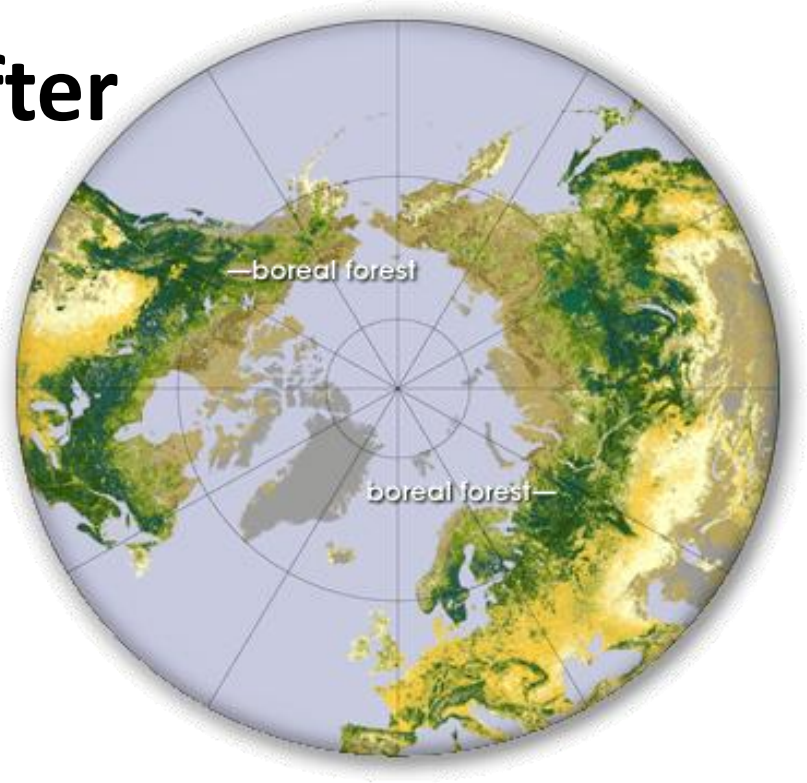
Water related changes after intensive boreal forest harvesting



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HydroPredict' 2012 Conference
23 - 27 September 2012
Vienna, Austria

Layout: Tuula Aspegren

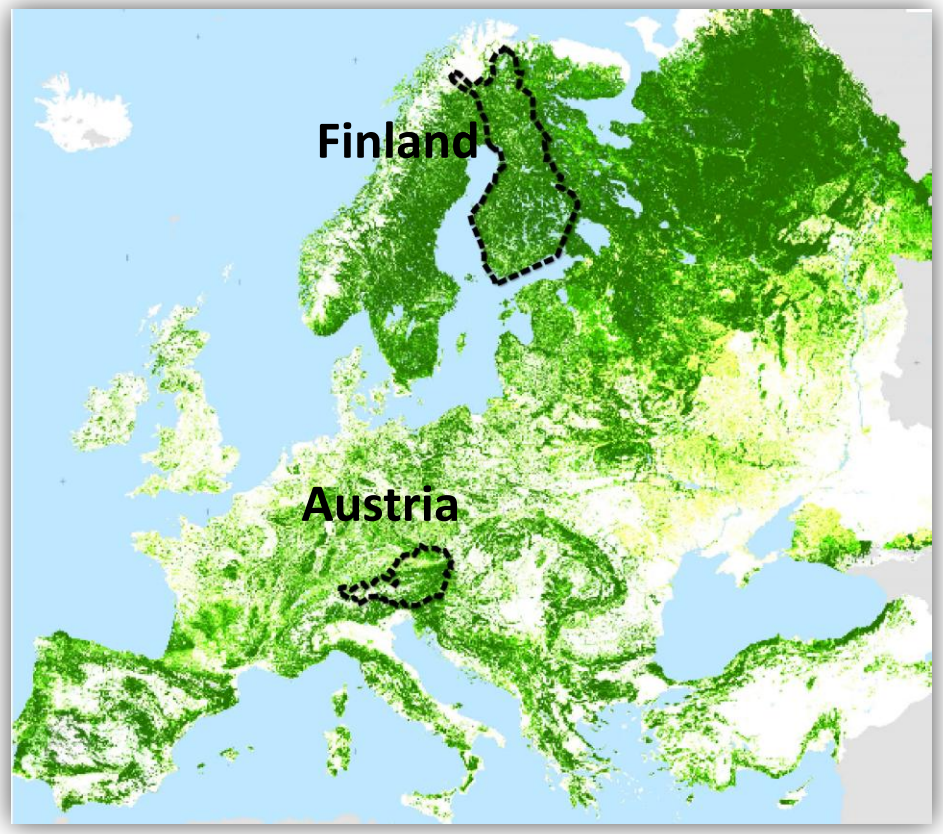
Perspective

Increasing forest biomass harvesting needs long term environmental research

Key words

- INTENSIVE WOOD HARVESTING
- RUNOFF AND GROUNDWATER MONITORING
- NITRATE LEACHING
- BOREAL FORESTS

European forest map

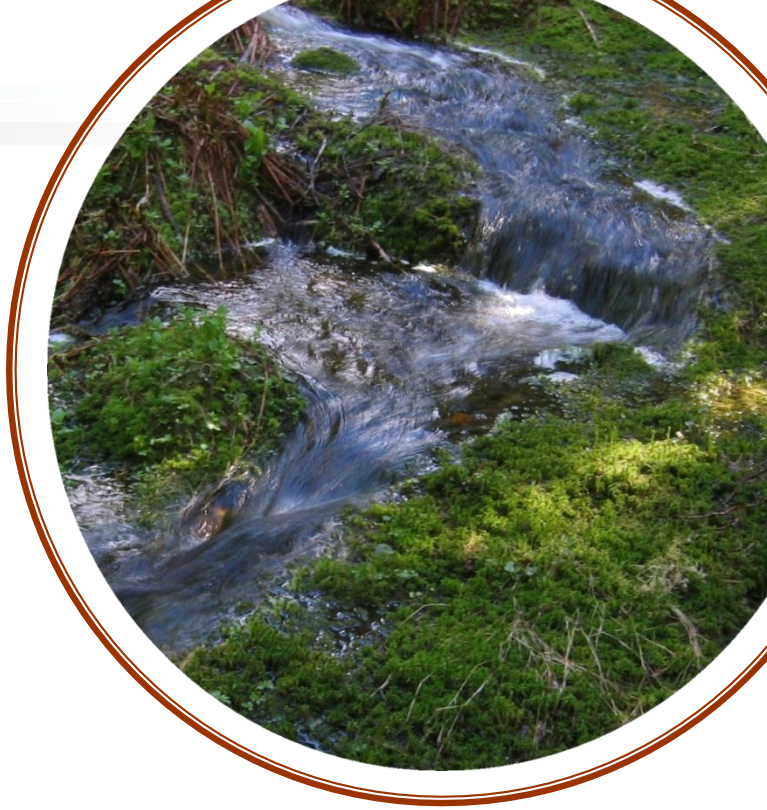


Source: (EFI) www.upm.com

In Finland the share of forested land area is the highest in Europe

According to the FAO it is 73 percent

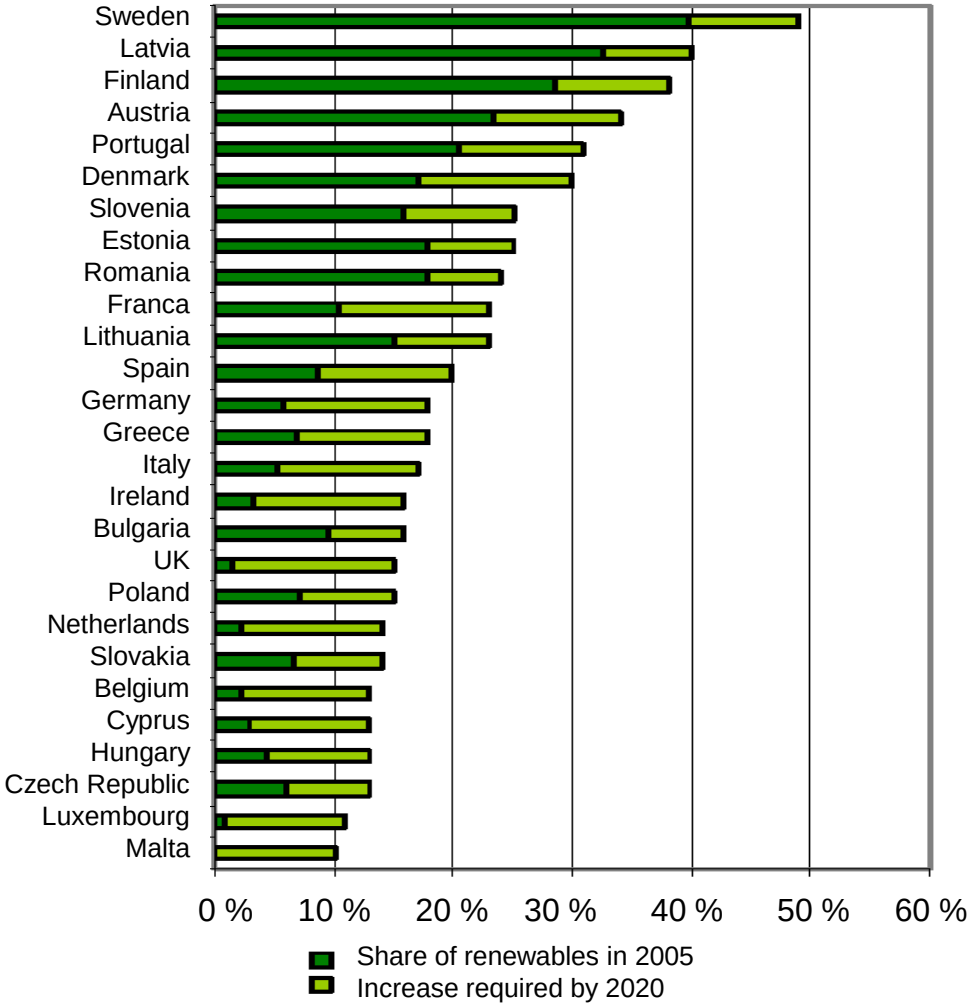
Finland belongs mainly to the Boreal Forest Zone



Content

1. **Utilization of forest biomass**
2. Water related forest regeneration research since 1974 in Finland
3. Hydrological effects of stump harvesting
4. Conclusions

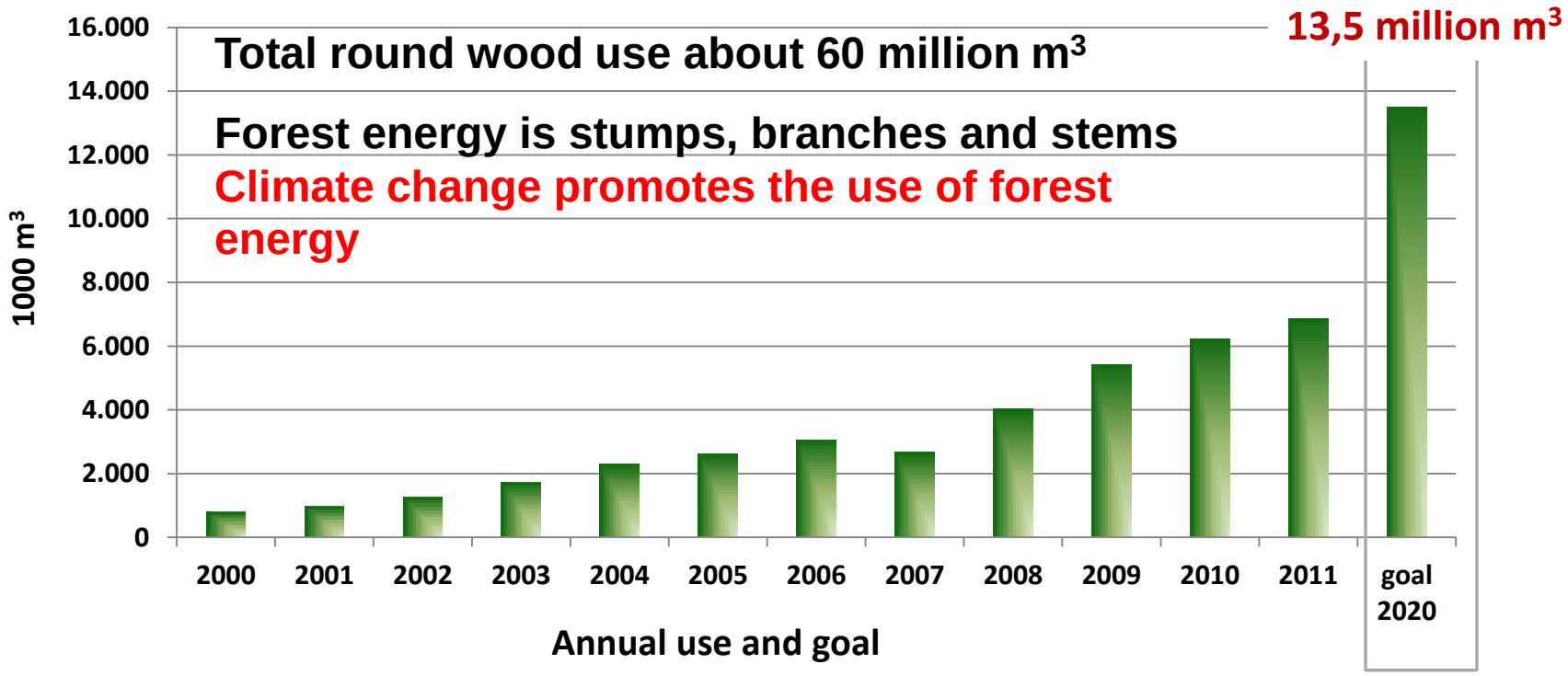
EU targets for renewable energy in 2020



Source: Renewables Directive (Directive 2009/28/EC 2009), 2009.

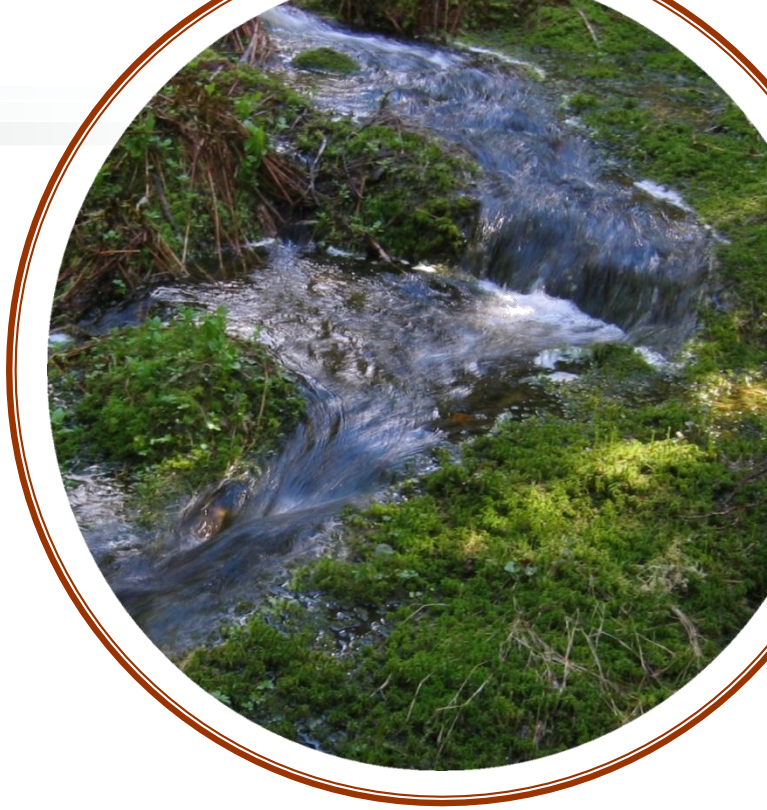
The goal of forest biomass energy use in Finland by 2020 and the total use 2000 – 2011

Source: Metla, Forest Statistics Information Service 2012



New forms to utilize raw wood material need better understanding

- how to maintain site fertility and biodiversity
- carbon dynamic in general
- how to protect water resources systems



Content

1. Utilization of forest biomass
2. **Water related forest regeneration research since 1974 in Finland**
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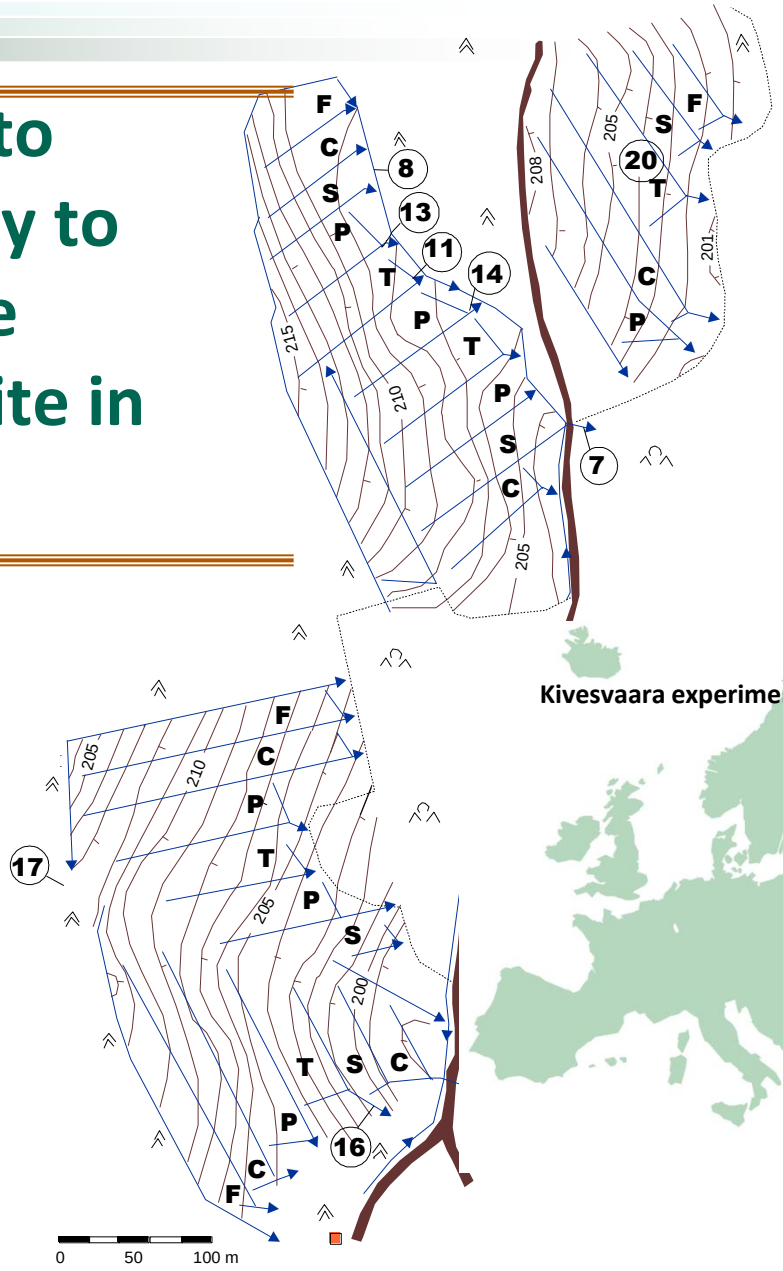
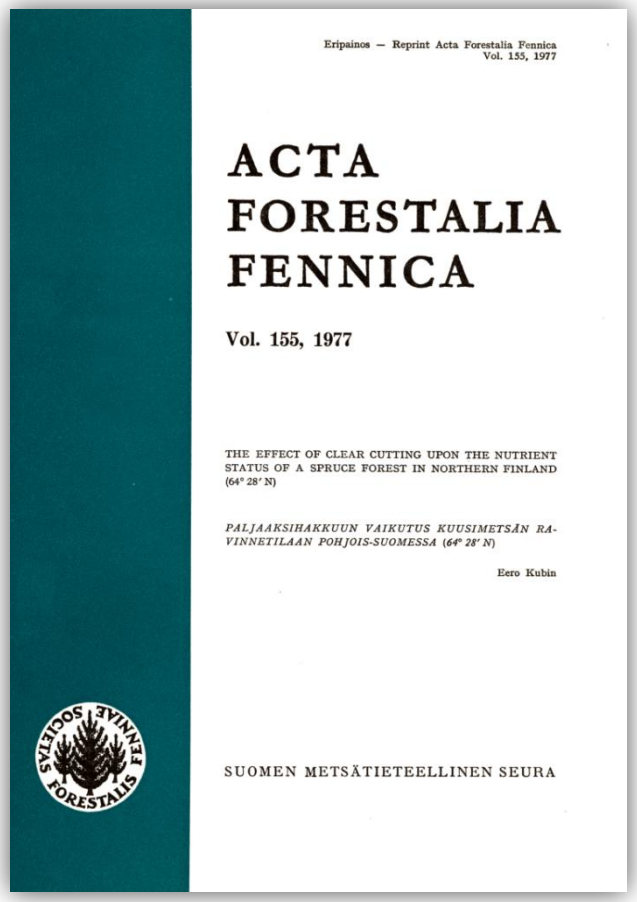
In Finland we first started to study the effects of forestry to runoff water quality at the Kivesvaara experimental site in 1974



- Forested strip
- No treatment after clear cutting
- Scalped strip
- Heavy reforestation plough
- Complete turning of the soil

- Spruce forest
- Pine stand (young)
- Boundary of forest sector
- Ditch and direction of flow
- Contour line
- Road
- Field laboratory
- Sampling point

To understand better nutrient leaching, harvested and waste wood were measured and analyzed what was the loss of nutrients in the stem wood and how much remain on the site



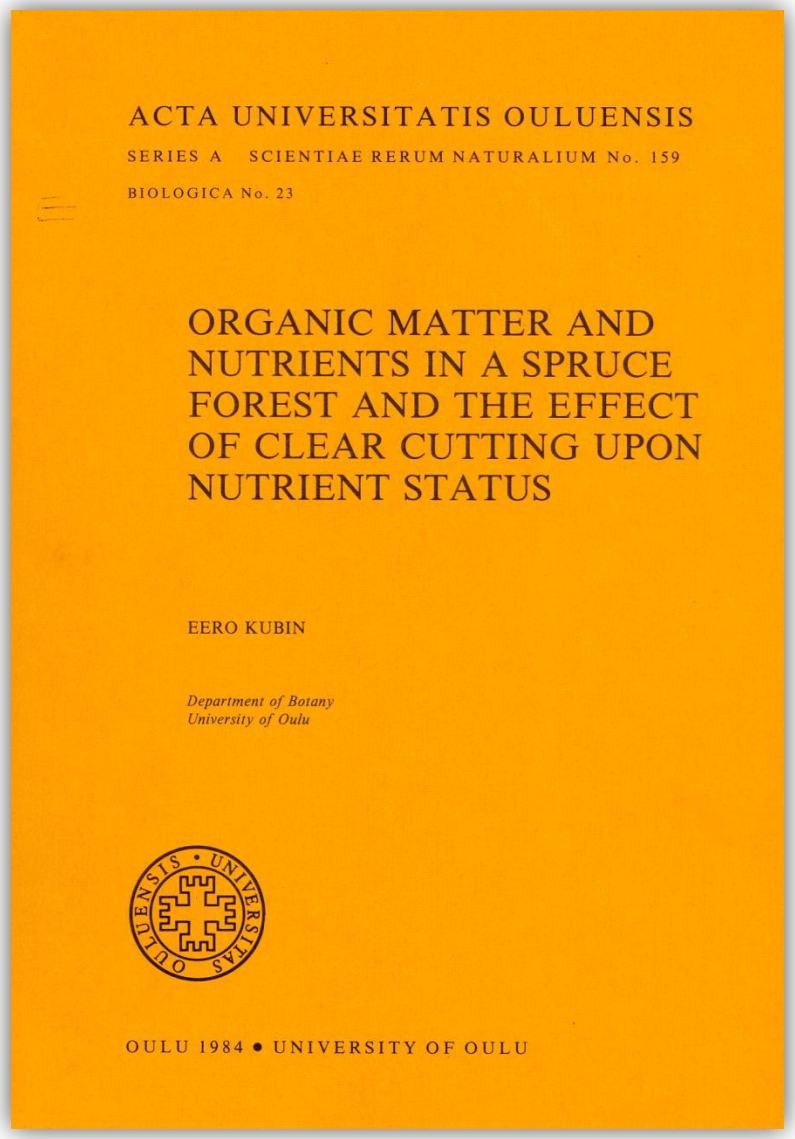
Harvested wood 49 tn

Waste wood 35 tn

Stumps 22 tn

All together 105 400 kg

Reseach was in 1884 extended to spruce stand structure, biomasses and nutrients



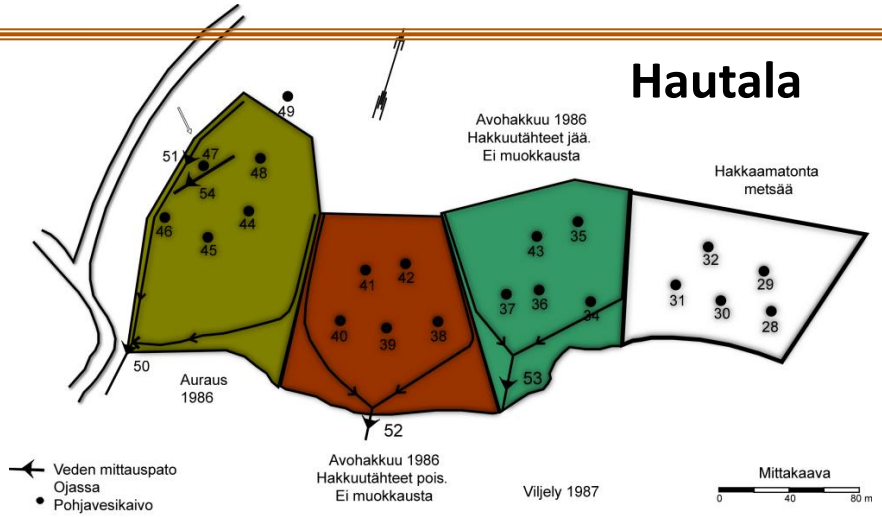
Structure of old spruce stand in northern Finland (66° 22' N, 29° 15' S)

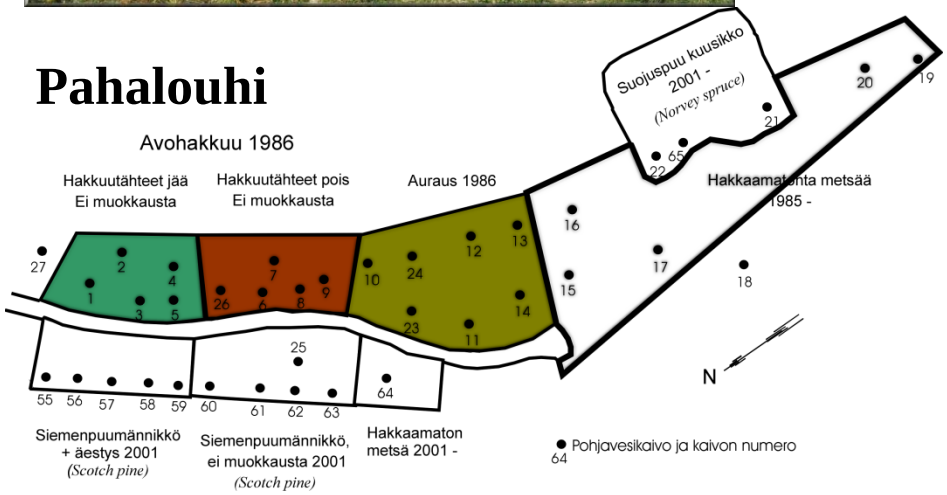
Based on the doctoral thesis by Eero Kubin 1984

			Biomass kg/ha	%	% of total
TREE LAYER					
	BRANCH SYSTEM	NEEDLES	6 600	5,5	
		LIVING BRANCHES	17 100	14,2	
		CONES	200	0,2	
		DEAD BRANCHES	4 100	3,4	
	EPIPHYTES	TOTAL BIOMASS	900	0,7	
	TRUNK	WOOD	56 600	47,0	
		BARK	10 700	8,9	
	BUSHES	TOTAL BIOMASS	100	0,1	
	ROOT SYSTEM	TOTAL BIOMASS	23 800	20,0	76
			120 100	100,0%	
GROUND-LAYER VEGETATION					
	DWARF SHRUBS	TOTAL BIOMASS	3 000	16,3	
	HERBS AND GRASSES	TOTAL BIOMASS	100	0,5	
	MOSSES	TOTAL BIOMASS	2 400	13,0	
	ROOT SYSTEMS	DWARF SHRUBS	12 300	66,9	
		HERBS AND GRASSES	600	3,3	12
			18 400	100,0%	
LITTER AND RAW HUMUS					
	LITTER	TOTAL AMOUNT	4 900	27,0	
	RAW HUMUS	TOTAL AMOUNT	13 500	73,0	12
			18 400	100,0%	
		All organic layers	156 900		100

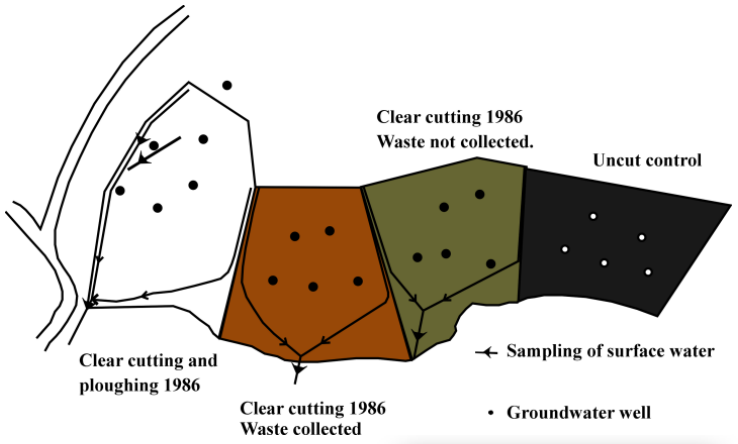
Source: Havas, P. & Kubin, E. 1983. Structure, growth and organic matter content in the vegetation cover of an old spruce forest in Northern Finland. Ann. Bot. Fennici 20(2): 115-149.

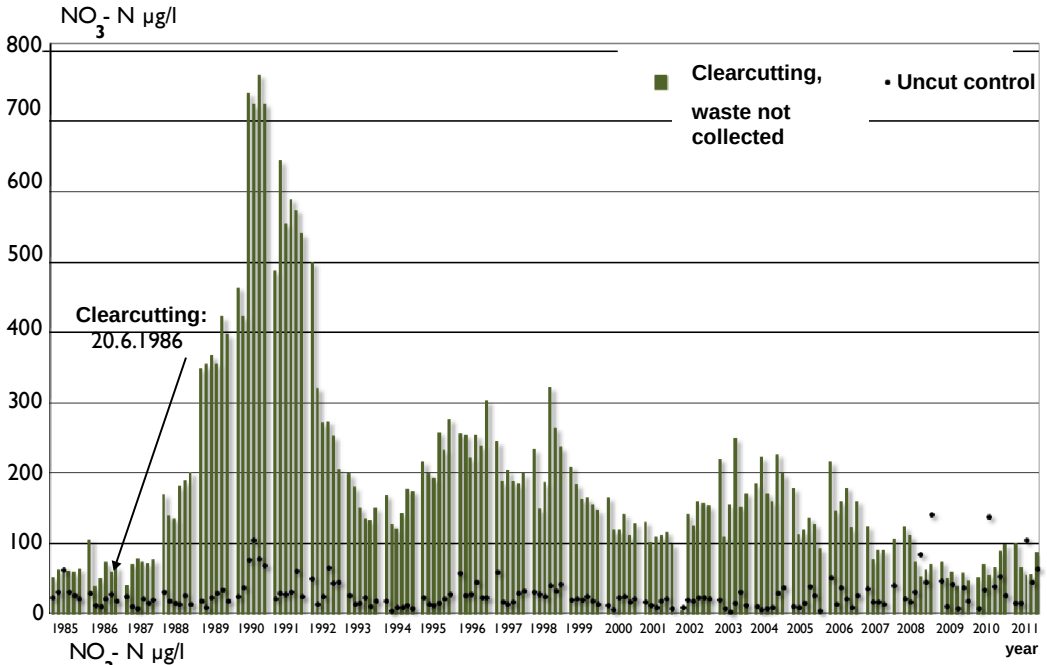
In 1985 research was then extended on groundwater quality after waste wood harvesting

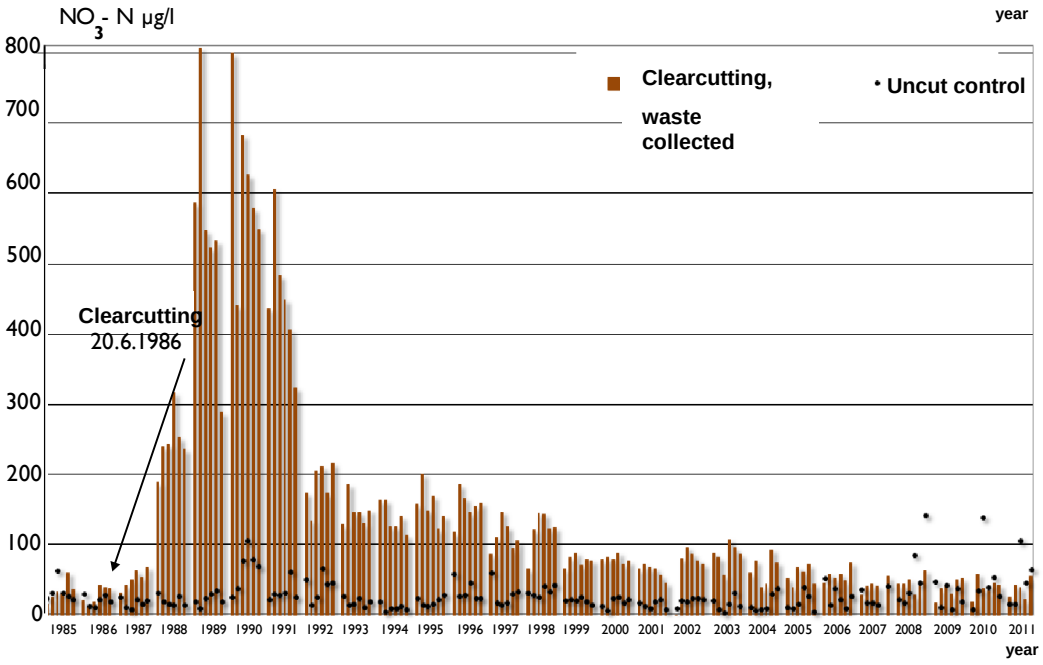




Example of groundwater quality monitoring: 26 years nitrate nitrogen

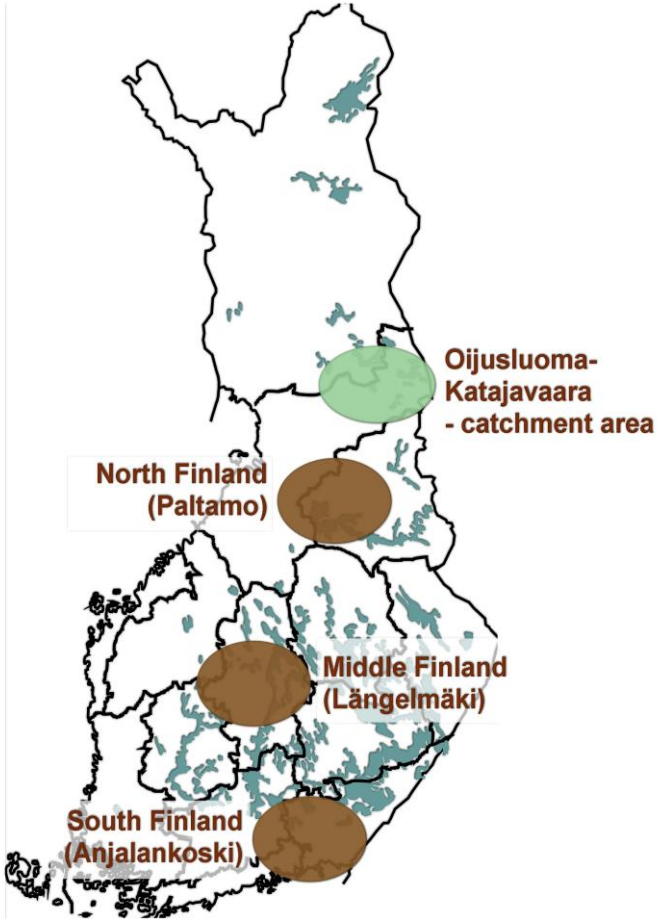




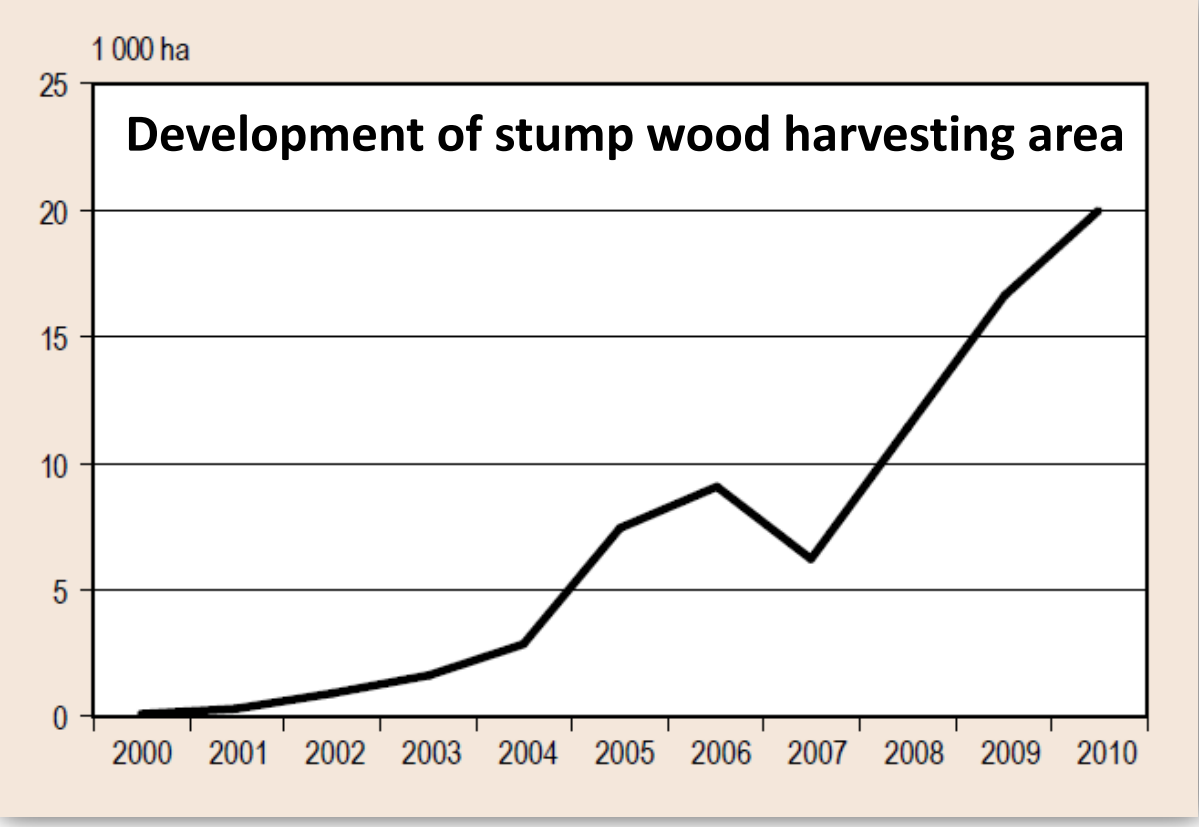


In 2007 studying the effects of stump harvesting on groundwater quality was the next step

- New research in Metla (Finnish Forest Research Institute)
- Financed also by the Ministry of Agriculture and Forestry
- New information for science, forestry practice and policy makers



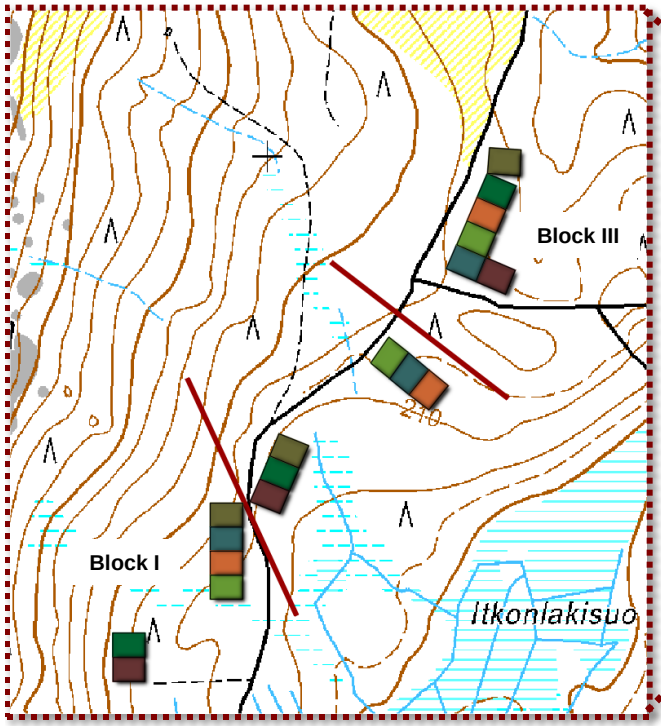
Stumps are the new source of energy

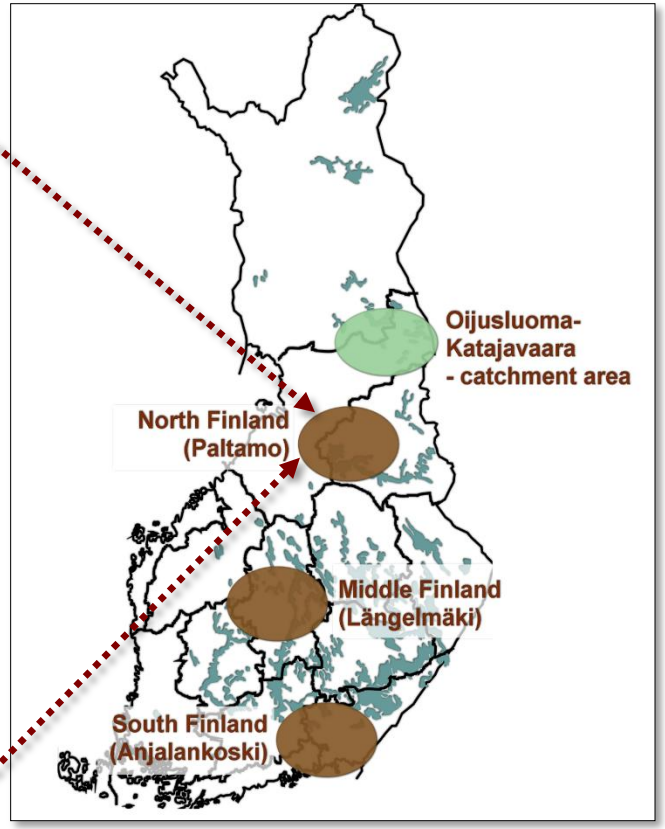


Computational stumps and root harvesting area based on consumption of forest stumps in 2000 - 2010

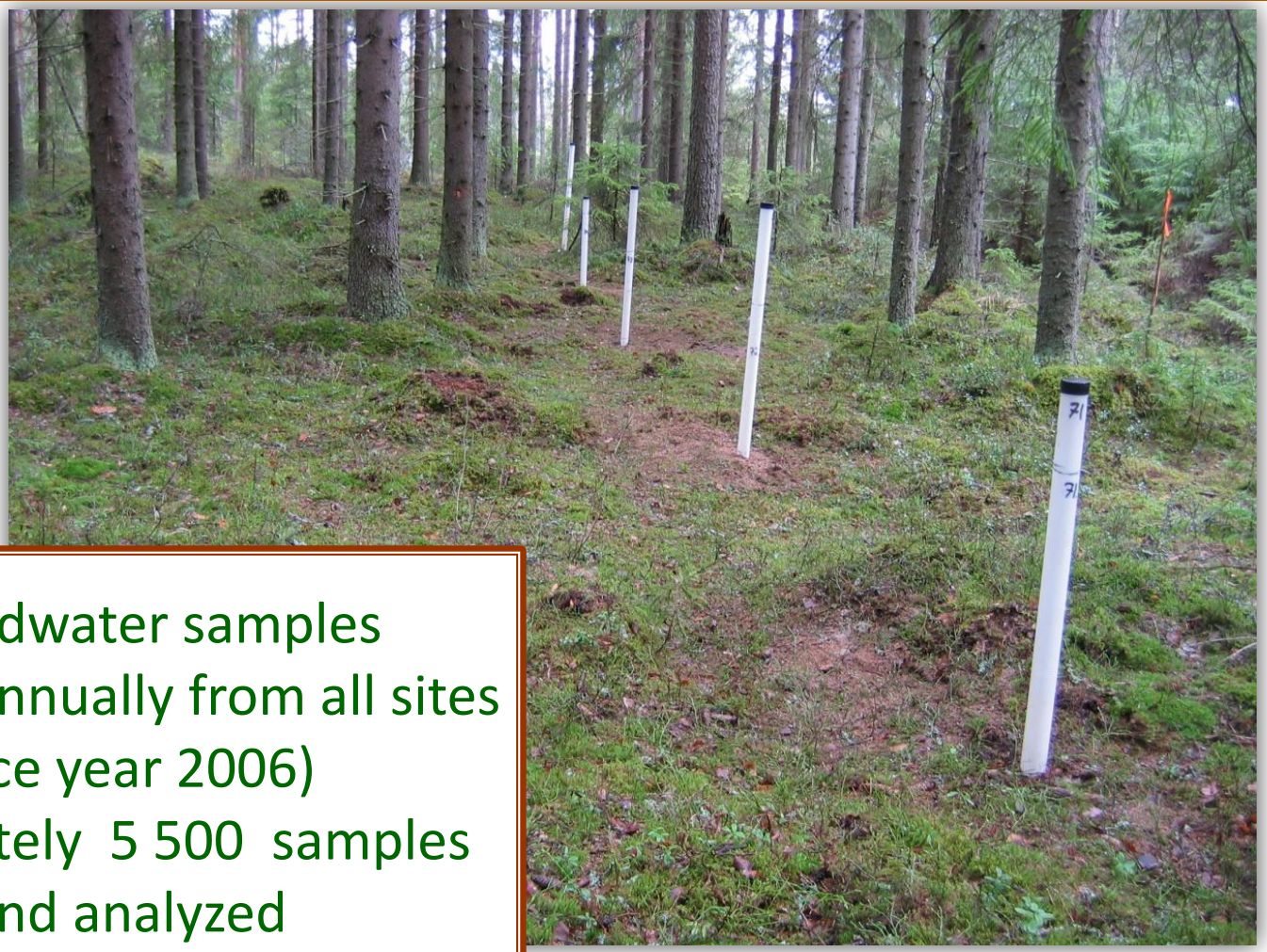
Groundwater research areas with stump harvesting

- Uncut control
- Clear-cut, no restocking
- Clear-cut, no waste wood harvesting, spruce planting
- Clear-cut, 70 % logging residue removal, spruce planting
- Clear-cut, 70 % logging residue removal, stump removal, retaining 25 stumps/ha, spruce planting
- Clear-cut, all stumps and waste wood harvested, spruce planting





Uncut control



- 747 groundwater samples collected annually from all sites
- So far (since year 2006) approximately 5 500 samples collected and analyzed

Actions in stump harvesting study sites

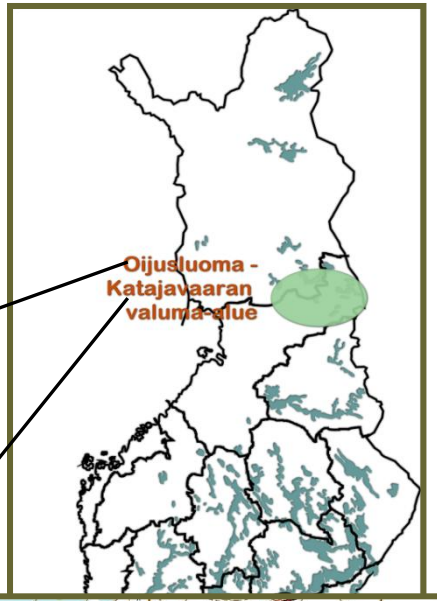
Uncut forest

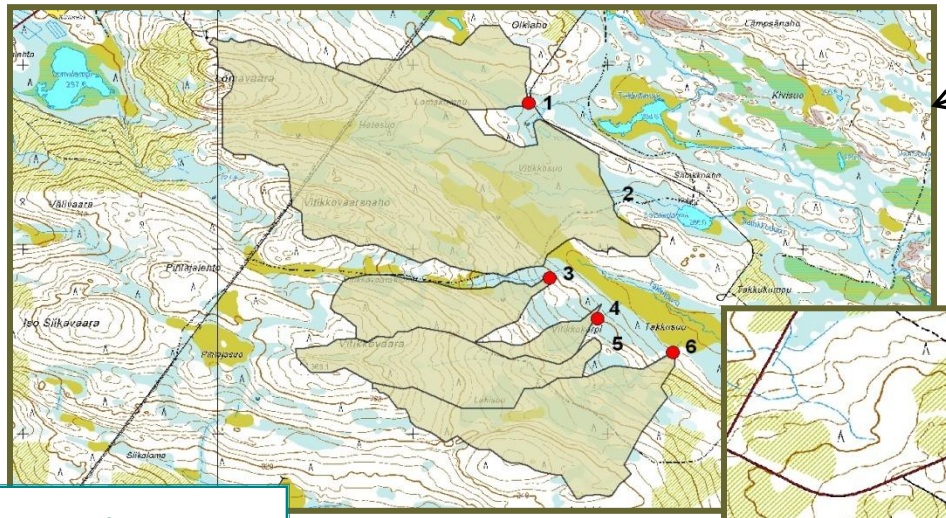
Clear cutting

Harvesting of logging residue

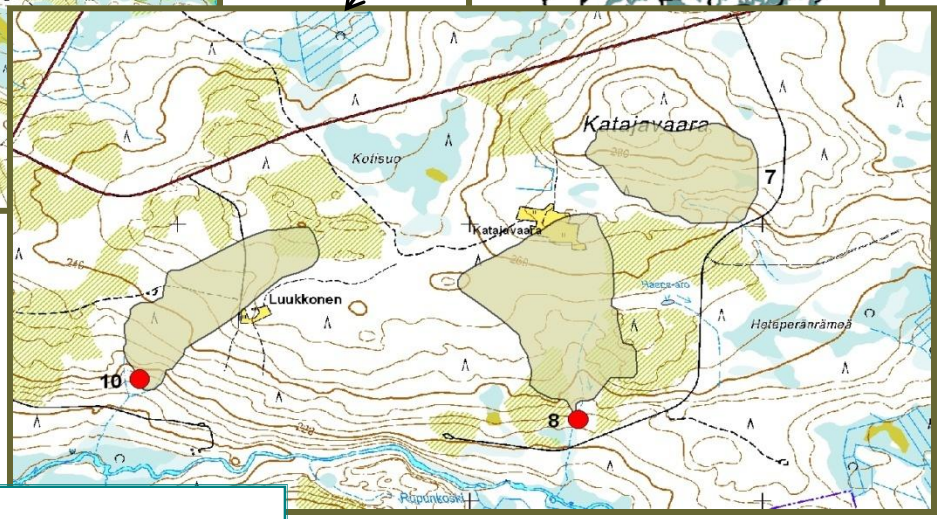
Stump removal

Small catchment areas were also included to the study





Oijusluoma

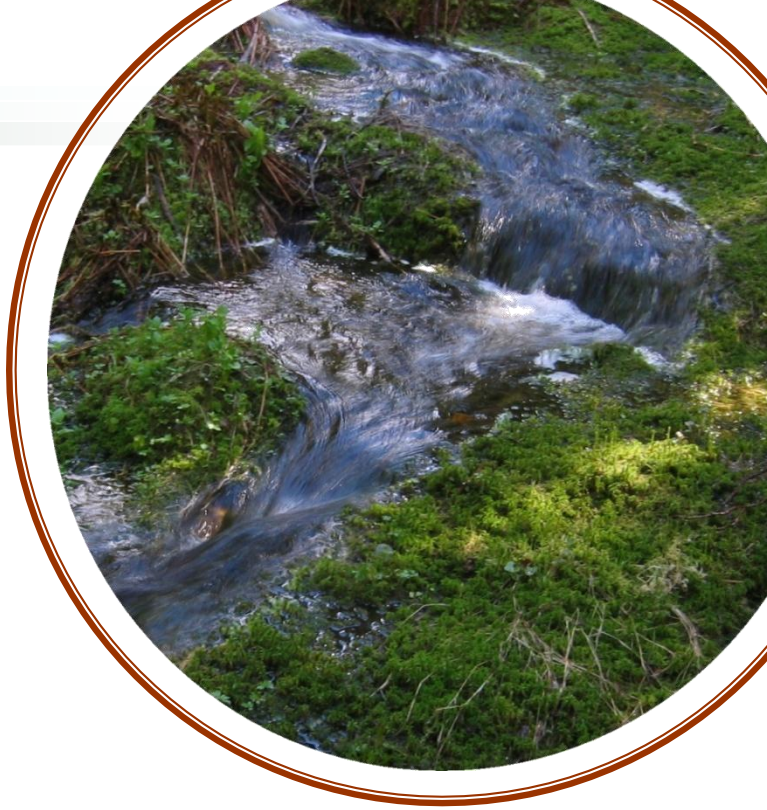


Katajavaara

- **Stream water quality and runoff monitoring ongoing in the catchments marked with red dots**

Oijusluoma,
catchment area 1

Katajavaara,
catchment area 10



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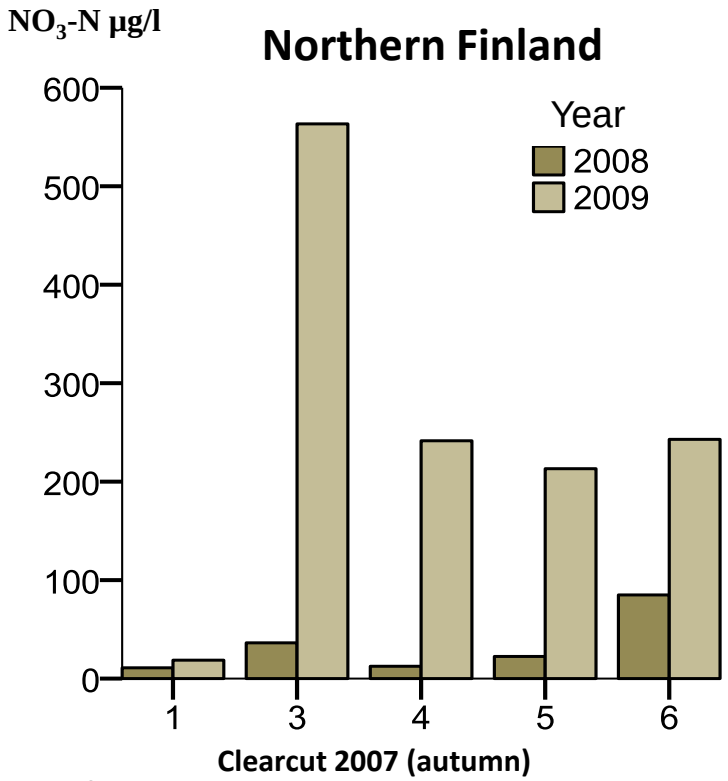
Already one year after stump uplifting there were statistically significant differences between uncut control and treatments



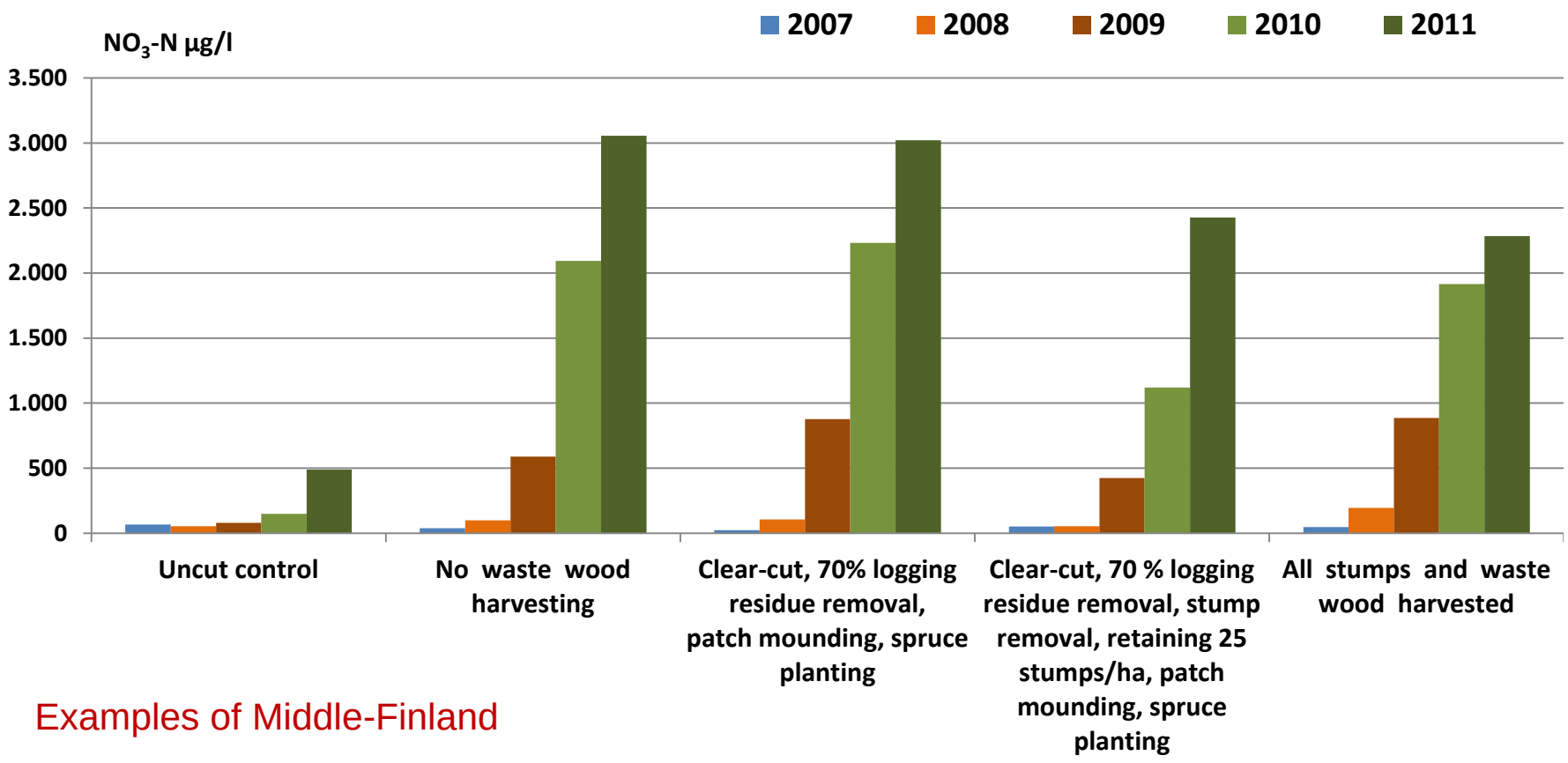
	Northern Finland, 2009				
	1	3	4	5	6
1		0,001***	0,001***	0,001***	0,001***
3	0,001***		1,356	1,071	0,670
4	0,001***	1,356		9,549	9,892
5	0,001***	1,071	9,549		9,554
6	0,001***	0,670	9,892	9,554	

	Standard deviation		Range		n	
	2008	2009	2008	2009	2008	2009
1	5	26	25	116	30	25
3	35	424	127	1200	26	16
4	5	206	16	660	25	16
5	31	169	136	503	24	19
6	148	226	602	997	55	46

1: Uncut control
3: Clear-cut, no waste wood harvesting, spruce planting
4 : Clear-cut, 70 % logging residue removal, spruce planting
5: Clear-cut, 70 % logging residue removal, stump removal, retaining 25 stumps/ha, spruce planting
6: Clear-cut, all stumps and waste wood harvested, spruce planting

Tested with Siegel-Castellan's inequality. Source: Kokko, A. 2012. Kantojennoston ja hakkuutähteiden korjuun vaikutus pohjaveden laatuun. Opinnäytetyö, Rovaniemen ammattikorkeakoulu.

After the first year nitrate nitrogen leaching to groundwater is increasing from year to year

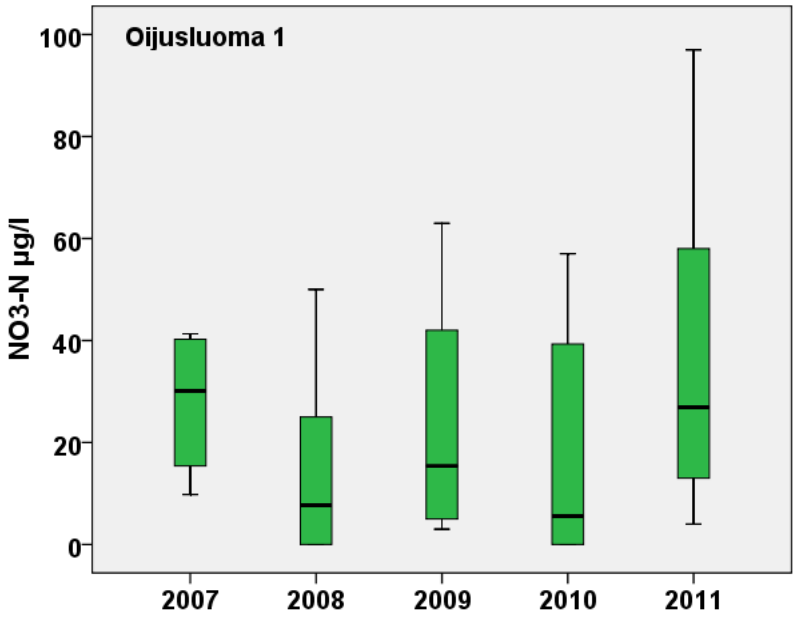


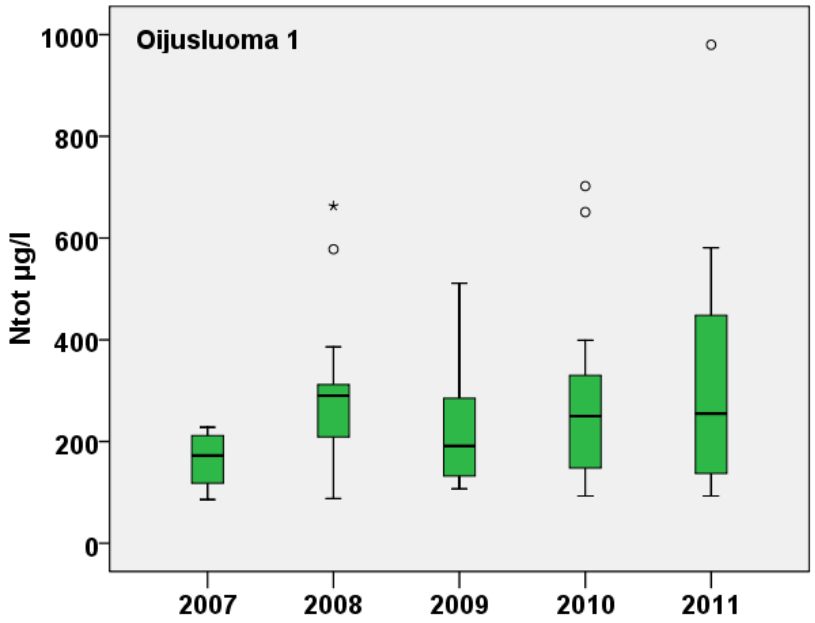
Examples of Middle-Finland

Program leader Antti Asikainen, the magazine of UPM Kymmene in 2012, ”this project is globally unique and must be continued still five years”

Source: METSÄNhenki. UPM:n lehti metsänomistajille 3/2012: 24-25.

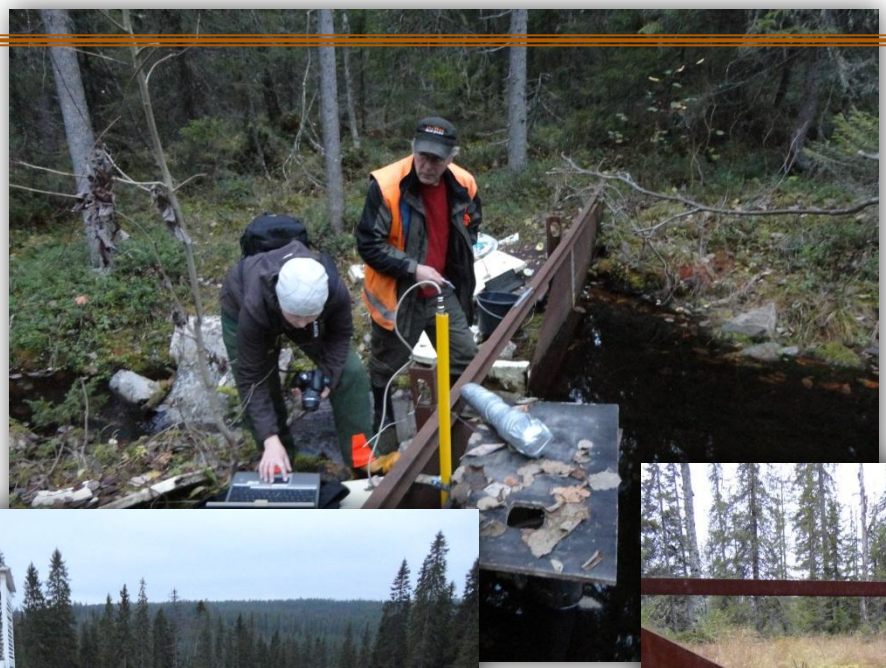
Results from catchment areas indicate also nitrogen leaching

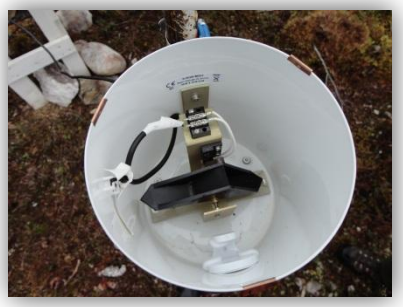




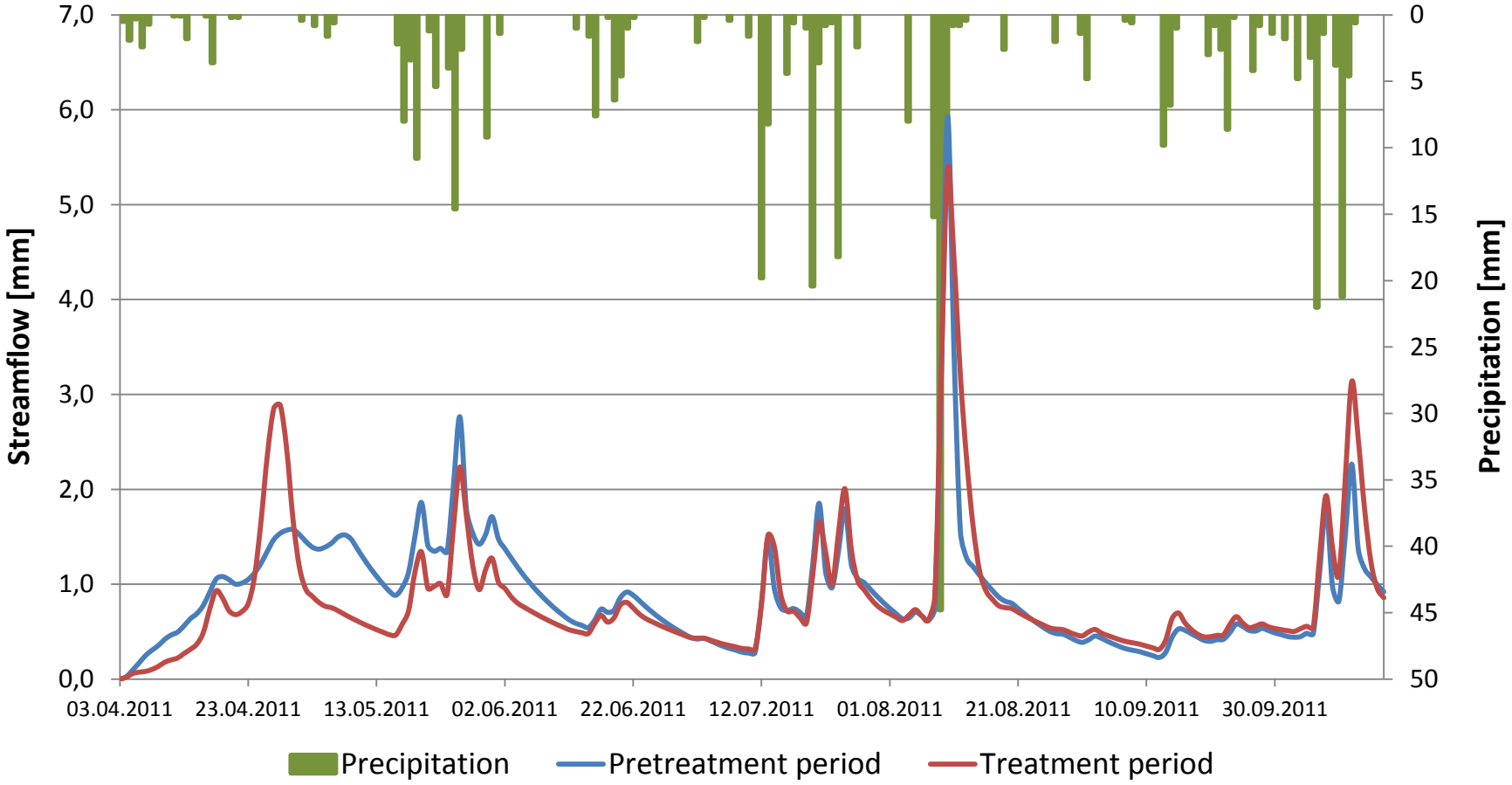
Clearcut and stump uplifting 2010, planting 2011

Data collecting from catchment areas

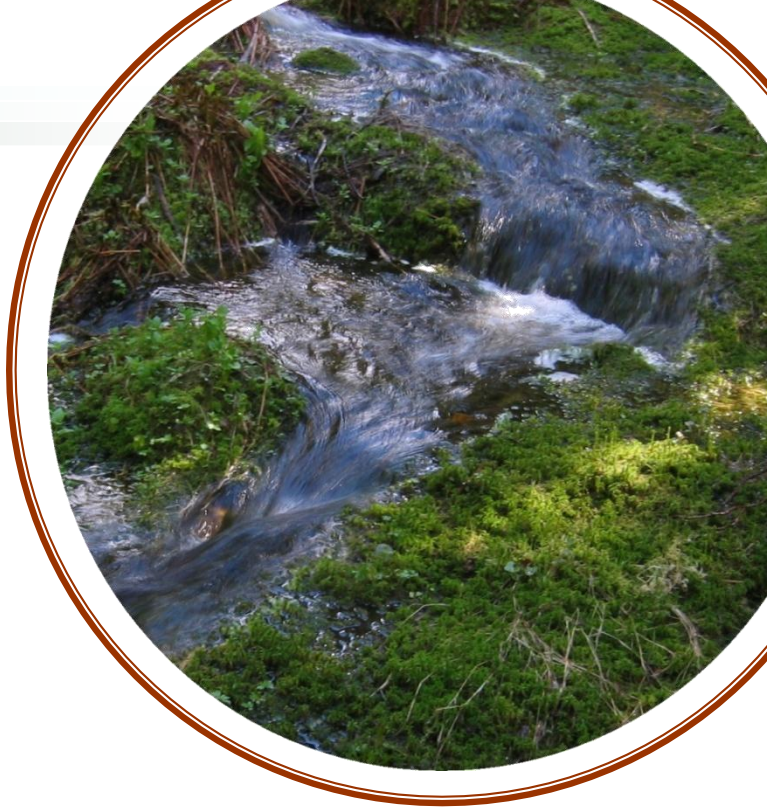




Simulated runoff before and after clearcutting (HBV model)



Source: Kremsa, J. et al. 2012. Effects of forest treatment on hydrological processes in the boreal environment. Preliminary manuscript.



Content

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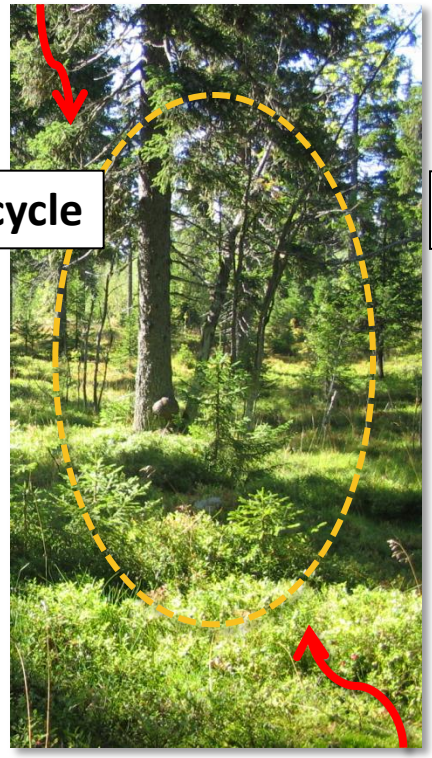
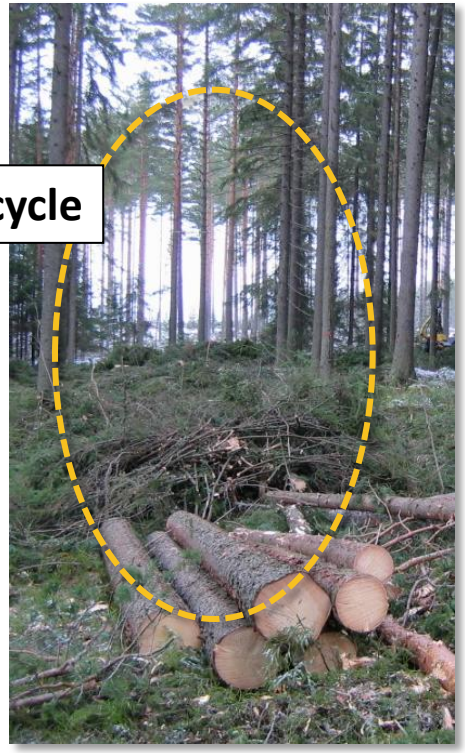
Conclusions

- Leaching of nitrate nitrogen increased in all treatments compared with uncut control. Maximum in Längelmäki study site is about 3 mg/l. Limit value for drinking water in Finland is 11 mg/l NO_3-N.
- After intensive harvesting there is less biomass to decompose resulting a little bit less hydrological effects compared with conventional cuttings.
- However intensive biomass harvesting needs more environmental research, especially long term monitoring.

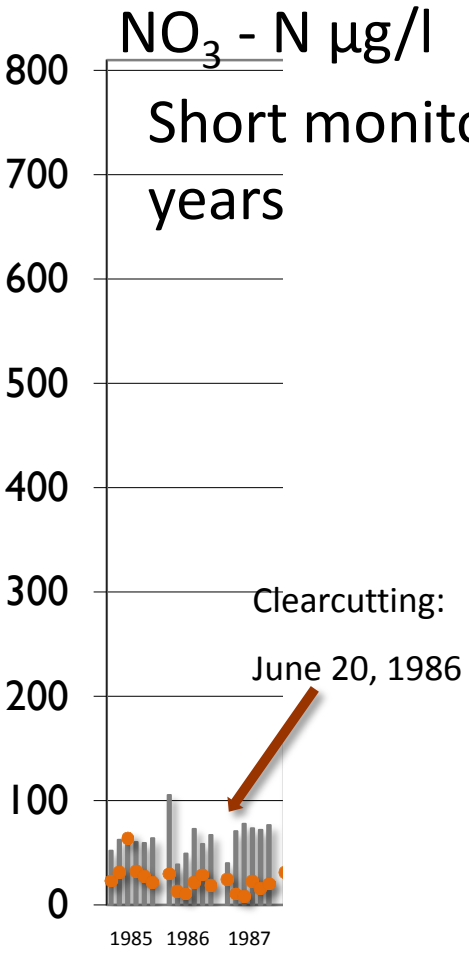
NO_3-N cycle in the boreal forest. What are the effects of climate change and whole tree harvest with lifting stumps?

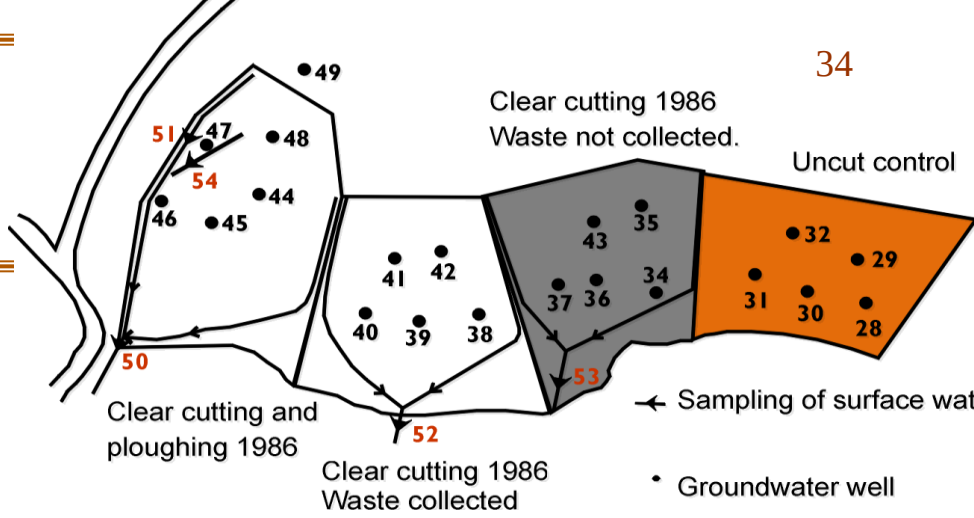
	Natural state	Conventional cutting	Whole tree harvesting
			
Deposition: Interception		+	+
Leaching: Depends on site		+	+ (?)
Decomposition: Slow		+	+ (?)

Quarter economy

- How long is a quarter in environmental forest research?
- See the next three slides!

Groundwater monitoring in Hautala, Finland

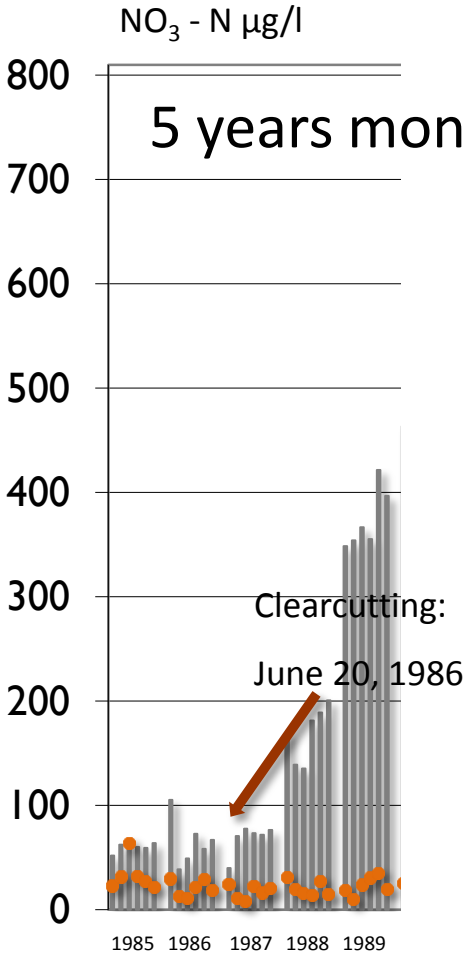


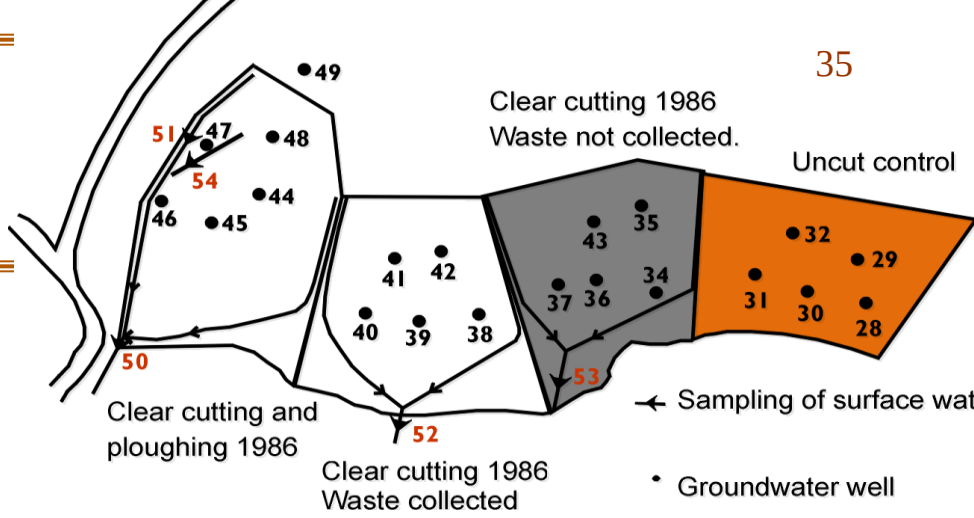


Uncut control

Waste not collected

Groundwater monitoring in Hautala, Finland

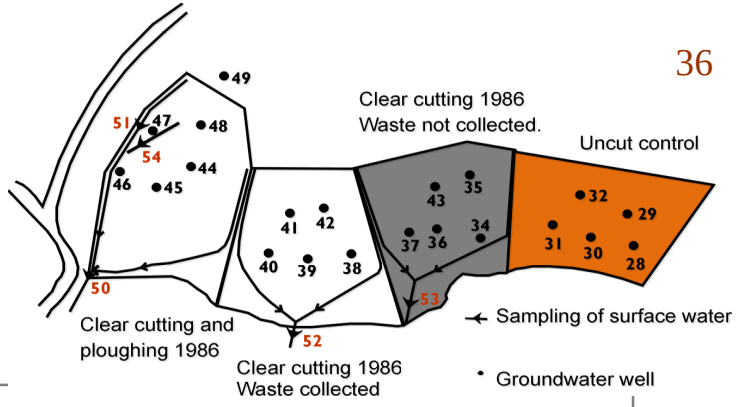


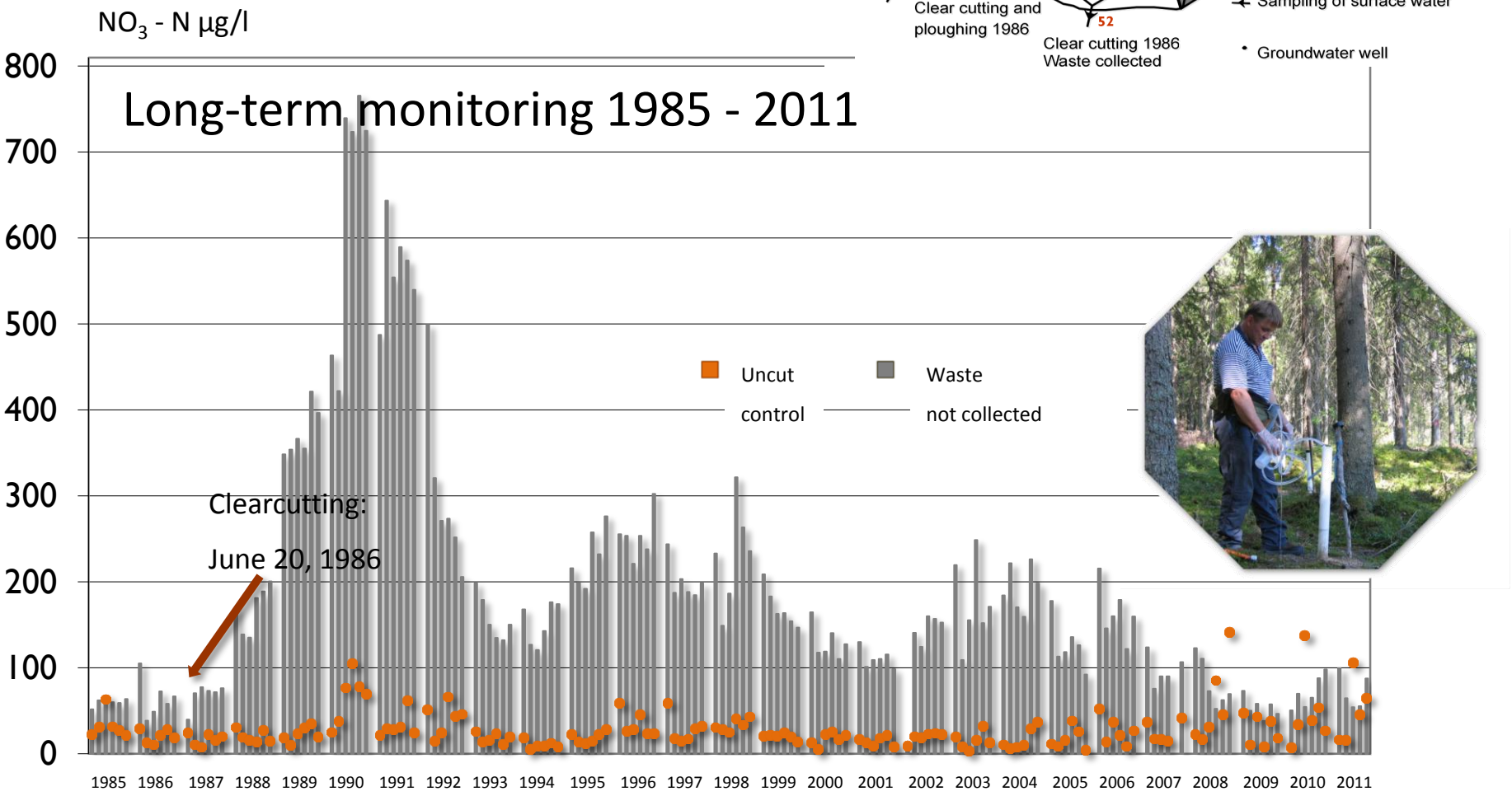


Uncut control

Waste not collected

Groundwater monitoring in Hautala, Finland





Quarter economy

- The quarter in environmental forest research is 25 years!!!!

Thank you all who participated to project over 25 years!

Thank you all who have participated to this project over 25 years!