5. Natural background loss

- Natural background loss of nutrients depends e.g. on
  - Geology (mineral composition, weathering), climate
    - Soil, topography, vegetation
- Natural background loss has to be known to estimate anthropogenic load
  - Especially from forestry
  - Source apportionment
- Difficult to find pristine counterparts
  - Especially for agricultural areas (e.g. clayey soils)
  - Atmospheric N
  - Remaining ”pristine” catchments usually small, scale effect?

Strong interseption

Soil protected by perennial vegetation

High infiltration

No added nutrients
P saturation of Fe ja Al oxides low
N bound to vegetation

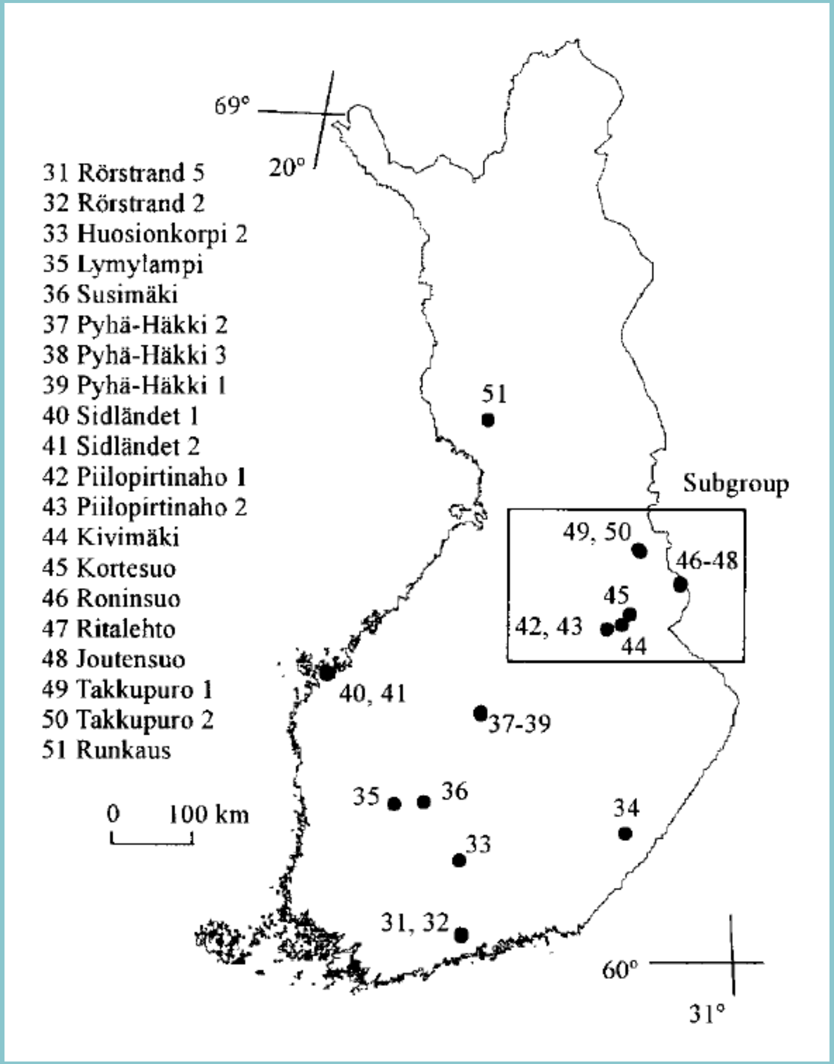
Phosphorus loss from land to ocean

Phosphorus species	Pre human 10^{12} g y^{-1}	Present 10^{12} g y^{-1}
Total P	10.8–17.8	18.7–31.4
Geochemically reactive P	3.1–4.8	3.4–10.1

Compton et al. (2000)

Natural background loss in Finland
Study I

- Reference data to estimate nutrient losses from forestry (Mattsson ym. 2003)
- 21 semi-natural forested catchments (0.074–38 km^2) across Finland (excl. Northern Lapland)
  - No forestry activities in last 20–30 years → stem volume large (18 900 m^3 km^{-2} (national mean 9 300 m^3 km^{-2})
    - Spruce 55%, pine 35%, broad-leaved trees 10%
  - Peatland
    - 10–71%, mean 33% (national mean 34%)
  - Atmospheric deposition the main anthropogenic pressure
  - Deposition, precipitation, stem volume largest in the south, runoff in the north
- Water quality monitored for 1997–1999 (on average 11 samples per year)
- Runoff estimated from reference catchments (no measuring weirs were built)



Results
Study I

Total suspended solids

- **Mean concentration 0.7 mg l^{-1}**
- **Erosion negligible, nutrients in a dissolved (or colloidal) form**

Total phosphorus

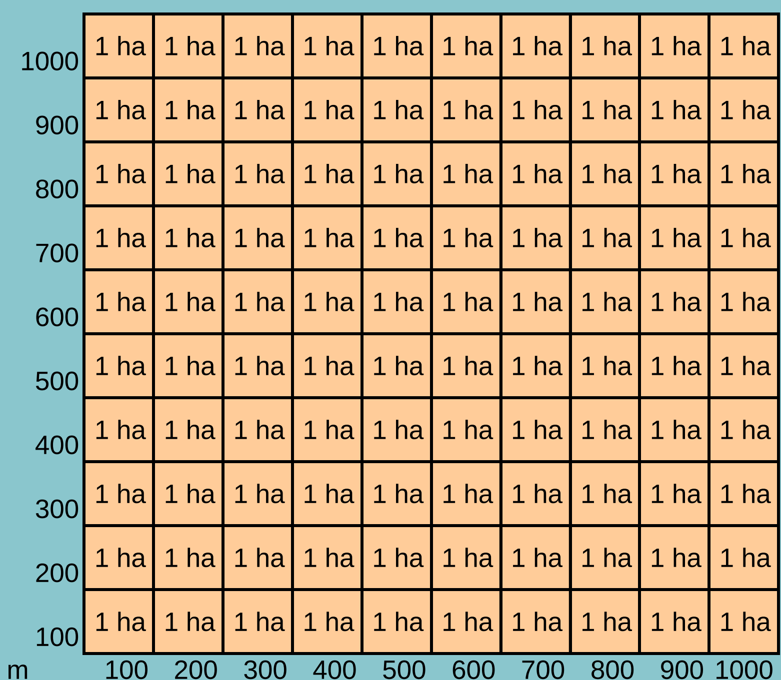
- **Mean concentration 15 µg l^{-1}**
- **Compare with: 6–80 µg l^{-1} in semi-pristine catchments in the USA (Smith et al. 2003)**
- **Mean loss 5.4 kg km^{-2} y^{-1} (2.1–18, mostly < 10 kg km^{-2} y^{-1})**
- **Concentration correlated positively with temperature sum and stem volume → higher concentrations in the south**

Reactive phosphorus

- **Mean concentration 4.2 µg l^{-1}**
- **Dissolved P fractions were not analysed**

Some units

- In agriculture and forestry commonly: hectare (ha)
  - In this course mostly: square kilometre (km^2)
  - $1\ km^2 = 100\ ha = 1\ 000\ 000\ m^2$
  - Natural background loss
    - $5.4\ kg\ km^{-2}\ y^{-1} = 54\ g\ ha^{-1}\ y^{-1} = 5.4\ mg\ m^{-2}\ y^{-1}$



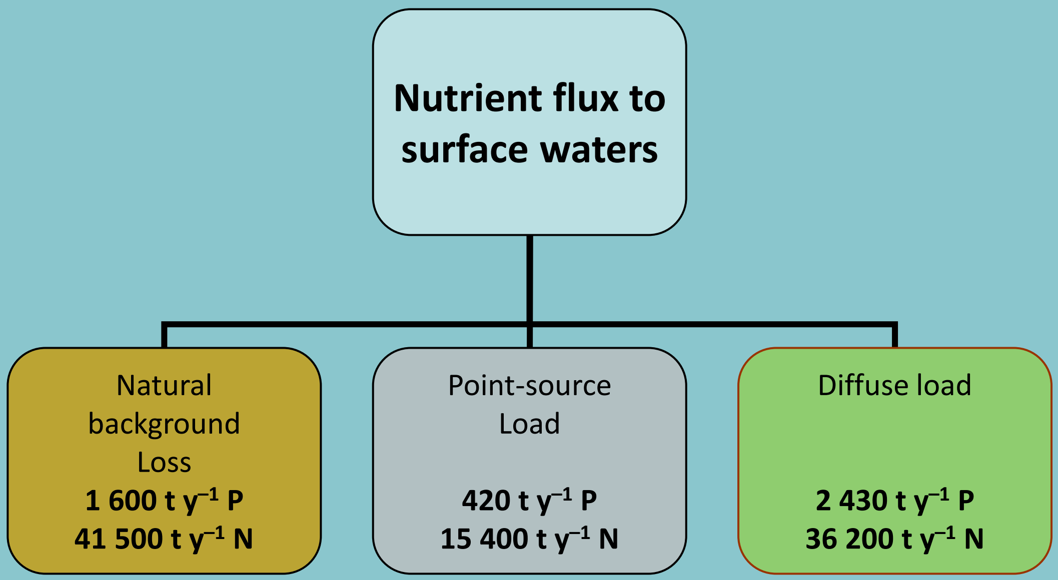
Results
Study I

Total nitrogen

- Mean concentration 430 µg l^{-1}
- Compare with: 20–500 µg l^{-1} in the USA (Smith et al. 2003)
- Loss **140 kg km^{-2} y^{-1}** (77–230 kg km^{-2} y^{-1})
- 95% organic N
- Concentration correlated positively with temperature sum and inversely with latitude → concentrations higher in the south
- Concentration also correlated positively with spruce and stem volume
- Spruce is a climax species and thrives in more fertile soils → more decomposable material
- Stem volume → more decomposable material
- N is commonly the minimum nutrient in forests → atmospheric N is efficiently bound

- NO_3-N
  - Mean concentration 8.8 µg l^{-1}
- NH_4-N
  - Mean concentration 8.5 µg l^{-1}
- General conclusion
  - TN and TP concentrations and losses higher in the south due to larger amount of organic matter and its stonger mineralisation
  - N:P ratio 29

Nutrient flux to surface waters in Finland in 2016



Natural background loss in Finland
Study II

- 21 'unmanipulated boreal catchments, first-order streams' (0.07–14 km^2) in eastern Finland + 3 areas in southern and western Finland (Kortelainen ym. 2006)
  - Atmosheric load relatively low, thinning performed in some catchments
  - 2 catchment had a measuring weir, for others, runoff was estimated based on near-by catchments
- Monitored for 3–32 years (11–20 samples per year, sampling was aimed at flood periods)
- Explaining variables
  - Catchment characteristics
    - Altitude
    - Slope
    - Peat-%
    - Fertility
    - Stem volume of tree species
  - Climate
    - Temperature sum
    - Latitude
    - Precipitation
    - Runoff
  - Deposition

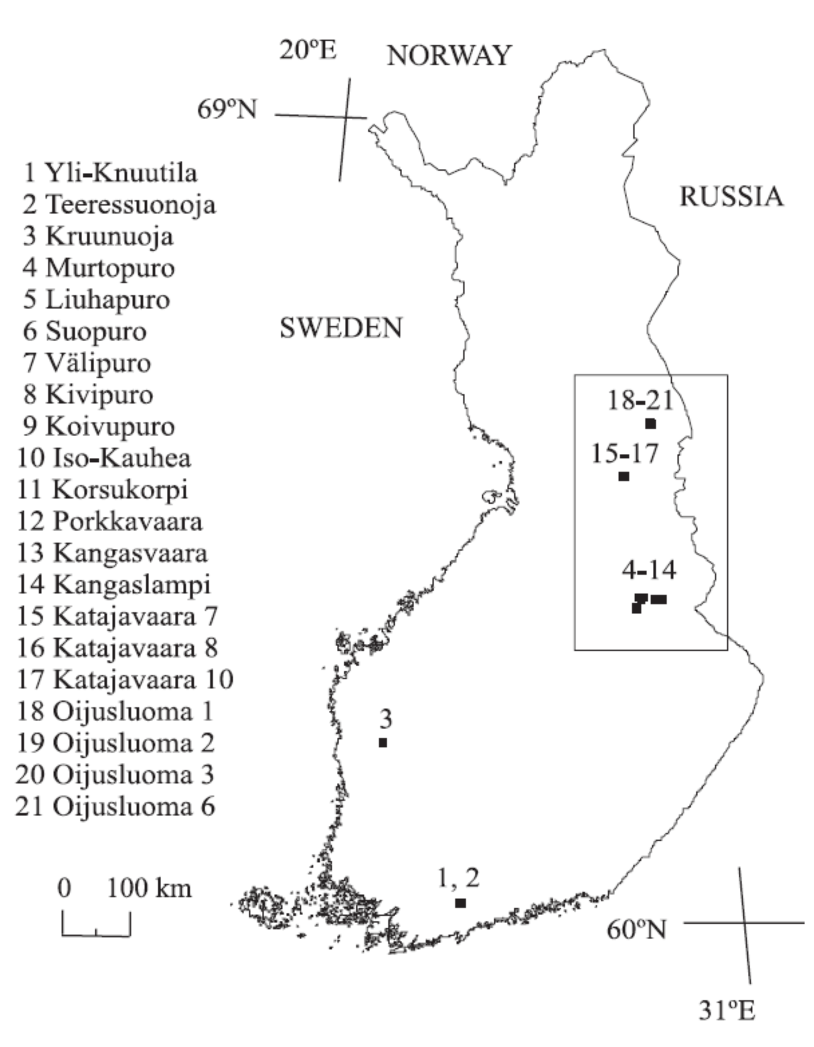


Figure 1. Location of the study catchments.

Results

Study II

- 18 catchments in eastern Finland
  - Peat-% explained 52–75% of TOC, TN, TON, NH_4-N and Fe losses
  - Slope explained 56% ot TP loss (inverse relationship)
  - TOC loss explained 95% of TON loss and 61–73 % of NH_4-N, Fe and TP losses
- Stem volume and vegetation did not explain the losses
- Mean losses
  - 130 kg km^{-2} y^{-1} TN
  - 5.0 kg km^{-2} y^{-1} TP
  - 1.7 kg km^{-2} y^{-1} RP
- N mainly in an organic form (87%)
  - NO_3-N losses were marked (43–65% of TN) only in two fertile catchments in southern Finland
- The share of ”dissolved” (<0.45 µm) fraction
  - 97% TOC, 94% TN, 79% TP
- N in deposition was retained by 59–92%
  - N minimum nutrient in forests

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