Agriculture and Water Quality
Phosphorus

Faruk Djodjic
Uppsala, 7th February 2013

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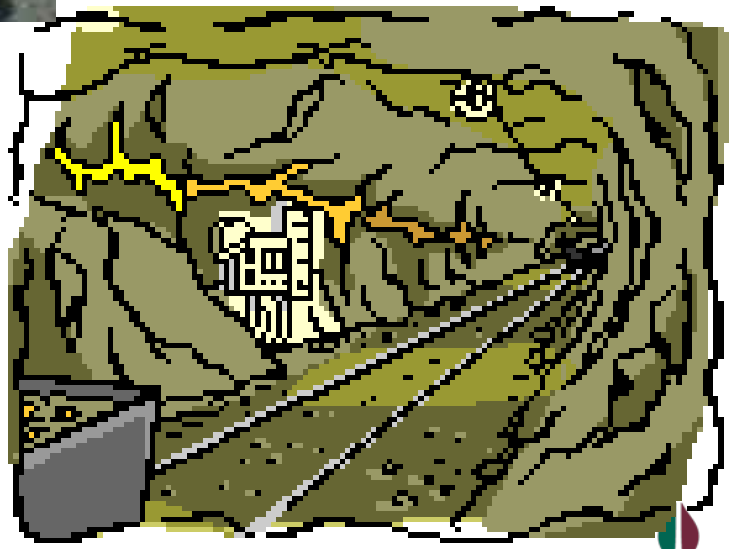
- Introduction
- Production och reservs
- Eutrofication
- P in agriculture
- P losses
- P budget
- Abatement

- Introduction

Important nutrient

Finite source



Eutrofication

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Production & reserves in the world

TABLE 1. World phosphate rock production, reserves, and reserve base.

Country	Average production, 1997-2001, thousand tons	Reserves[1], million tons	Reserve life[2], years	Reserve base, million tons	Reserve base life[2], years
United States	44,851	1,102	25	4,408	98
Brazil	4,875	364	75	408	84
China	24,134	1,102	46	11,020	457
Israel	4,487	198	44	882	196
Jordan	6,350	992	156	1,873	295
Morocco/ Western Sahara	25,346	6,281	248	23,142	913
Russia	11,020	220	20	1,102	100
Senegal	1,860	55	30	176	95
South Africa	3,152	1,653	524	2,755	874
Syria	1,955	110	56	882	451
Togo	1,917	33	17	66	34
Tunisia	8,697	110	13	661	76
Other countries	12,364	1,322	110	4,408	357
Total (rounded)	**151,000**	**13,224**	**88**	**51,794**	**343**

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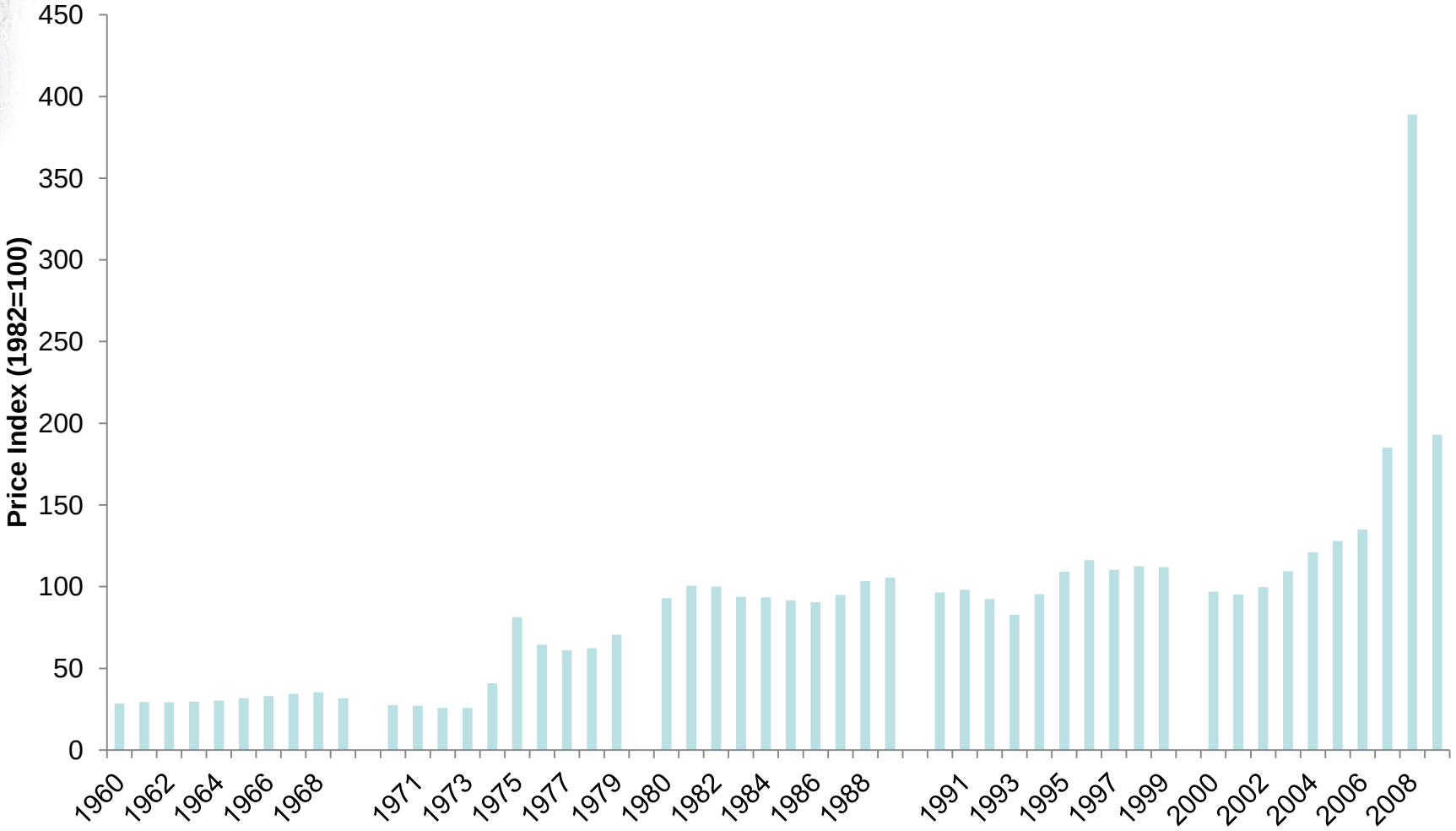
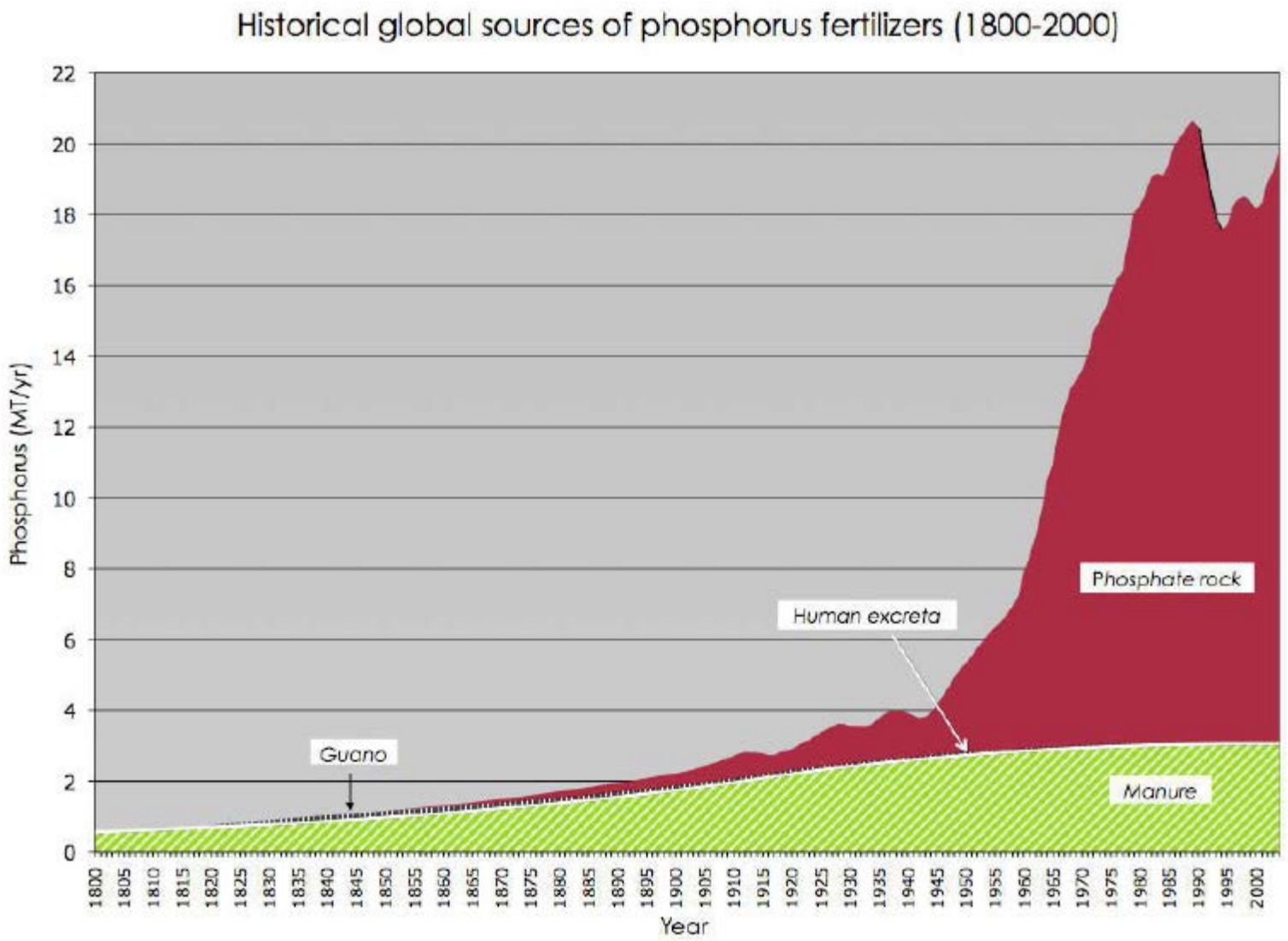
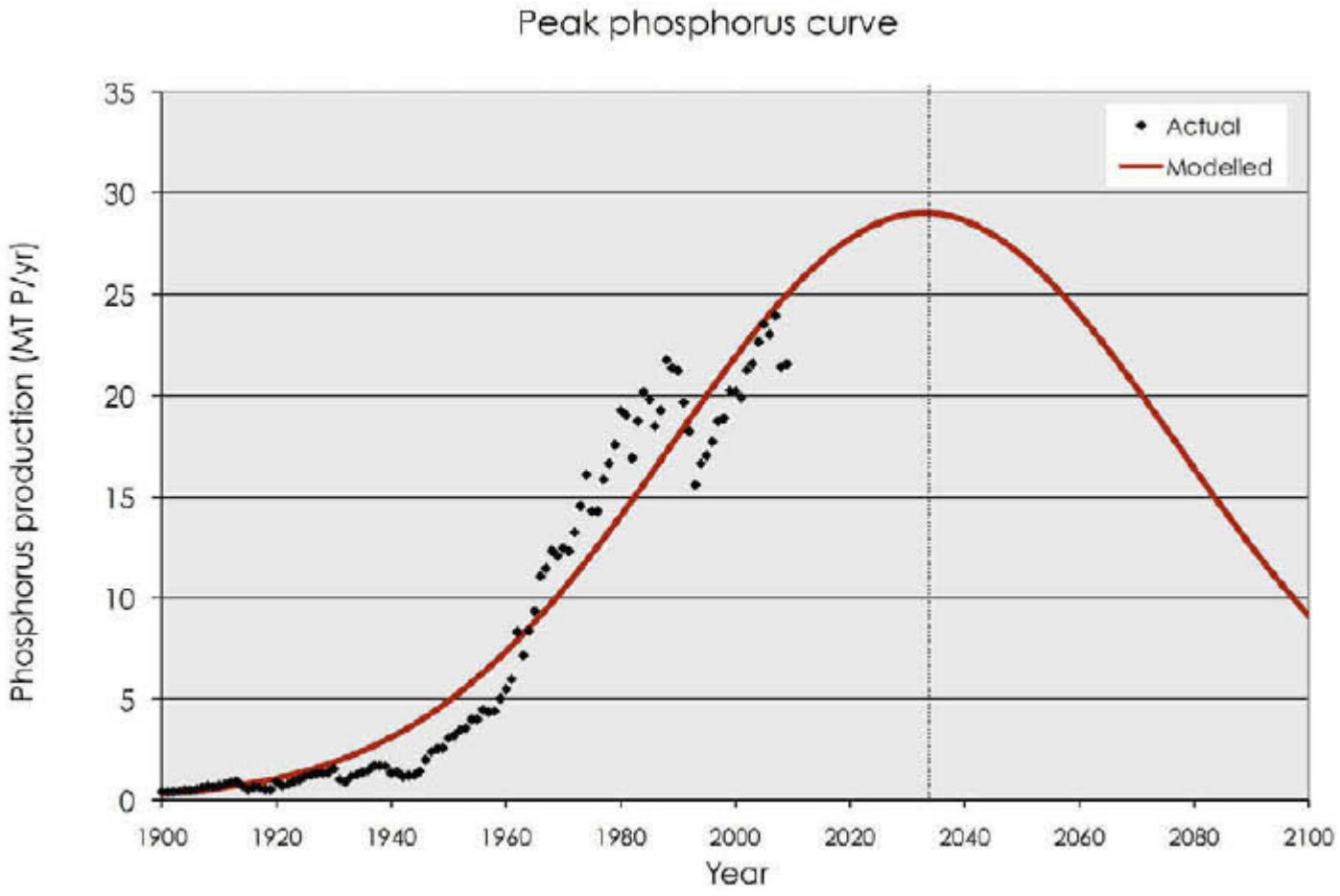
Production & reserves in the world



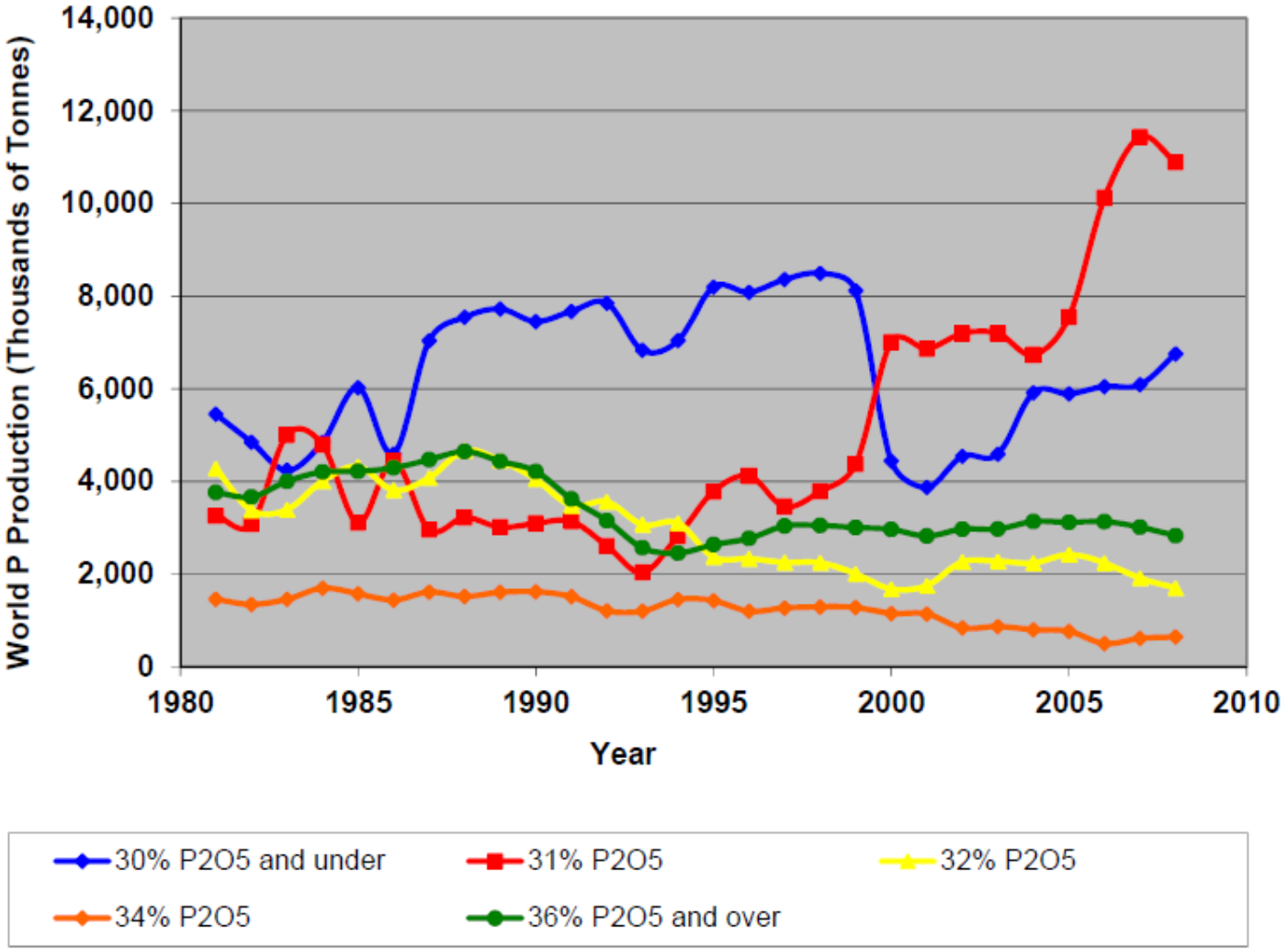
Production & reserves in the world



Production & reserves in the world



World Phosphorus Production by Grade



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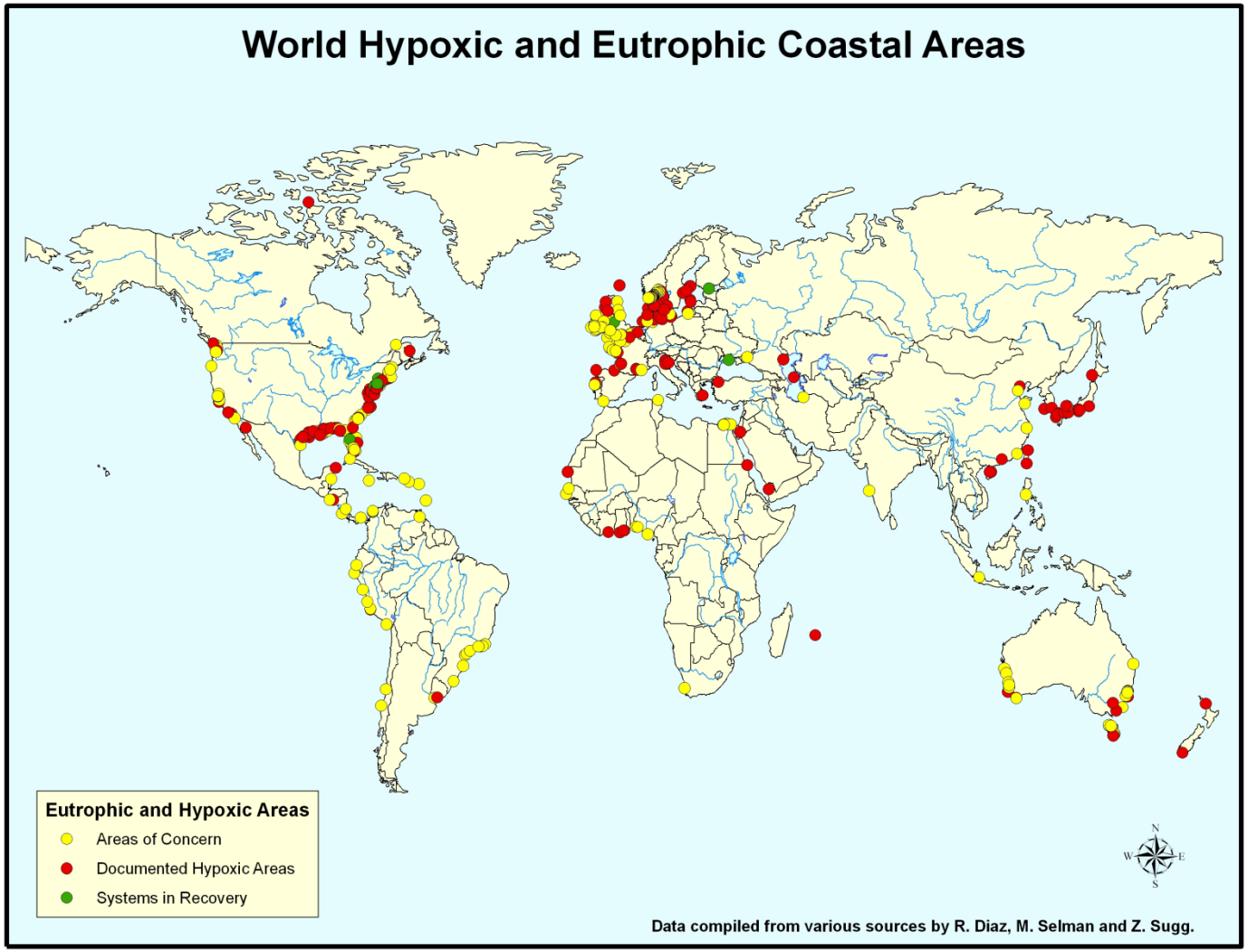
Eutrophication



This map identifies 415 eutrophic and hypoxic coastal systems worldwide. Of these, 169 are documented hypoxic areas, 233 are areas of concern and 13 are systems in recovery. The map is based on research conducted by WRI's NutrientNet program and Dr. Bob Diaz at the Virginia Marine Institute.

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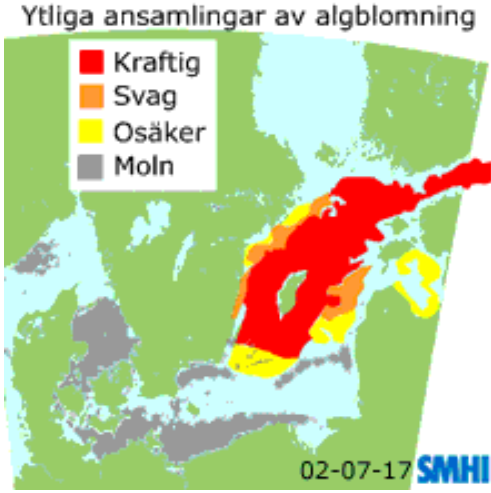
Eutrophication

Cyanobacterial blooms in the Baltic Sea
TERRA MODIS 2004-07-29
Data from NASA, processed by SMHI



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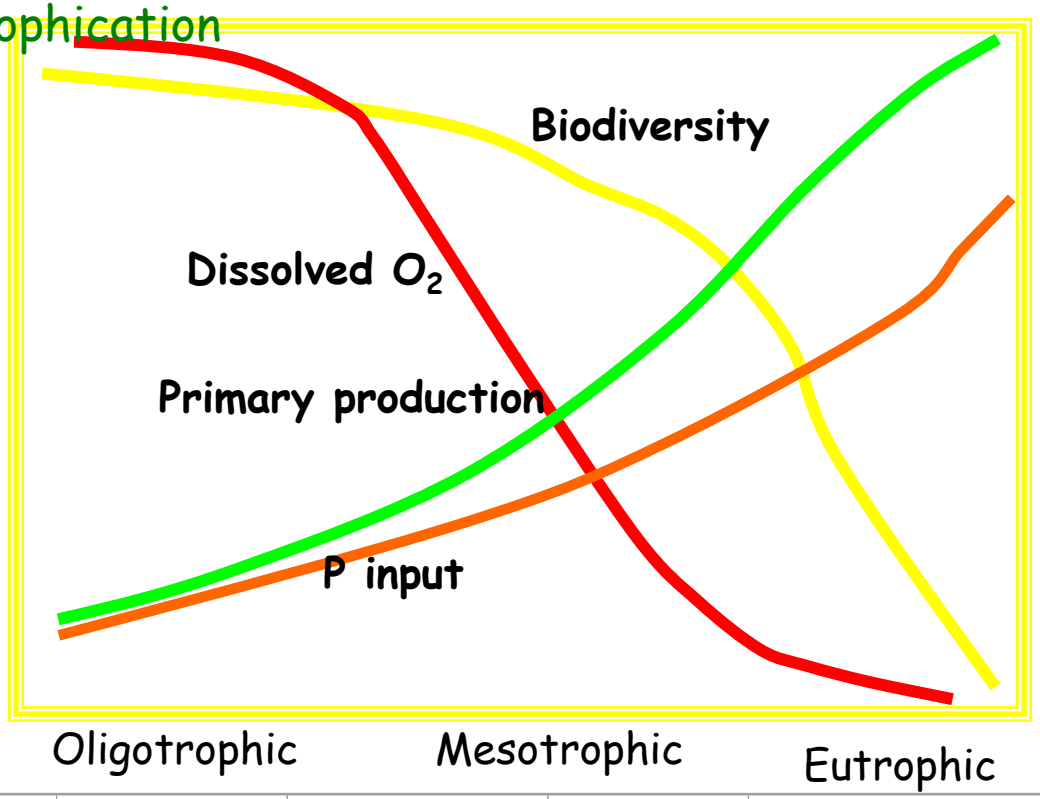
Eutrophication

- 780 (~1000) lakes with measured concentrations > 25 mg/l
- 3700 according to "Riksinventeringen 2000"

Eutrophication



Corell 1998,
Eutrofication - concept

Trophic level	Total P (µg/l)	Clorophyll a (µg/l)	Secci depth (m)	Alge volume (mm3/l)	Prim. prod. (gC/m2,yr)	Total N (mg/l)	Dom. fish
Oligo	<15	<3	>4	<0,1	<25	<0,4	salmon, lavaret
Meso	15--25	3--7	2,5--4	0,1--1,0	25--75	0,4--0,6	perch, lavaret
Eutrophic	25--100	7--40	1,0--2,5	1,0--8,5	75--250	0,6--1,5	perch, roach
Hyper	>100	>40	<1	>8,5	>250	>1,5	roach, bream

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Eutrophication

Zero eutrophication

Nutrient levels in soil and water must not be such that they adversely affect human health, the conditions for biological diversity or the possibility of varied use of land and water.
This objective is intended to be achieved within one generation.

http://www.miljomal.se/

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EC Framework water directive

By 2009 programmes of measures as provided for in the EC Water Framework Directive will be established, specifying how good ecological status is to be achieved in lakes and streams and in coastal waters.

…ensure all aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands meet 'good ecological status' by 2015.

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HELCOM Baltic Sea Action Plan

	P (t)	N (t)
Denmark	16	17210
Estonia	220	900
Finland	150	1200
Germany	240	5620
Latvia	300	2560
Lithuania	880	11750
Poland	8760	62400
Russia	2500	6970
Sweden	290	20780
Transboundary Common pool	1660	3780

HELCOM Ministerial Meeting, Krakow, Poland, 15 November 2007

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Eutrophication

	Source	Gross nitro-gen (t/year)	Net nitro-gen (t/year)	Anthropo-genic nitrogen, gross (t/year)	Anthro-pogenic nitrogen, net (t/year)	Gross phos-phorus (t/year)	Net phos-phorus (t/year)	Anthropo-genic phos-phorus, gross (t/year)	Anthropo-genic phos-phorus, net (t/year)
Diffuse sources	Agricultural land	52,700	34,400	38,200	24,300	1,590	1,010	940	620
	Forest land	47,800	38,700	3,300	2,600	1,260	950	20	20
	Unforested, montane and mire land areas	16,100	12,700			730	530		
	Deposition on water	16,300	10,700	16,300	10,700	160	90		
Point sources	Storm water (cities)	1,700	1,500	600	600	190	140	100	70
	Local on-site wastewater treatment	1,800	1,100	1,800	1,100	240	170	240	170
	Municipal wastewater treatment	20,300	17,000	20,300	17,000	420	350	420	350
	Industry	5,300	4,800	5,300	4,800	360	320	360	320

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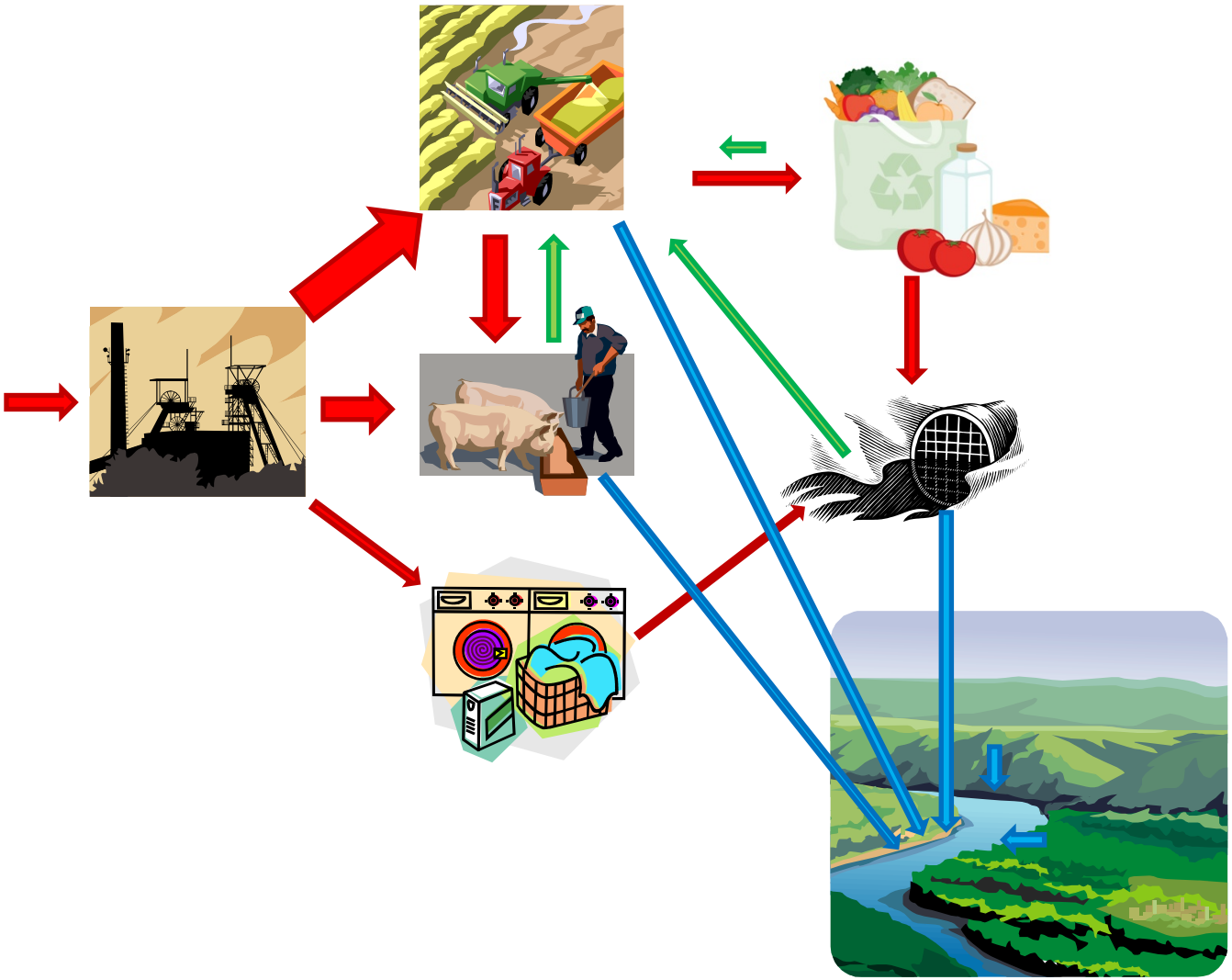
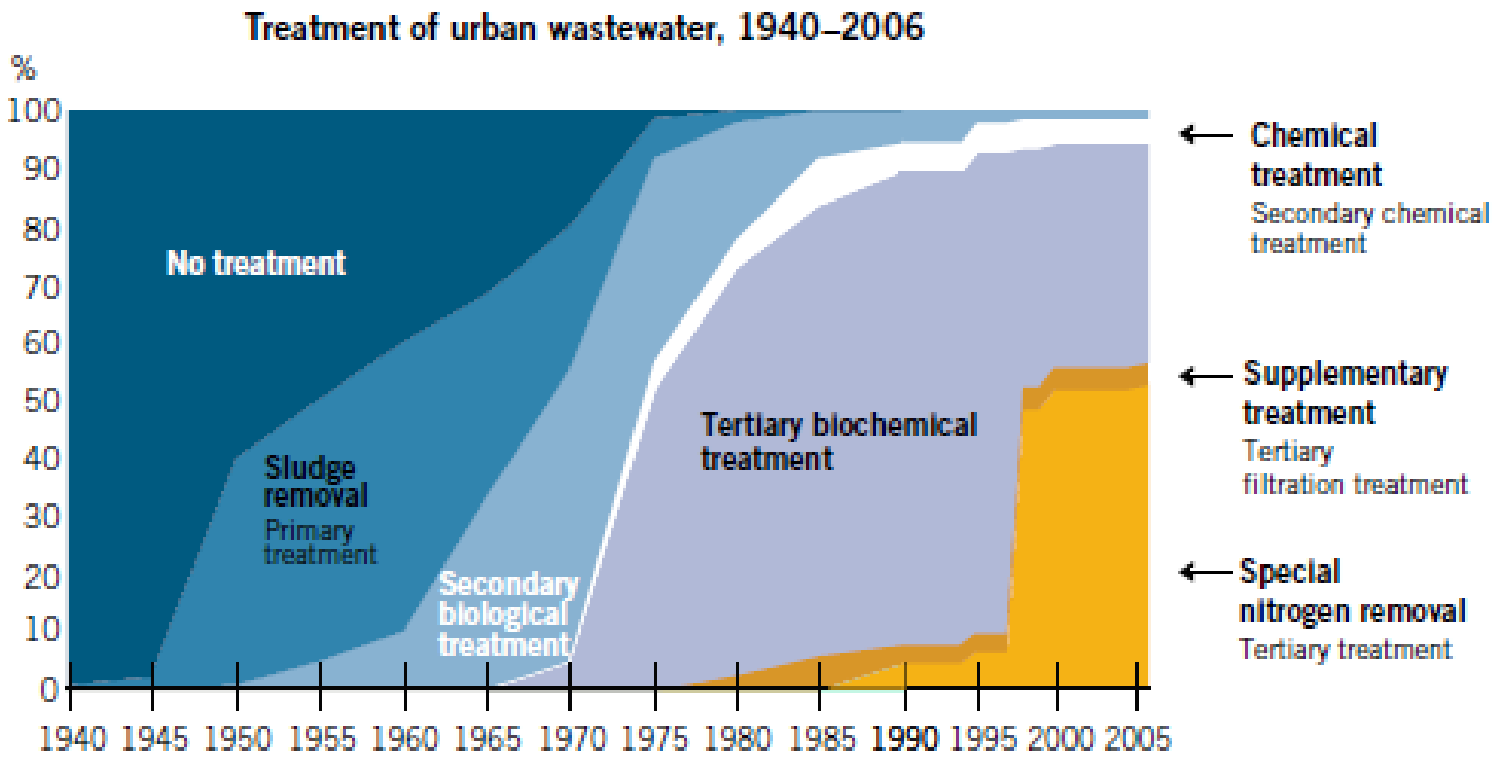
Eutrophication

P cycle



Eutrophication



- 95 % of urban waste water undergoes chemical and biological treatment
- 95 % P removal
- 60 % N removal

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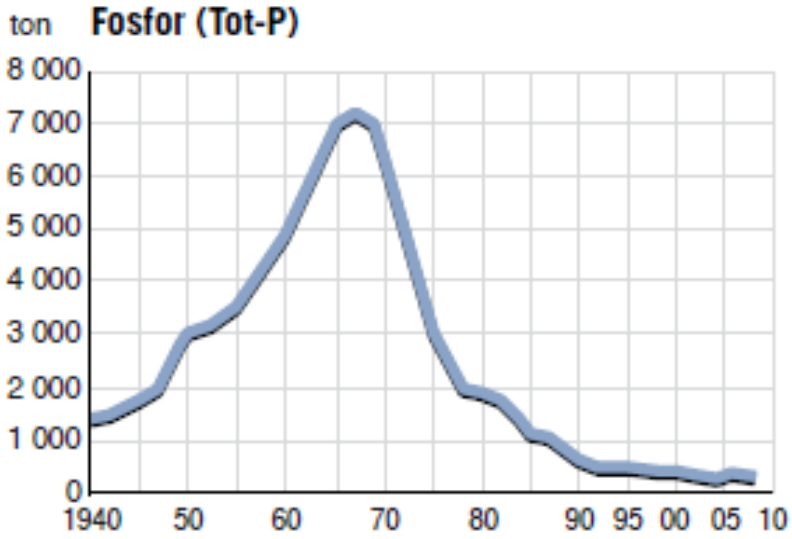
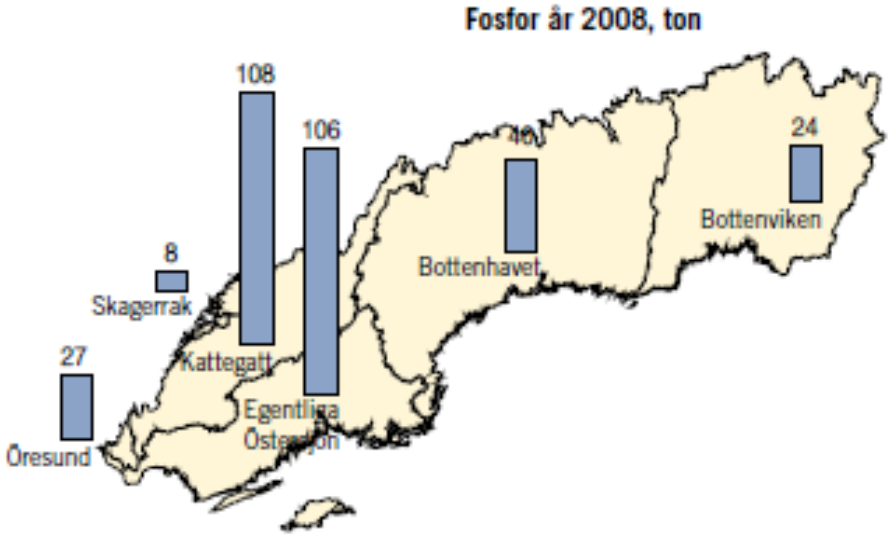
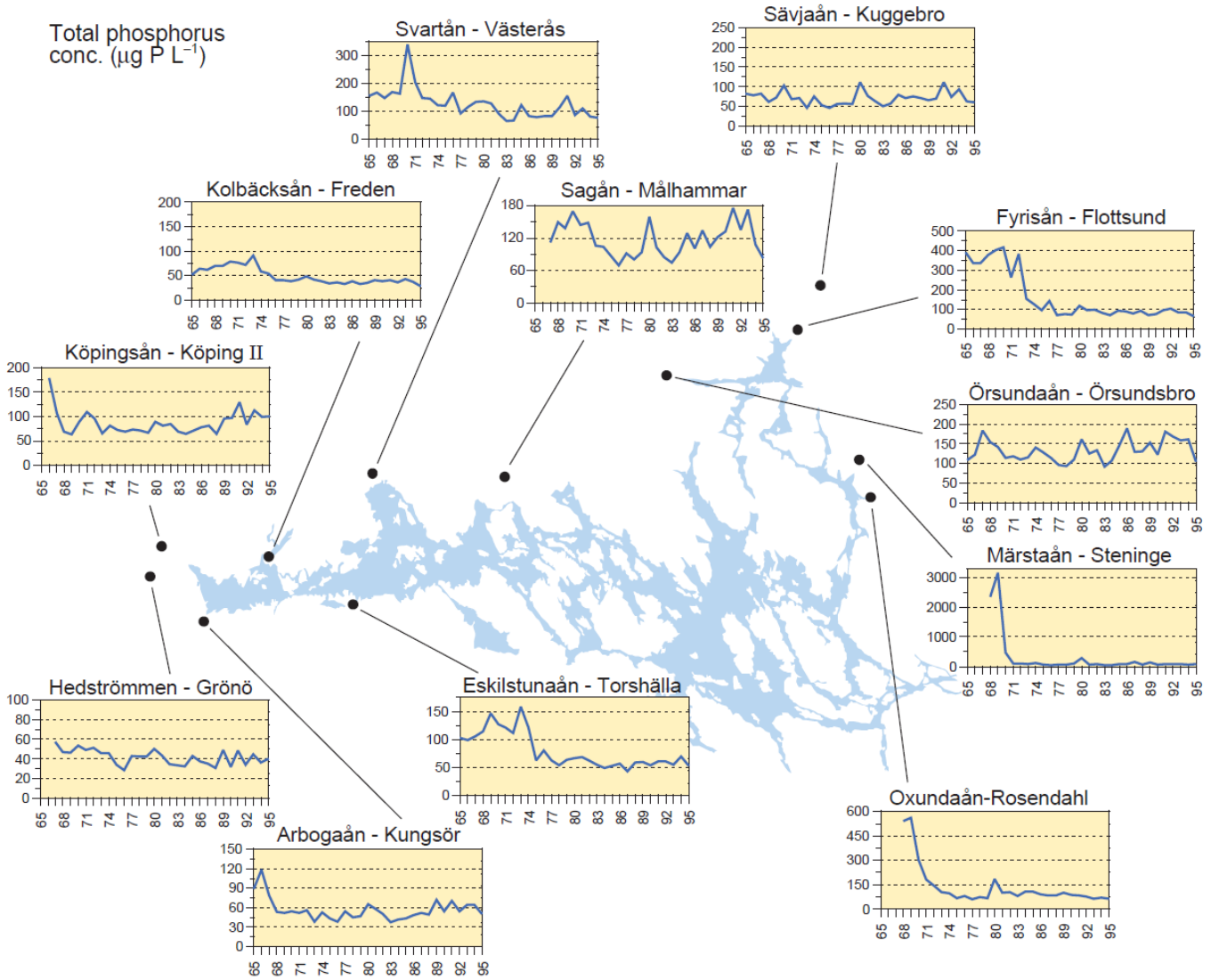
Eutrophication





Eutrophication

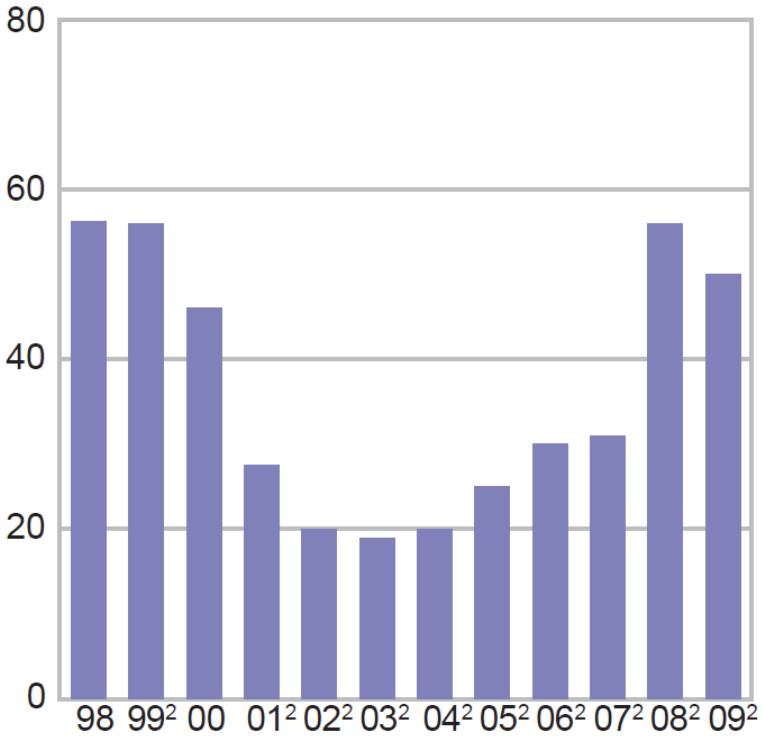
Figure 1. Annual mean concentrations of Tot-P at specified sampling stations in 12 tributaries of L. Mälaren. Generally, pollution abatement measures were put into action 1970–1975, in some cases earlier. Modified from Wallin (23).



Sewadge sludge

- 2.8 % P
- Swedish production ca 230 000 t ts ≈ 6 300 t P
- Maximum values for metals (7) and recommendation values (4) for organic compounds
- Less than 30 % of sludge exceeds one of these values
- Swedish EPA : By 2015 shall at least 60 % of sludge return to productive land, and at least half to arable land

Sludge brought back to agriculture



1) Torrsubstans.
2) Från Sveriges rapportering enligt Slamdirektivet.

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Eutrophication

Recent sewage sludge production and quantities recycled to agriculture in the 27 EU Member States (Doujak 2007, EC, 2006, EC, personal communication, 2009, IRGT 2005)

Member State	Year	Sludge production	Agriculture	
		(t DS)	(t DS)	(%)
Austria (a)	2005	266,100	47,190	18
Belgium				
• Flemish region	2006	76,254 (b)	1,981	3
• Walloon region	2003	23,520	11,787	50
• Brussels region (c)	2002	2,792	878	31
Denmark	2002	140,021	82,029	59
Finland	2005	147,000	4,200	3
France	2002	910,255	524,290	58
Germany	2006	2,059,351	613,476	30
Greece	2006	125,977	56.4	0
Ireland	2003	42,147	26,743	63
Italy	2006	1,070,080	189,554	18
Luxembourg	2003	7,750	3,300	43
Netherlands	2003	550,000	34	<0
Portugal	2002	408,710	189,758	46
Spain	2006	1,064,972	687,037	65
Sweden (e)	2006	210,000	30,000	14
United Kingdom	2006	1,544,919	1,050,526	68
Sub-total EU 15		*8,649,848*	*3,462,839*	*40*
Bulgaria	2006	29,987	11,856	40
Cyprus	2006	7,586	3,116	41
Czech republic	2006	22,0700	8,300- 25,400	4- 12
Estonia (d)	2005	nd	3,316	?
Hungary	2006	128,380	32,813	26
Latvia	2006	23,942	8,936	37
Lithuania	2006	71,252	16,376	23
Malta		nd	nd	nd
Poland	2006	523,674	88,501	17
Romania	2006	137,145	0	0
Slovakia	2006	54,780	0	0
Slovenia	2006	19,434	27	< 0
Sub-total for EU 12		*1,216,880*	*190,341(f)*	*17*
Total		**9,866,728**	**3,653,180**	**37**

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Eutrophication

- Totaly ca 750 000 households lacks connection to WTP (2005).
- Ca 450 000 permanent housing (ca 60 %).
- Ca 250 000 part-time (recreational) housing (ca 40 %)
- Ca 650 000 with WC
- Ca 125 000 with WC and just sludge separation (illegal since 1960-ies)

Source Avloppsguiden.se

P in agriculture

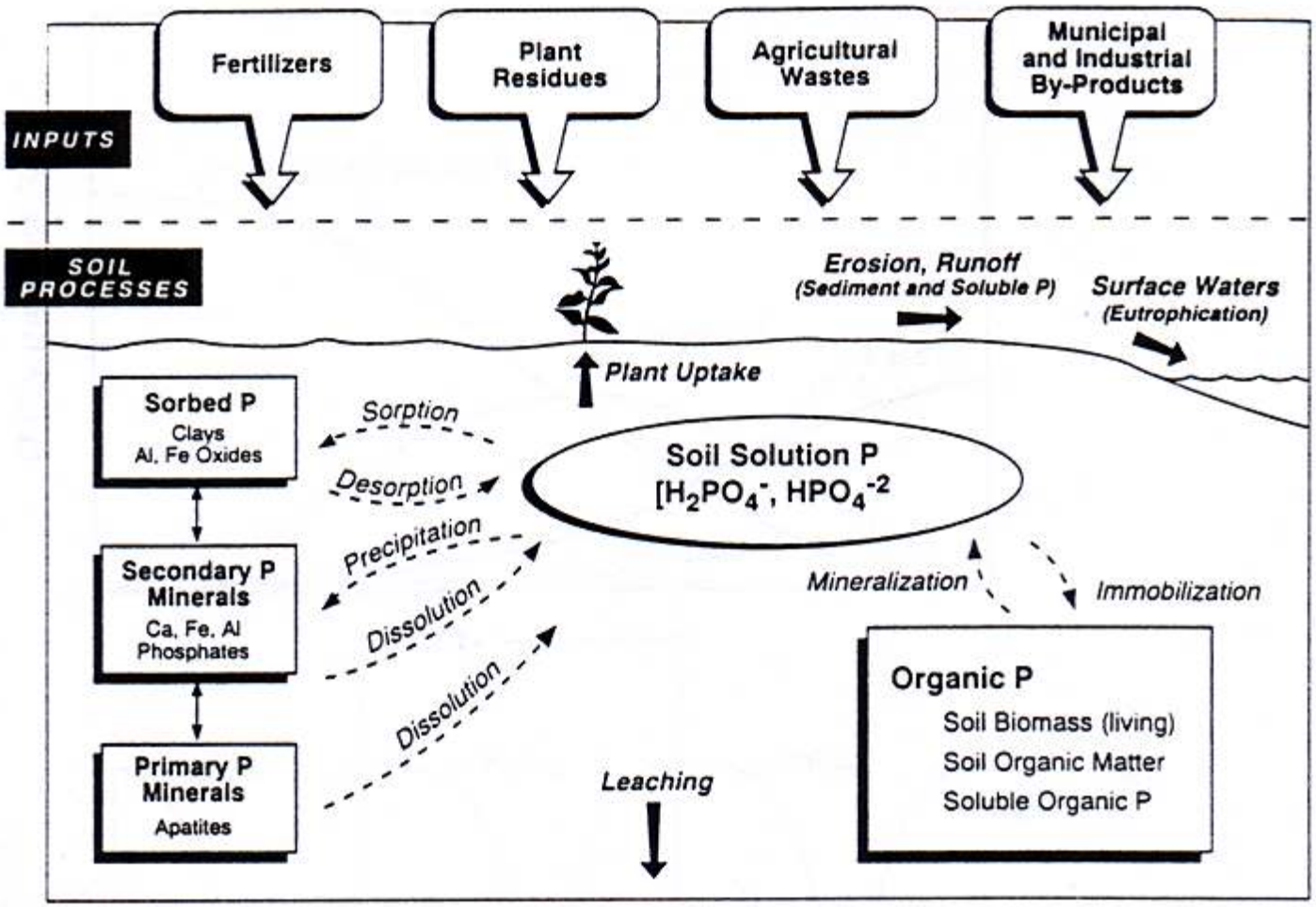
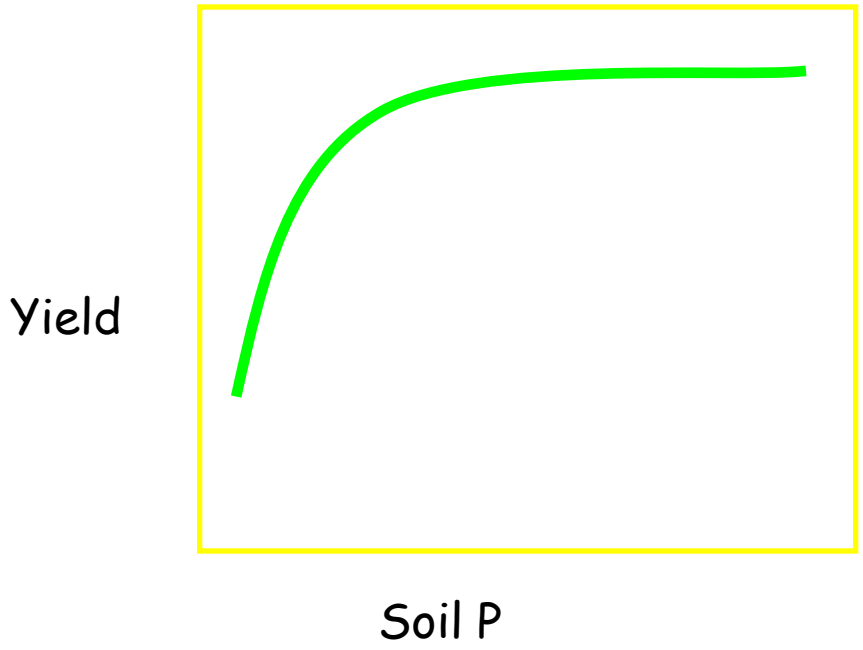


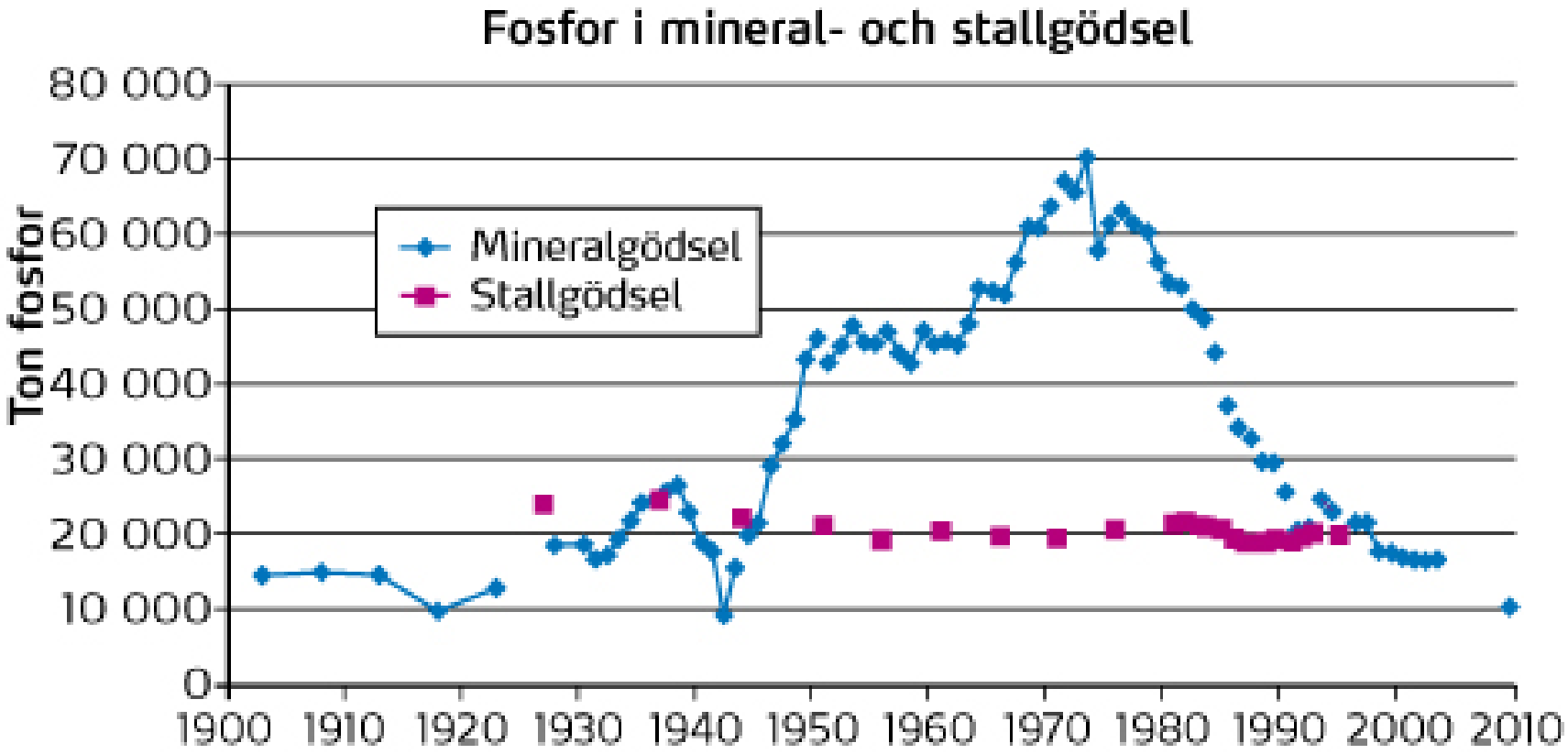
Figure 5-4 The soil phosphorus cycle. An overview of the physical, chemical, and microbiological processes controlling the availability of P to plants and P transport in runoff or leaching waters. (Adapted from Gachon, 1969.)

Pierzynski et al., 1994.

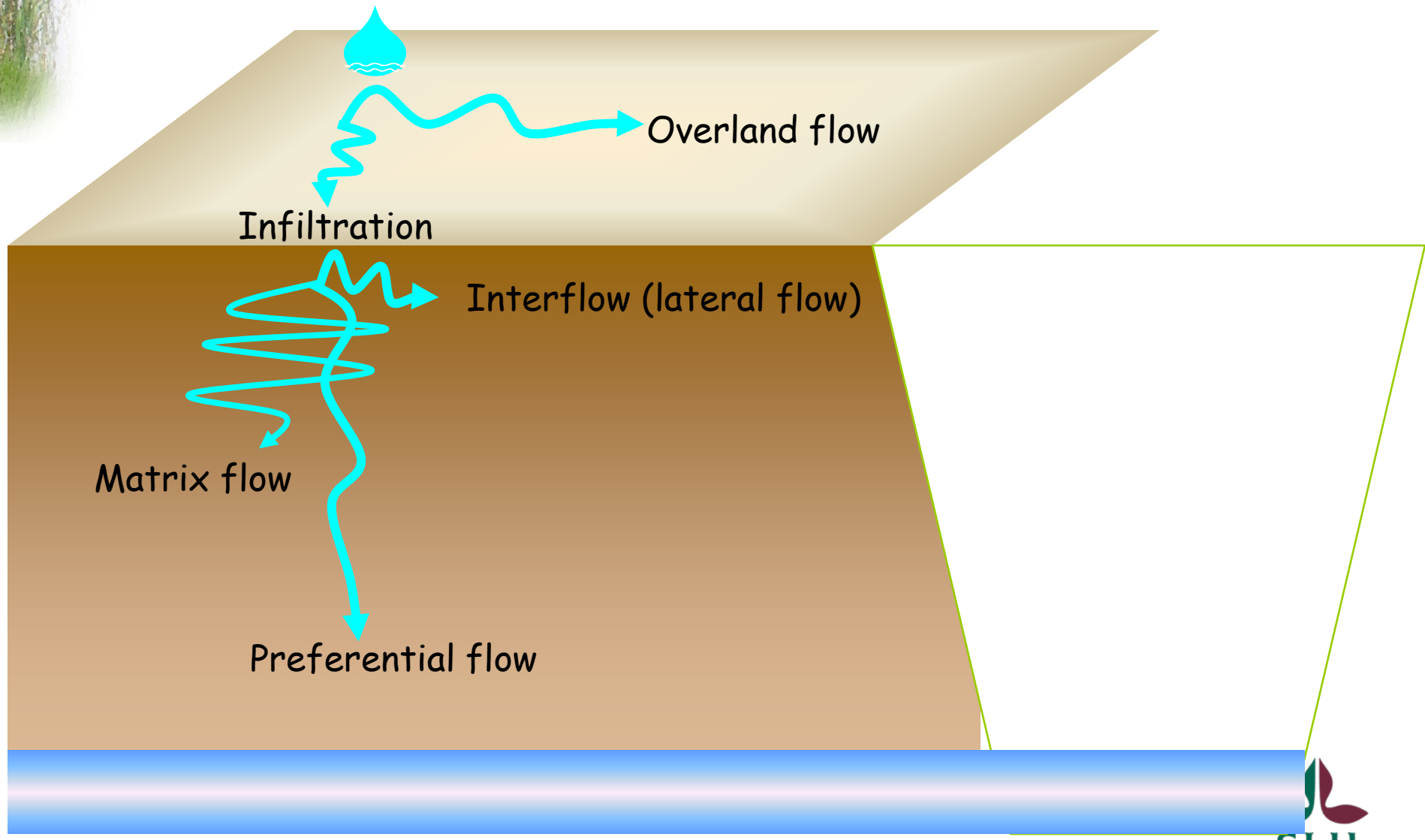
- P in agriculture



- P in agriculture



Terminology commonly associated with hydrochemical transport pathways

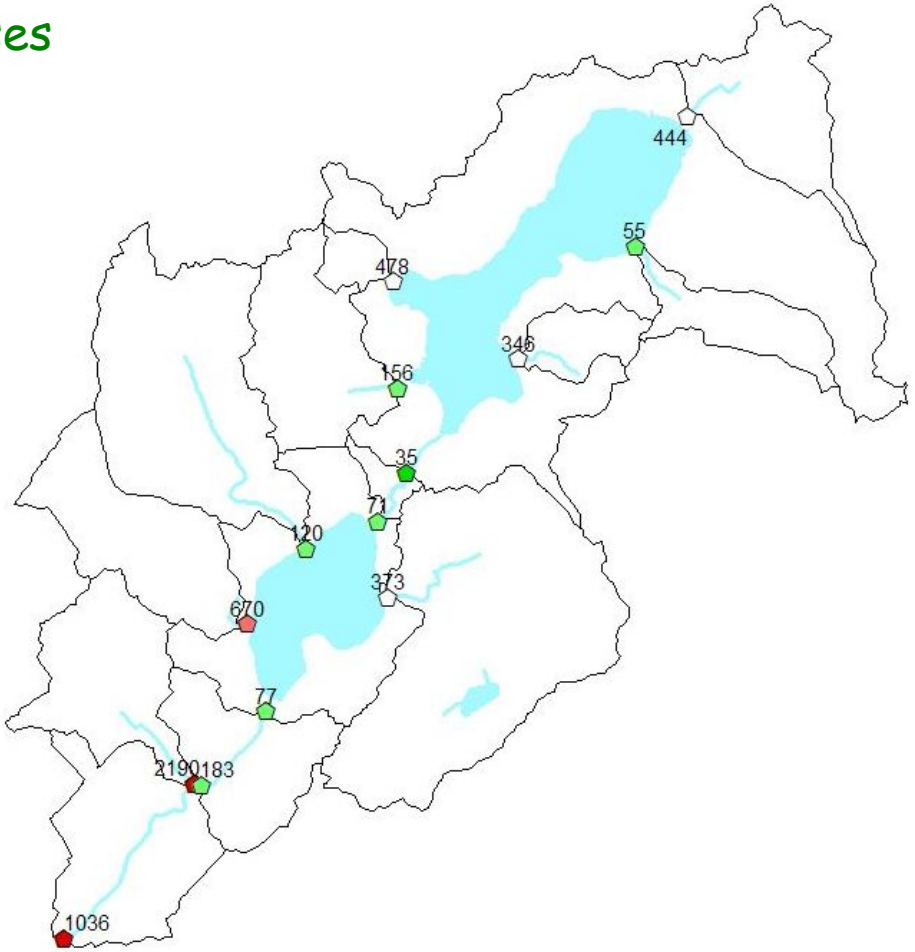


P losses

P forms in water

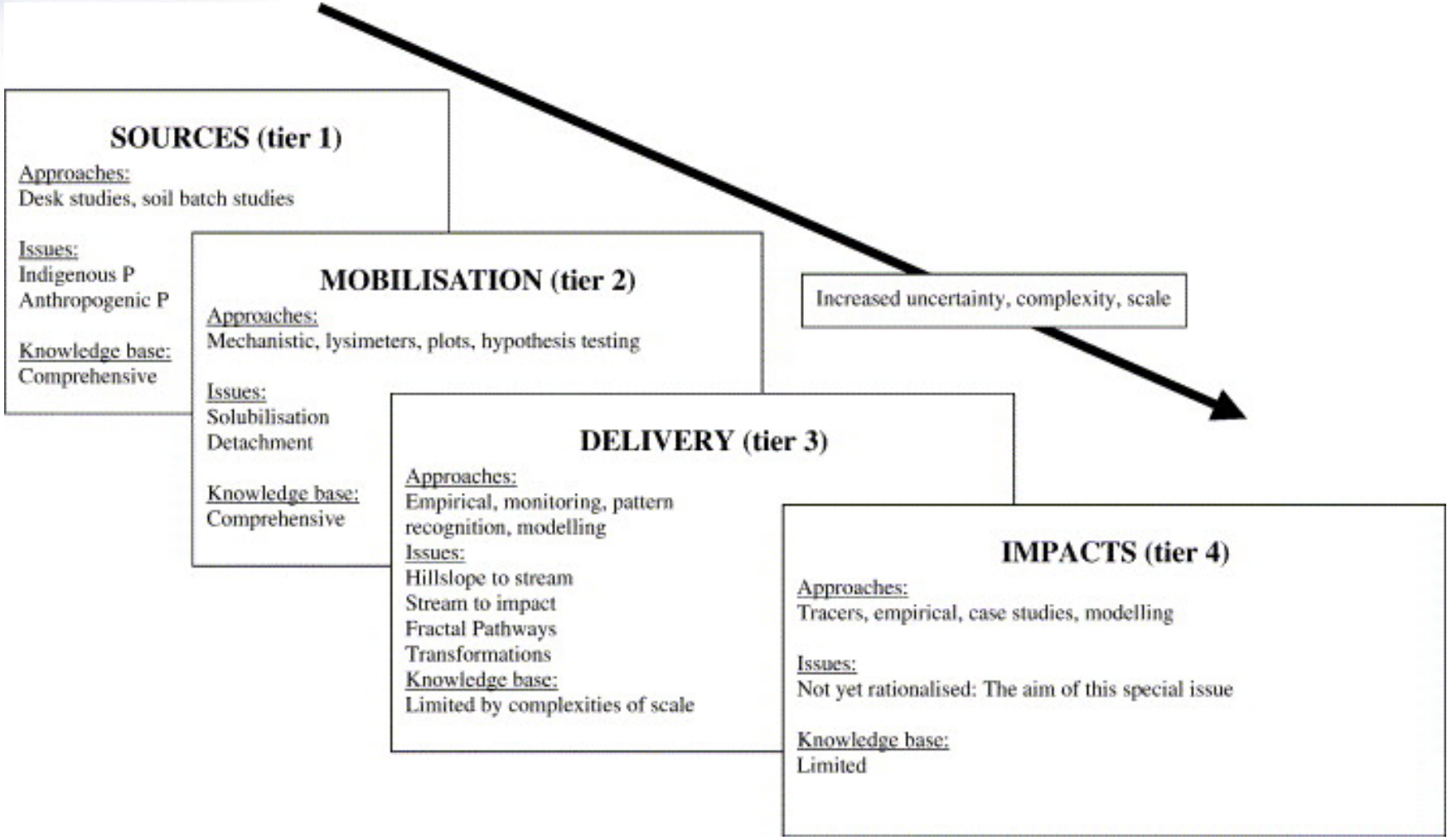
- Dissolved Reactive P (DRP)
- Unreactive P (UP)
- Total P (TP)

- Episodic patterns
- High variations in time
- High variations in space
- Flow-proportional measurements



TP concentrations (µg/l) in small catchment

P losses



Haygarth et al., 2005

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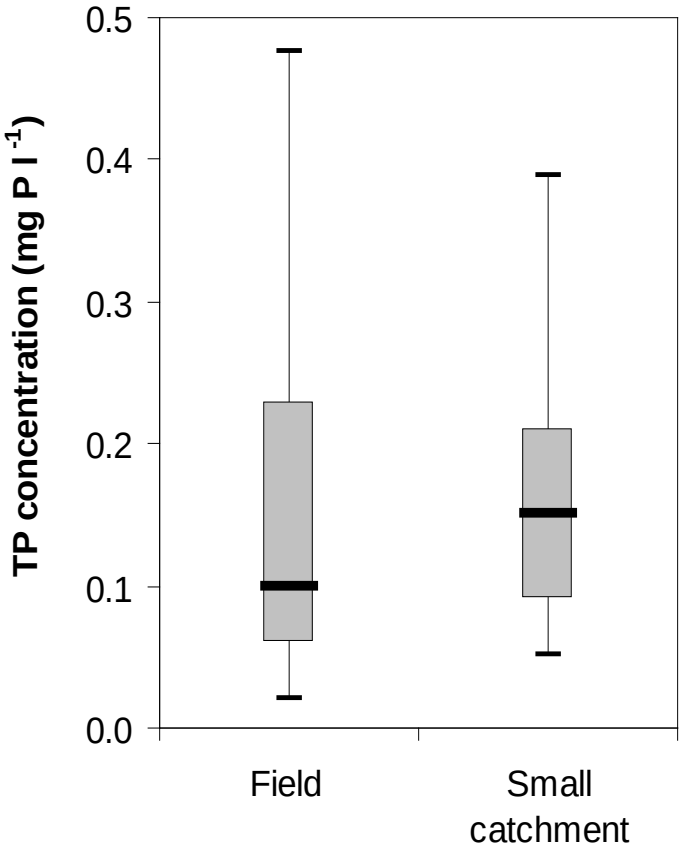
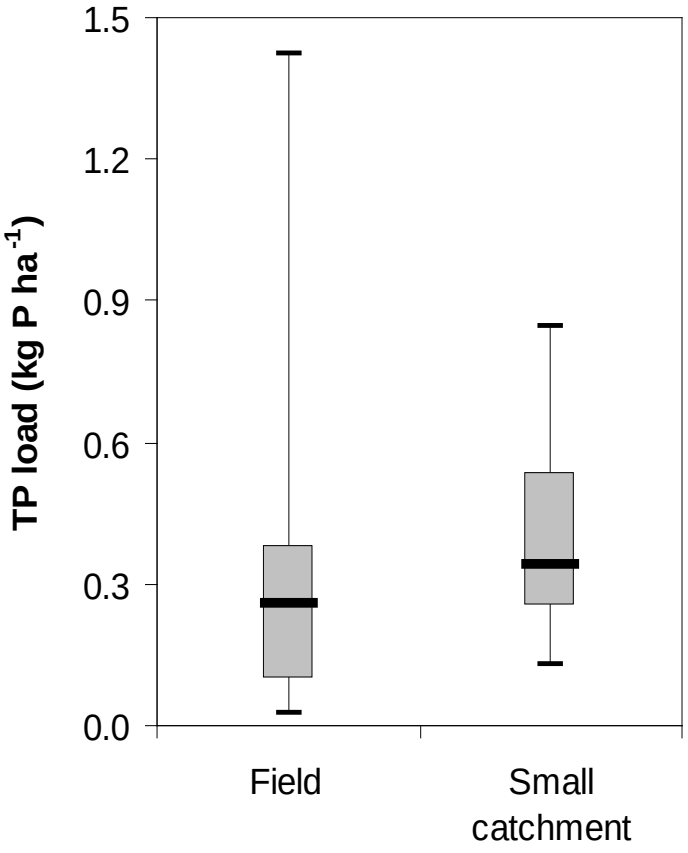
P losses - variations





Discharge weighted annual TP concentrations and loads (I) from 13 cultivated monitoring fields in Sweden mainly for the period 1982-2005 (Johansson and Gustafson, 2007) and (II) from 23 small agricultural catchments with few point sources from scattered dwellings monitored between 7 and 21 years (Kyllmar and Grill, 2007).

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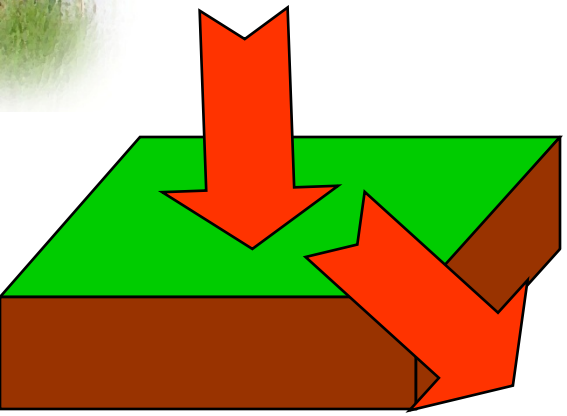
P budget –field level

P supply:
Manure
Fertilizer



P off take:
Yield
Losses

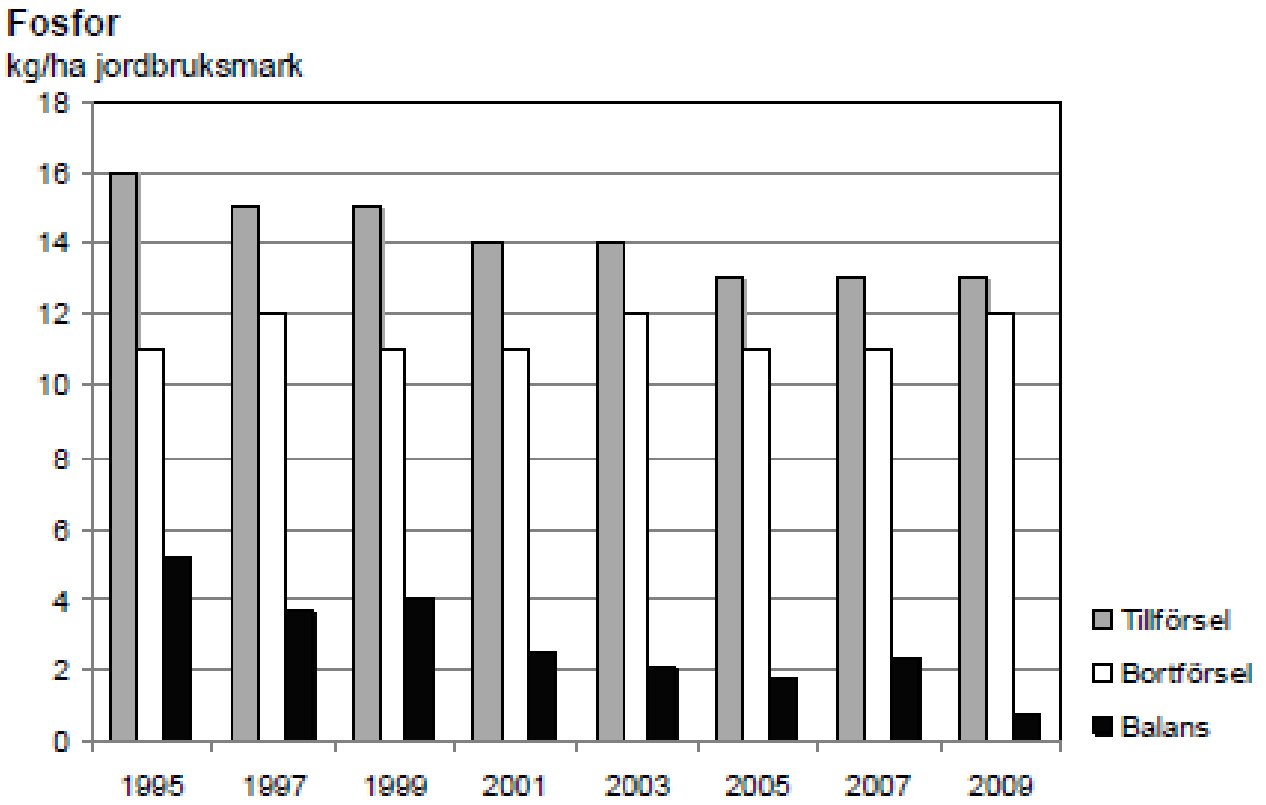
		P rate (kg/ha) P-AL class				
Crop	Yield t/ha	I	II	III	IV	V
Grains	5	35	25	15	10	0
Oil plants	2	35	25	15	10	0
Grass	6	35	25	15	10	0
Potato*	30	100	80	60	40	20
Sugar beets	45	50	40	25	20	0
Beans	3,5	35	25	15	10	0

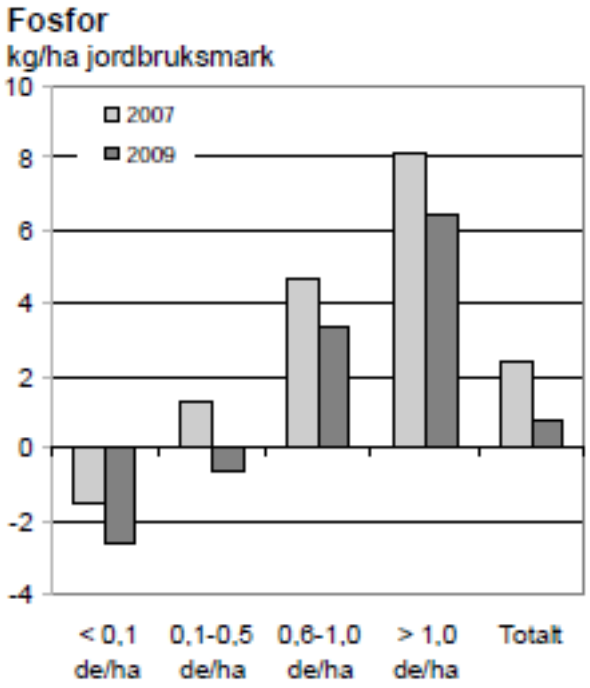
Crop	Yield (t/ha)	Kg P/ha
Wheat, grain	5	16
Barley, grain	4	14
Grain straw	4	4
Oil plants	2	12
Potato*	30	15
Sugar beets	45	18
Beans	3,5	13
Pasture grasses	6 (ts)	16

Losses:

up to 3 kg/ha yr, usually 0.2-0.5 kg/ha yr

P budget





SCB, Surplus/deficit of P from arable land for farms with different animal density, 2001 & 2003

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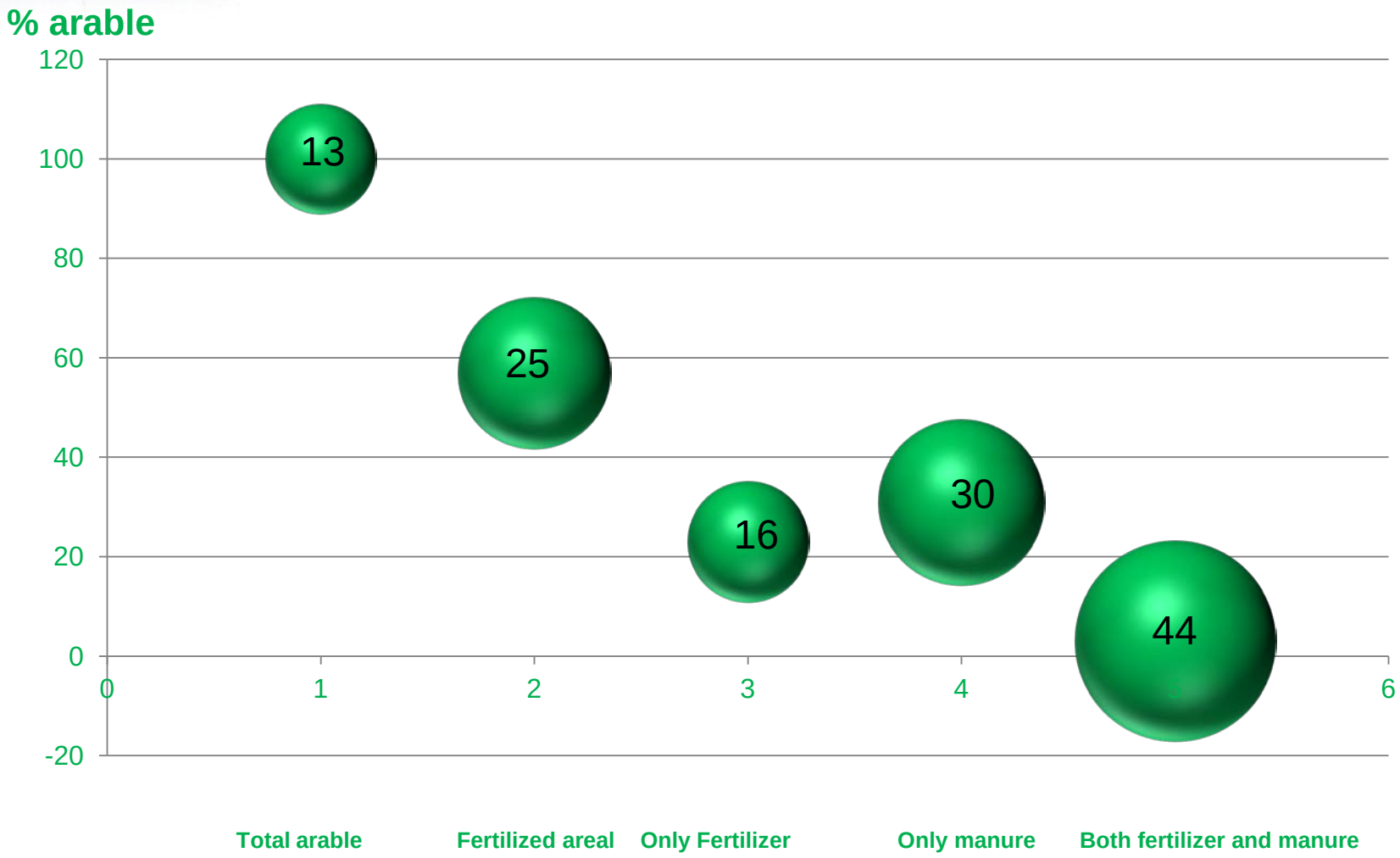
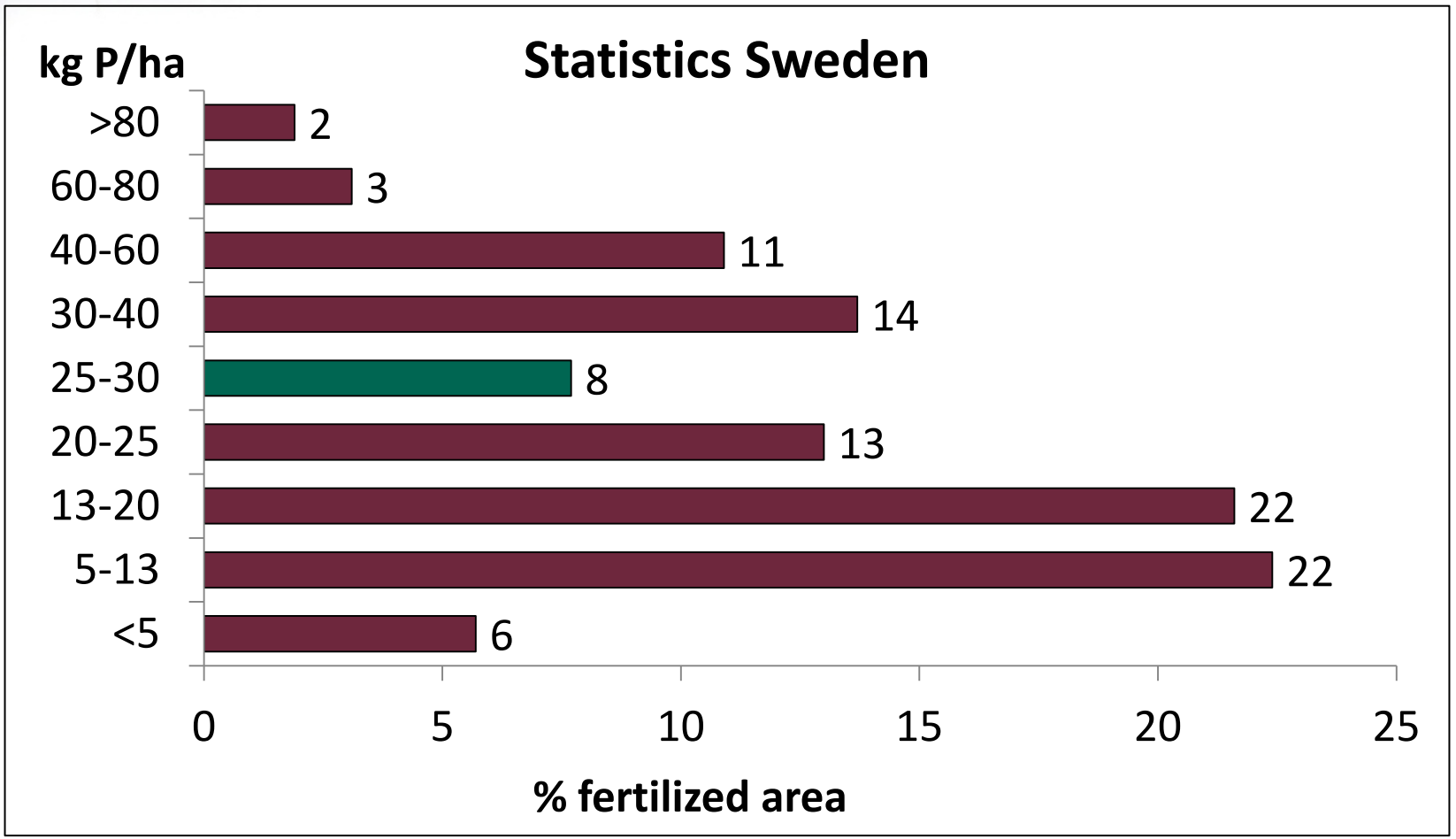
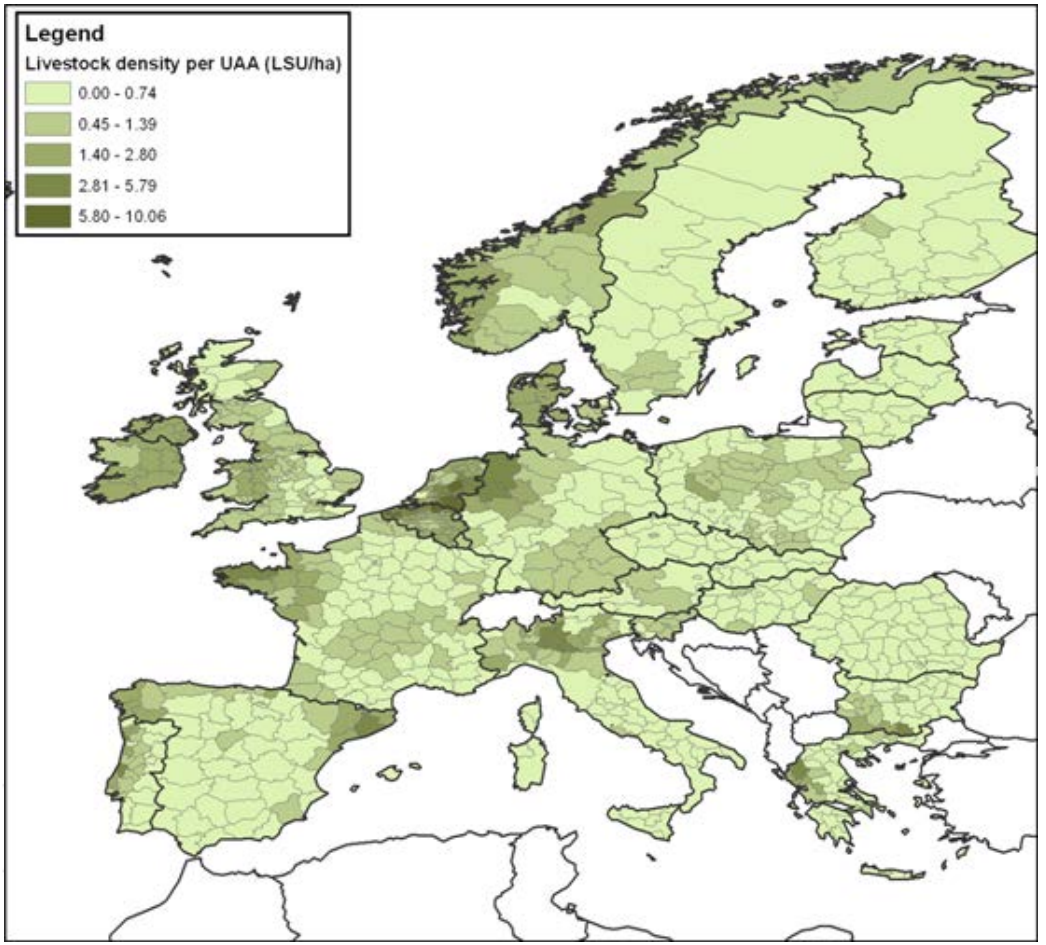
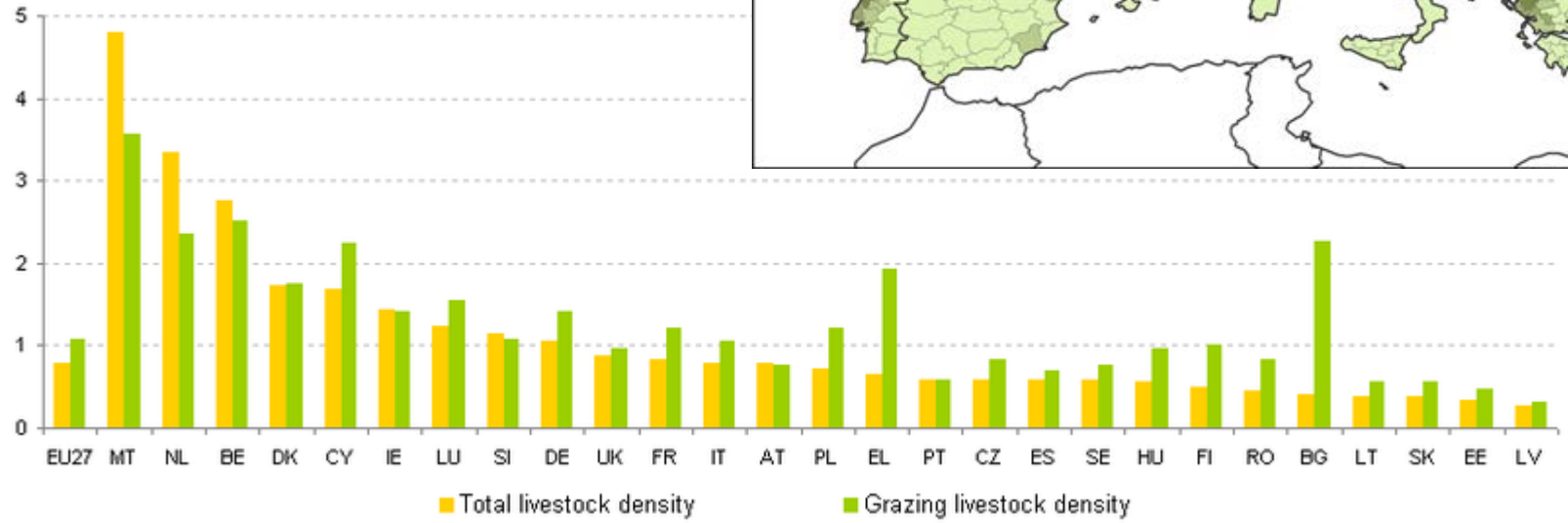
P in agriculture



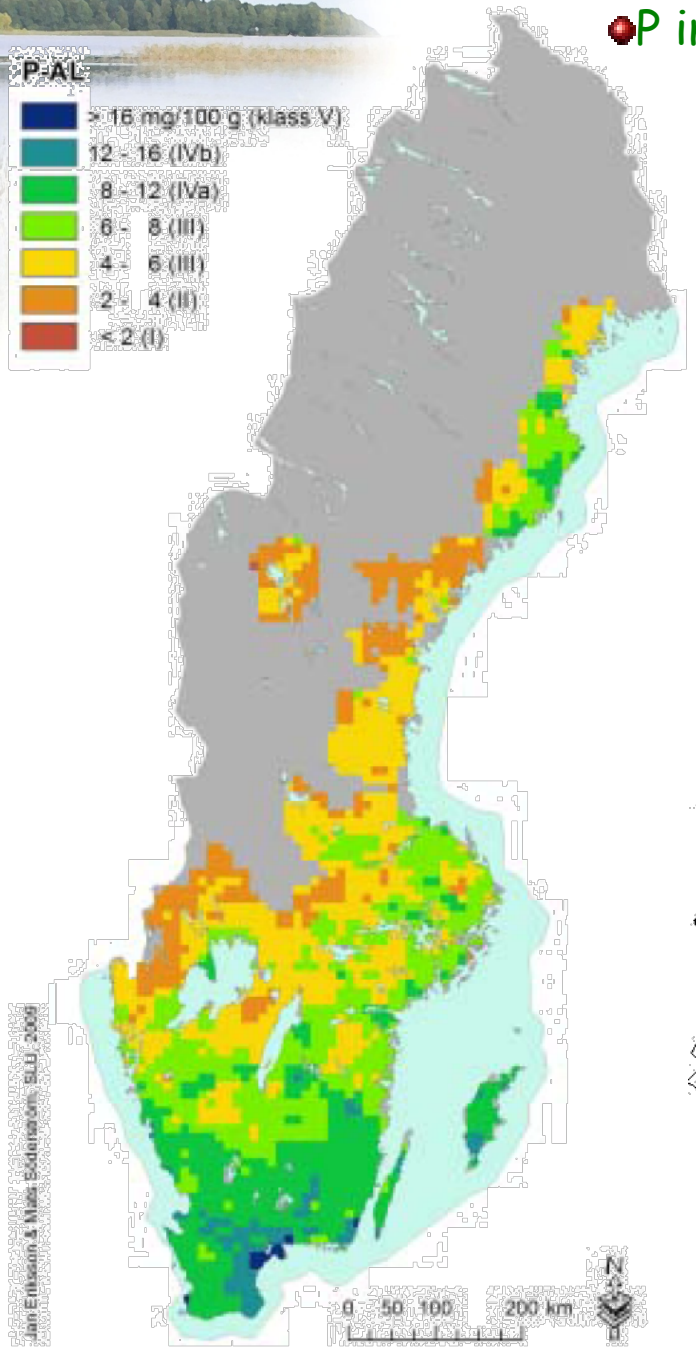

kg P/ha
Statistics Sweden
>80
60-80
40-60
30-40
25-30
20-25
13-20
5-13
<5
2
3
11
14
8
13
22
22
6
0
5
10
15
20
25
% fertilized area

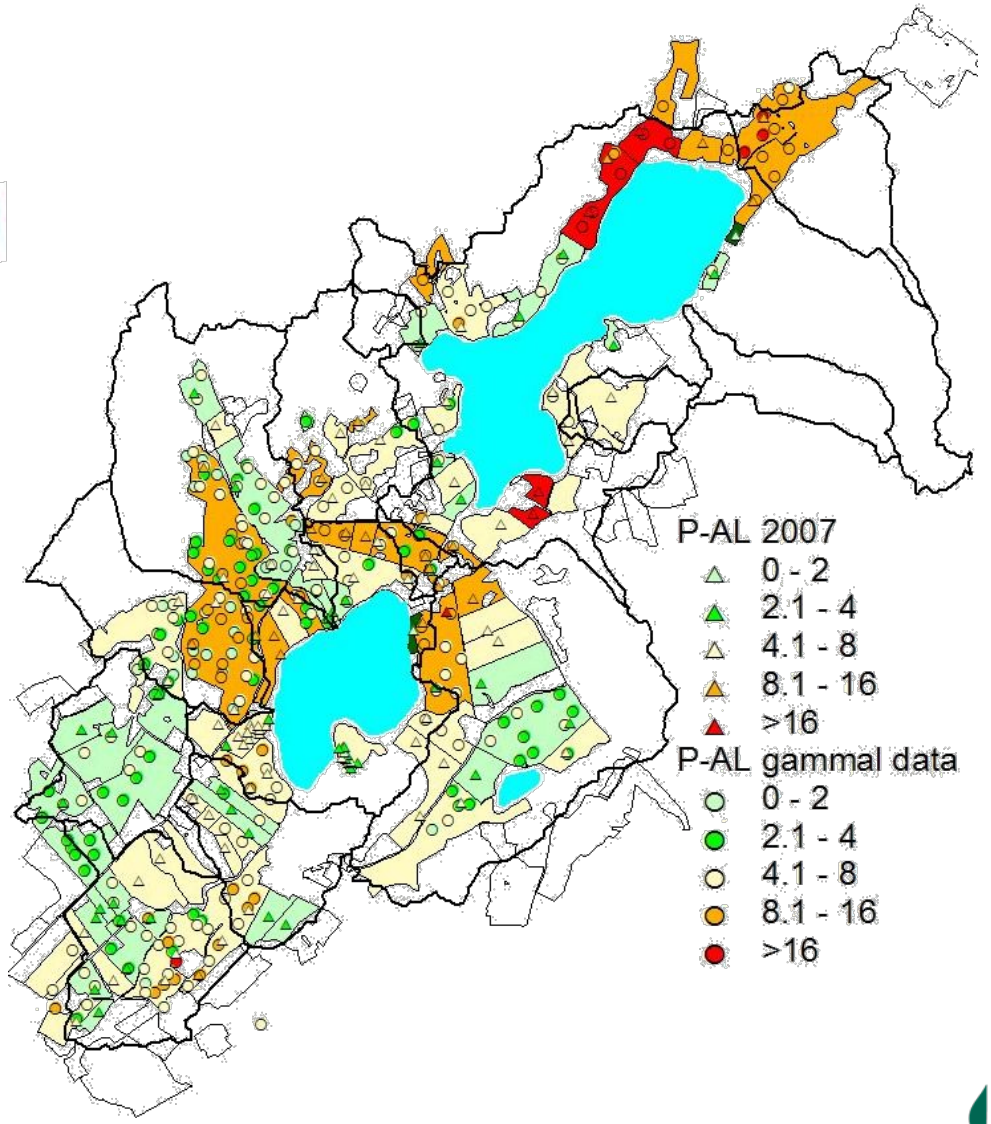
P in agriculture





P in agriculture





Abatement

1. *Legislation*
    a) *Animal density*
    b) *Storage capacity for manure*
    c) *Restrictions for manure and fertilizer applications*

2. *EU subsidies*
    a) *Buffer strips*
    b) *Wetlands*

3. *Information & education projects*
    a) *Focus on nutrients – extension services (www.greppa.nu)*

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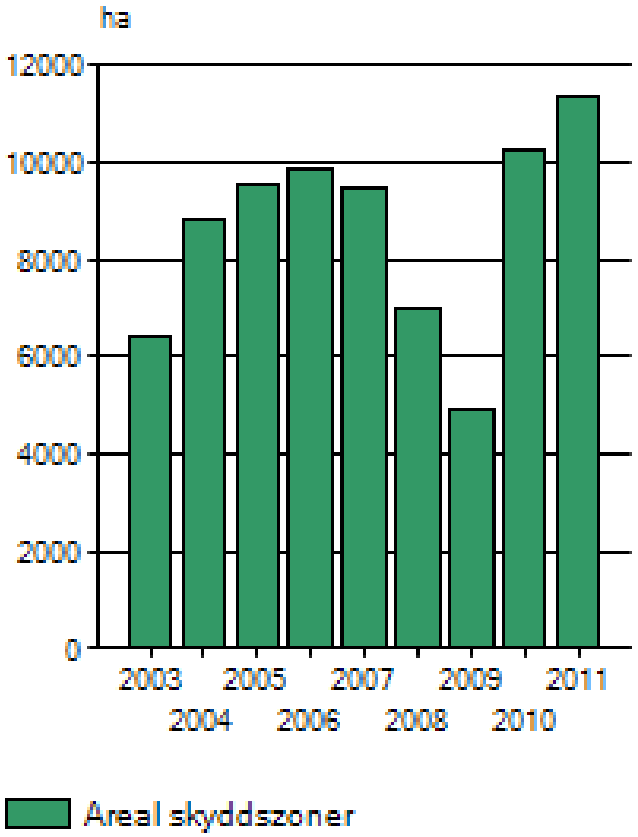
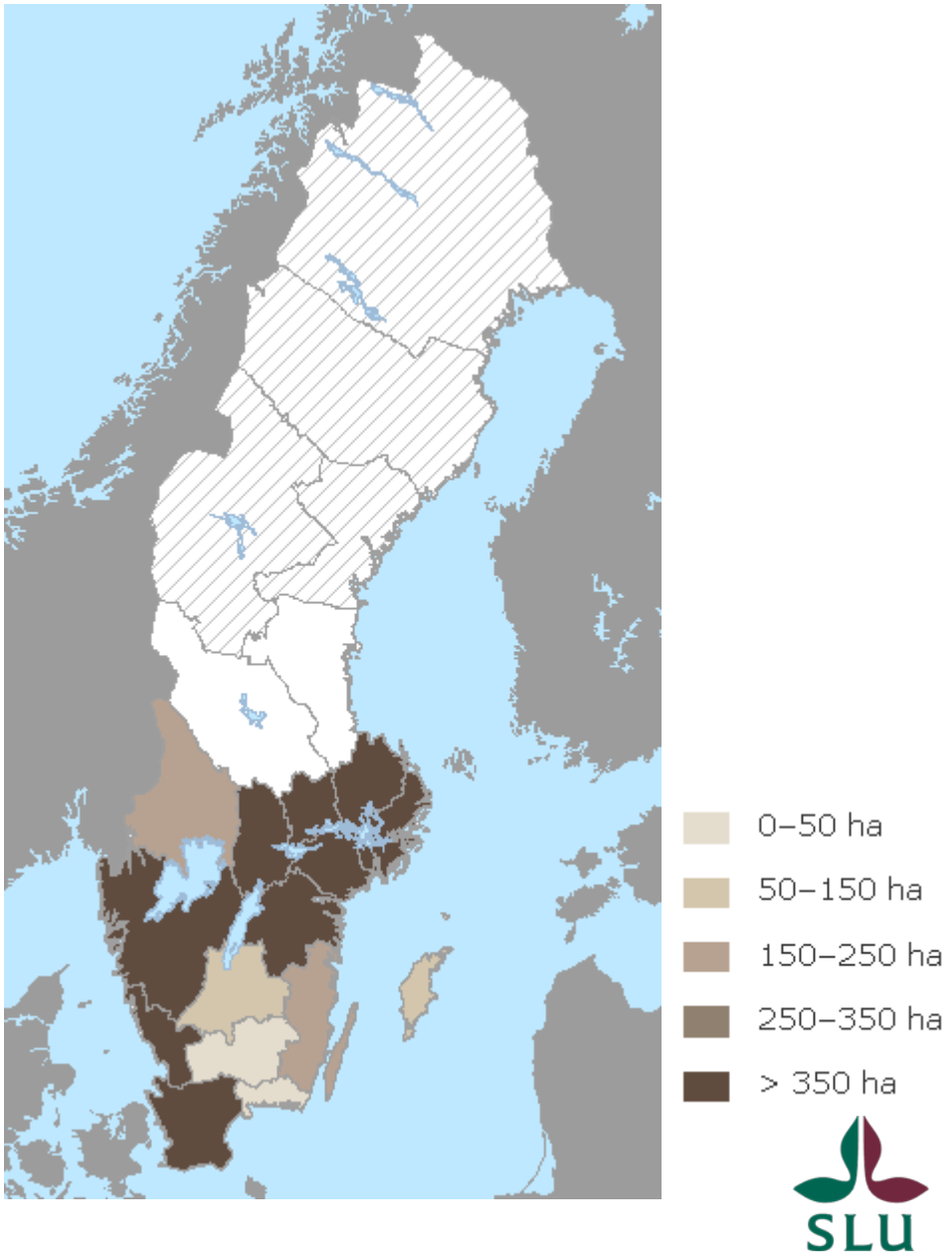

ha
12000
10000
8000
6000
4000
2000
0
2003
2004
2005
2006
2007
2008
2009
2010
2011
Areal skyddszoner


0–50 ha
50–150 ha
150–250 ha
250–350 ha
> 350 ha

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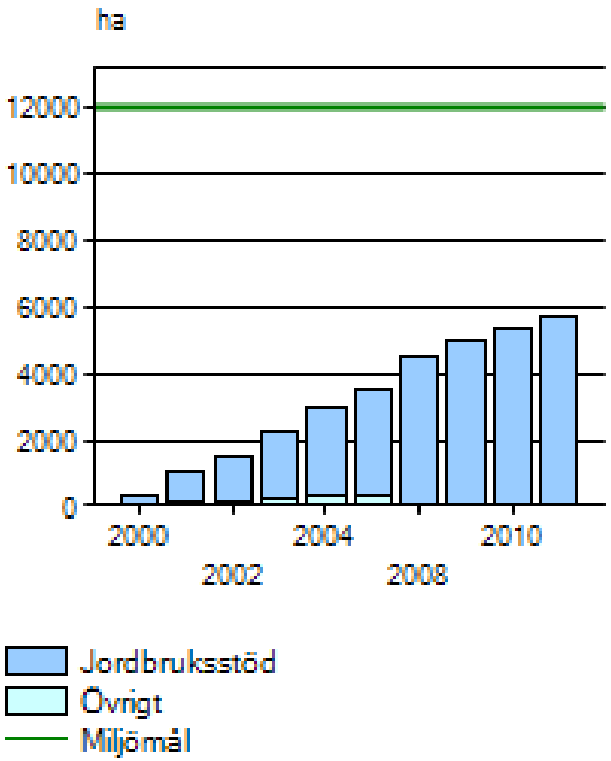
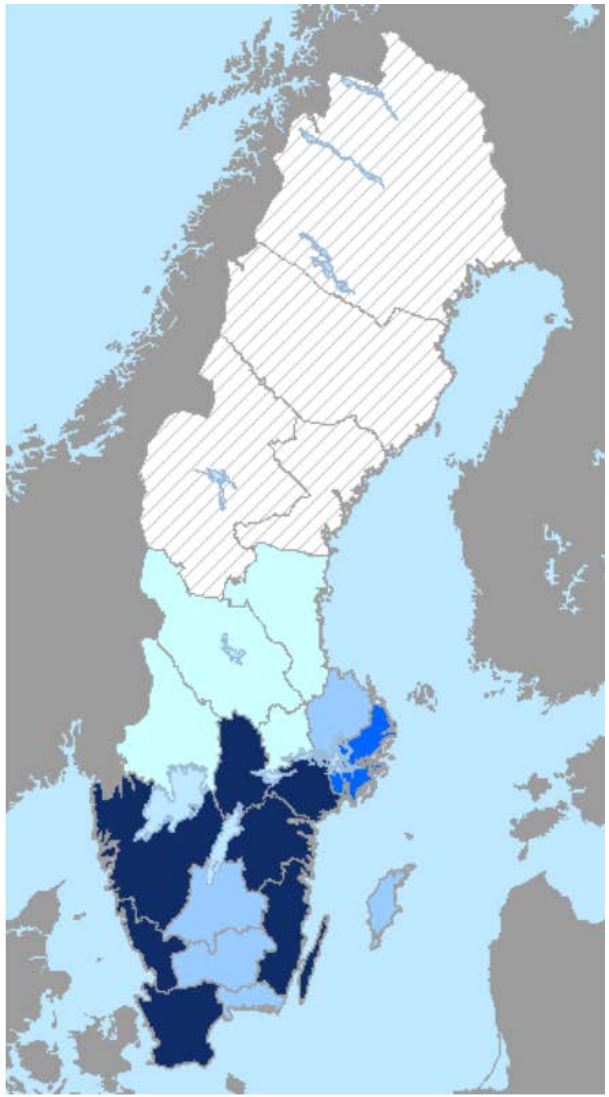
Areal anlagda våtmarker





Total areal våtmarker med EU:s jordbruksstöd, LIP och övrigt fördelat på län mellan åren 2000 och 2010.