

An aerial photograph showing a large, dark blue lake on the left side. The surrounding landscape is a mix of dense green forest and large, irregularly shaped clear-cut areas where the trees have been removed, revealing brownish soil. A winding road or path is visible in the upper right quadrant. The overall scene illustrates the impact of logging on a natural forest environment.

The effect of clear-cutting on iron leaching

**Marjo Palviainen, Leena Finér, Ari Laurén,
Sirpa Piirainen, Samuli Launiainen & Mike Starr**

Raudasta on moneksi seminaari 23.10.2012, SYKE

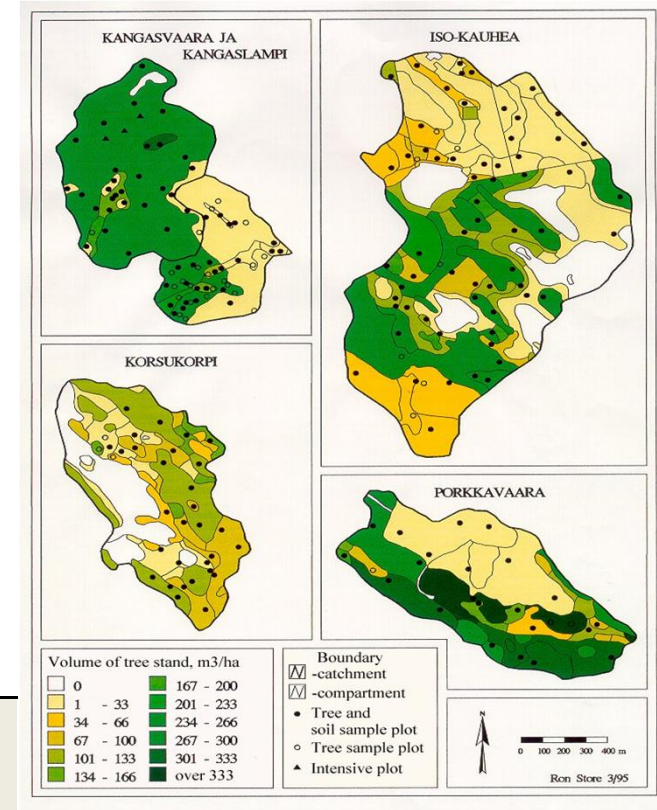
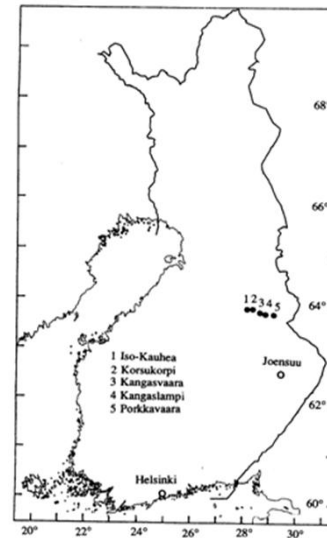
Iron is susceptible to leaching after clear-cutting

- Clear-cutting may increase ground water level, runoff and peak flows.
- Fe is released rapidly from logging residues, especially from dead roots.
- Soil preparation may affect soil hydrological properties, water flow paths and runoff
- Fe compounds that are precipitated deeper in the soil in podsolization process, are exposed on the soil surface after soil preparation.
- High Fe concentrations are toxic to water organisms.



VALU project: The effects of forest harvesting and scarification on catchment water and nutrient fluxes

- Five forested catchments studied since 1991
- Catchment-scale: amount and quality of runoff
- Plot-scale: the mechanisms of nutrient release and retention



Catchment	Elevation of dam, m a.s.l.	Elevation of highest point, m a.s.l.	Slope, %	Area, ha	Peatlands, %	Total stem volume m ³	Total stem volume m ³ ha ⁻¹
Iso-Kauhea	200	231	2	176	50	16704	95
Korsukorpi	198	221	2	69	56	4157	60
Porkkavaara	182	226	5	72	16	12907	179
Kangasvaara	187	238	7	56	8	15394	275
Kangaslampi	184	238	6	29	9	2449	84

Paired-catchment method

Kangasvaara:

- Clear-cutting 1996 (19 ha, 34% of the catchment area)
- Soil preparation 1998
- Planting 1999
- The width of buffer strip 33-71 m

Iso-Kauheja:

- Clear-cutting 1996 (20 ha, 12% of the catchment area)
- Soil preparation 1998
- Planting 1999
- The width of buffer strip 10-450 m

Control areas: Porkkavaara,
Kangaslampi, Korsukorpi



Iron concentrations in stream water

- Stream water samples were taken 7-14 times per year
- Clear-cutting had no significant effect on Fe concentrations in stream water

Calibration period (Hydrological years 1992-1996)	Kangasvaara		Porkkavaara		Iso-Kauhea		Korsukorpi	
	Mean	sd	Mean	sd	Mean	sd	Mean	sd
Total Fe $\mu\text{g L}^{-1}$	220	49.9	176	27.6	986	118.5	2796	720.6

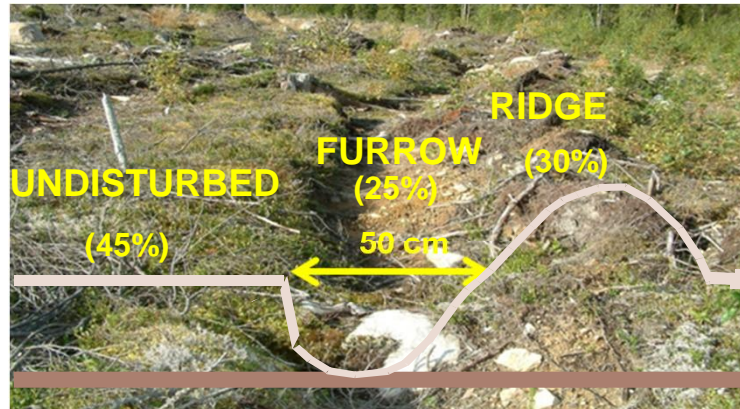
Iron leaching – Stream water



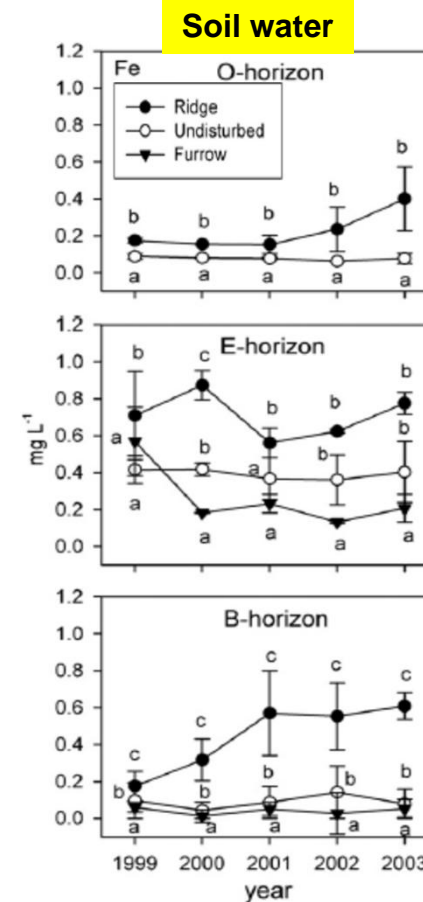
Calibration period (Hydrological years 1992-1996)	Kangasvaara		Porkkavaara		Iso-Kauhea		Korsukorpi	
	Mean	sd	Mean	sd	Mean	sd	Mean	sd
Runoff mm a ⁻¹	311	48	409	72	385	73	425	56
Fe kg ha ⁻¹	0.57	0.10	0.63	0.10	2.97	0.73	9.55	4.00

- Clear-cutting increased runoff significantly only in the second year after treatment at Kangasvaara catchment.
- No significant effect on Fe leaching.

Iron concentrations in soil water and ground water



- Greatest Fe³⁺ concentrations in ridges and lowest in furrows.
- No significant effect on ground water Fe concentrations.



Ground water	Before clear-cutting (1994-1996)		ANOVA	After clear-cutting (1997-2001)		ANOVA
	Control areas	Treatment areas		Control areas	Treatment areas	
Total Fe (mg L ⁻¹)	0.34	0.64	n.s.	0.21	0.57	n.s.

(Mannerkoski et al. 2005, Piirainen et al. 2007)

Iron leaching – Soil water

- Leaching was greatest in ridges and smallest in furrows.
- Soil preparation increased Fe³⁺ leaching from below the B-horizon by 112% compared to clear-cutting alone.
- The extent and intensity of soil preparation has an essential impact on leaching.

	Undisturbed Fe kg/ha	Furrow Fe/kg/ha	Ridge Fe kg/ha
<i>E-horizon (1999-2003)</i>			
Mean	0.54	0.28	0.89
Σ	2.71	1.40	4.47
<i>B-horizon (1999-2003)</i>			
Mean	0.03	0.01	0.17
Σ	0.13	0.05	0.86

Comparison to other studies

Catchment	Clear-cutting % of the catchment area	Buffer strip	Peatlands, %	Fe concentrations	Fe export	Reference
Murtopuro	58	no	50	sig.	sig.	Ahtiainen 1990
Kivipuro	56	yes	32	n.s.	n.s.	Ahtiainen 1990
Vanneskorvenoja	40	yes	14	n.s.	n.s.	Haapanen et al. 2006
Porraskorvenoja	40	yes	13	sig.	sig.	Haapanen et al. 2006
Lehmikorvenoja	39	yes	14	n.s.	n.s.	Haapanen et al. 2006
Paroninkorpi	76	yes	1	sig.	sig.	Haapanen et al. 2006
Kangasvaara	34	yes	8	n.s.	n.s.	This study
Iso-Kauhea	12	yes	50	n.s.	n.s.	This study
Balsjö	30	no	2	n.s.	n.s.	Löfgren et al. 2009
Balsjö	73	yes	8	n.s.	n.s.	Löfgren et al. 2009

Future research prospects

- The effects of clear-cutting on Fe concentrations and leaching seem to vary between different areas but why ?
- How new forest management measures, such as stump harvesting, affect Fe leaching ?
- More information would be needed how timber harvesting in peatland forests affect Fe export and Fe concentrations in receiving water bodies.

