2020 HELCOM Stakeholder Conference

New Metric for BSAP Nutrient Abatement Targets – with Focus on Phosphorus (P)

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Eutrophication is a shared problem
We could share solutions, too

Lake Erie, Total P loading 1967-2013 – We're doing great!

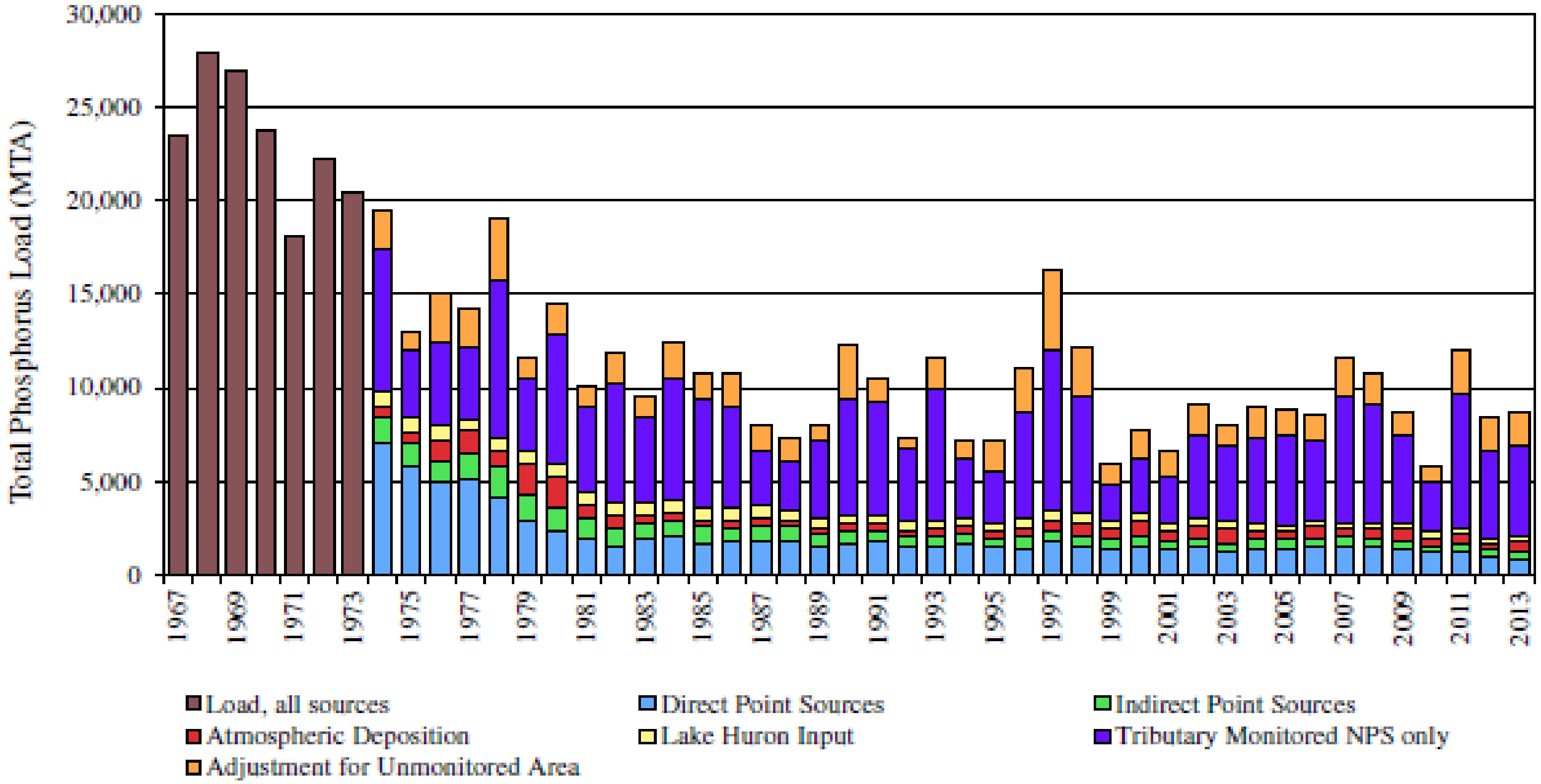
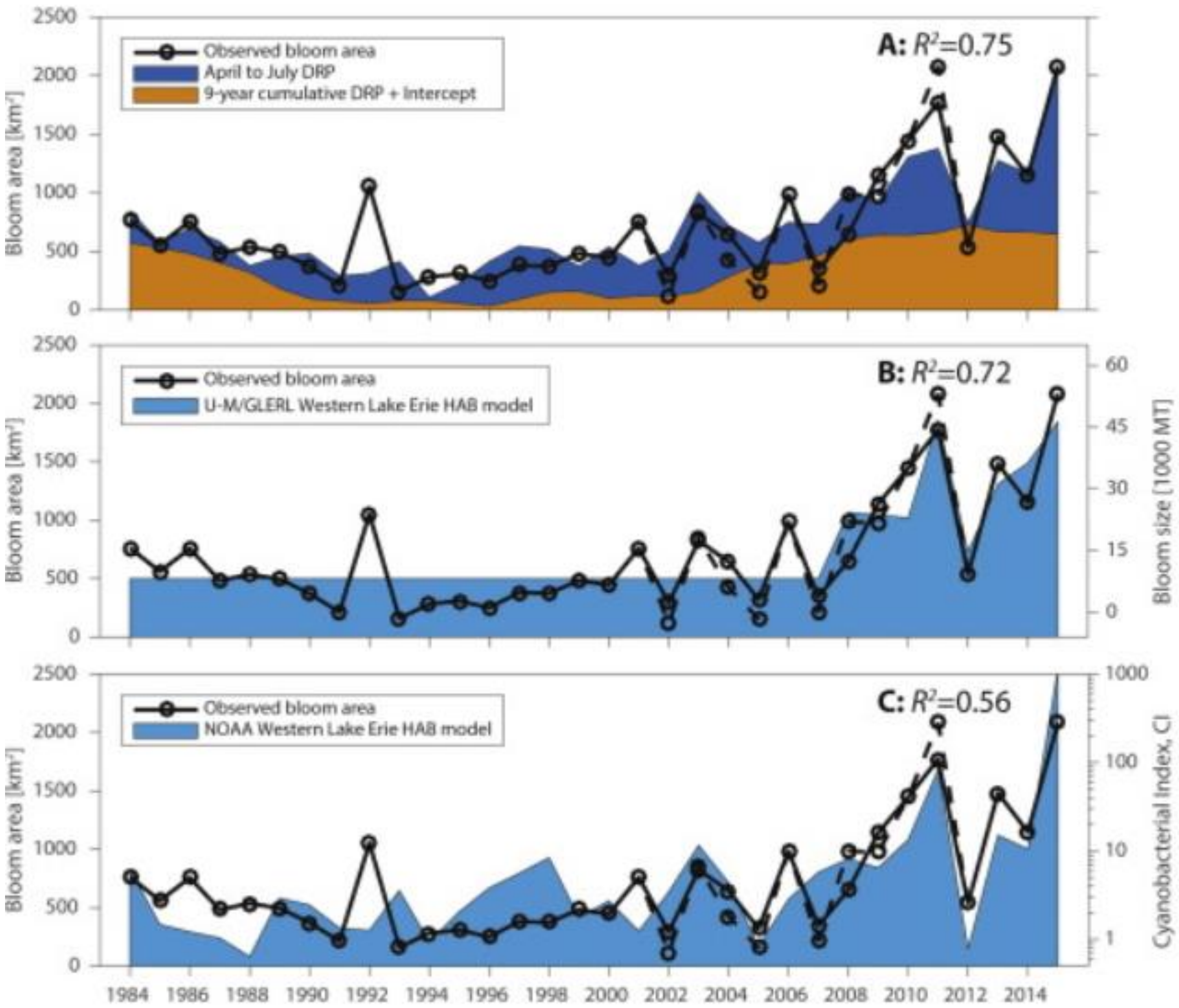


Fig. 1. Total phosphorus loads (MTA) to Lake Erie by source type (1967–2013). No source type attribution data are available prior to 1974.

Lake Erie, it’s re-eutrophying – We’re doing miserably!



Location	Years	SRP	PP
		kg ha^{-1} yr^{-1}	
Sandusky	1974 to 1984	0.298	1.39
	1985 to 2002	0.129 (−57%)	1.17 (−16%)
	2003 to 2014	0.456 (+253%)	1.53 (+30%)
Raisin	1982 to 1984	0.132	0.56
	1985 to 2002	0.066 (−50%)	0.39 (−31%)
	2003 to 2014	0.128 (+94%)	0.39 (0%)
Maumee	1974 to 1984	0.342	1.47
	1985 to 2002	0.168 (−51%)	1.05 (−29%)
	2003 to 2014	0.363 (+116%)	1.18 (+12%)

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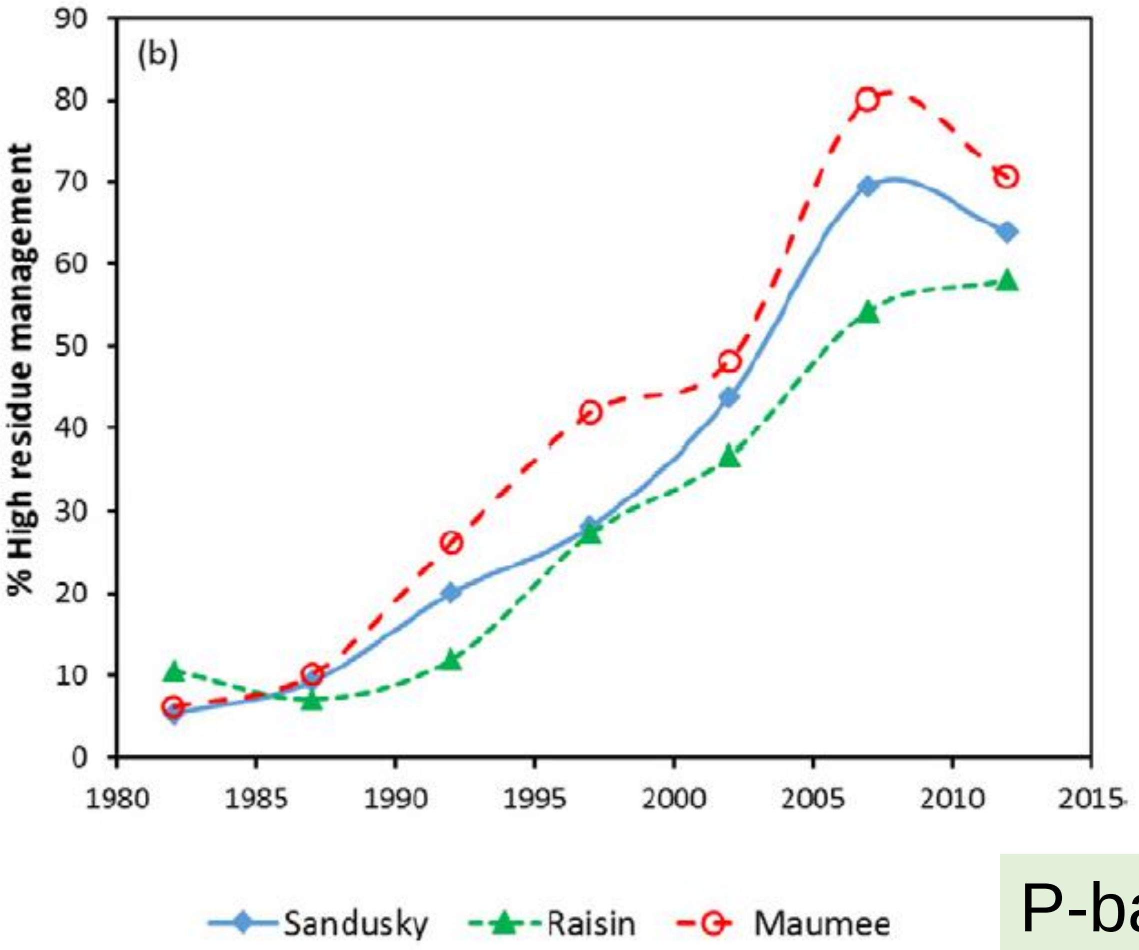
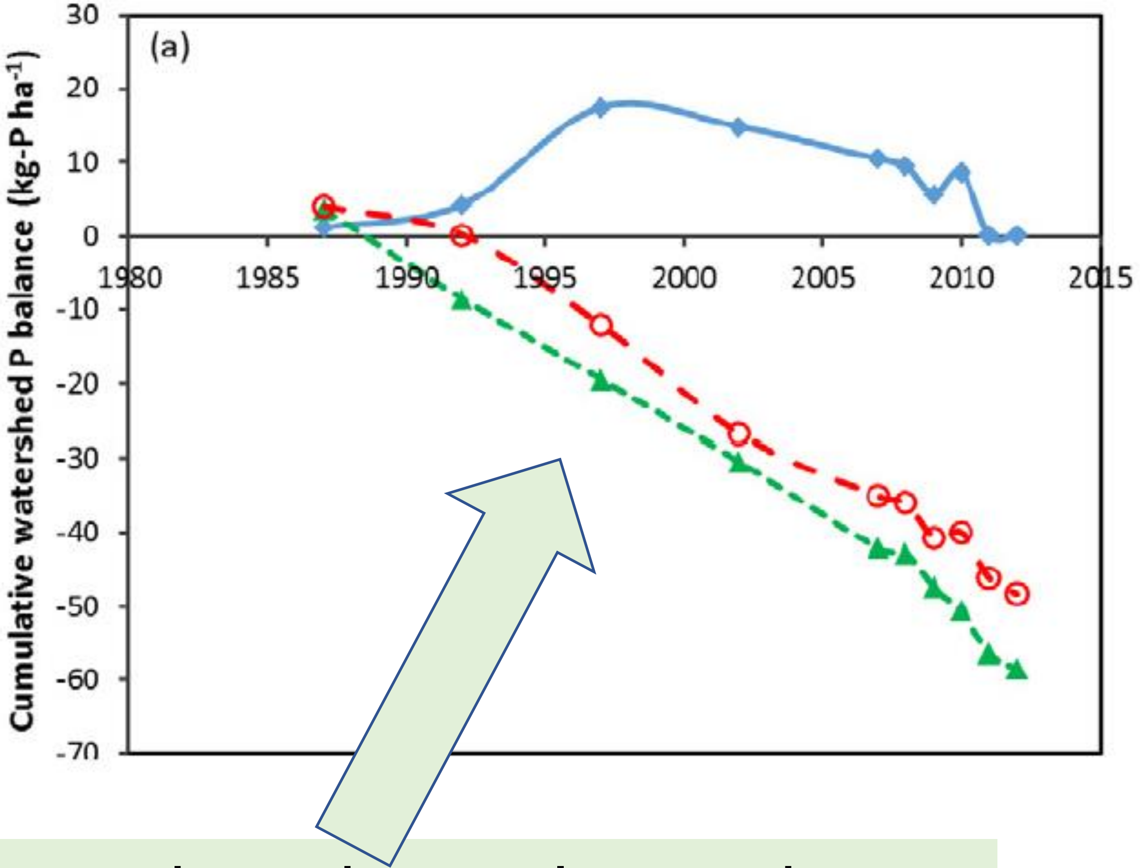
What has happened? No-till & Conservation Tillage up





P-balances have been plummeting

Soil Conserving Tillage Systems Tend to Elevate Dissolved Reactive P (DRP) loading

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Table 1 continued

Practice	Description	Effectiveness (% reduction) Dissolved P	Particulate P	References
Buffer strips/riparian zones	Slows flow, increases infiltration and removes sediment bound P	−258 to 88	35–96	Abu-Zreig et al. (2003)[b,k], Blanco-Canqui et al. (2004)[b], Chaubey et al. (1995)[b], Daniels and Gilliam (1996)[c], Dillaha et al. (1989)[b], Schmitt et al. (1999)[b], Lee et al. (2000)[b], Lowrance and Sheridan (2005)[d,k]
Constructed wetlands	Removes sediment bound P	−72[j] to 94	47–70	
Transport management/Control				
Strip cropping/contour				

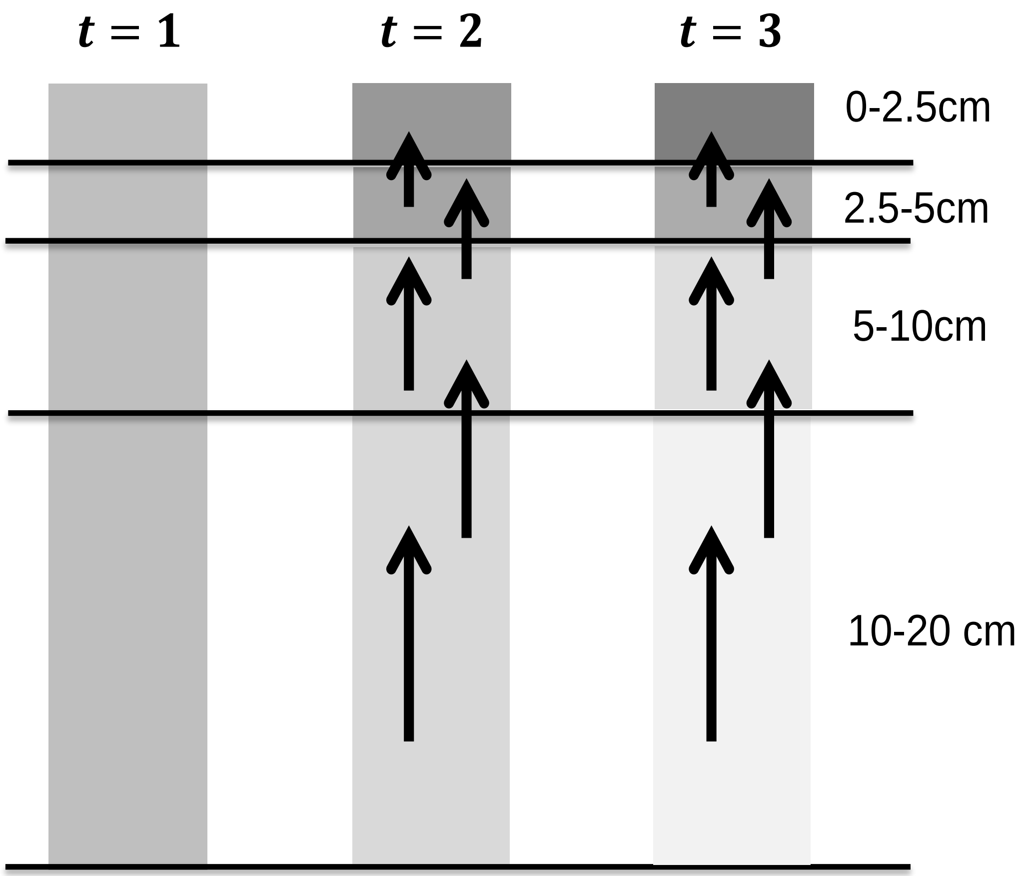
Table 1 USDA-NCRS promoted conservation practices to minimize the loss of P from agriculture and the range of effectiveness for dissolved P (as DRP) and particulate P found in field experiments across the U.S. and Canada

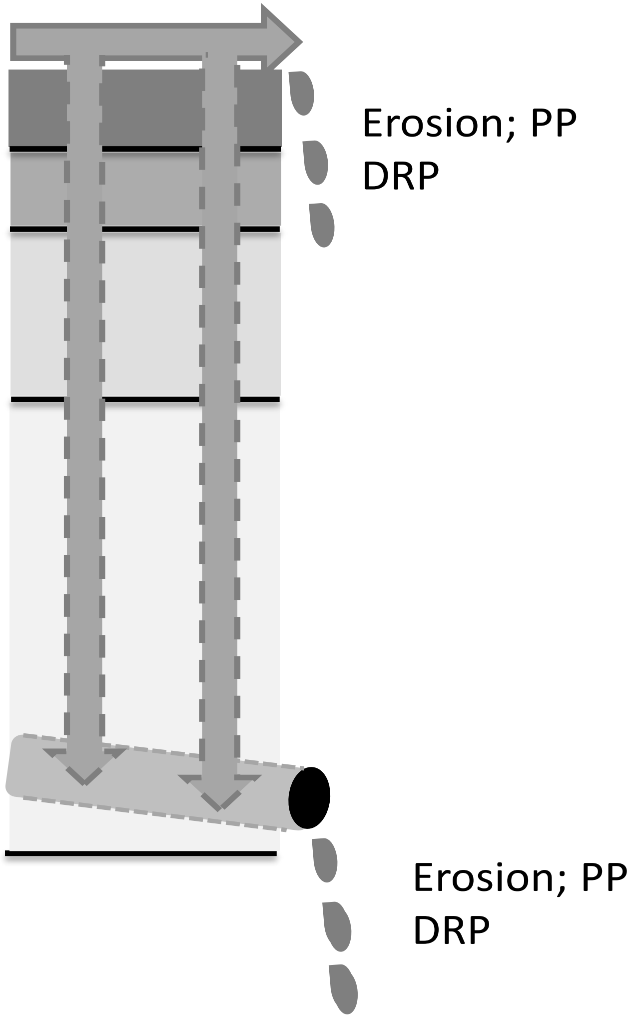
Practice	Description	Effectiveness (% reduction) Dissolved P	Particulate P	References
Farm inputs Dietary P	Match animals nutritional requirements to feed	13–89	<1	Ebeling et al. (2002)[b], Ghebremichael et al. (2007)[a], Hamrahan et al. (2009)[b] and Jokela et al. (2012)[b]
Corn hybrids	Use of low phytic-acid corn in feed to reduce manure P	45–48	Negligible	Leytem et al. (2008)[c], Penn et al. (2004)[c] and Smith et al. (2004a)[b]
Feed additives	Addition of phytase enzyme to increase P utilization	n.s.—52	Negligible	Penn et al. (2004)[c] and Smith et al. (2004a, b)[b]
Source management/Avoid Nutrient management	Rate—based on soil testing. P inputs are based on crop requirements	10 % reduction for every 10 % reduction in STP	n.d.	Vadas et al. (2005)[d]
		>80 % reduction moving from N based to STP based litter application	Negligible	Sharpley et al. (2009a)[e]
		60–88 % reduction moving from N based to P based litter application	Negligible—67	Eghball and Gilley (1999)[b], Miller et al. (2011)[b] and Sweeney et al. (2012)[b]
	Application timing—apply during seasons with low runoff potential	41–42	Negligible	Schroeder et al. (2004)[b] and Sharpley (1997)[b]
	Application method—incorporate, band or inject P into conservation tilled soil	20–98[i]	n.s.—60 % increase	Eghball and Gilley (1999)[b], Kibet et al. (2011)[b], Kimmell et al. (2001)[c], Little et al. (2005)[b], Rotz et al. (2011)[a], Tarkalson and Mikkelsen (2004)[b] and Sweeney et al. (2012)[b]
Conservation crop rotation	Sequence different rooting depth and plant acquisition mechanisms to optimize soil P uptake	85	Negligible	Smith et al. (2015a)[f]
Soil inversion	Reduce P enrichment in topsoil	n.s.—92	Negligible—59 % increase	Quincke et al. (2007)[b], Sharpley (2003)[b] and Smith et al. (2007)[b]
Transport management/Trap Conservation cover	Permanent vegetative cover to increase soil infiltration and remove sediment bound P	n.s.—63	65–90	Sharpley and Smith (1991)[d] and Zhu et al. (1989)[e]

Uusitalo et al 2017

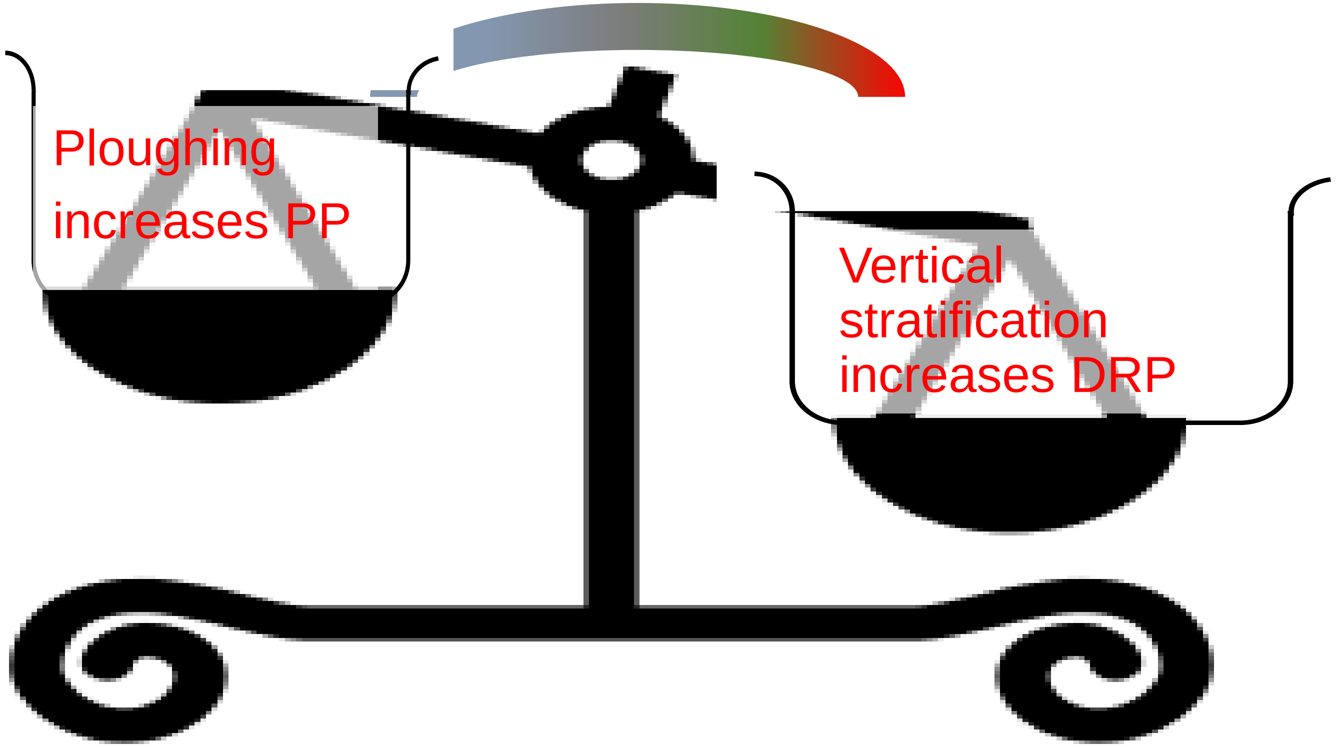
Change from ploughing	DRP	PP
Stubble over winter	+93%	-2%
Shallow autumn tillage	+28%	+9%
No-till	+209%	-54%

Why? Gradual Enrichment of P in Top Soil when Undistrubed.

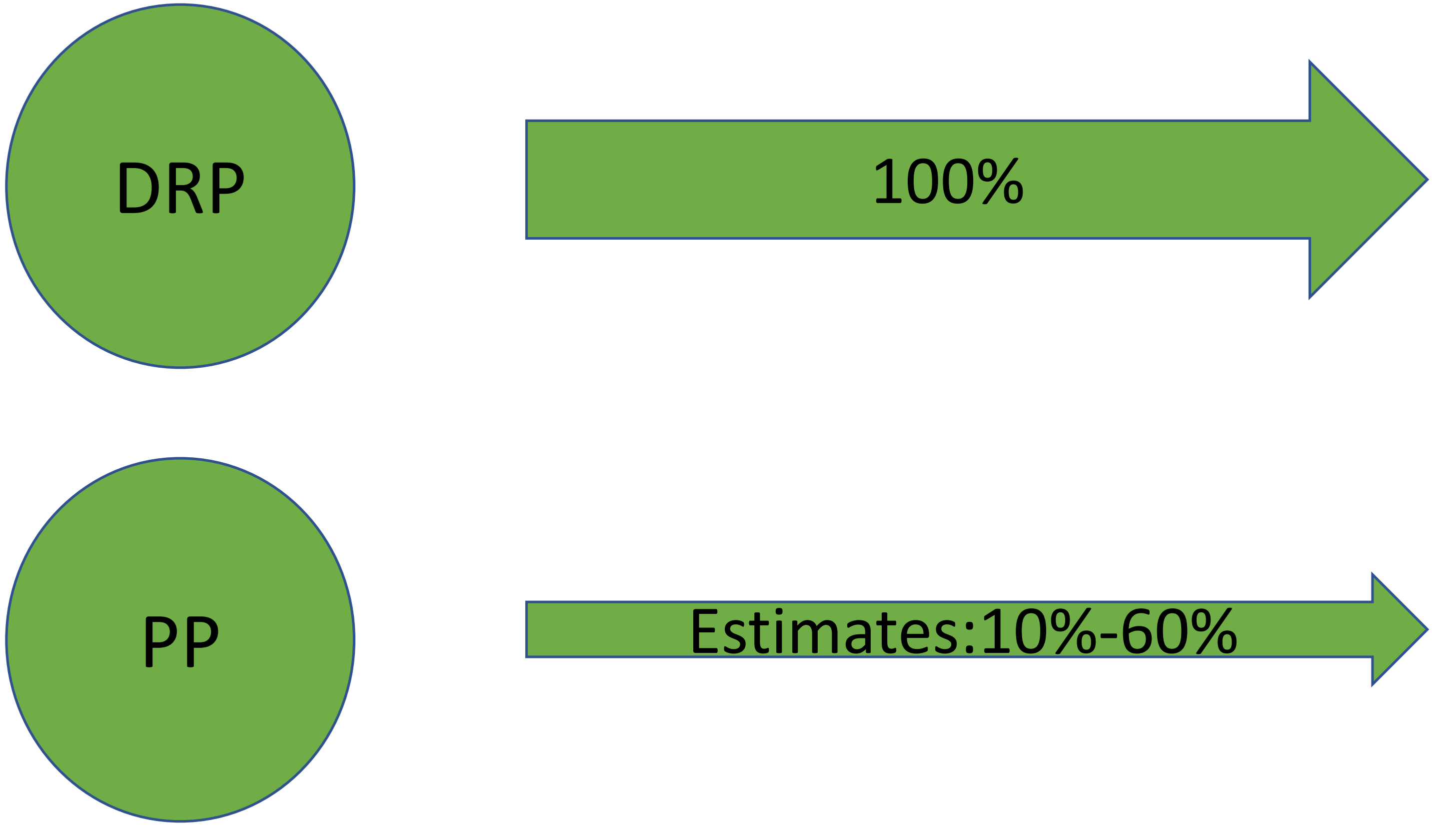


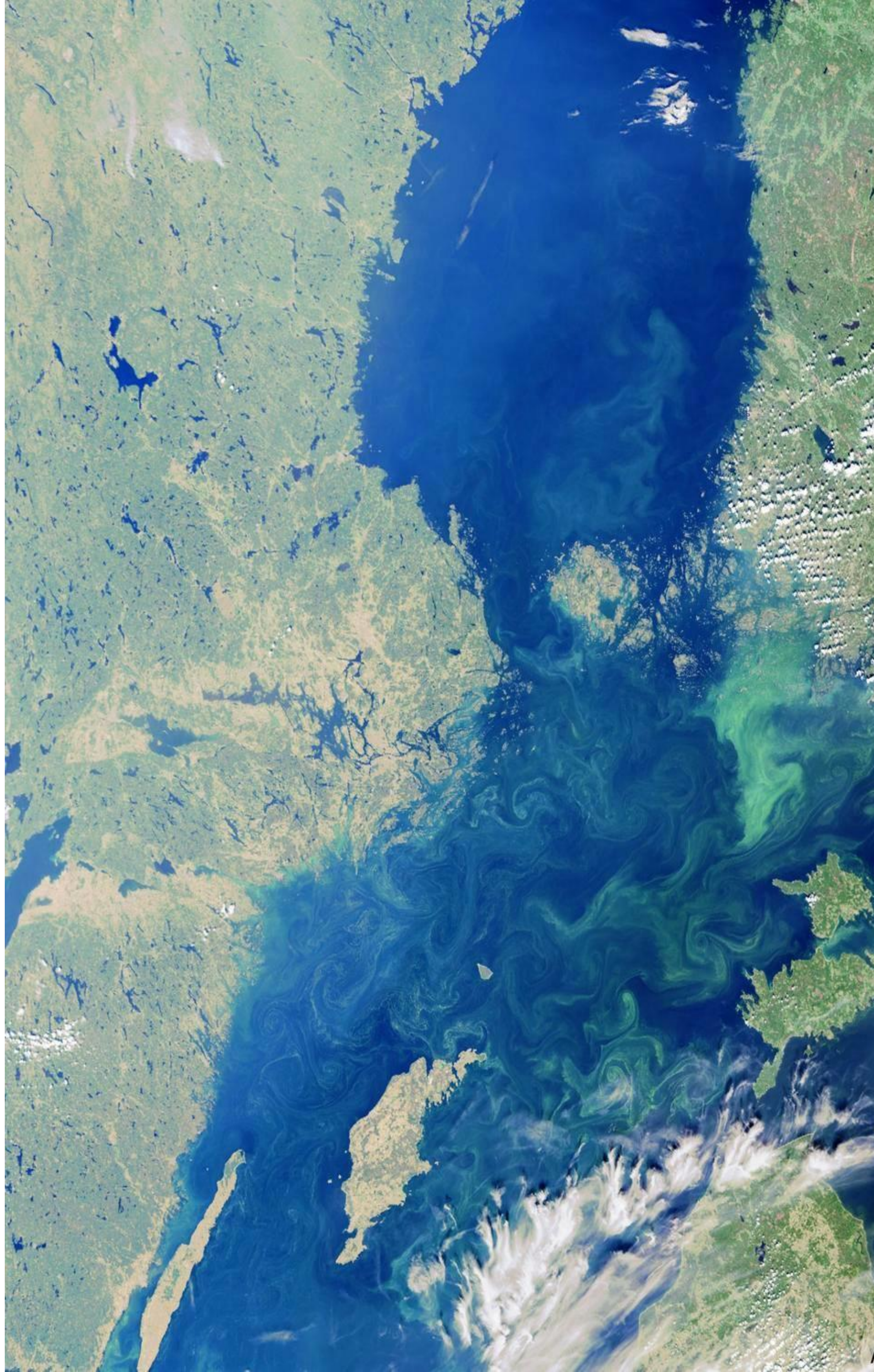


Striking Balance Between two Evils

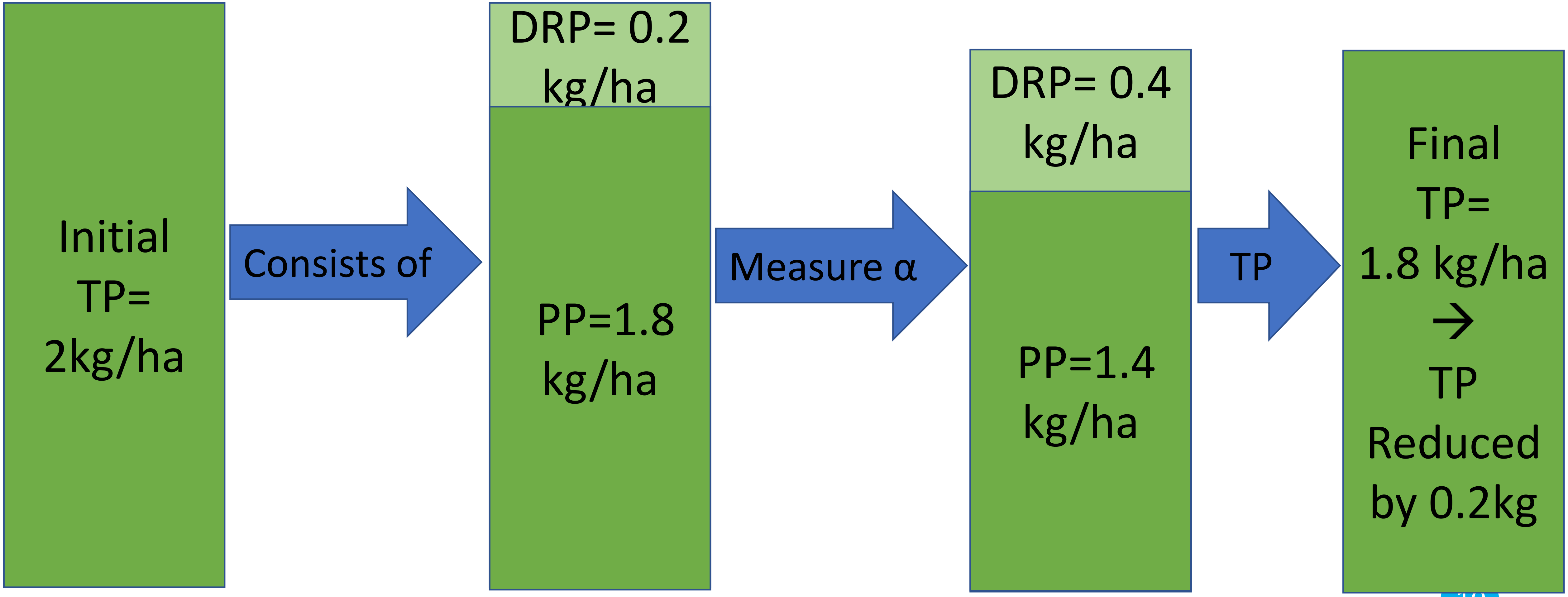


Plot Twist: DRP is (much) More Potent than PP in Promoting Algae Growth !





Example: Measure ALPHA (α) on One Hectare of Agricultural Land.



Doing ALPHA Costs 10€.

Unit Abatemen Costs: 10€/0.2kg(TP) = 50 €/kg(TP)

50€/kg

Alternative measure in agriculture 100€/kg

Alternative measures in large point sources 200€/kg

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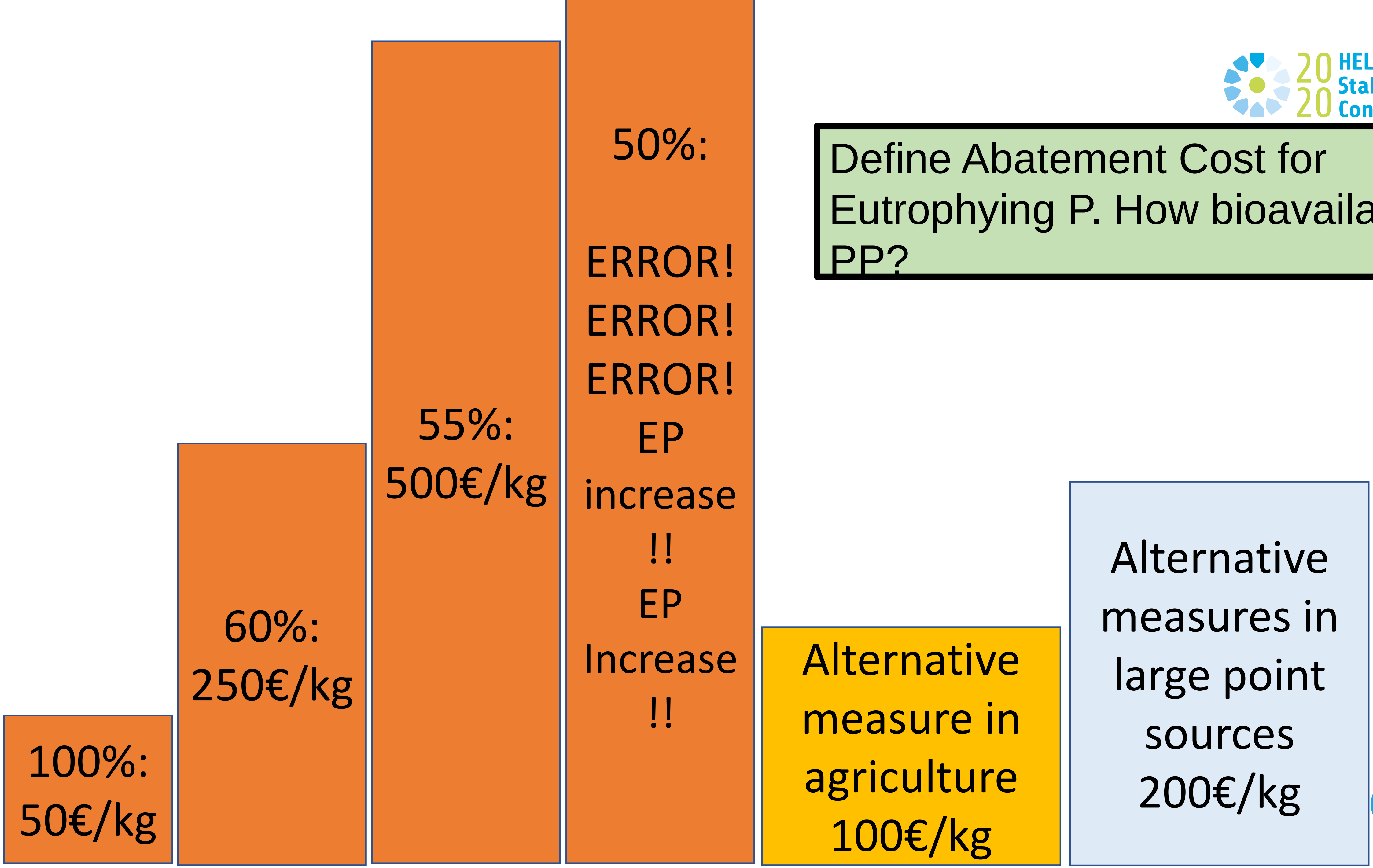
Define Abatement Cost for Eutrophying P. How bioavailable is PP?



With PP-DRP Trade-offs Revising the Metric is a Game-Changer

What Gets Measured Gets Done! Mimic CO_2-equivalents

$$TP=PP+DRP \rightarrow EP=\beta PP+DRP$$

Where

β=Long-term bioavailability of PP

Cannot determine the right β!!

Uncertainty! Morphology! Source area soils! Time!

GWP of methane and Nitrous oxide as indicated by IPCC rapports	Time horizon 20	100	500
Carbon dioxide	1	1	1
Methane (1990)	63	21	9
Methane (1995)	56	21	6.5
Methane (2001)	62	23	7
Methane (2007)	72	25	7.6
Methane (2013)	84-86	28-34	
Nitrous oxide (1990)	270	290	190
Nitrous oxide (1995)	280	310	170
Nitrous oxide (2001)	275	296	156
Nitrous oxide (2007)	289	298	153
Nitrous oxide (2013)	264-268	265-298	

Start the process and the parameters start getting more precise!

Introduce in BSAP? 1. The Lake Erie way (revised plan 2019)

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TABLE 1: Binational Phosphorus Load Reduction Targets

LAKE ECOSYSTEM OBJECTIVE	WESTERN BASIN OF LAKE ERIE	CENTRAL BASIN OF LAKE ERIE
Minimize the extent of hypoxic zones associated with excessive phosphorus loading, particularly in Lake Erie's central basin.	40 percent reduction from 2008 levels in total phosphorus entering the western and central basins of Lake Erie to achieve an annual load of 6000 Metric Tons to the central basin. This amounts to a reduction from Canada and the United States of 212 Metric Tons and 3,316 Metric Tons, respectively.	
Maintain algal species consistent with healthy aquatic ecosystems in the Nearshore.	40 percent reduction in spring (March – July) TP and SRP loads from the following tributaries where localized algae is a problem[3]:	
	Thames River – Canada	Sandusky River – United States
	Maumee River – United States	Huron River, Ohio – United States
	River Raisin – United States	
	Portage River – United States	
	Toussaint Creek – United States	
	Leamington Tributaries – Canada	
Maintain cyanobacteria biomass at levels that do not produce concentrations of toxins that pose a threat to human or ecosystem health.	40 percent reduction in spring TP and SRP loads from the Maumee River (United States). This equates to a target spring load of 860 Metric Tons TP and 186 Metric Tons SRP.	Not Applicable

Introduce in BSAP? 2. The Chesapeake Bay Way (STAC proposal 2020 https://www.chesapeake.org/stac/publications/workshop-publications/)

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The CBP should move to set program goals and assessing progress through “eutrophying units” that characterize algal and hypoxia effects, as soon as feasibly possible.

Introduce in BSAP? 3. The Baby Step Way

A measure that increases DRP load

Not possible!

We cannot measure all agricultural DRP/PP sources!

Choice Between Keeping the Certainly Wrong Metric and Starting to Develop an Unbiased One

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