Murky Waters: multidimensional issues linking macronutrient sources & impacts in catchments

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Exploring uncertainties & expectations.....

Beliefs driving catchment management policy:

(1) Point sources are being addressed, so we need to focus efforts on diffuse transfers to meet river water quality & ecological targets

(2) Catchments are inherently leaky: P losses from agriculture are a primary cause of nuisance algal growth in rivers

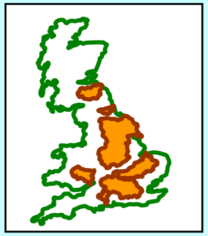
(3) Reducing P losses from agriculture will achieve desired improvements in river water quality & ecology

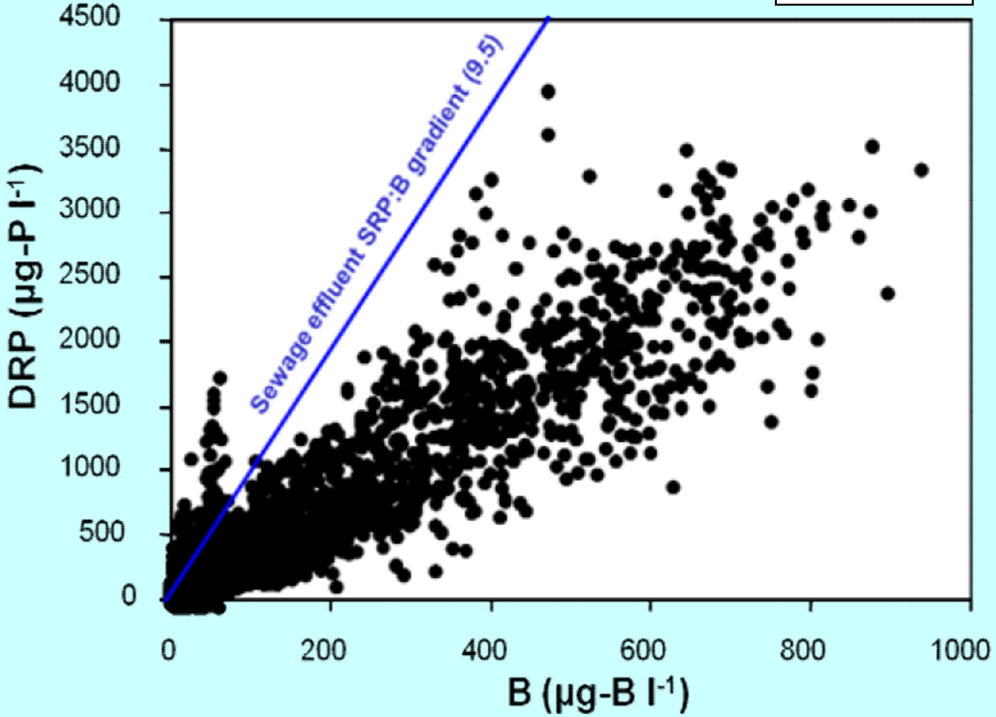
A UK river water quality perspective

For P, dissolved reactive (DRP) concentrations during periods of ecological sensitivity pose the greatest risk for nuisance algal growth in lowland rivers

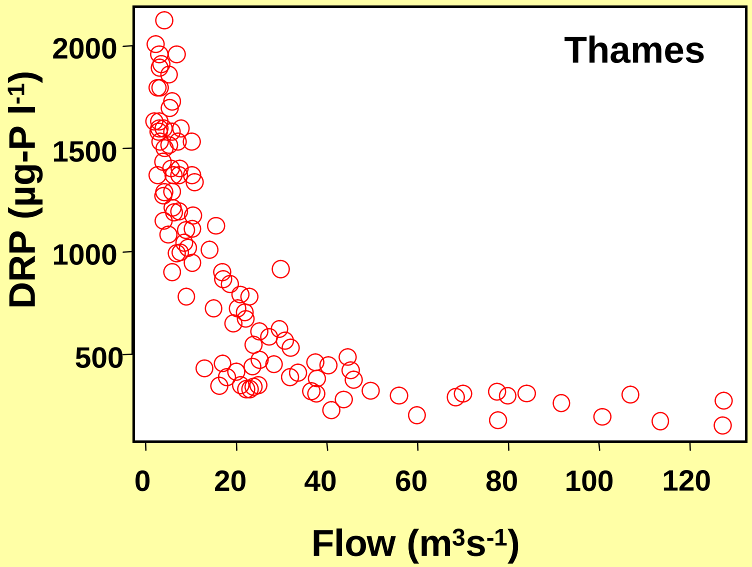
Use of background tracers: boron (detergents) as a tracer of sewage effluent

Across 54 major UK lowland rivers: P shows a dominant sewage fingerprint





…Coupled with flow dependence:



Dilution with flow – dominance of point sources at low flows

Jarvie et al, 2006. Science of the Total Environment, 360, 246– 253

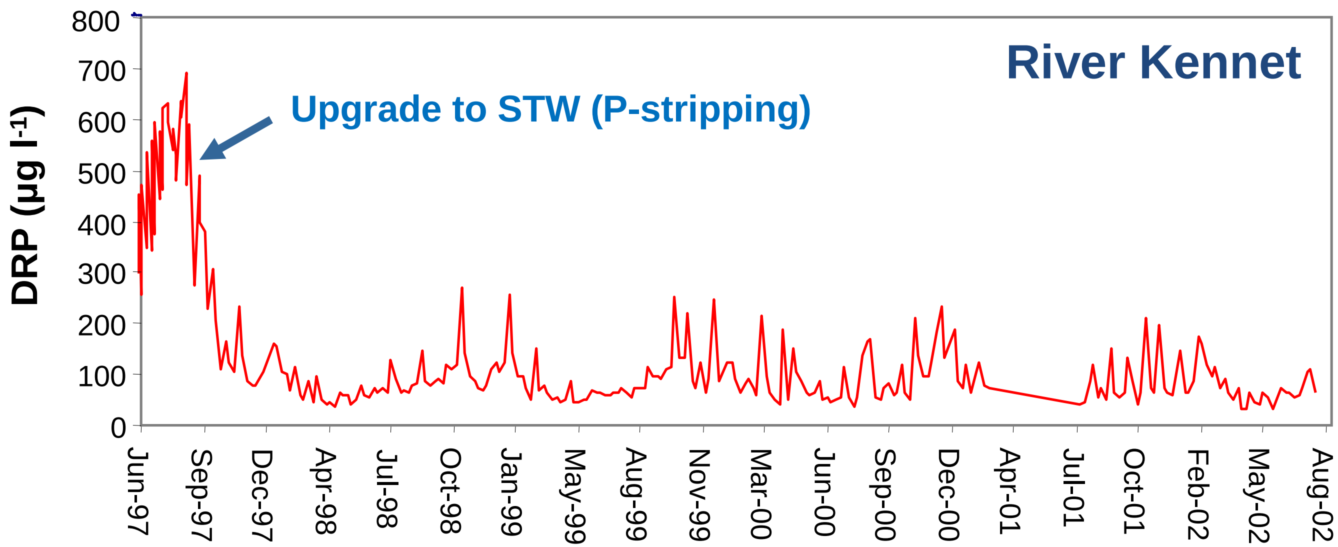
Yes, diffuse sources dominate annual TP loads......

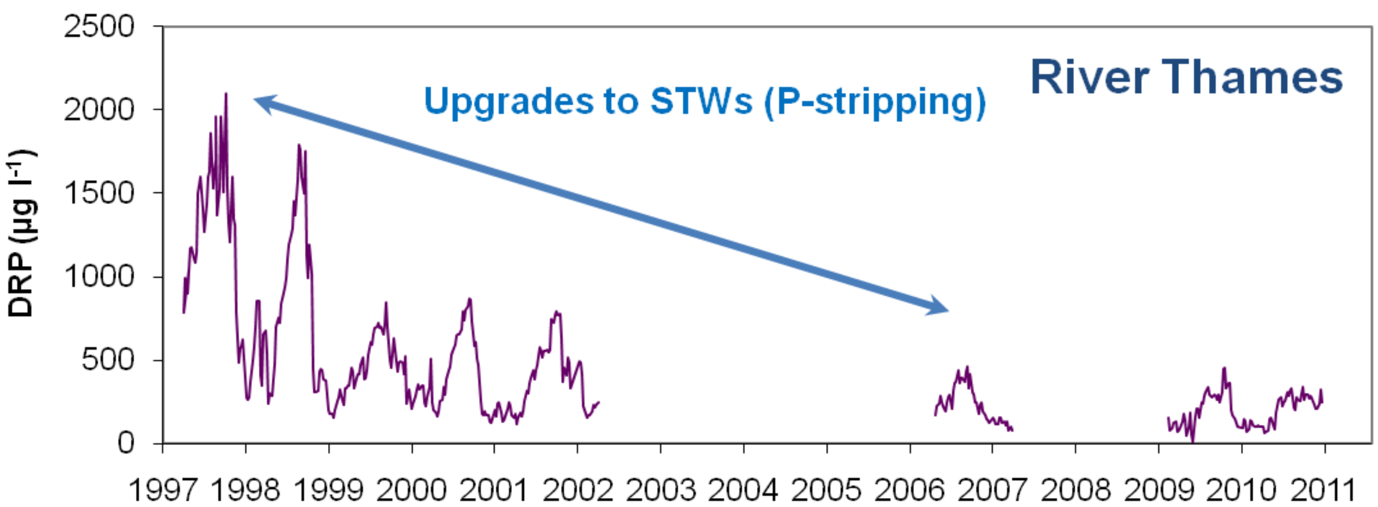
Basin	Sub-catchment	Area (km^2)	Land use	TP loads (kg $ha^{-1}y^{-1}$)	% point source	% of time TP loads were point source dominated
Wye	Dinedor	8.7	Mixed beef/sheep & cereal/potato	0.82	33	75
	Kivernoll	9.9	Intensive arable	1.17	58	89
Avon	Cools Cottage	1.6	Woodland & permanent pasture	0.37	5	<1
	Priors Farm	4.7	Intensive dairy on heavy clay soils	2.0	31	28
Welland	Digby Farm	0.4	Permanent pasture	0.39	0.3	88
	Lone Pine	1.2	Sheep & spring cereals	0.67	1.1	93

.....BUT even in **headwater agricultural catchments**, **point sources dominate TP loads most of the time** (especially under baseflows, periods of ecological sensitivity)

Jarvie et al, 2010. Agriculture, Ecosystems and Environment 135, 238-252.

Successes in P remediation: point source P controls





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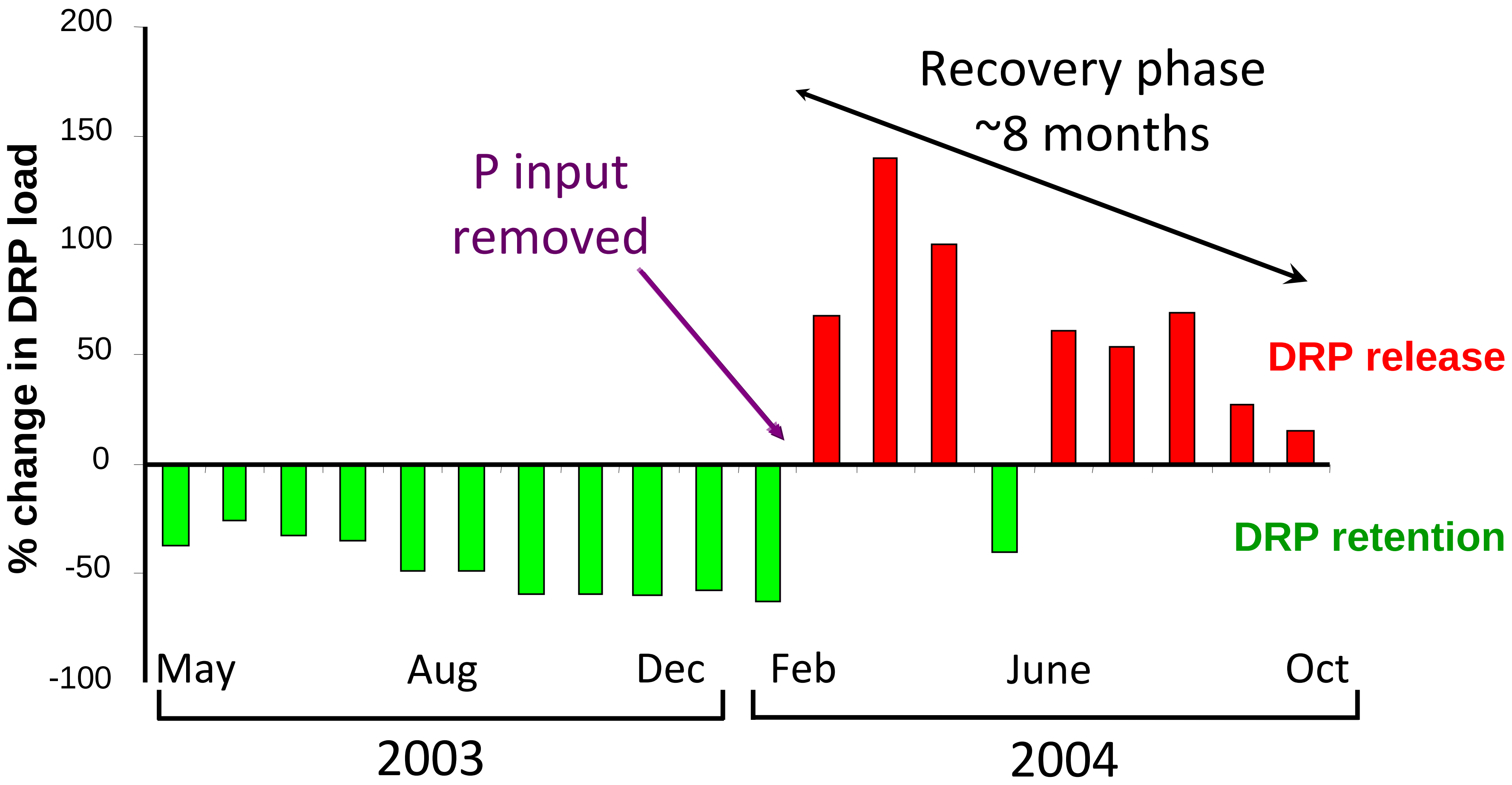
‘Legacy P’: responses to point source P remediation in rivers

River reach mass balance studies (R. Lambourn):



Short water & sediment residence times - rapid recovery

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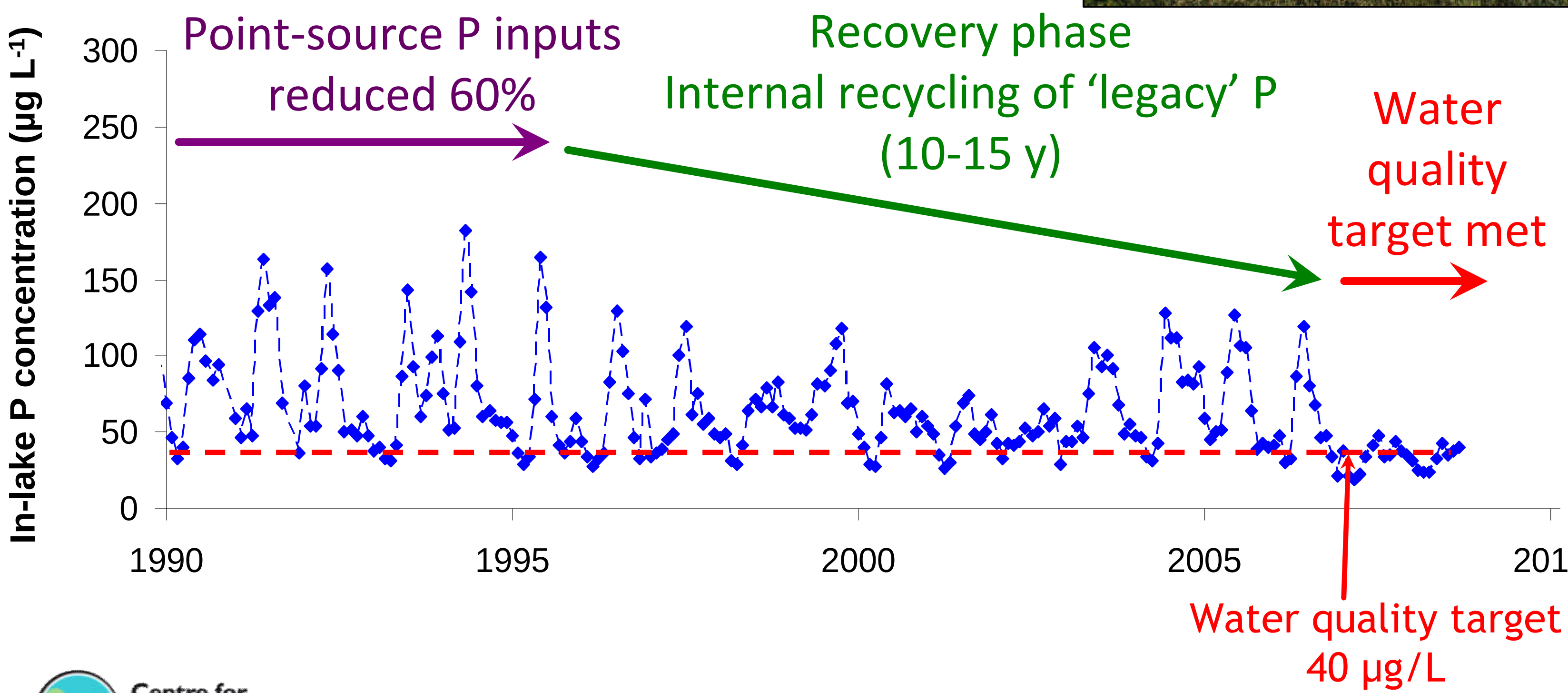
Jarvie et al., 2006. J Hydrology, 330, 101– 125

Legacy P: longer residence times mean delayed WQ responses in lakes



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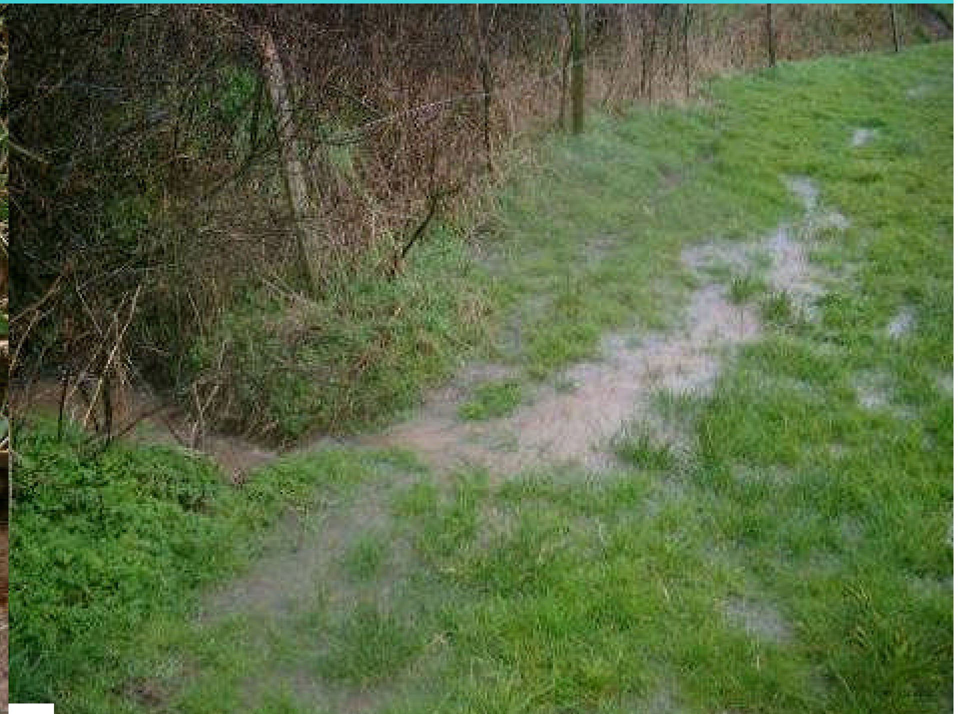
Loch Leven, Scotland (Source: Linda May, CEH)

Longer legacy 'lag' effects after agricultural controls?



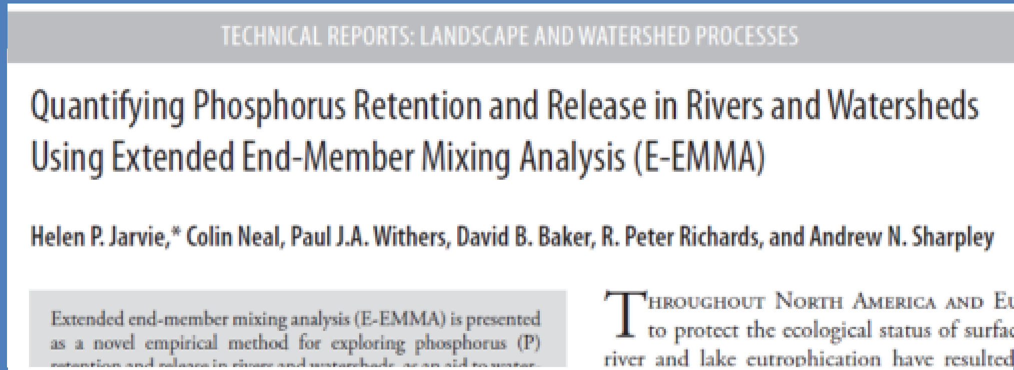
- Multiple sources & forms of P
- 'Landscape filtering' of P along the watershed-river continuum
- Storage & re-release of 'legacy' P

Evaluating P retention & release at the watershed scale

Extended End-member Mixing analysis (E-EMMA)

Simple & versatile tool, relies solely on routinely-measured P concentration and flow data.

- Up to **50% retention** of **annual Total P loads**
- Up to **80% retention** of Total P loads under ecological-critical **low flows (spring & summer)**
- Buffering along the watershed-river continuum **regulates delivery** of P to help **reduce ecological impacts** downstream


TECHNICAL REPORTS: LANDSCAPE AND WATERSHED PROCESSES

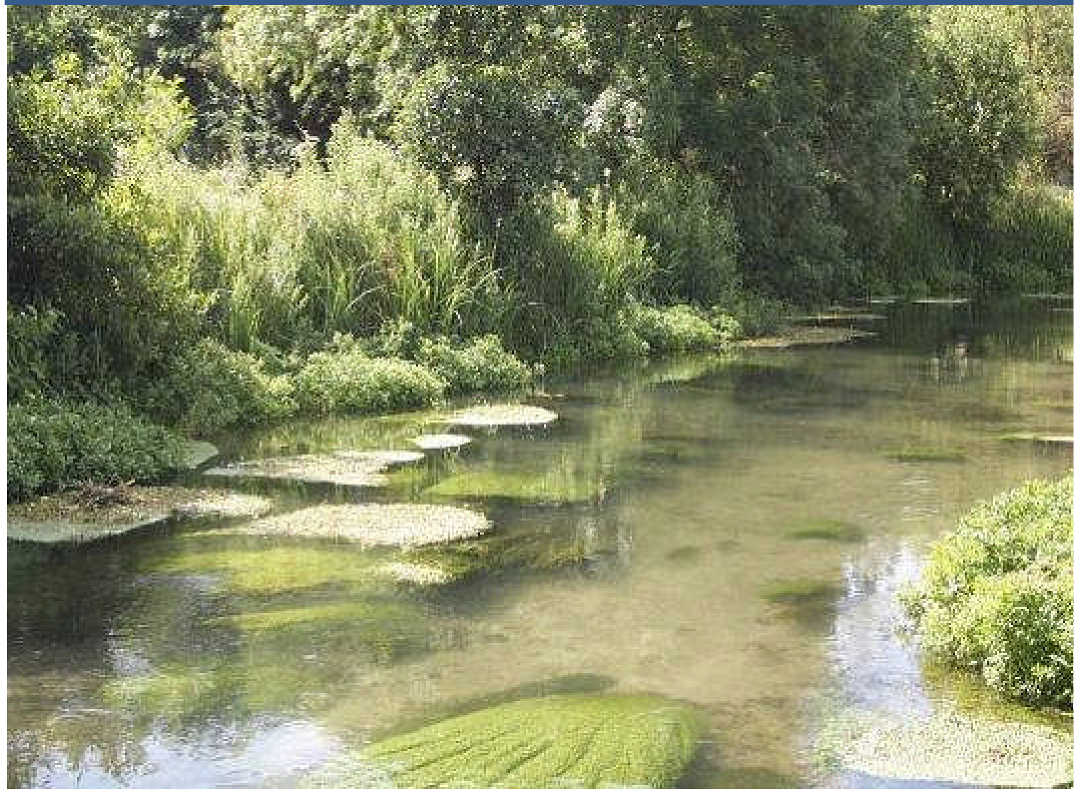
Quantifying Phosphorus Retention and Release in Rivers and Watersheds Using Extended End-Member Mixing Analysis (E-EMMA)

Helen P. Jarvie,* Colin Neal, Paul J.A. Withers, David B. Baker, R. Peter Richards, and Andrew N. Sharpley

Extended end-member mixing analysis (E-EMMA) is presented as a novel empirical method for exploring phosphorus (P)

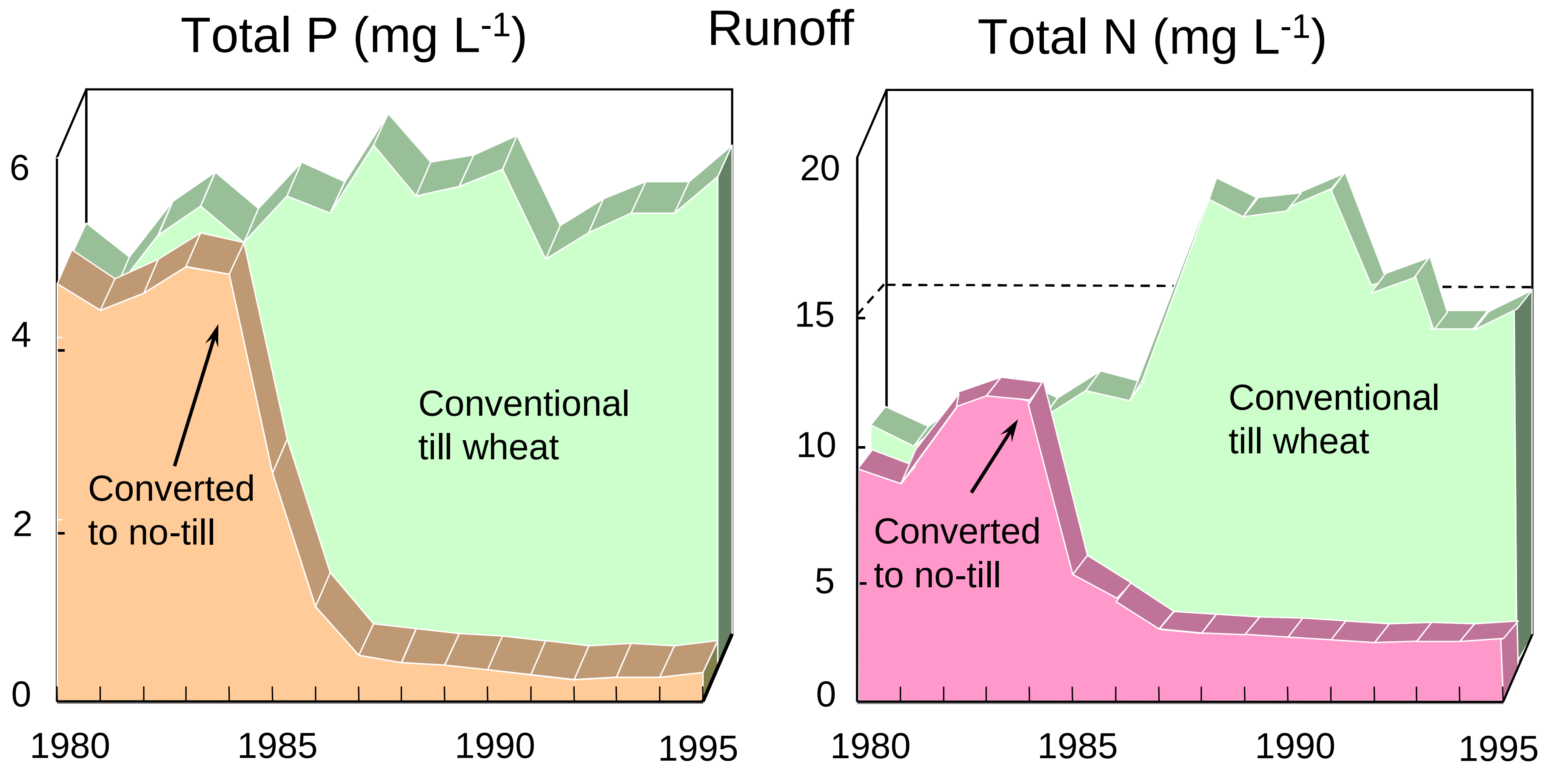
THROUGHOUT NORTH AMERICA AND EU
to protect the ecological status of surfac
river and lake eutrophication have resulted

J. Environmental Quality, 40, 492-504



BMP successes: Conservation tillage

No-till reduced erosion from wheat fields (2 ha) by 95%



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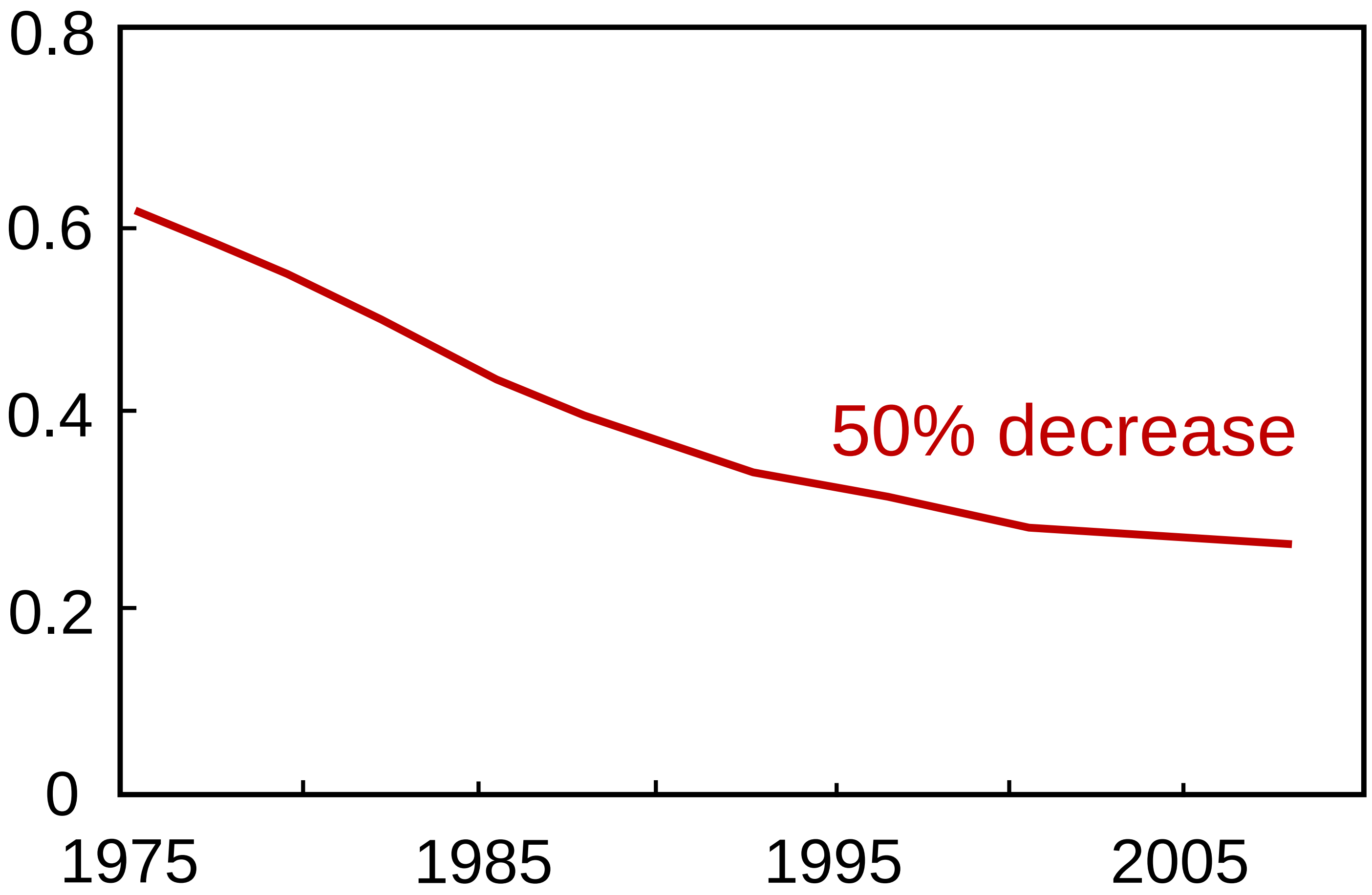
From: Sharpley and Smith, 1994 – El Reno, OK

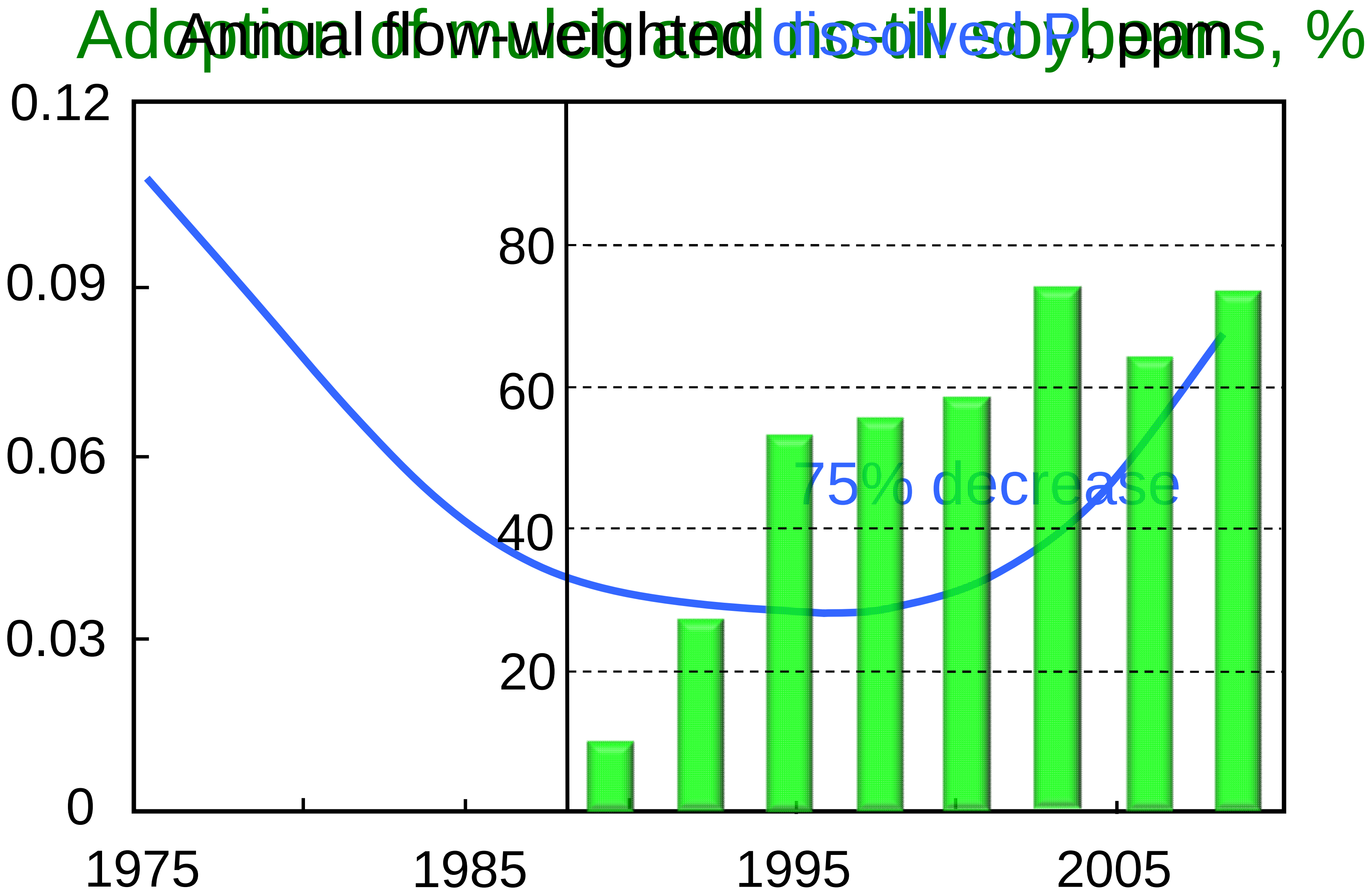
Conservation tillage

Maumee River - Annual flow-weighted Total P (mg/L)



Dave Baker & Peter Richards, OH

Trends in P – Maumee River



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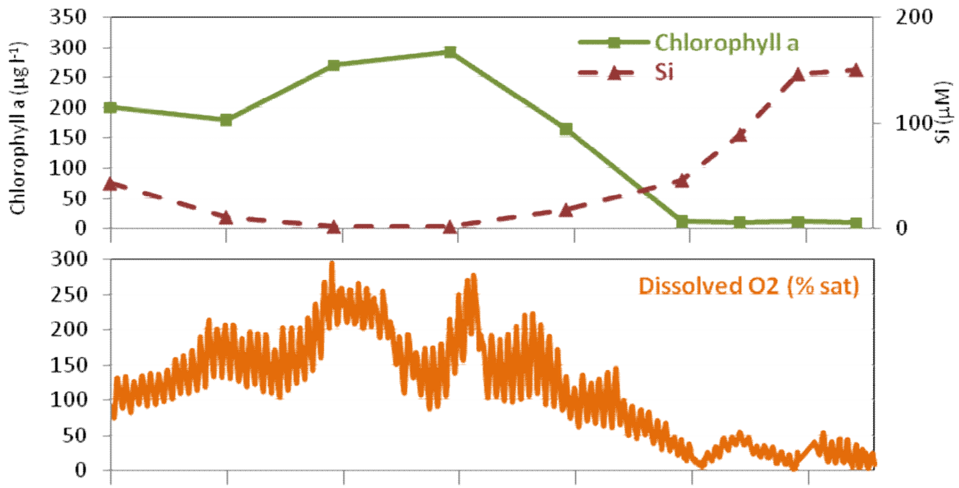
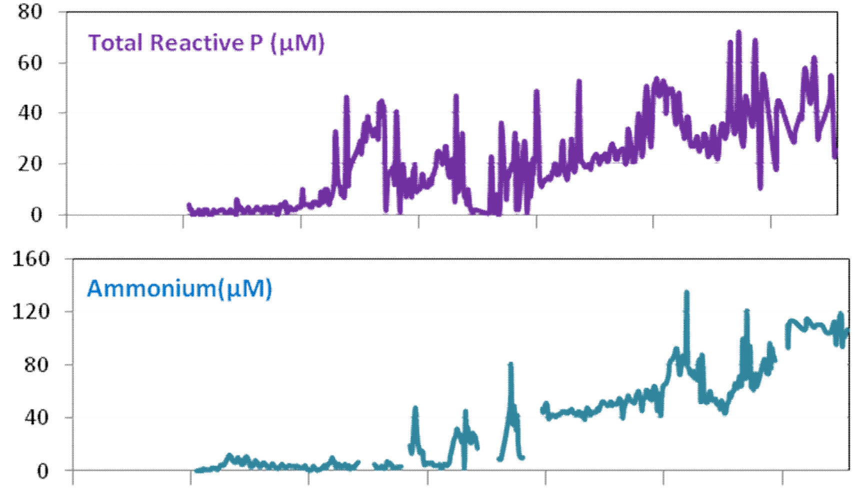
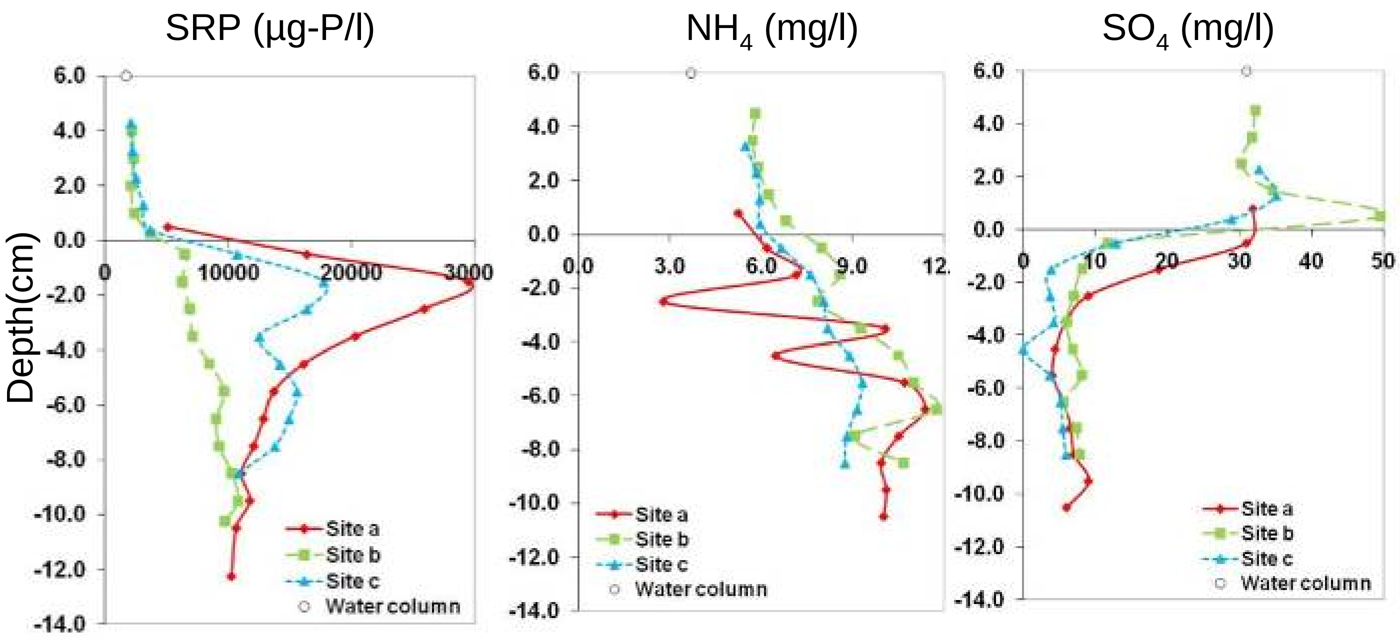
Process mechanisms: coupled macronutrient cycles

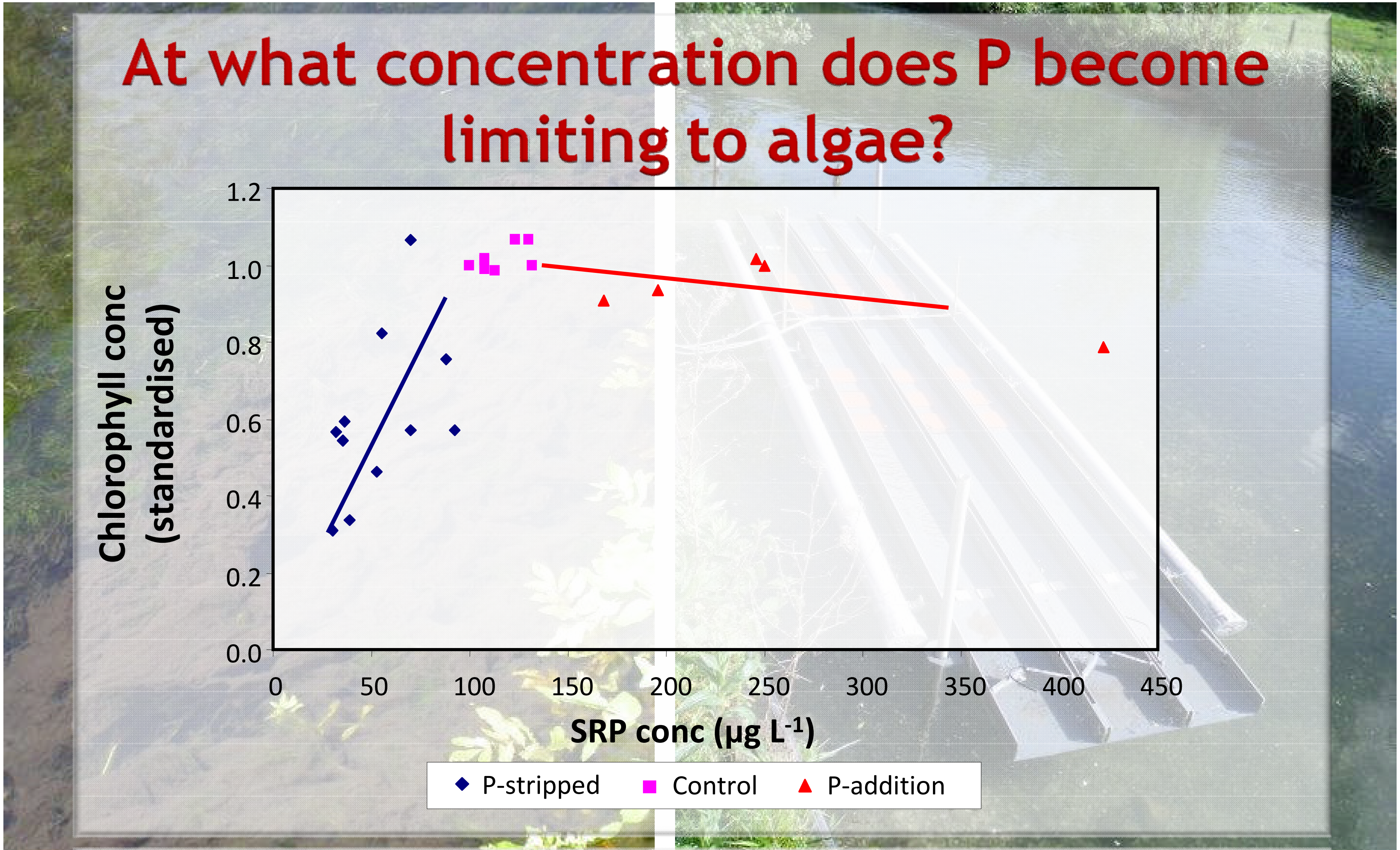






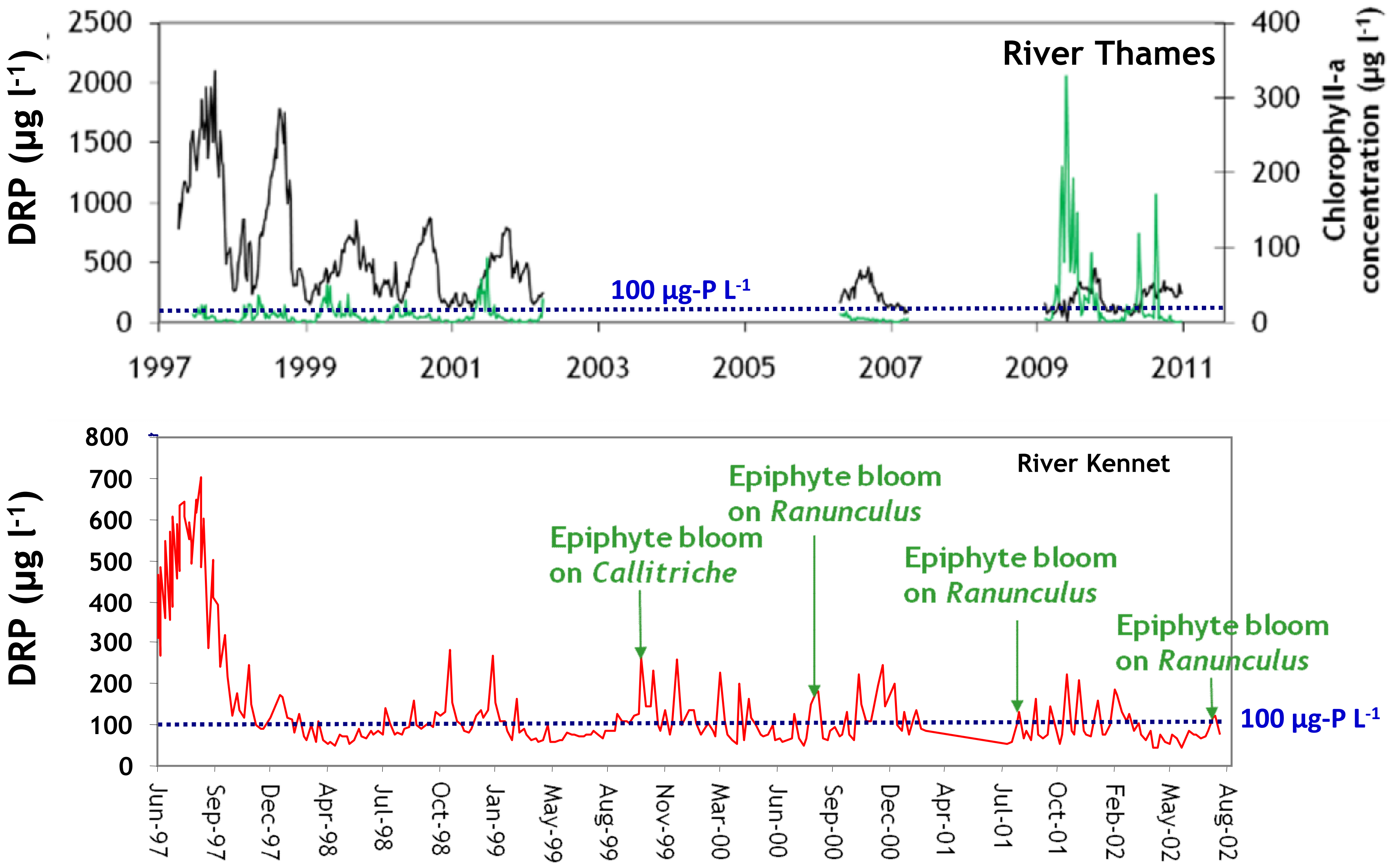
Palmer-Felgate et al (2011), Sci. Tot. Environ., 409, 2222-2232

P thresholds for nuisance algal (periphyton) growth



Bowes et al (2007) Canadian J. Fisheries and Aquatic Sciences 64 (2): 227-238

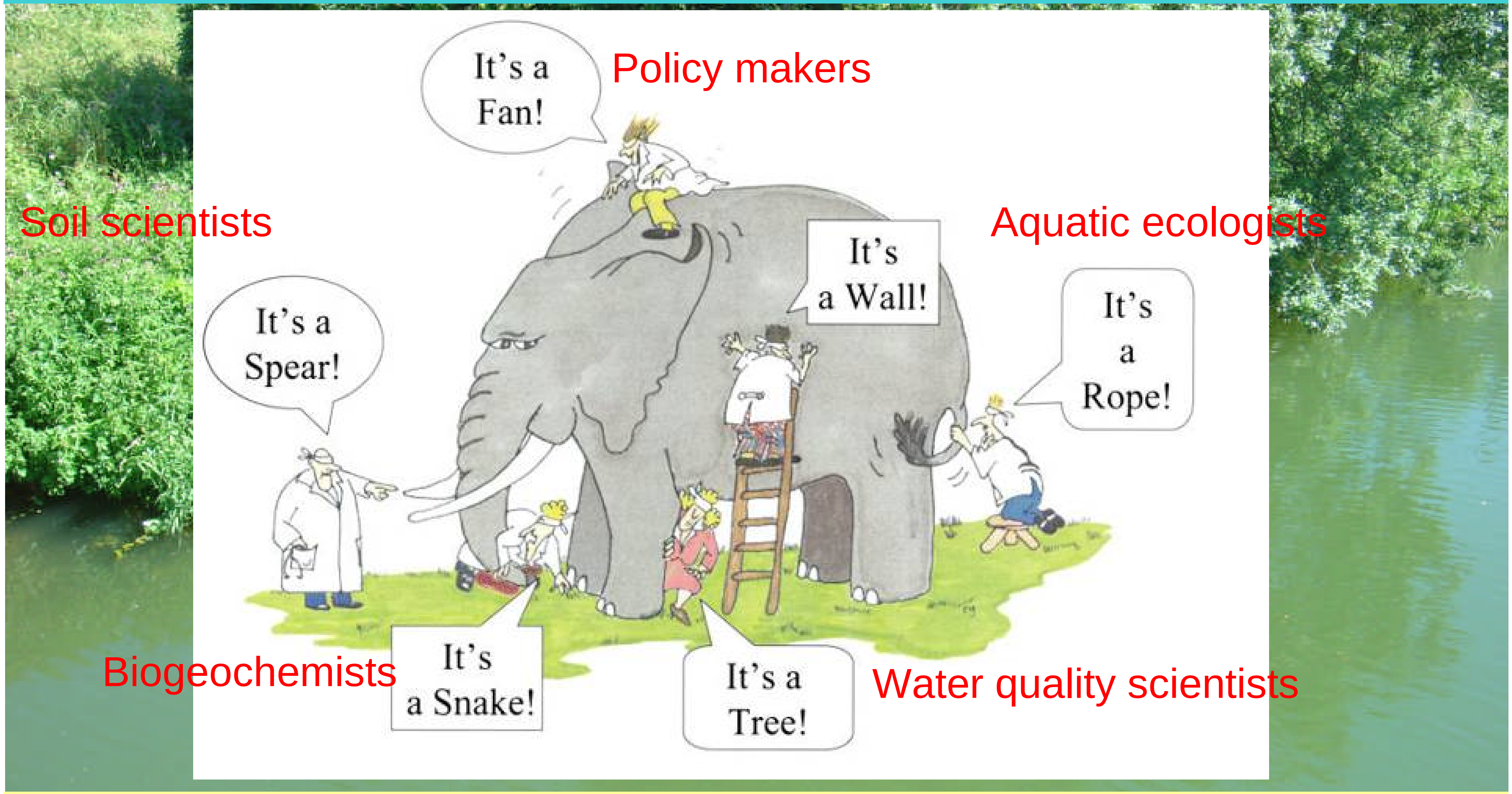
Even murkier - ecological responses to P remediation



Ecosystem response?

Murky waters...

Big opportunities for more integrated approaches....



Current focus on diffuse-source P controls & nutrient criteria alone may not necessarily achieve the desired ecological & water quality outcomes within short policy-relevant timescales….

Which do you prefer?

Source: Colin Neal, CEH & Ian Bateman, UEA

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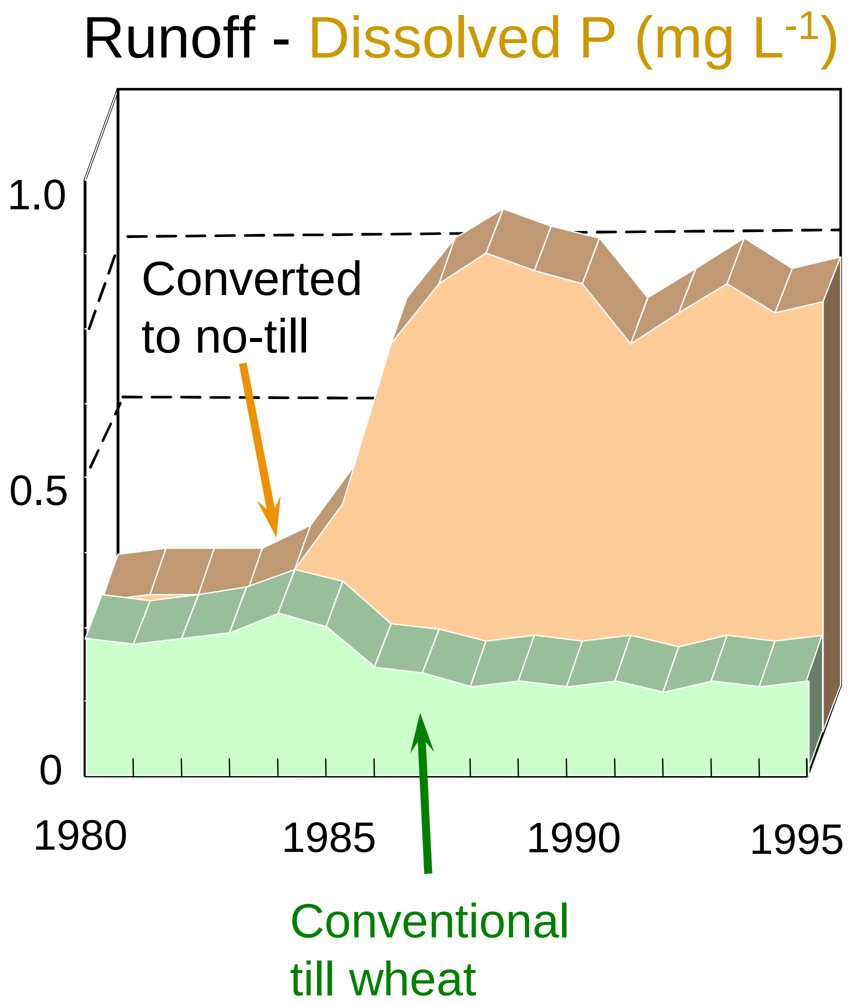
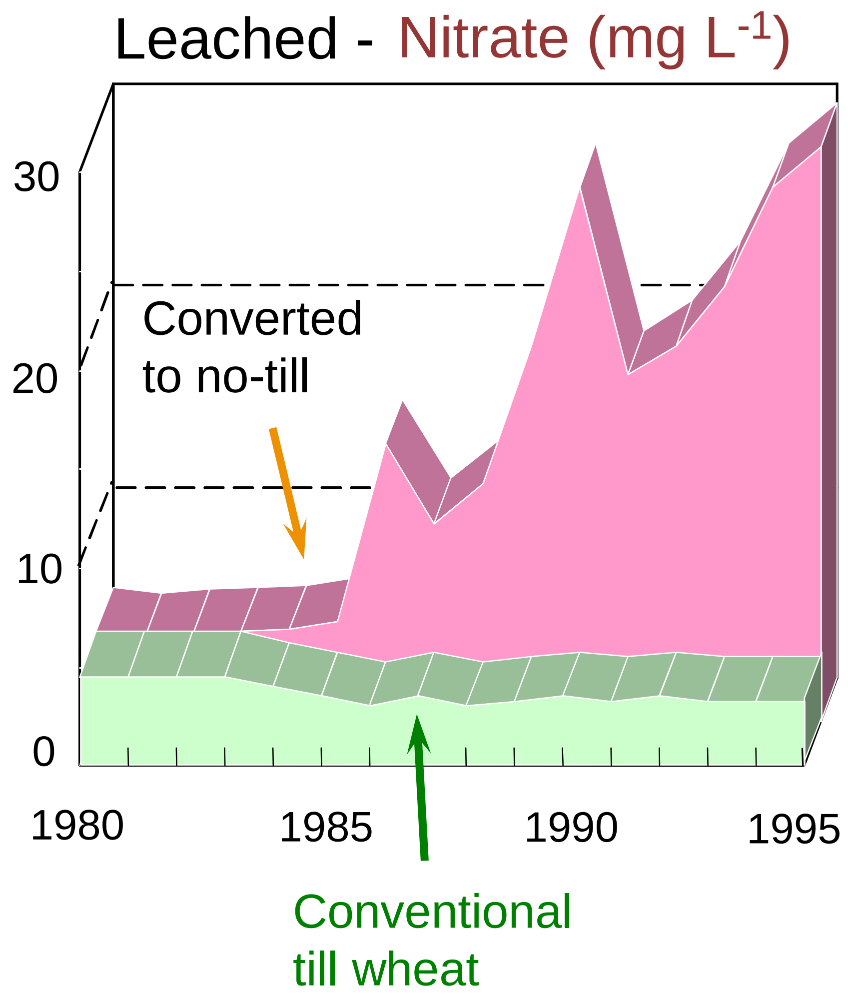
Conservation compromises

Infiltration increased 33%





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