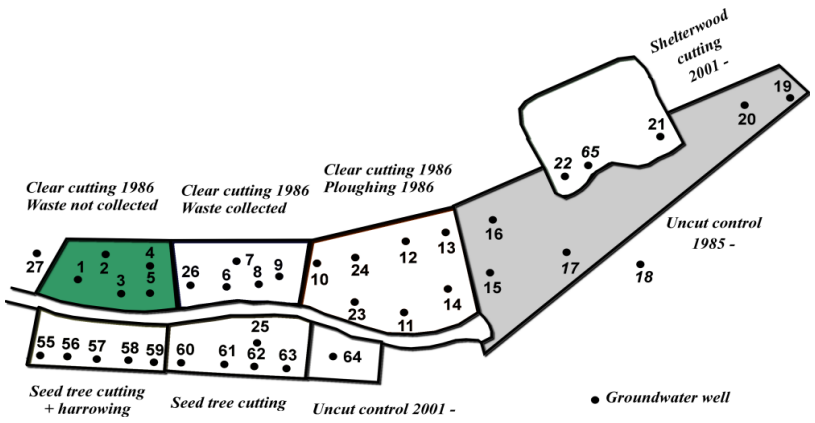
✓Before present stump harvesting research the effect of clear-cutting to groundwater quality has been studied since 1985

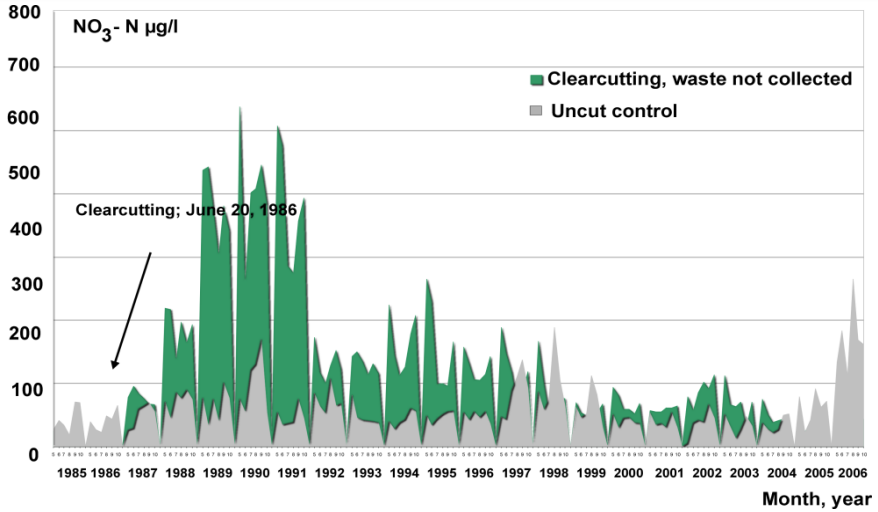
✓ Altogether thousands of samples were analyzed and groundwater table followed

✓ The next slides; examples

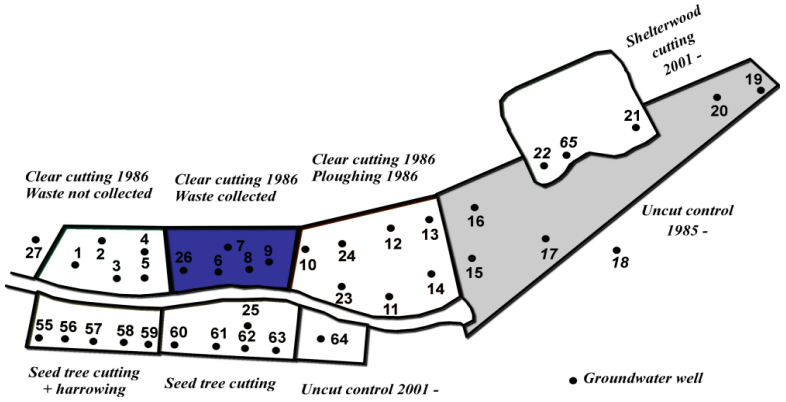
# Example of nitrate nitrogen leaching into groundwater in Pahalouhi 1985 - 2006

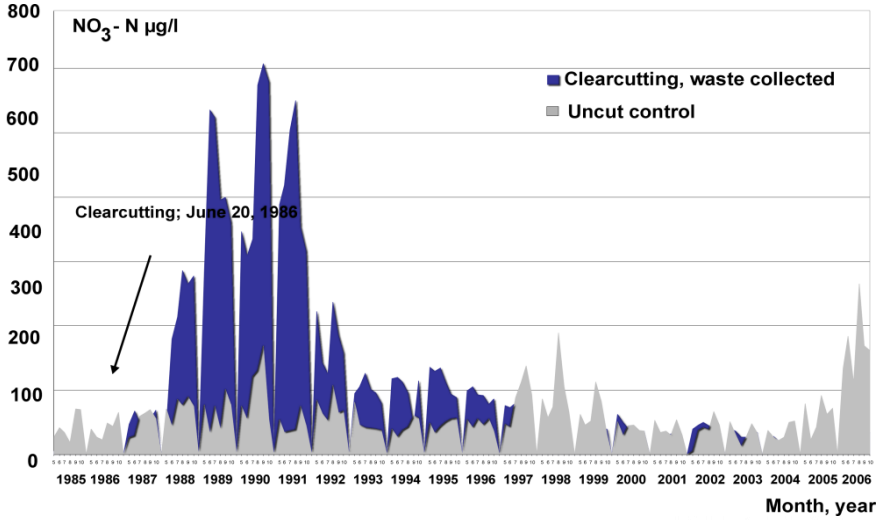
## Waste wood left




## Waste wood harvested



# The effects of tree layers were studied since 2002

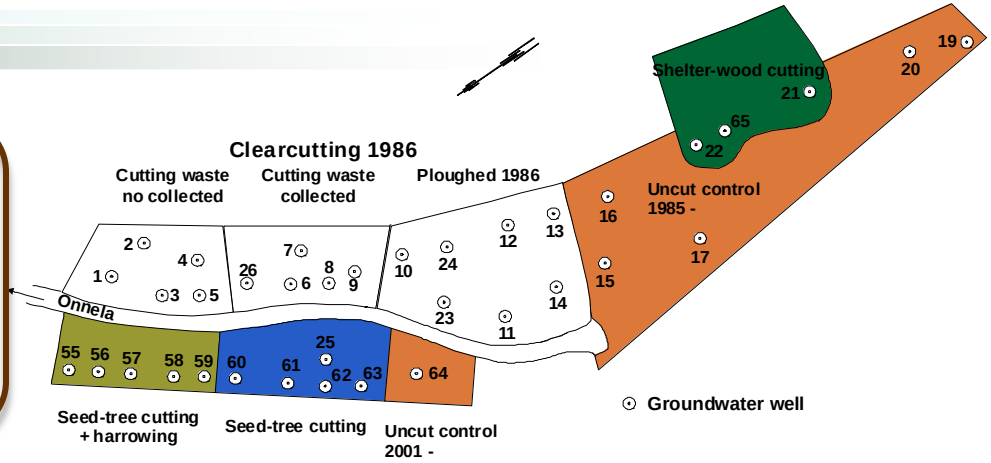
No felling

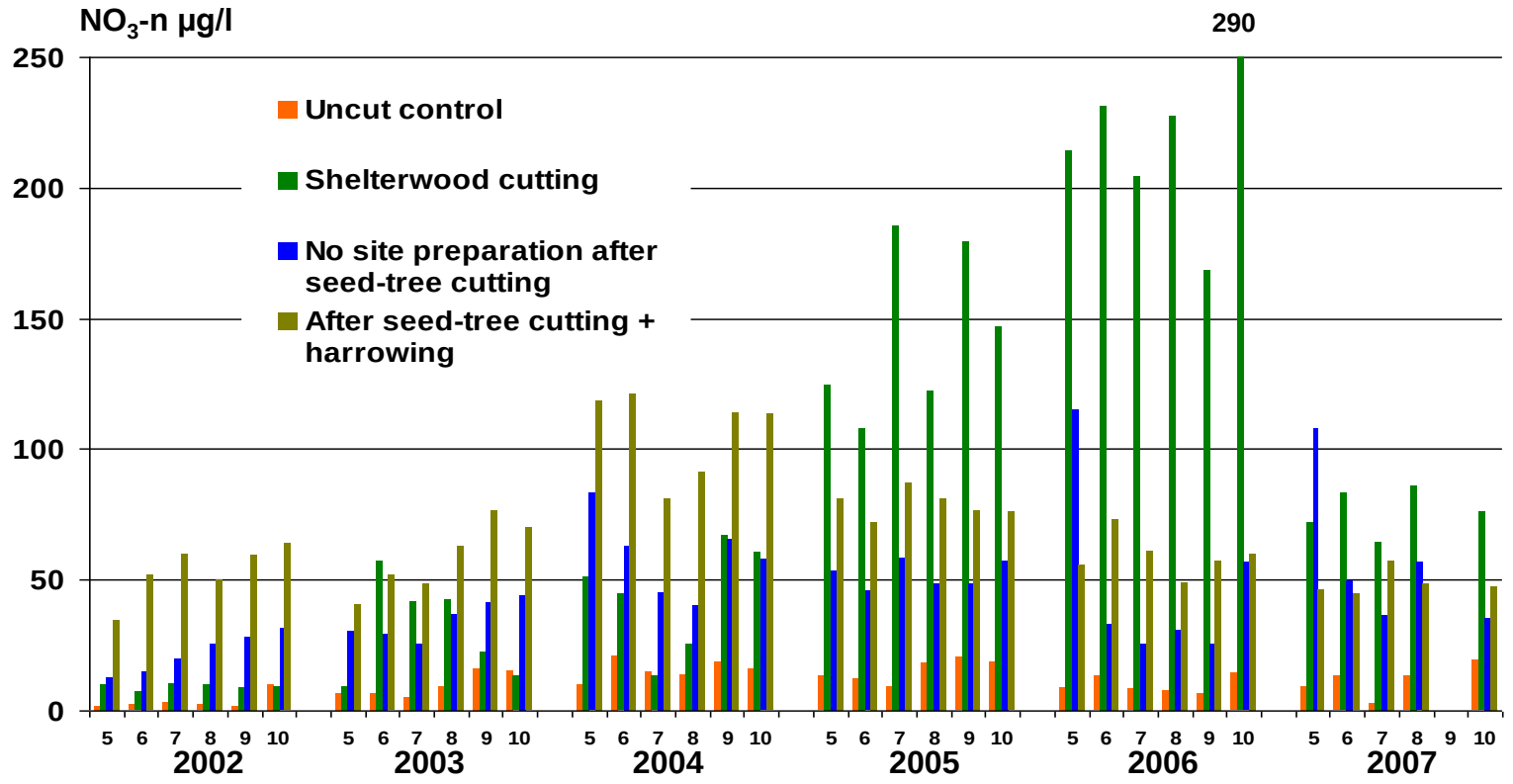
Seed tree cutting, pine

Clear-cutting

Spruce shelterwood

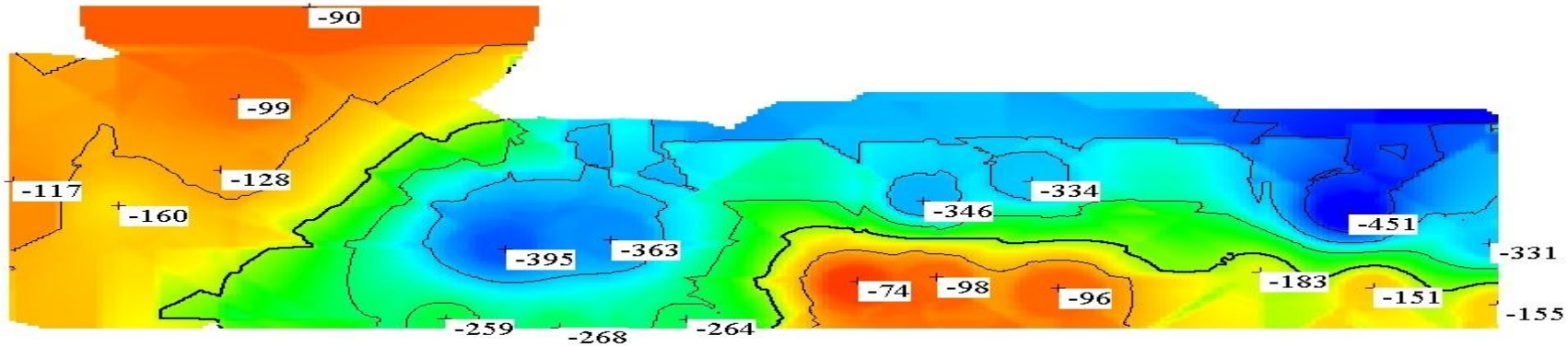
Vegetation, especially tree layer, has an important role in groundwater quality



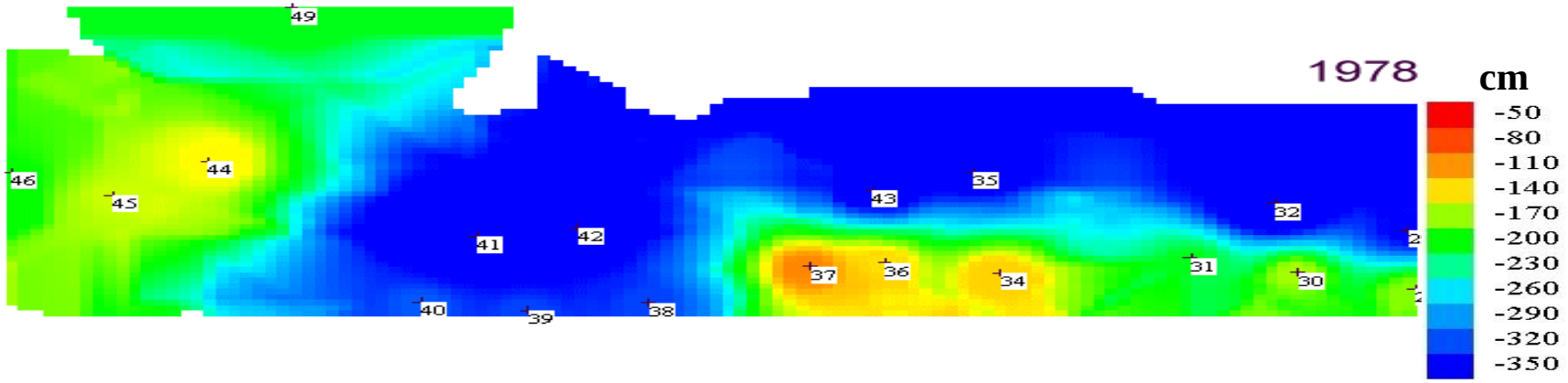



# Groundwater table varies from year to year

Mean depth of groundwater in Hautala experimental field 1978 - 2004




Animation: Annual groundwater depth in 1978 - 2004



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# Conclusions

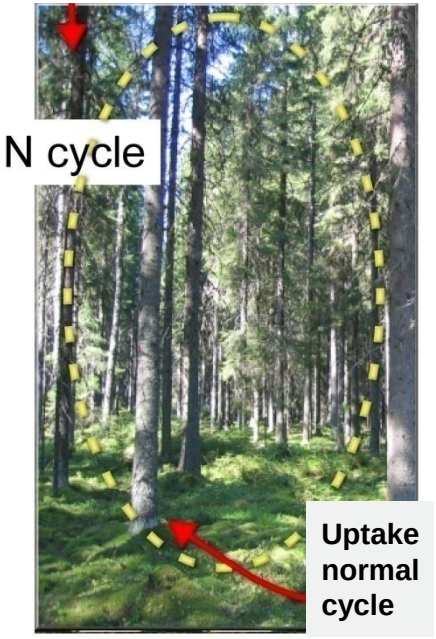
- ✓ Nitrogen leaching is increasing after cutting and harvesting. Maximum, however, in Kivesvaara study site is about 1-2 mg/l. Limit value for drinking water is 25 mg/l
- ✓ Re-vegetation and stocking have important role to minimize nitrogen leaching after clearcutting
- ✓ Nitrogen cycle in changing environment and intensive biomass harvesting needs more research, especially long term monitoring and catchment base study
- ✓ Generally, forest clear-cut has been supposed to be a drastic treatment to the environment. However it is evident that there is differences and the recovery might be – depending on site - relatively fast

# Thank you for your attention!

# Nitrogen cycling in changing environment is not fully understood

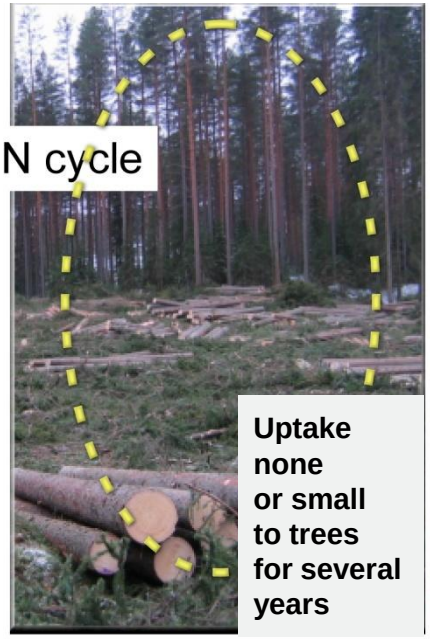
What are the effects of climate change and whole tree harvest with lifting stumps?

**Natural stand**
**Deposition depends on site and location**




- Decomposition slow
- Raw humus accumulation
- Leaching small
- Biodiversity

**Conventional cutting**
**No Interception is missing**
**Deposition same above crown**




- Decomposition increases
- Leaching increases
- Output in harvested wood, not very significant
- $CO_2$-release not well known
- Biodiversity changes

**Whole tree harvesting**
**with lifting stumps.**
**No changes in deposition**


- Decomposition in micro environment??
- Leaching decreases?
- Output in whole tree harvesting significant!
- The effects are not well known
- Bioversity and groundwater?

**Skidding timber**
**on mountain forests**
**Erosion**

Slope effects on runoff