Optimal Phosphorus Abatement

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Assessing the Environment In Outcome Units (AEIOU): Using Eutrophying Units for Management

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P-species and eutrophication

- P-loading to water bodies a collection of different chemical species
- Main forms **particulate P, dissolved reactive P**, dissolved unreactive P
- Variation in short- and long-run bioavailability of the species
- Also other elements coupled to loading influence bioavailability
- Nevertheless, water conservation programs set the targets in terms of total P, an unweigthed sum of all P-species (Baltic Sea Action Plan, Chesapeake Bay TMDL, Gulf of Mexico,…)
- Should we try to determine and adopt P04-equivalents, in the same way as GHGs are converted to CO2-equivalents?
- With nutrients, more spatial and temporal variation, so…

Why bother?

1. Trends in loading push our conservation efforts to non-point sources
2. Characteristics of non-point pollution
3. Cost-effectiveness
4. Multiple narrow, unlit corridors between the sediments and the meeting rooms where policies and policy instruments are drafted

1. Relative share of loading from point sources decreases; from non-point sources increases

Loading types, Lake Erie 1967-2013

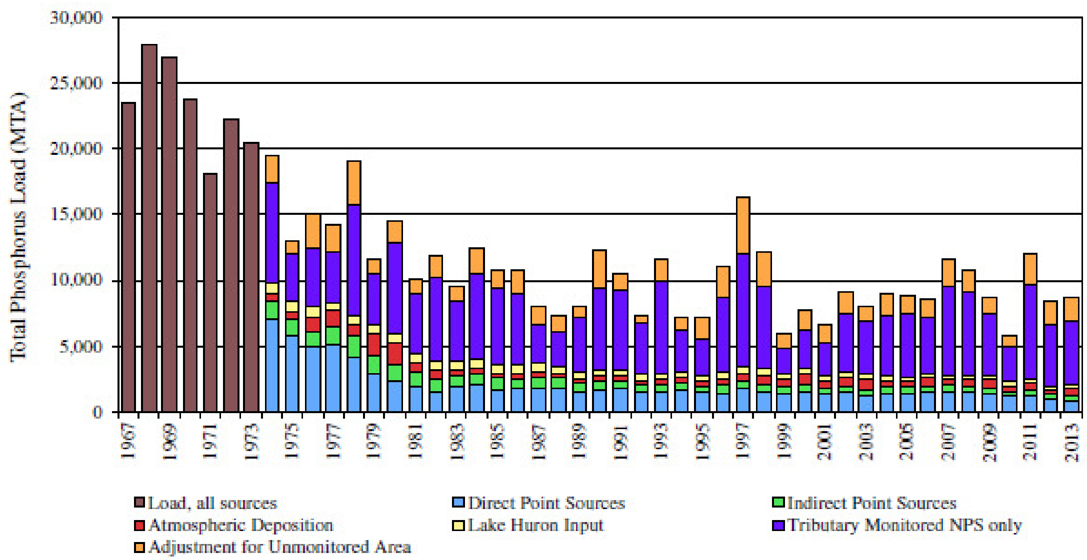

Fig. 1. Total phosphorus loads (MTA) to Lake Erie by source type (1967–2013). No source type attribution data are available prior to 1974.

Maccoux et al 2016

- More pressure for policies to be effective and efficient in regulating non-point loadingc

Baltic Sea

http://www.vliz.be/v/images/9/9d/Balticsea_Fig2.jpg

Baltic Sea, similar trends

Phosphorus load from St.Petersburg, Russia
(Russia, discharges to the Gulf of Finland)

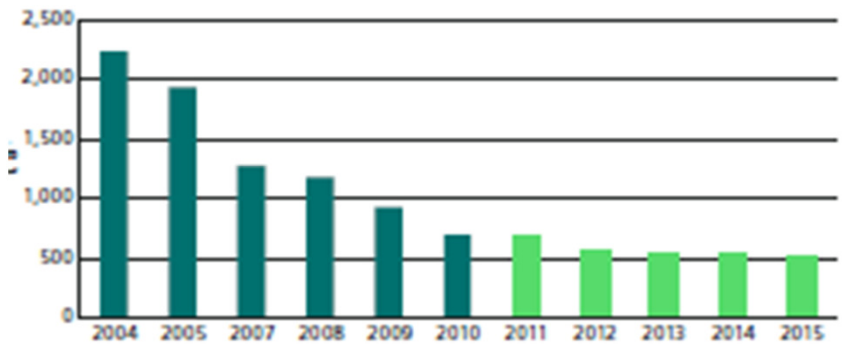

Figure 6-2 Phosphorus load ($t\ a^{-1}$) from the City of St. Petersburg from 2004 to 2010 and estimated development by the year 2015. (Source: Vodokanal; www.vodokanal.spb.ru)

P loading from all municipal waste water treatment plants in Finland

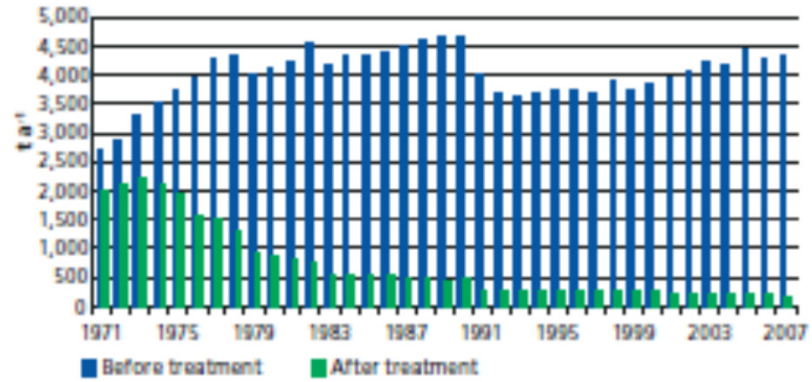

Figure 6-1 Phosphorus load ($t\ a^{-1}$) from all municipal wastewater treatment plants in Finland from 1971 to 2007. (Source: SYKE)

- Anything left of the point sources?
- Baltic Sea total: 22% of waterborne loading (6,700 tons out of 31,000 tons)

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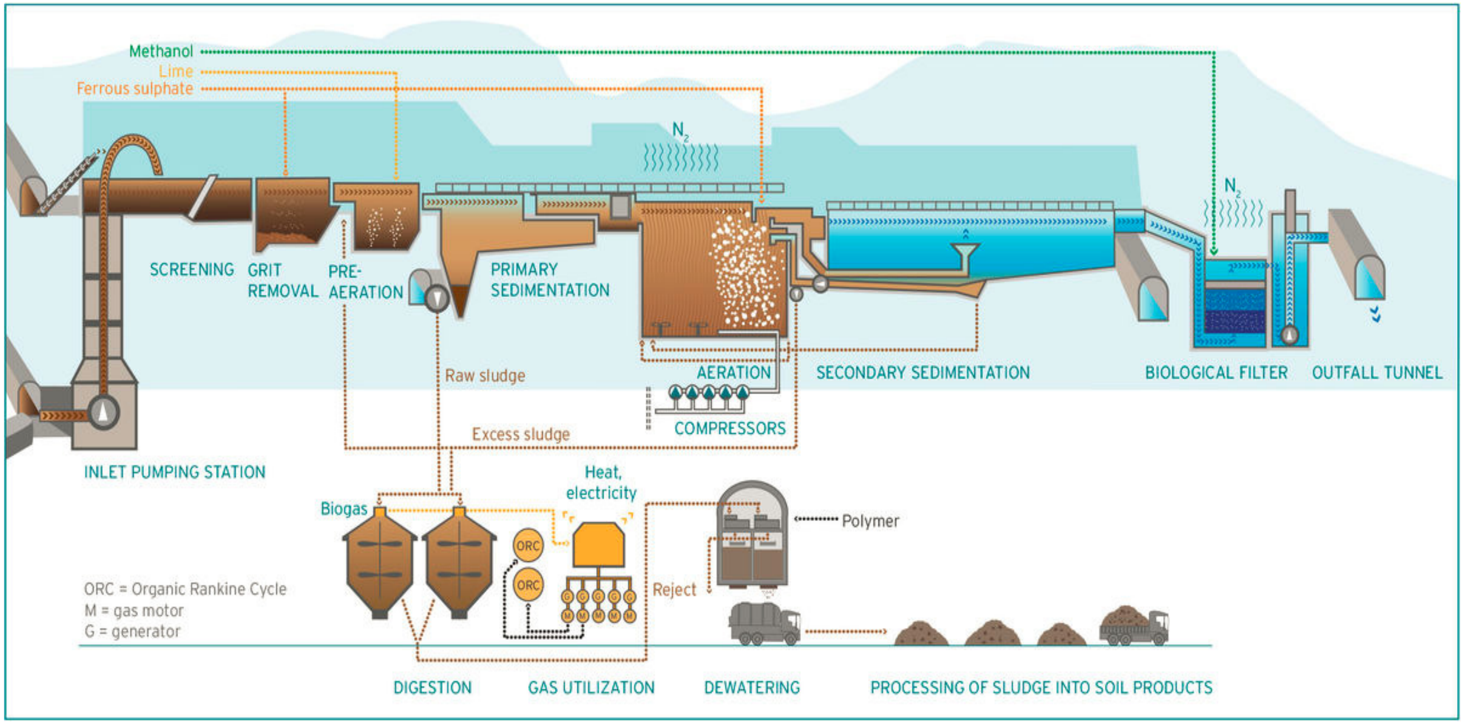
2. Food Chain and Nutrient Loading

Non-point loading **Point loading**

Food Chain and Nutrient Loading: point-sources



- One-dimensional mandate: remove nutrients and harmful substances
- Removal of nutrients can be isolated into controllable, steady processes and sub-processes
- Division of labour, continuous monitoring
- Any decision made or supported by many individuals
- A decision mainly (eventually) affects the loading of a single substance
- Emphasis in steering the process, not decision making

Food Chain and Nutrient Loading: non-point sources

- Mandate: run a business, produce food, be a farmer
- Countless secondary effects: social, regional, environmental (positive and negative)
- All processes interlinked, muddled up by unpredictable natural conditions
- Division of labour weak
- **Any decision affects the entire matrice of nutrient loading**

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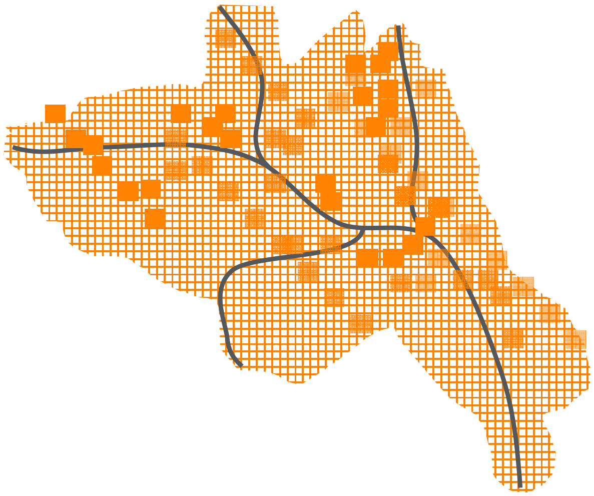
Major trade-offs between P species with popular coservation practices

From the shared Youtube presentation (Uusitalo et al 2017):

Change from ploughing	DRP	PP
Stubble over winter	+93%	-2%
Shallow autumn tillage	+28%	+9%
No-till	+209%	-54%

"*Well-intentioned conservation measures, while reducing PP losses, may have unintentionally contributed to the rise in ecologically damaging SRP loads entering the WLEB after the early 2000s.*" Jarvie et al (2017)

3. Cost-effectiveness – quick and dirty approach



PP, DRP loading from a random catchment

DRP from a WWTP

3. Cost-effectiveness – quick and dirty approach

Current: autumn ploughing

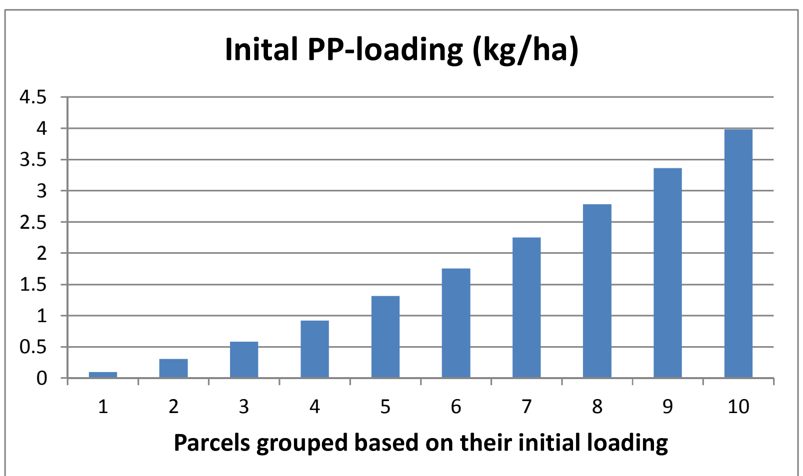
Option: switch to no-till

Cost: 8 €/ha

Effects on loading: previous slide

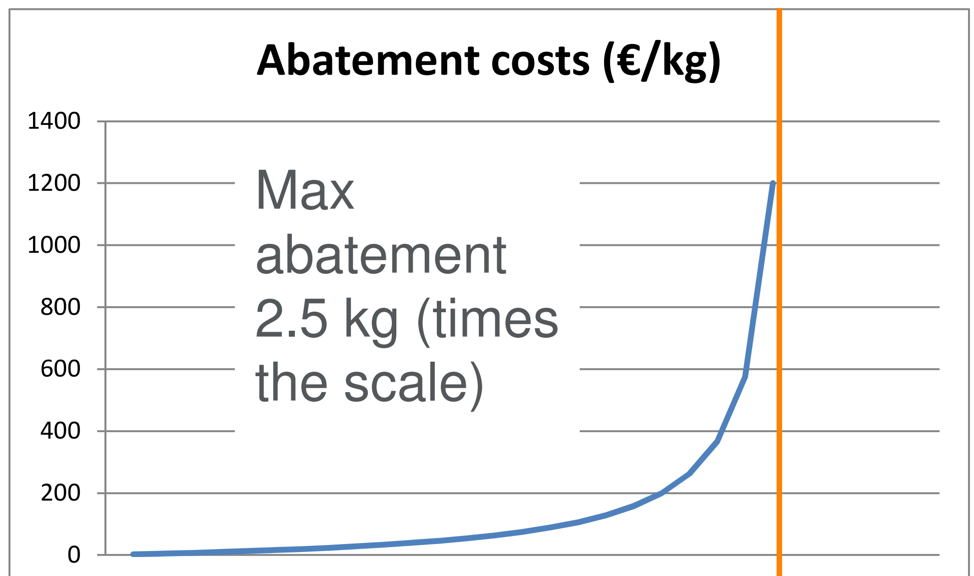
DRP homogenous: 0.15 kg/ha

Divide parcels into ten categories w.r.t initial PP delivery



Call the engineer, ask for an abatement cost curve for DRP (origo at the current situation)

Engineer: ”Roger”

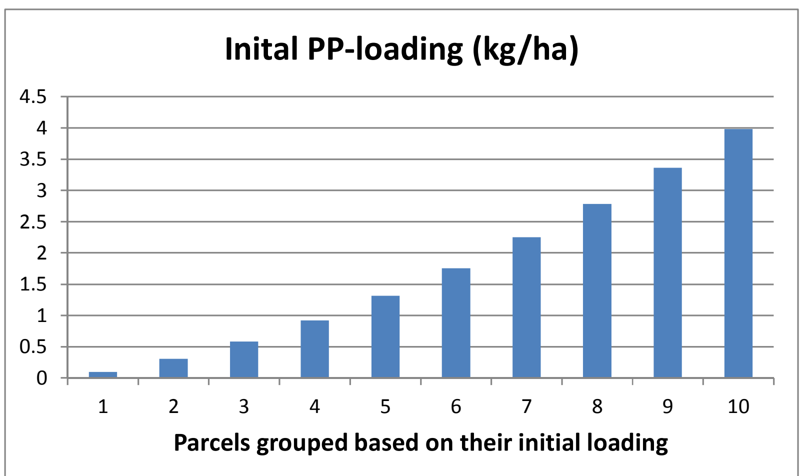


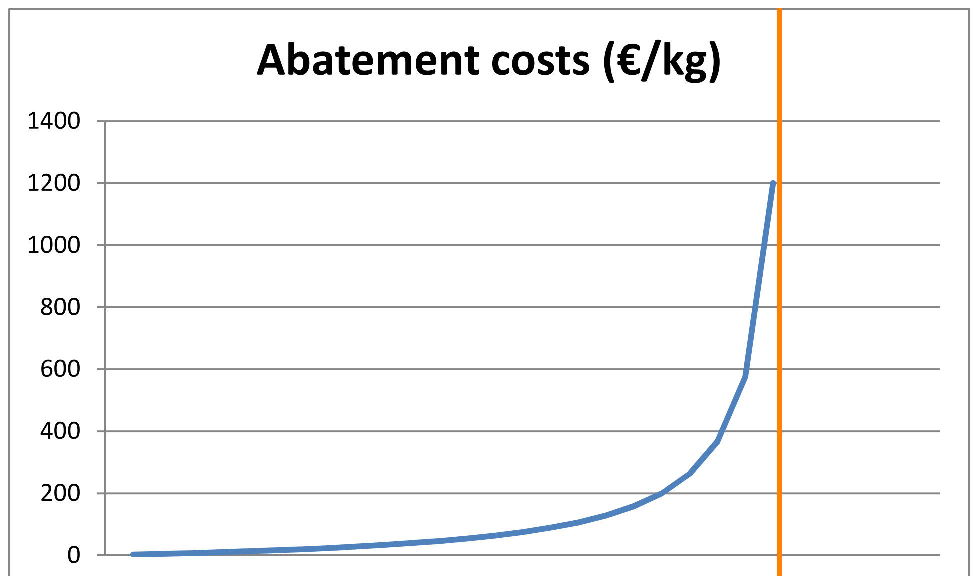
3. Cost-effectiveness – define the metric & target

Metric = = EPU; Target 30% reduction

$$\mathrm{EPU} = \beta PP + DRP$$

Were β is the bioavailable fraction of PP. By setting β=1, we get the current TP-metric

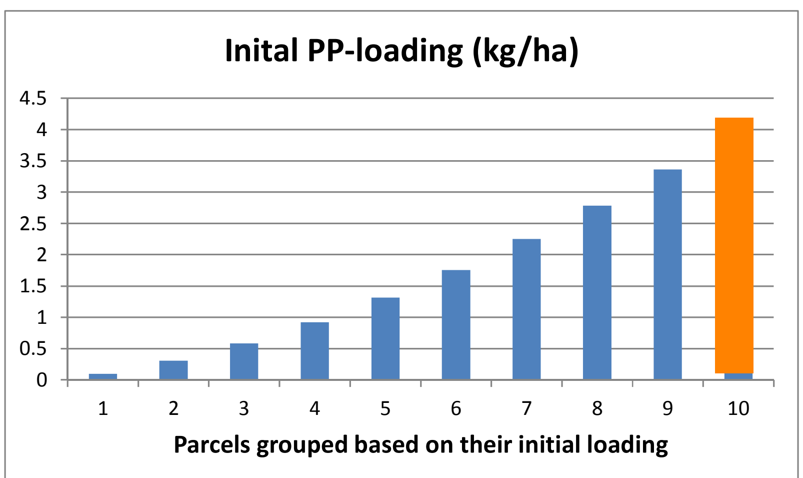


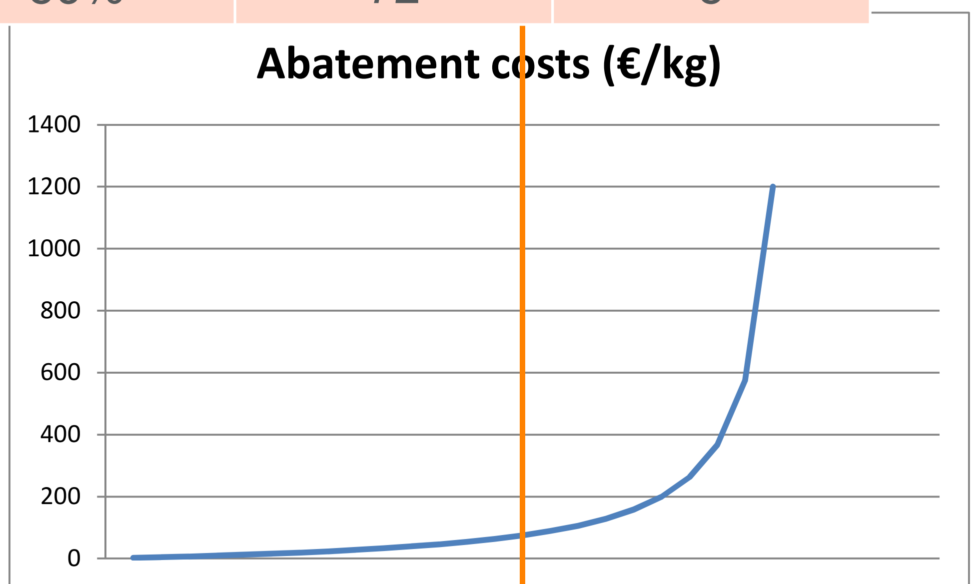


3. Cost-effectiveness – define the metric & target

Cost-effective allocation with ***β*=0.2**

β	No-till %	WWTP %(of max)	Total cost (€)	Initial EPU loading
1	50%	4%	42	19
0.8	50%	20%	53	15
0.5	40%	48%	78	10
0.3	30%	56%	88	7
0.2	10%	56%	72	5



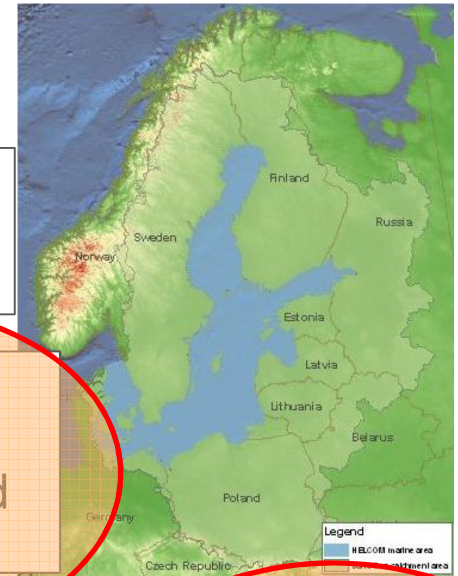


4. The narrow corridors, Baltic

A country designs & implements programs to meet BSAP

BSAP sets country specific targets in terms of TP, TN

But the information will not pass through this, policy-oriented corridor without our help



Sediment processes release/bind nutrients

Farmers respond to incentives & regulations

Nutrient species transported and transformed by streams and rivers

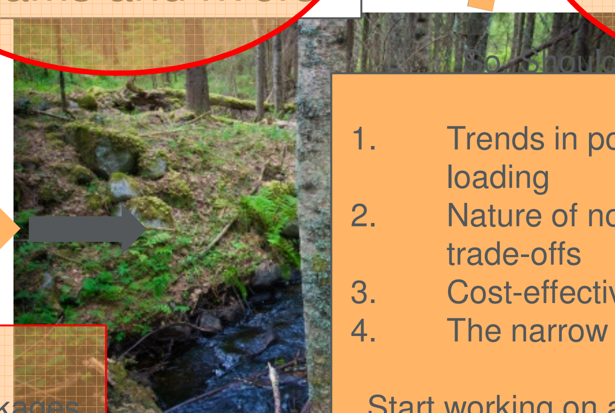
Nutrient species accelerate algae growth

In islotation, we understand that speciation matters in each of these processes

H_2O PP

DRP NO_3

Fe NH_4



Nutrient species respond to farmers actions

We can improve our undesrtanding of the interlinkages of the science oriented steps with…science

So, should we, because of

1. Trends in point and non-point loading
2. Nature of non-point pollution and its trade-offs
3. Cost-effectiveness
4. The narrow corridors

Start working on a metric that unifies the policy processes, instruments and regulations and science in an unbiased as possible manner?