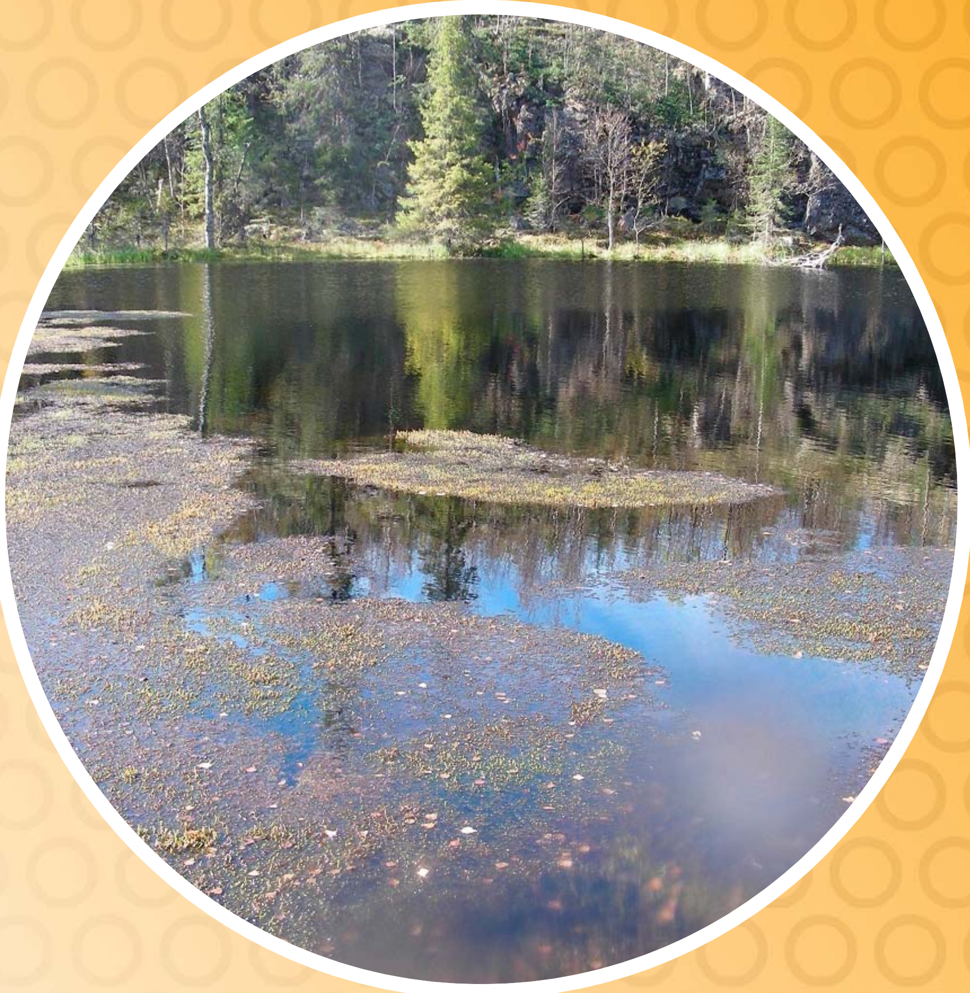
Potential for improving downstream water quality by restoration



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Response to drainage and restoration: bog above, spruce mire below

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Water quality studies in restoration sites

- There are about 20 monitored catchments with water quality data in Finland.
- Time series are up to 18 years after restoration (Seitseminen; 13 years in Nuuksio)
- In many cases pre-restoration period has been rather short.
- Comparable reference areas with monitoring at the same time nearby are lacking in the oldest sites
- Studies have been conducted in 10 different regions and cover different types of mires rather well
- In addition to runoff monitoring, there is also a comprehensive network of groundwater quality monitoring sites with proper reference areas and calibration periods
- As a whole, restoration impacts (0,03 million ha) are known better than drainage impacts (5 million hectares in Finland).

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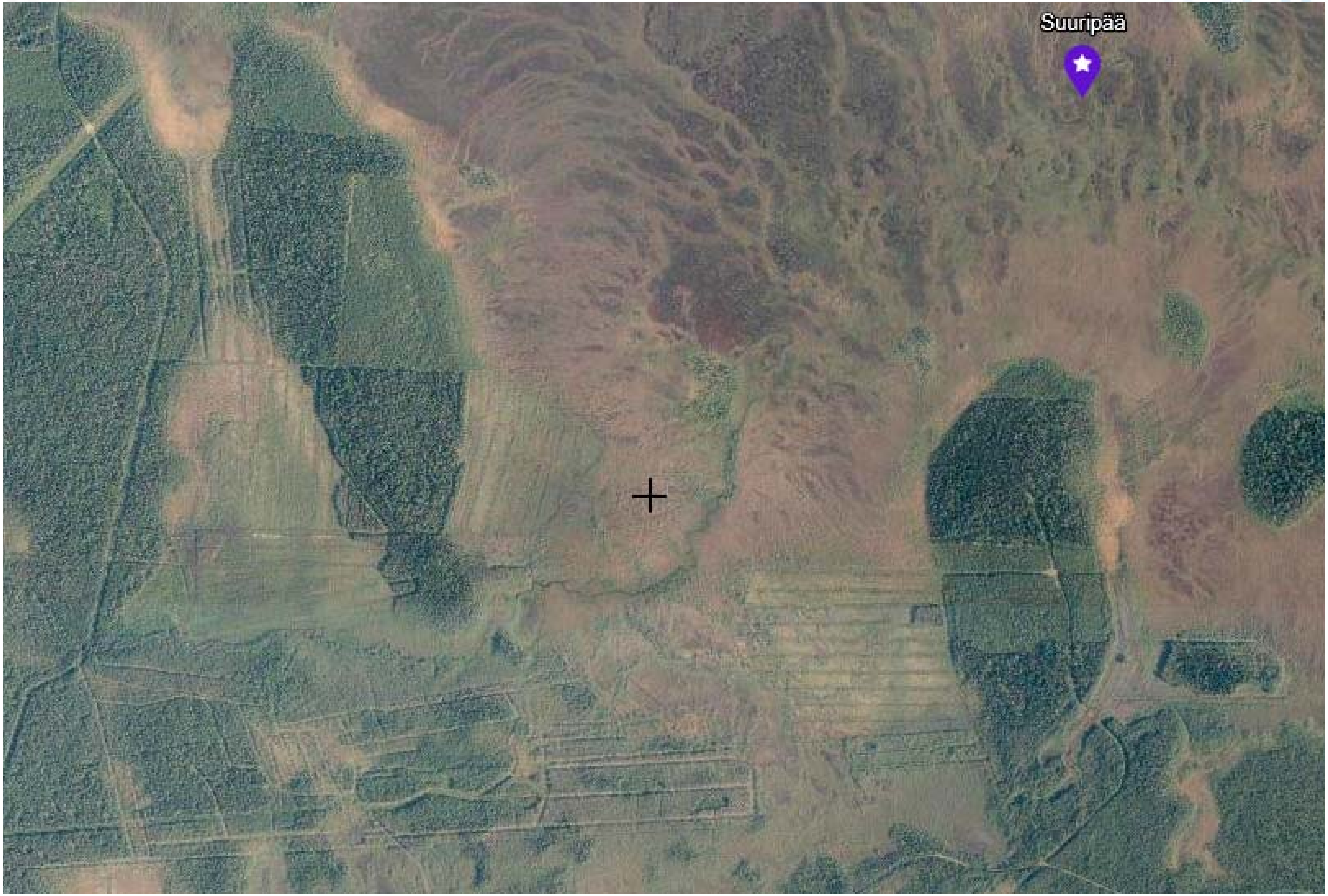
Representativity; e.g. rich fens in the aapa mire region



Water-carried export of main nutrients and organic carbon in pristine and active forestry sites (Finnish water quality monitoring network in forestry land)

	Total P	Total N	TOC	number
	kg/ha yr	kg/ha yr	kg/ha yr	of sites
Pristine catchments	0,03	1	41	11
Peatland forestry sites	0,08	2,1	82	20

TOC export of 41 kg/ha yr may be underestimation due to many northern sites; Kortelainen et al 2006 give a value of 62 kg/ha yr for unmanaged areas, mire % 33 on average

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Specific load

- Specific load is the excess of leaching due to a procedure, addressed to the area in which the procedure is performed; the result expressed in this way is a concentrated one, but comparable between different measures.
- Studies are conducted in catchments, in which any impacts can be evaluated. In actual cases, the dilution, the proportion of any measure of the watershed, determines actual concentration changes in the recipient watercourse.
- Increased dilution after filling of ditches must be taken also into account in the interpretation of concentration changes inside catchments.

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Increase in leaching adressed to the area restored (specific load); sum of 4-9 years: blue; medians, red: outliers, extreme values

	Total P	Total N	TOC	number	comments
	kg/ha	kg/ha	kg/ha	of sites	
Seitseminen oligotrophy	3,0	14	640	5	2 catchments with a lake
Nuuksio spruce mires	1,7	22	900	3	buffer in outflow
Evo spruce mires	3,5	9	340	1	with a lake
Haapasuo bog	0,1	1	30	1	previous restorations
Suuripää rich fen	0,1	7	50	1	
Helvetinjärvi bogs	0,5	2	0	3	Also oligotrophy
Helvetinjärvi spruce mire	15,4	60	1200	1	4 years since restoration
Punassuo	3,7	31	310	1	old peat minings

What does this mean?

- The median of 7 study sites with forestry history in the previous table as a reference value, restoration would increase leaching of P, N and TOC 110 %, 43 % and 41 %, respectively, as a 10 year mean after restoration, addressed to the actual restored area - leaching rates of average forestry land as a starting point.
- However, taking the maximum values would make restoration look much worse; 9, 7 and 3 times increase.
- Most of the excess comes in 2-4 years, some delay in dry years
- In 10 years, the negative impacts have already disappeared.
- Predictability: spruce mires may be problem. In addition to Helvetinjärvi there is a preliminary case with similarly high values. Phosphorus is the most severe problem, but also inorganic nitrogen.
- In the less fertile mires there is much variation especially in phosphorus; fertilization may be the reason. About 30 % of forest drained peatlands have been fertilized with phosphorus in the past.

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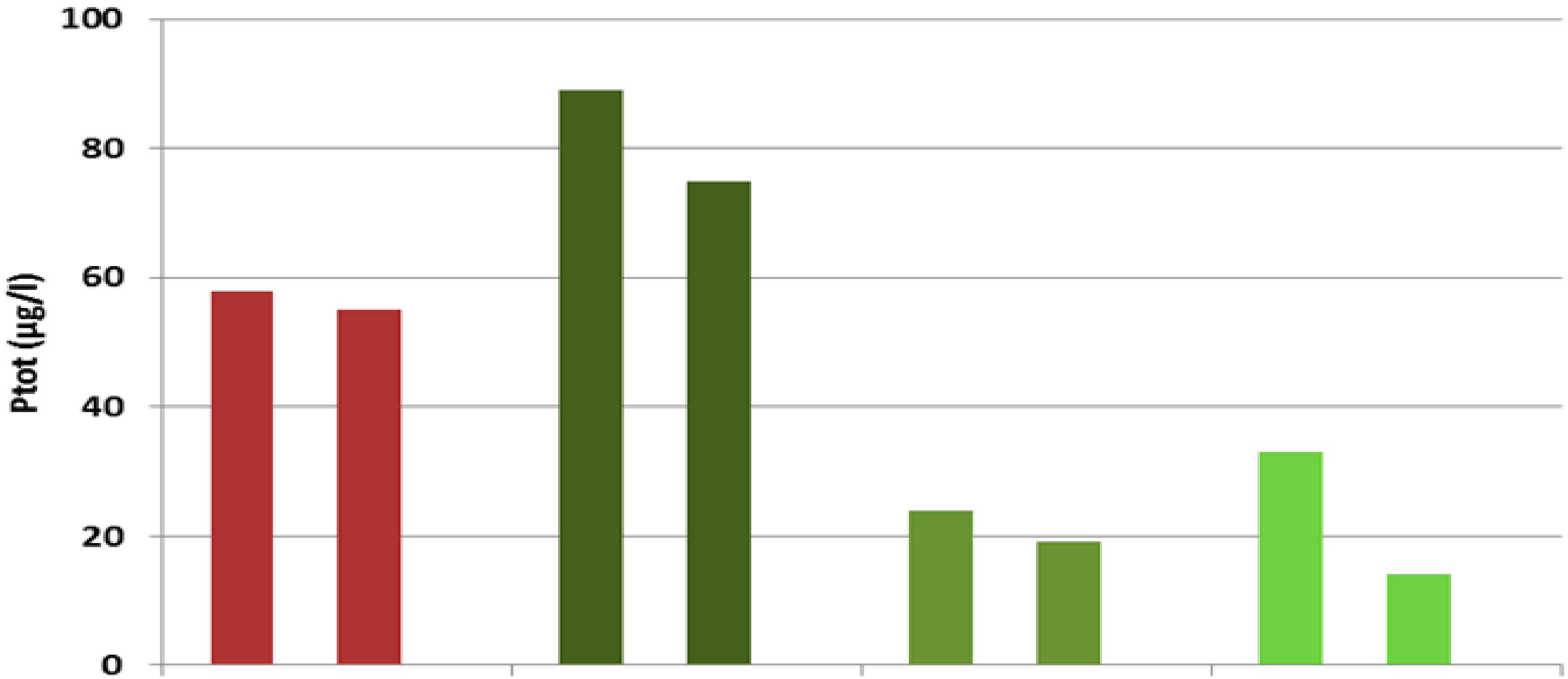
Water quality impacts of restoration

Phosphorus concentration as an example; Seitseminen & Nuuksio



Active forestry
Near by areas

Recently restored
(1–3 yr earlier)

Old restoration
(12 – 18 yr earlier)

Pristine sites

Ref: Tuukkanen ym. 2017 (Metsätalouden vesiensuojelupäivät 12.-13-9-2017);
Sallantaus 2018 (LifePeatLandUse)

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Where are we?

- Most ”negative” impacts have stolen the whole show
- Willingness to pay is negative..
- We must be able to predict those cases, in which we have too much unwanted impacts
- Forestry measures seem to have doubled the leaching rates in forestry land, based on slide 5; specific loads of restoration are mostly comparable to forestry measures but return soon to lower values and concern minute areas compared with foresty

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Peatlands in the landscape; basics of hydrology in Finland; just to remind you

- The bedrock is practically impermeable
- Bedrock is overlain by sedimentary cover of about 3-4 m median thickness
- Poorly permeable till soils are dominant
- Water table is close to the surface
- Water movement is concentrated to the surface and subsurfical soil layers; ground water component small

Any ditches in the landscape intercept water flow effectively

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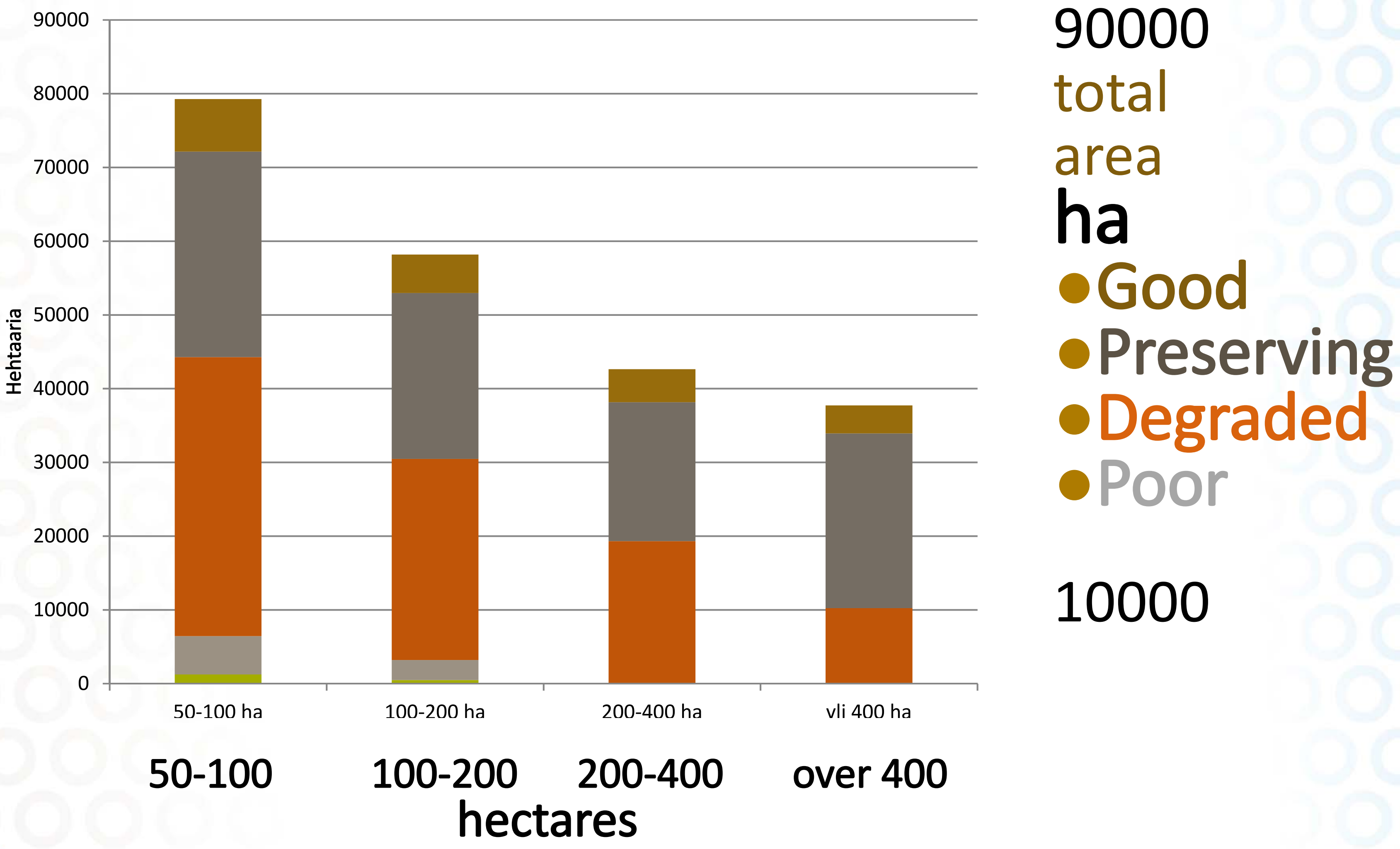
Vaaranalussuo

Undrained mires outside protection areas; state classified as Good, Preserving, Degraded and Poor. To be degraded, a fen must have lost at least 25 % of its original watershed; S & Middle boreal



An example of mire patches in a hydrologically degraded stage, water divides red; easy to restore?

S

Restoration of hydrochemical ecosystem services?

Photo H. Nousiainen

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Suurisuo – a southern aapa mire

Study site for fen hydrochemistry

Aapamire is a fen, formed in conditions in which upland runoff feeds water to the mires through-out growing season, aided by short summer, cool climate, mean evaporation exceeding precipitation also in the summertime

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Annual retention, input includes deposition, and retention percentage in Suurisuo 2012-2013.

Runoff 330 mm/a. Total watershed is about 3 times larger than the mire.

Al	Ca	Mg	Na	P	N	S
			mg/m^2			
300	380	42	75	13	510	550
			%			
61	25	10	5,6	*55*	*48*	58

Mean outflow concentration (flow weighted)

			mg/l			
0,22	1,3	0,5	1,5	*0,012*	*0,64*	0,47

Total organic carbon = 33 mg/l, net loss 6400 mg/m^2a

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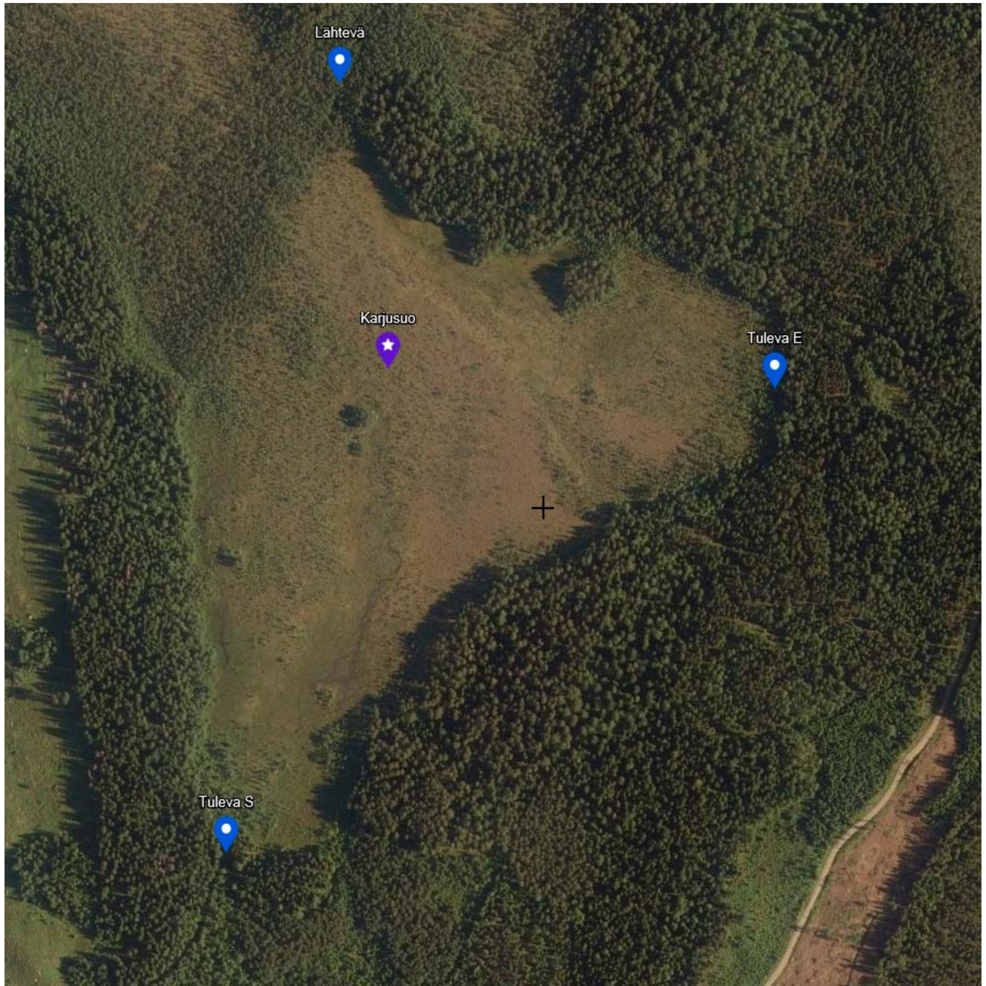
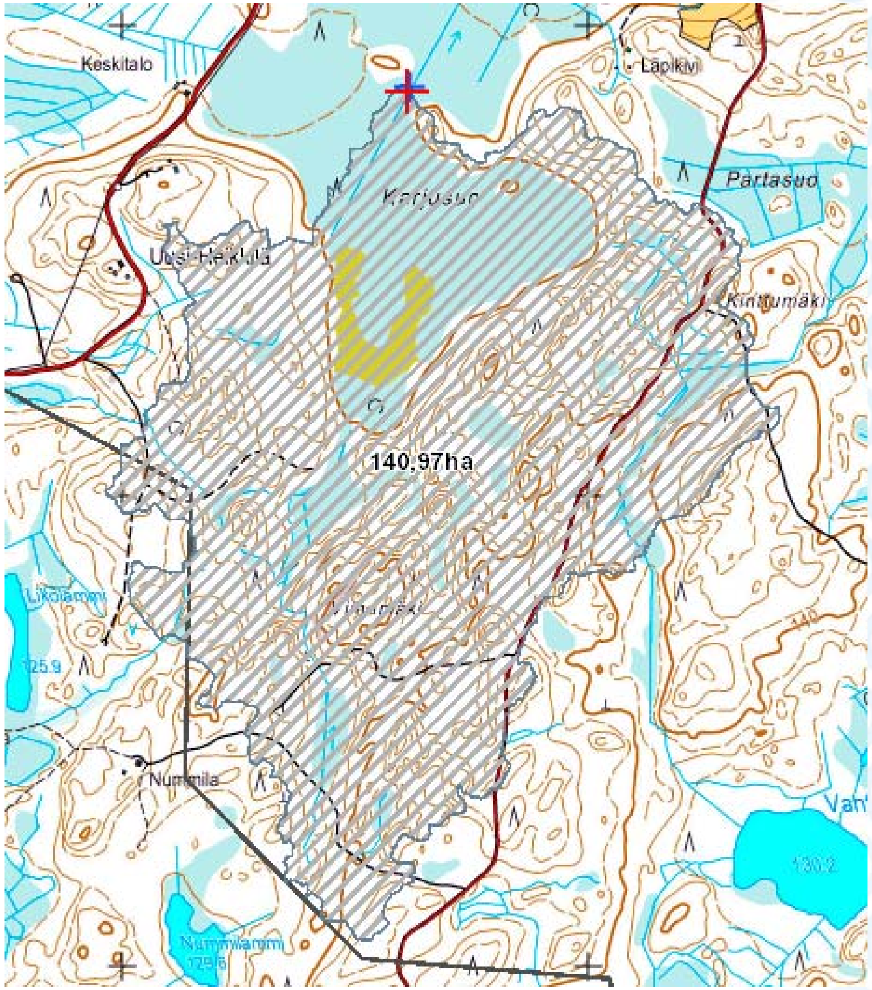
Case Karjusuo; catchment feeding water to the mire is 6 times larger than the mire





S Y K E

Retention in Karjusuo;
watershed 6 times larger than the mire

	Al	K	Ca	P
	µg/l	mg/l	mg/l	µg/l
Outflow conc.	236	0,48	2,26	**9**
diff% in-out	**54**	-3	36	**34**

	N	NO3-N	SO4	Ti
	µg/l	µg/l	mg/l	µg/l
Outflow conc.	625	7,7	2,15	2,71
diff% in-out	25	**92**	**43**	**55**

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Retention of elements in minerotrophic mires:

- Large areas of undrained mires have lost significant amounts of waters original feeding these mires due to surrounding ditches and are not capable of performing hydrochemical ecosystem services typical to them
- **These ecosystem services are worth restoring!**
- Restoration of natural flow paths; a pre-requisite
- Restoring hydrology is key aspects in Hydrology Life – positive experiences needed. Small steps started in protected areas, but water quality services need verification
- Win win win win?
- Funding?

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