Phosphorus from farmland to water in Sweden

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Baltic Sea


Cyanobacterial blooms in the Baltic Sea
MODIS AQUA 2005-07-11, data from NASA
processed by SMHI

Swedish responsibility
-290 t P to the Baltic Sea

Minister meeting two weeks ago in Krakow

Next: how much reduction from agriculture ?

High prizes - former fallows are tilled

P soil-water system (kg ha^{-1})

Deposition 0.2-1.2 kg ha^{-1}

Fertilizer 0-22 kg ha^{-1}

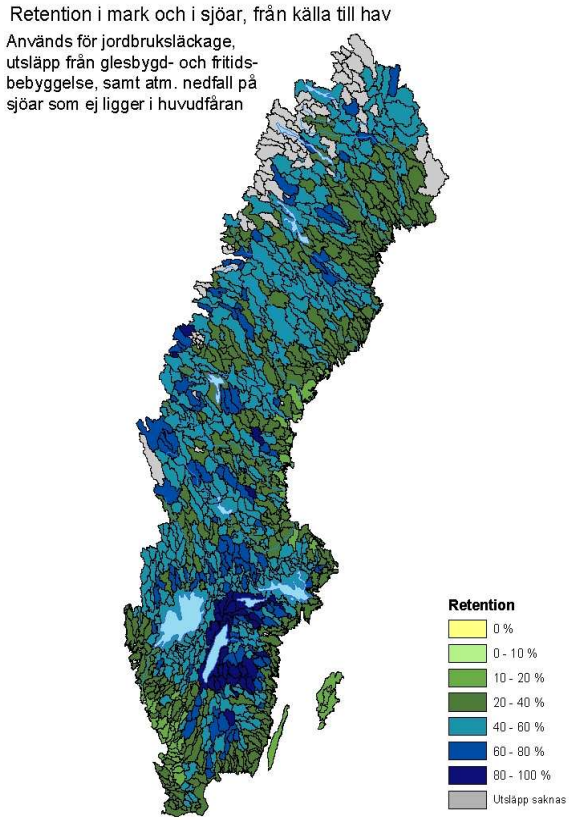
Crop 15-50 kg ha^{-1}

Crop residues 3-10 kg ha^{-1}

Surface runoff 0.02-2.0 kg ha^{-1}

Drainage 0.01-1.8 kg ha^{-1}

Average soil P balance

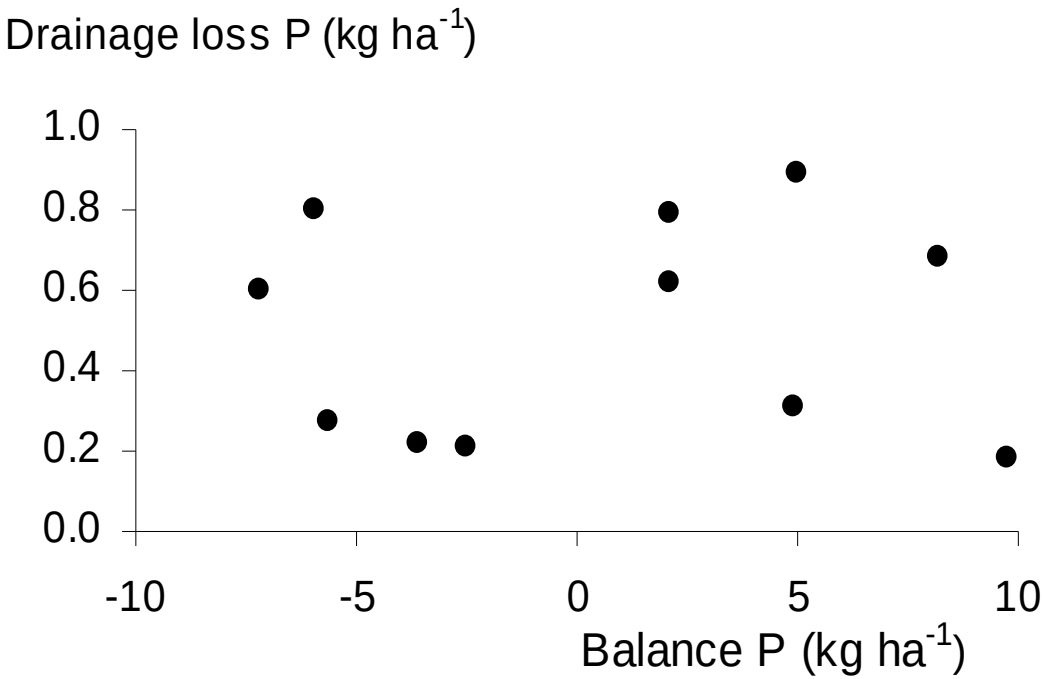


Average + 2 kg ha^{-1}

Live stock intensive areas + 8 kg ha^{-1}

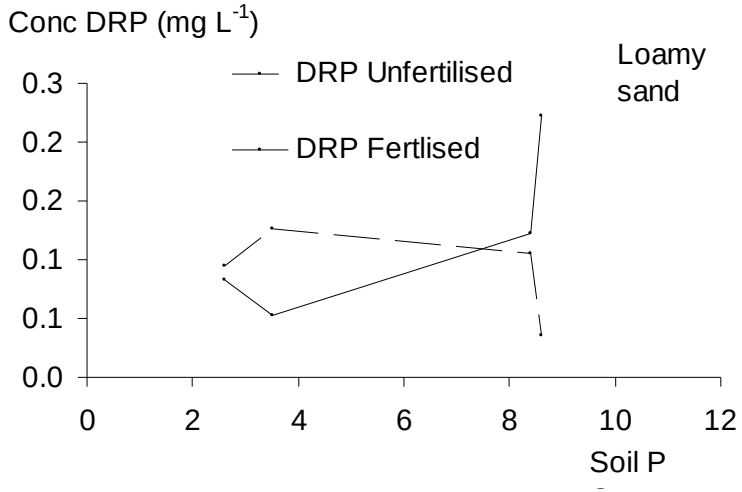
Soil P balance

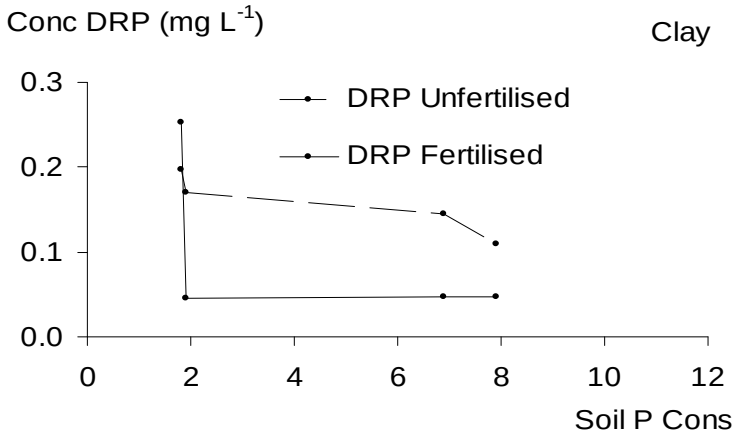
Average + 2 kg ha^{-1}
Live stock intensive areas + 8 kg ha^{-1}



Plot experiments

No direct relationship between topsoil P and dissolved reactive P concentration in drainage water





P-AL in Swedish soils

Quite often increase in deeper subsoil (60-90 cm) in drained soils (increasing clay concentration)

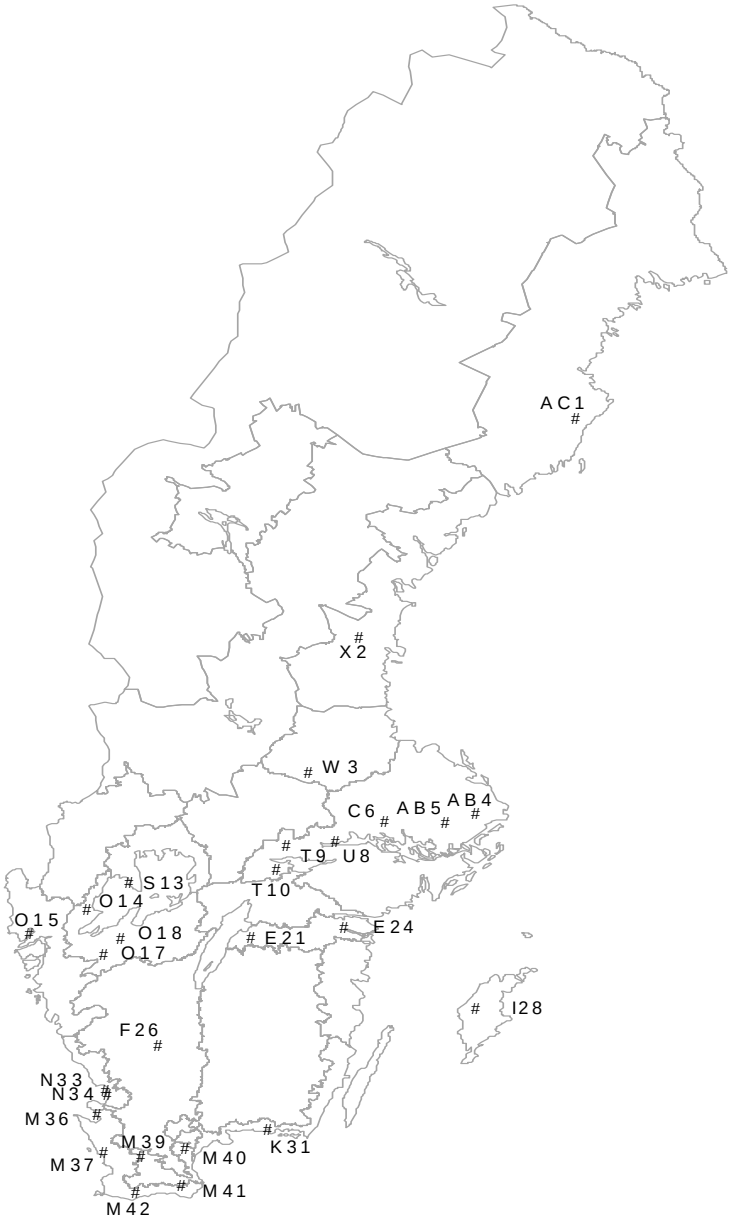
Degree of P saturation in soil extract

- DPS_1 = 100 * P-AL/(Al-AL + Fe-AL) (mole based)

- DPS_2 = P-AL/PSI

  PSI = sorption index (one point method)

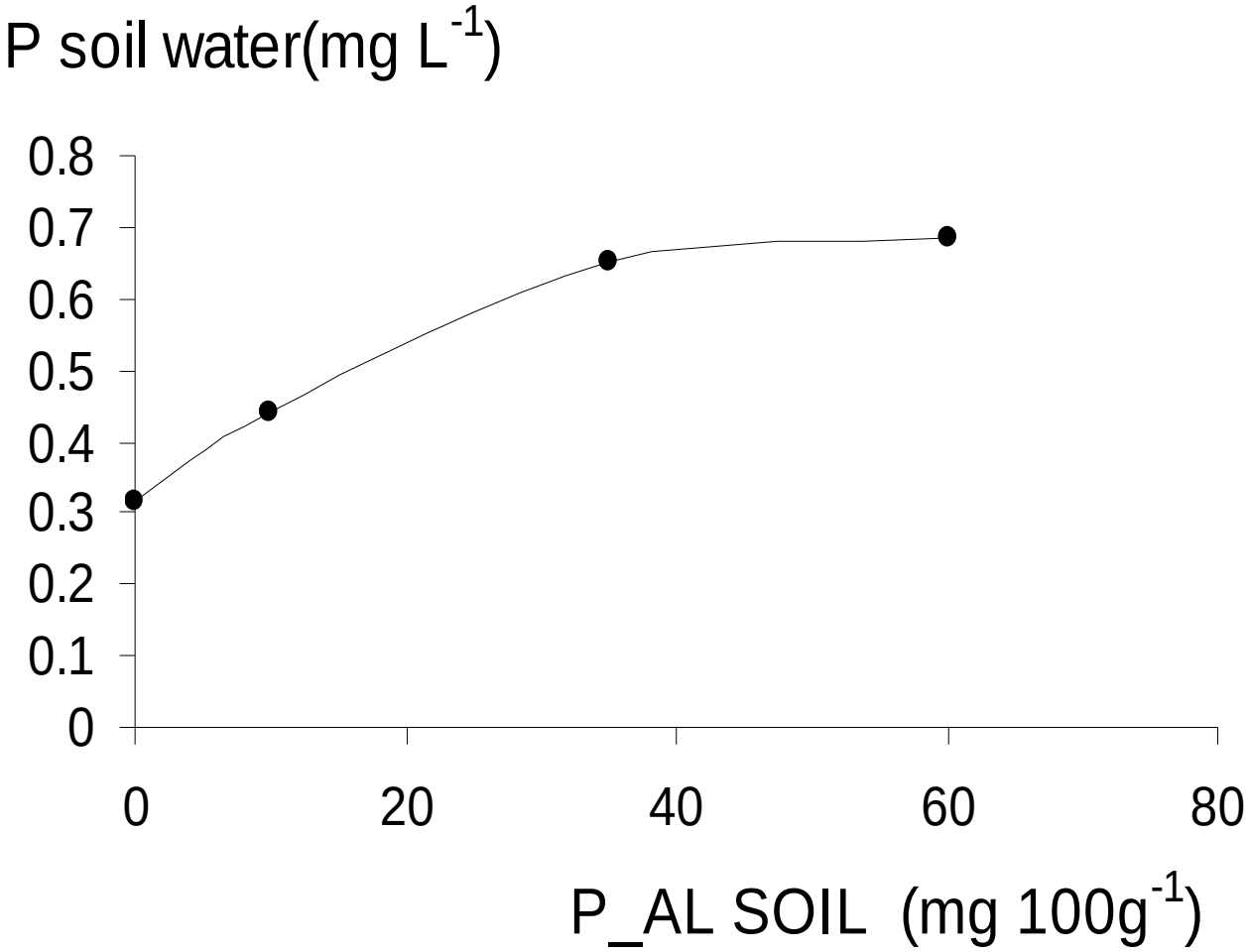
Average Swedish monitored fields



Layer	DPS_1 %	Clay %
0-20 cm	20	19
20-60 cm	11	28
60-90 cm	25	35

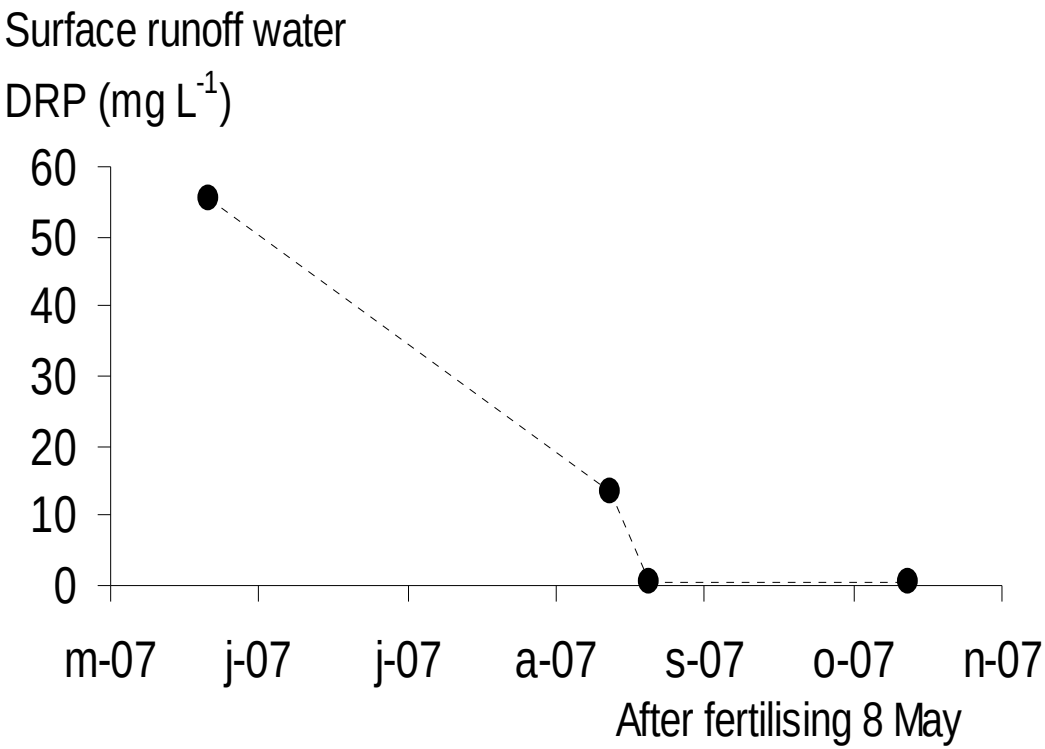
Agriculture in the north - cultivating in ridges

Relationship between P in soil and P in soil water



Suction lysimeters

Relationship between P in runoff water
P fertilizing and P in soil



Gerlach vessels


90% of loss in 1 % of the time

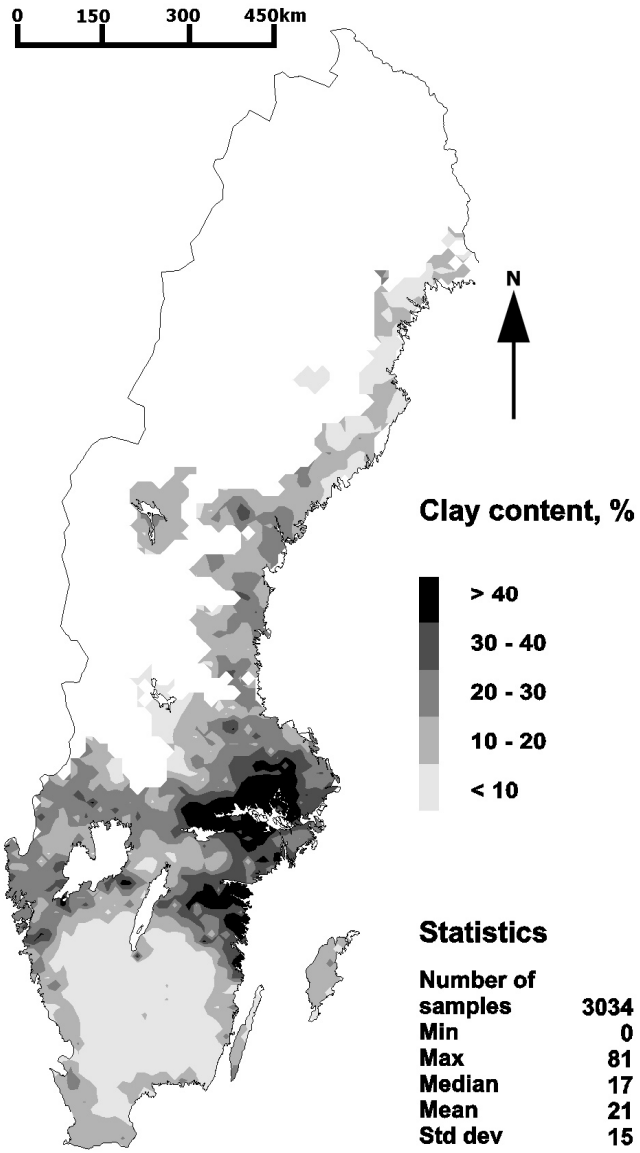

Counter measures
shall be effective
in the critical
episodes

Colloidal clay particles in drain water and streams

Marine clay soil with cracks

Extremely fast water infiltration

Clay soil are usually drained



Measures and mechanisms to reduce losses of dissolved reactive phosphorus (DRP) and particulate phosphorus to a recipient from a Swedish clay soil

Measure	**Mechanism**	**DRP**	**PP**
Balance + soil test Balanced addition manure/fertilizer	No increased P surplus in the soil	+++	+
Ferilizer placement Combi-drill or instant corporation	Improved contact with soil	+++	++
Reduced erosion Densely vegetated winter soil (grass) Spring tillage	Filtration of particles Less detachment/P desorption	0 ++	+++ ++
Improved water infiltration Reduced soil compaction	Less water channelization	++	+++
Trapping in artificial drainage Limed backfills	Improving infiltration and +chemical precipitation	+	++
Buffer zones Including around surface water inlets Grassed strips within the field	Intercepting surface-runoff P and improving water infiltration	-	+++

Silty soil with high surface runoff

Low resistance caused by cohesion

Low resistance caused by friction

Measures and mechanisms to reduce losses of dissolved reactive phosphorus (DRP) and particulate phosphorus **to a recipient** from a Swedish silty soil

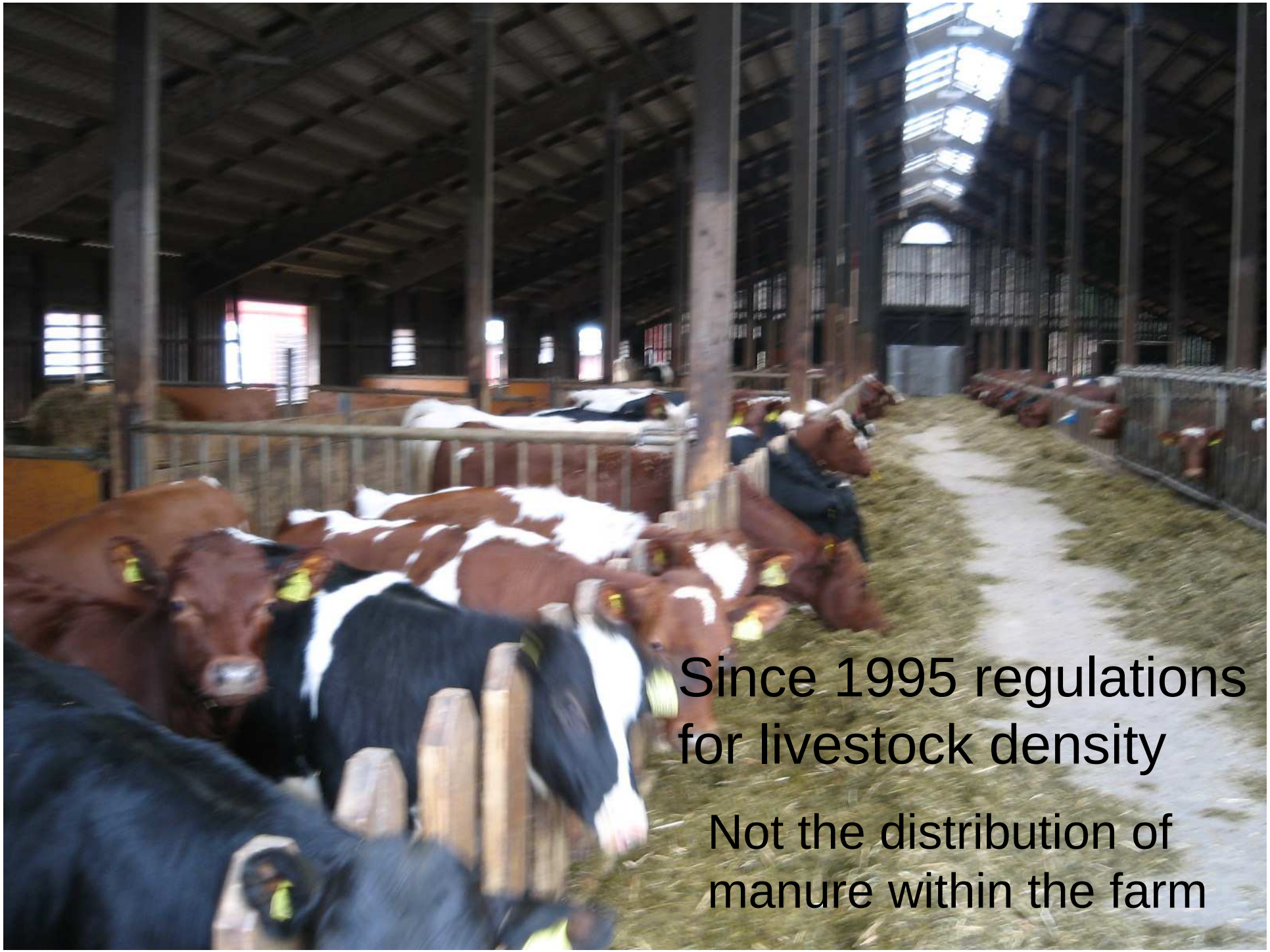
(NOT EDGE OF THE FIELD RESULTS)

Measure	Mechanism	DRP	PP
Balance + soil test Balanced addition manure/fertilizer	No increased P surplus in the soil	+++	+
Fertilizer placement Combi-drill or instant corporation	Improved contact with soil	+++	++
Reduced erosion Densely vegetated winter soil (grass) Spring ploughing	Filtration of particles Less detachment/P desorption	0% <5%	-10-20% -10-20%
Improved water infiltration Reduced soil compaction	Less water channelization	++	+++
Trapping in artificial drainage Limed backfills	Improving infiltration and +chemical precipitation	++	+++
Buffer zones Including around surface water inlets Grassed strips within the field	Intercepting surface-runoff P and improving water infiltration	++	+++

Sandy soil with percolating water

Measures and mechanisms to reduce losses of dissolved reactive phosphorus (DRP) and particulate phosphorus from a Swedish sandy soil

Measure	Mechanism	DRP	PP
Balance + soil test Balanced addition manure/fertilizer	No increased P surplus in the soil	+++	+
Fertilizer placement Combi-drill or instant corporation	Improved contact with soil	+++	++
Reduced erosion Densely vegetated winter soil (grass) Spring ploughing	Filtration of particles Less detachment/P desorption	0 ++	+ +
Improved water infiltration Reduced soil compaction	Less water channelization	++	++
Trapping in artificial drainage Limed backfills	Improving infiltration and +chemical precipitation	++	++
Buffer zones Including around surface water inlets Grassed strips within the field	Intercepting surface-runoff P and improving water infiltration	-	+


Since 1995 regulations
for livestock density
Not the distribution of
manure within the farm

Field with intensified production 1977-2007

Placement of fertilizer in band in spring

1977-2007 DRP 0.020 → 0.015 mg L^{-1}

Reduced tillage practice and improved soil structure

1. Increased organic content and aggregate structure of the soil
2. Rain water is fast infiltrated
3. No soil crust. Not so sensitive for dryness
4. The soil tolerates the traffic
5. Less soil compaction of the subsoil
6. Less costs and emissions from fuels

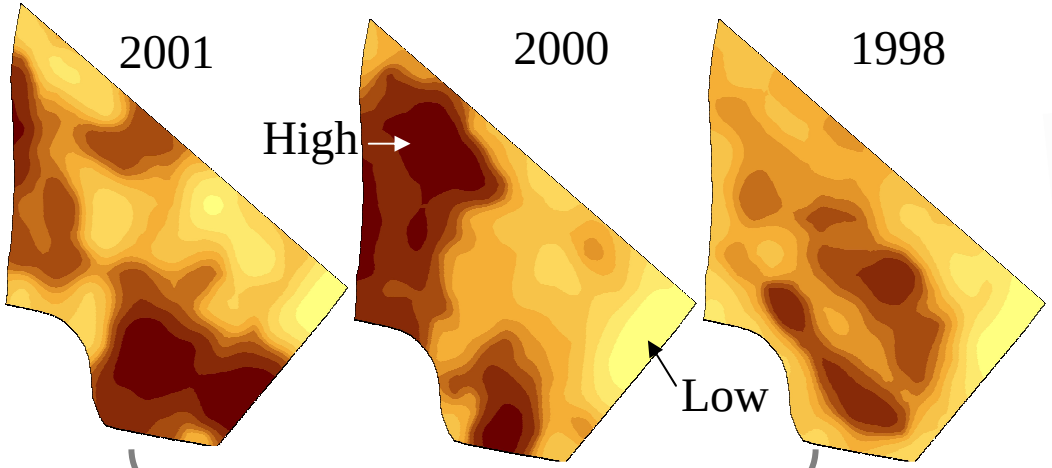
Drained plot experiments

Limed filter ditches

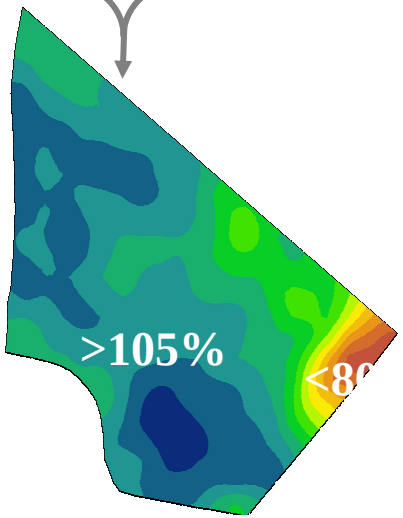
Less water transport in top soil and more water to the drainage system

Less particle transport

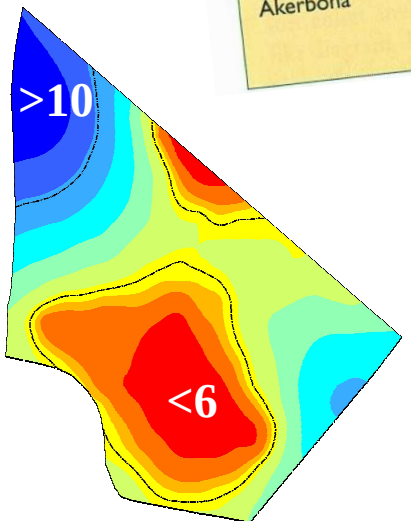
Fertilizing practicing precision farming



Crop barley



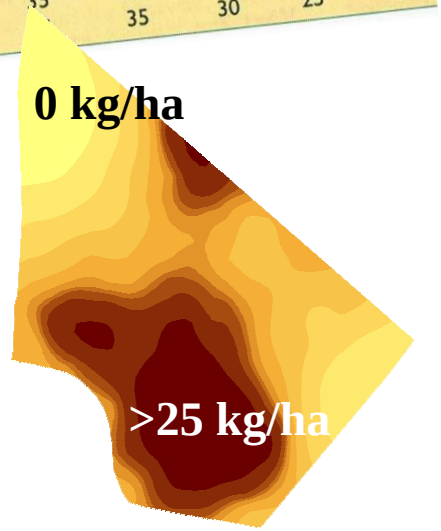
Expected relative crop



Soil P-AL from maps

Need of P Farmer organisation

Gröda	Skörd ton/ha	Klass Tal	Gödslingsbehov kg P/ha P-AL analys I 0-2	II 2-4	III 4-8	IV 8-16	V 16-
Stråsäd	3		30	20	15	10	0
	5		35	25	20	15	0
	7		40	30	25	20	0
	9		45	35	30	25	0
Olje-växter	1,5		30	25	20	15	0
	2,5		35	30	25	20	0
	3,5		40	35	30	25	0
	4,5		45	40	35	30	0
Ärter & Åkerböna	2,5		25	20	15	10	0
	3,5		30	25	20	15	0
	4,5		35	30	25	20	0
	5,5			35	30	25	0



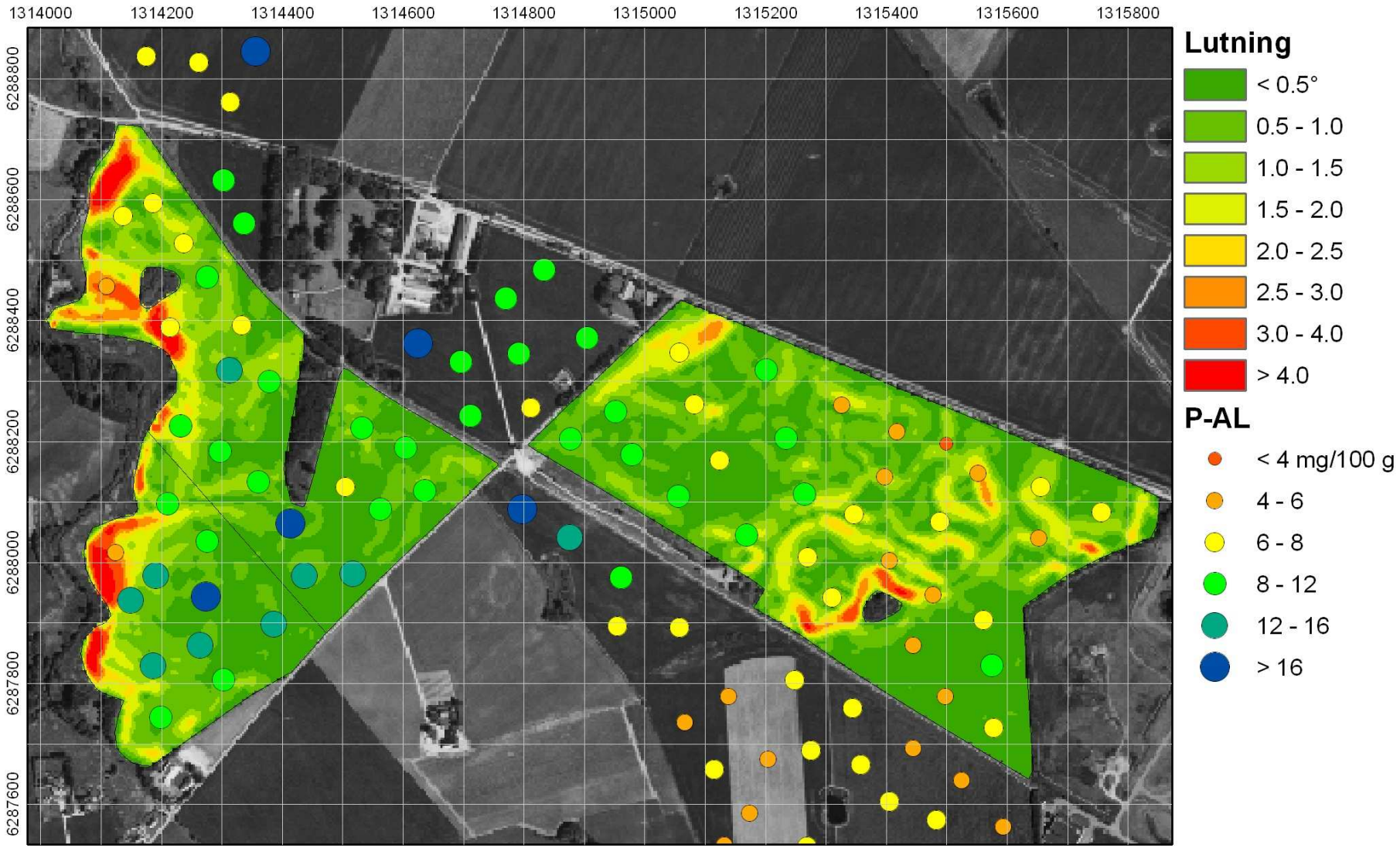
Varied need of fertilizers

Precisionsodling POS Sverige

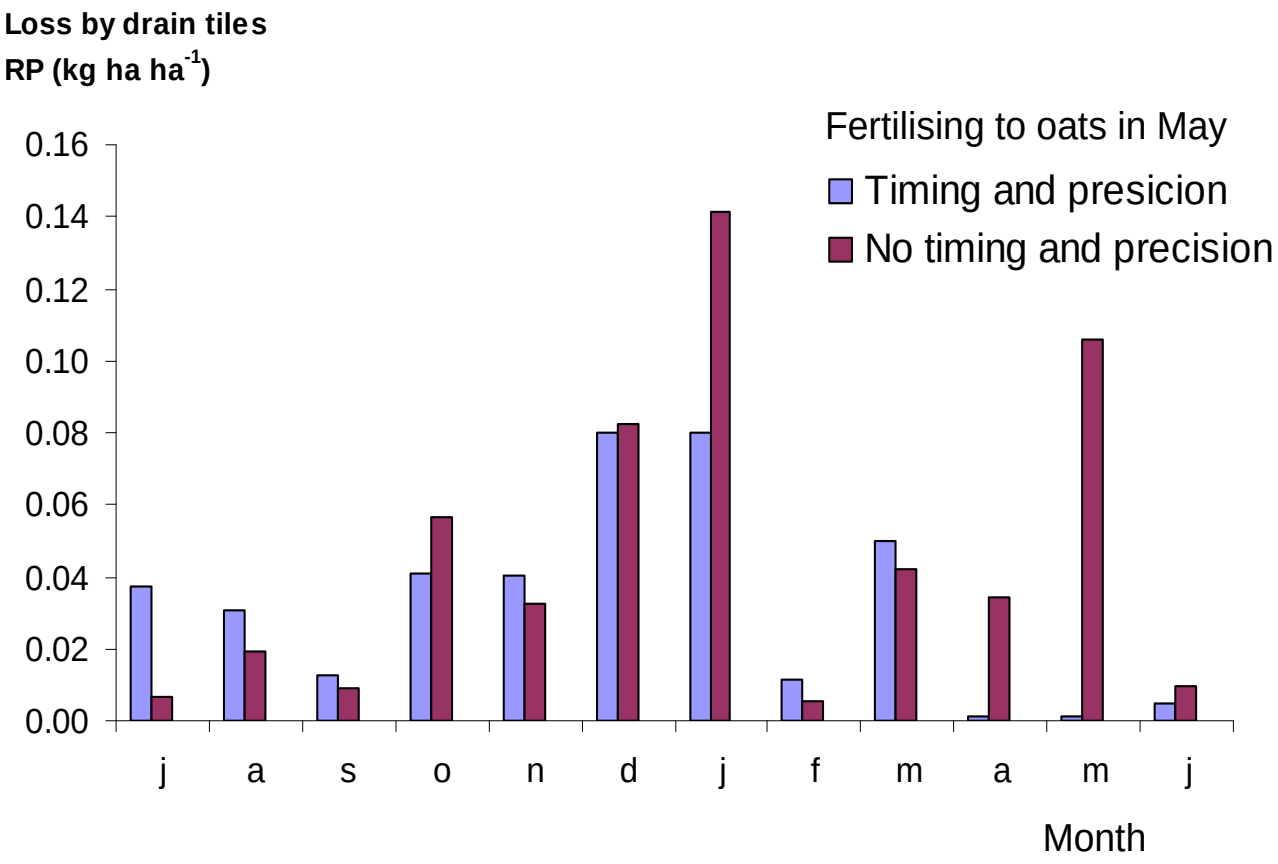
SLU Swedish University of Agricultural Sciences

Fertilizing practicing precision farming

Slope



Timing fertilizing relative precipitation



Full-scale field experiment

Countermeasures in catchments

Buffer zones

Biologic active wetlands

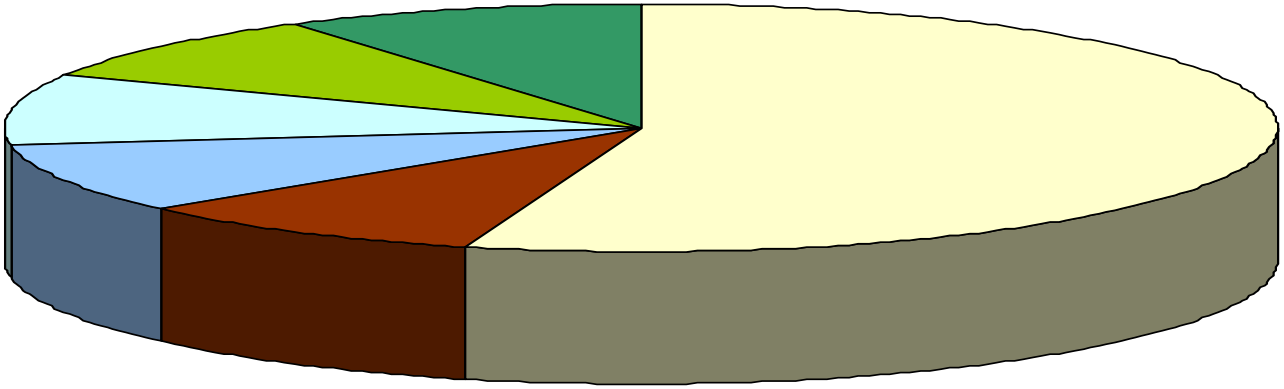
Sedimentation ponds


Subsidizes: grassed filter
strips along water courses
wetlands on former
agricultural land

Important factors when constructing wetlands

1. Long retention time
2. High P concentrations in inlet water
3. Even level of water flow and no short-cuts for the water
4. Zones of flooding in order to level out the water
5. Channels allowing the water to pass during extreme high flows
6. As little digging as possible
7. **If possible no wetlands on former agricultural soils**
8. A varied design with part of the wetland with open mirror of water and other parts are shallow
9. Steep transfers between shallow and steep parts
10. Management – frequent digging out the sediment - otherwise wetland may turn into a phosphorous source

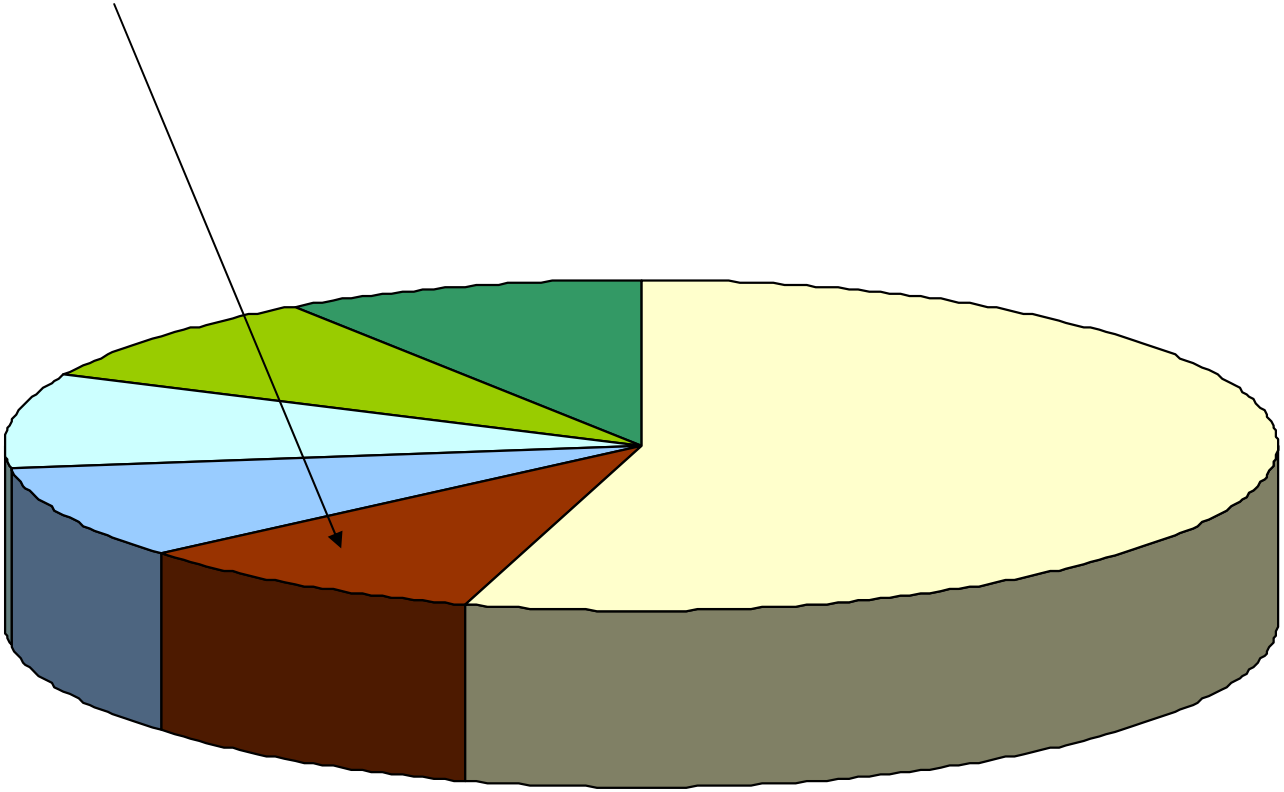
Constituents of phosphorus leaching



Natural background

Soil tillage

Factors with an impact on water infiltration, soil aggregates, and P mineralization. More knowledge on how tillage practice and time influence water infiltration and soil macropore systems in clay soils

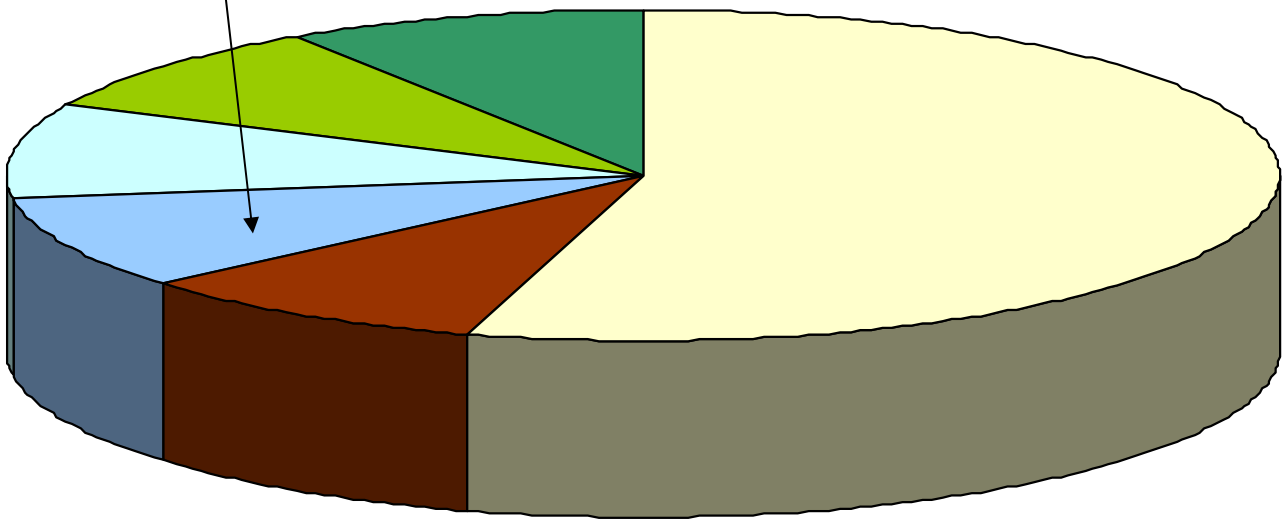


Manure

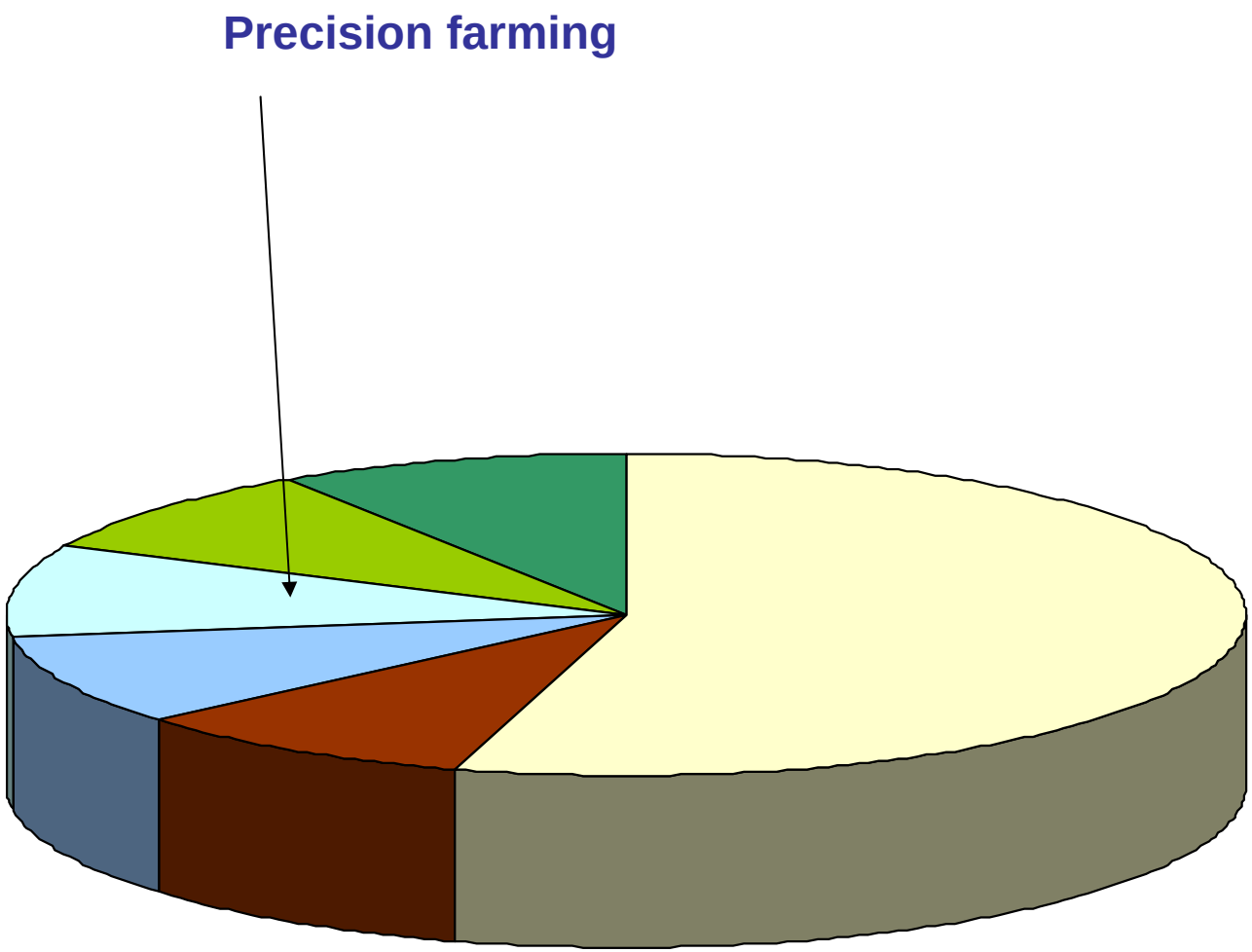
Slurry application on clay soils is still a problem

Appropriate conditions for spreading are rare.

Less P in manure by less P in fodder



Mineral fertilizing



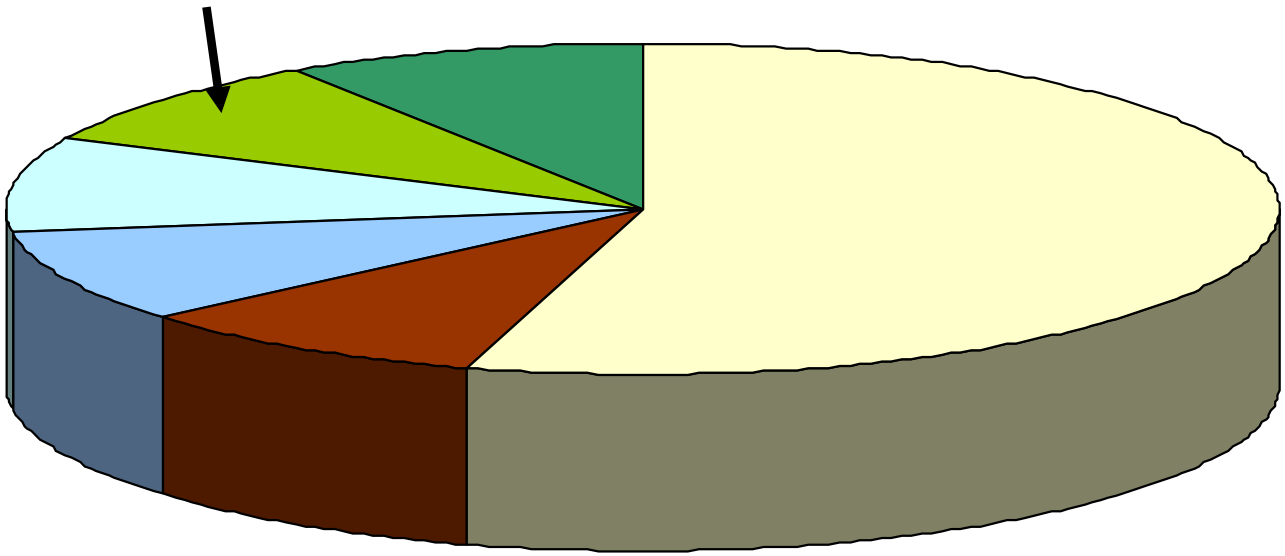
Winter crops :

May act as a filter – freezing and cutting crop material ?

Root development may take long time

How do ”new” catch crops act ?

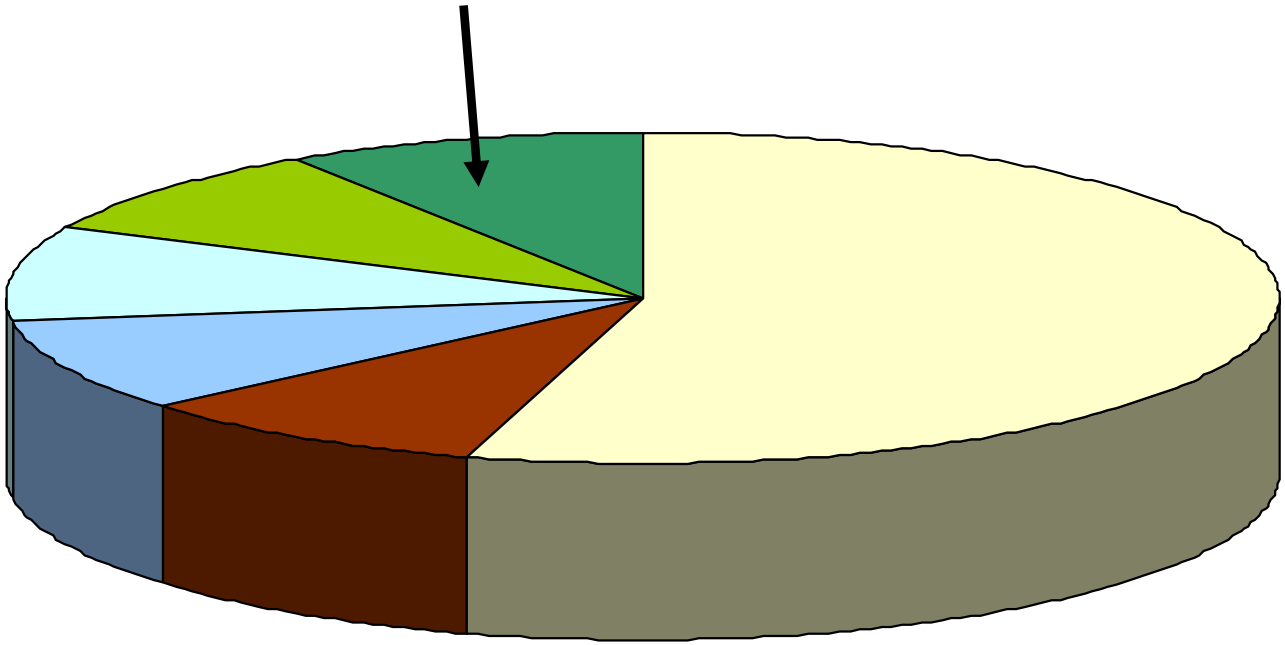
Winter wheat needs no fertilizing.



Phosphorus in green fallow:

Mobile in the same way as slurry

Distribution of the green crop in the crop rotation



Slow but significant reduced concentration of particulate phosphorus in the south of Sweden

Climate change means more episodic P losses more frequent freezing-thawing of crop and soil

Baltic Sea drainage basin

Från *Förändringar under ytan* (Monitor 19).

Extraction methods used for P in soil

	Extractions	**Method**
Denmark	Bicarbonate	P-Olsen
Estonia	New in 2004	P Mehlich-3
Finland	Ammonium-acetate	P-AAC
Germany	Calcium lactate	P-AC
Latvia	Double-lactate	P-DL
Lithuania	Ammonium-lactate (Ivanov)	P-AL
Poland	Double-lactate	P-DL
Russia NW	Hydrochloric acid	P-HCl
Sweden	Ammonium-lactate (Egnér)	P-AL

Typical soil P concentrations

	mg kg^{-1}	**Class**	**Method**
Denmark	40	II of III	P-Olsen
Estonia	50	IV of V	P-DL
Finland	12*	V of VII	P-AAC
Germany	100	IV of V	P-CaL
Latvia		III of V	P-DL
Lithuania	125	III of IV	P-AL
Poland		III of V	P-DL
Russia NW	30		P-HCl
Sweden	106	IV of V	P-AL

* mg L^{-1}