Welcome!

Sustainable Phosphorus Alliance

Who We Are

The **Sustainable Phosphorus Alliance** is a members organization that serves as North America's central forum and advocate for the sustainable use, recovery, and recycling of phosphorus in the food system.

Members and Partners

OCP

NACWA

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THE Water Research FOUNDATION

RENEWABLE NUTRIENTS

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STEPS Science and Technologies for Phosphorus Sustainability

PHOSPHOLUTIONS

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Agenda

12:30 – 1:00	P is for Planet: The Future of Sustainability in Phosphate	Maurício Fortuna, CRU
1:00 – 1:30	The Dichotomy in Sustainable Phosphorus Management: Why Do We Need a Convergence?	Kaushik Majumdar, Global Phosphorus Institute and African Plant Nutrition Institute
1:30 – 2:00	European Update	Ludwig Hermann, European Sustainable Phosphorus Platform (ESPP)
2:00 – 2:30	The Orthophosphate Paradox	Emily Remmel, National Association of Clean Water Agencies (NACWA)
2:30 – 3:00	Facilitated Policy Wrap-Up Discussion	Anna-Maria Marshall, University of Illinois, Urbana-Champaign

P is for Planet

What sustainability lessons can we draw from the tumultuous year in phosphate markets?

SEPTEMBER 2022

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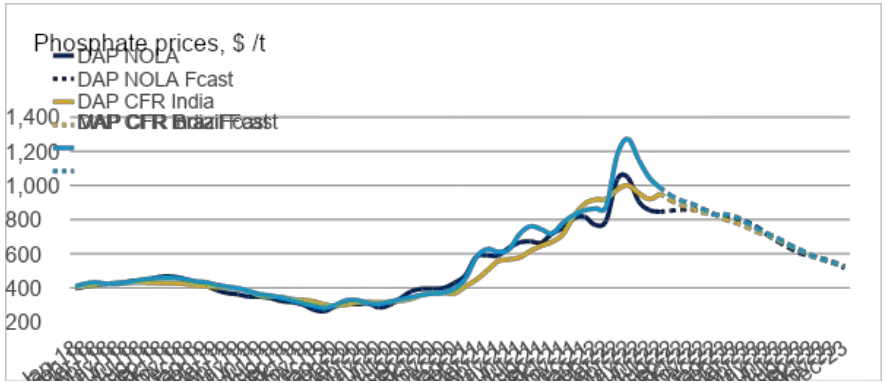
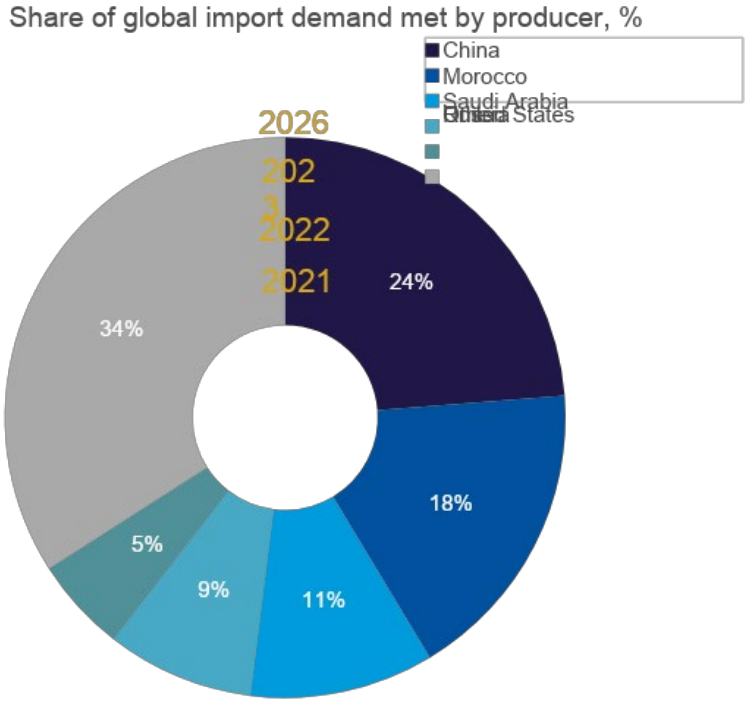
Global developments in phosphate markets

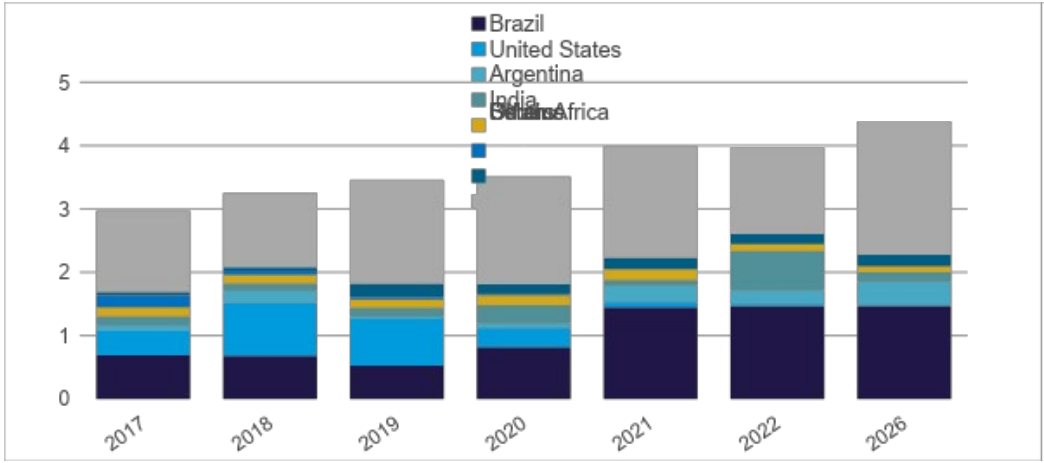
- The invasion of Ukraine has seen a shift in trade patterns in Russian fertilizers, as European buyers have largely shied away from Russian product, despite fertilizers not being directly covered by sanctions.
- Looking to guarantee food security, China has instated export restrictions on phosphate fertilizers. This has slashed their phosphate rock production and added further upwards pressures on prices.
- These market conditions combined with high commodity prices to cause a spike in fertilizer prices across the world in 2022.

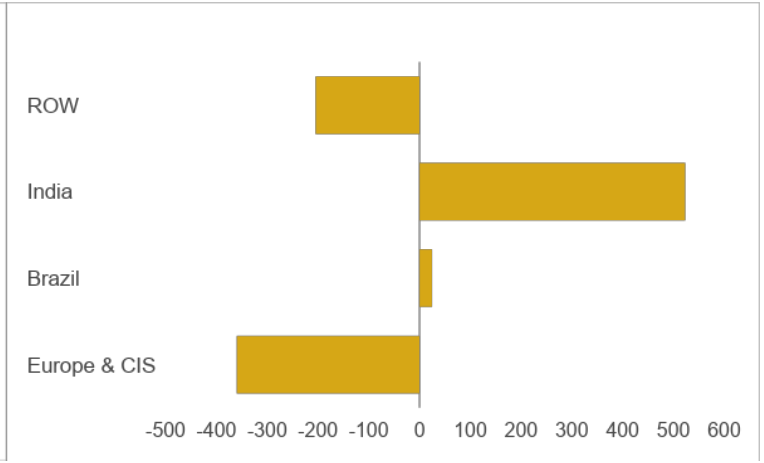


Data: CRU, S&P Global, co. reporting



Russia finds new export partners as Europe shuts the door



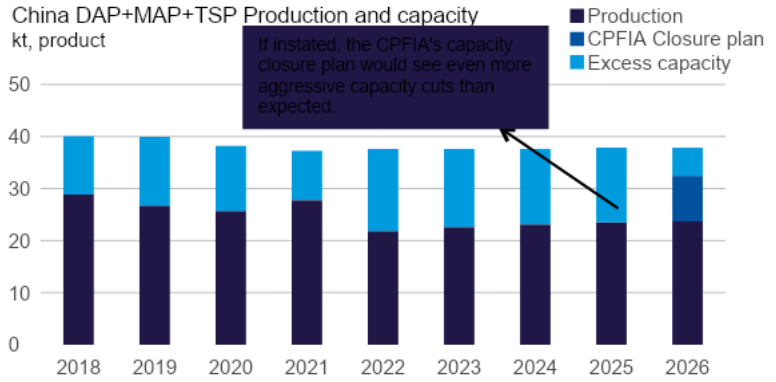


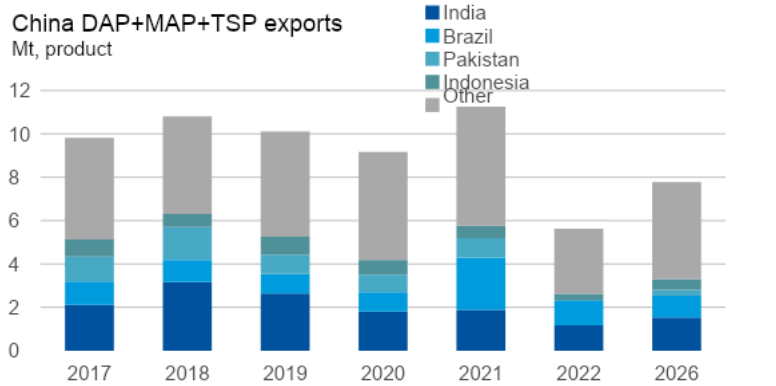
- Despite sanctions on most major producers, Russian fertilizer exports are not expected to be significantly lower in magnitude.
- European buyers largely stopped purchasing from Russia following the invasion of Ukraine.
- After a period of suspended exports from the Black Sea, Russian companies quickly found new trade partners.
- Russia has filled the gap in Chinese exports in India, sending discounted volumes. They have also sent significant volumes to Brazil and SEA.

Data: CRU, S&P Global

Export restrictions define China's markets

- Despite only holding a small portion of global reserves, China is the biggest producer and consumer of phosphate in the world.
- Food security is a top concern for the central government.
- In early 2022, high fertilizer prices saw the government instate several export restrictions, eventually culminating in a quota system of exports for each producer.
- These export restrictions curtailed phosphate exports in 2022 by about half compared to 2021.
- Though announcements haven't been made, it's widely expected that these restrictions will continue into 2023.
- It is likely China has already peaked as an exporter.
- The CPFIA's 5 year plan seeks to reduce China's DAP/MAP capacity by 20% in the next five years, to 15 Mt P2O5.
- Furthermore, the plan will strongly favour bigger companies, and will likely see some smaller producers shut down.
- **The strategic decisions of the Chinese government will be key in defining international phosphate markets.**

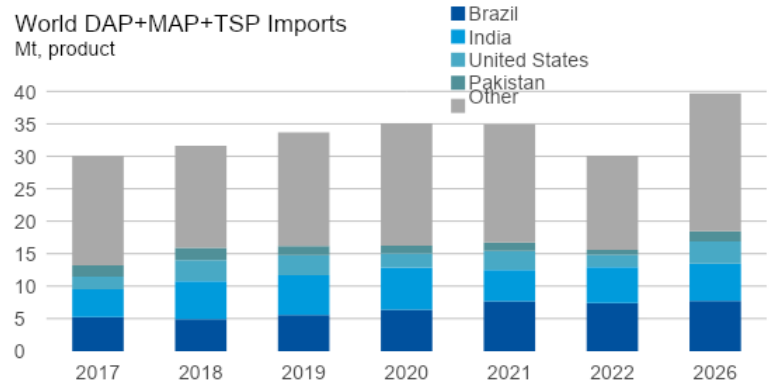


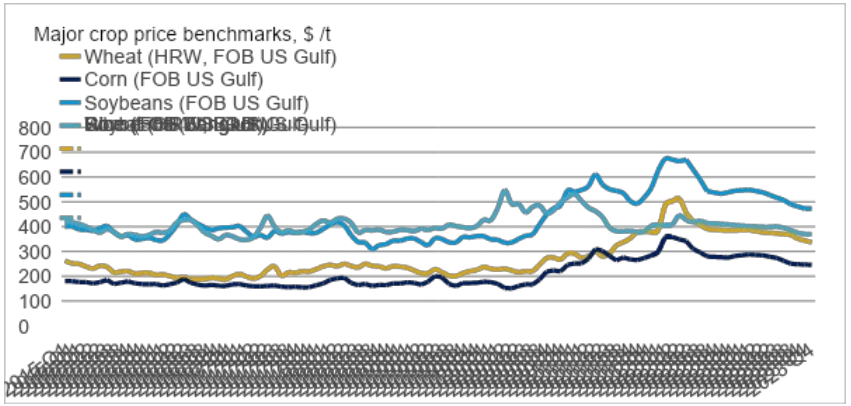


Data: CRU, S&P Global

Further developments in phosphate markets

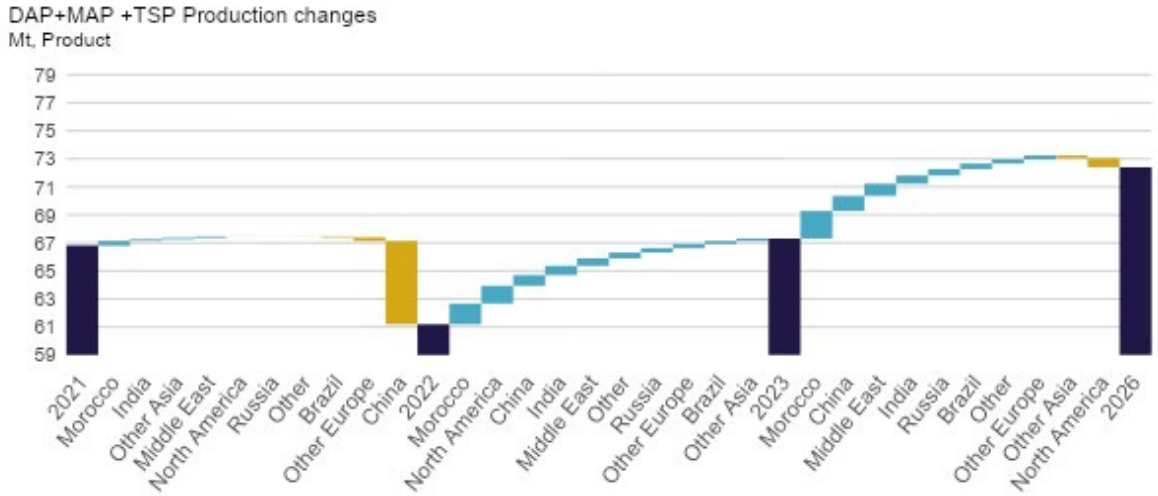
- In Brazil, buyers were concerned about the availability of phosphate and wound up purchasing large volumes at high prices early in the year, with inventories quite high. Overall imports were significantly lower, implying lower application.
- Similarly, the United States has wound up with large inventories despite production troubles due to Hurricane Ian.
- India is expected to import a large amount of phosphate fertilizers, boosting inventory and demand in preparation for the 2024 election.
- Globally, demand for key phosphates fell by an estimated 8%.
- High phosphate prices are supported by high crop prices, a result of pandemic lockdowns, inflation, speculative trading and fallout from the invasion of Ukraine.
- Crop prices are likely to have peaked, but will remain high in most of 2023. This has had significant ramifications in undoing progress to tackle hunger and poverty across the world.

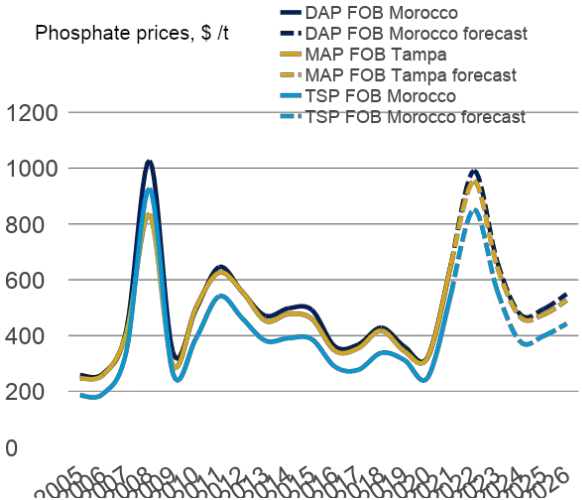




Data: CRU, S&P Global

Will markets normalise in 2023?

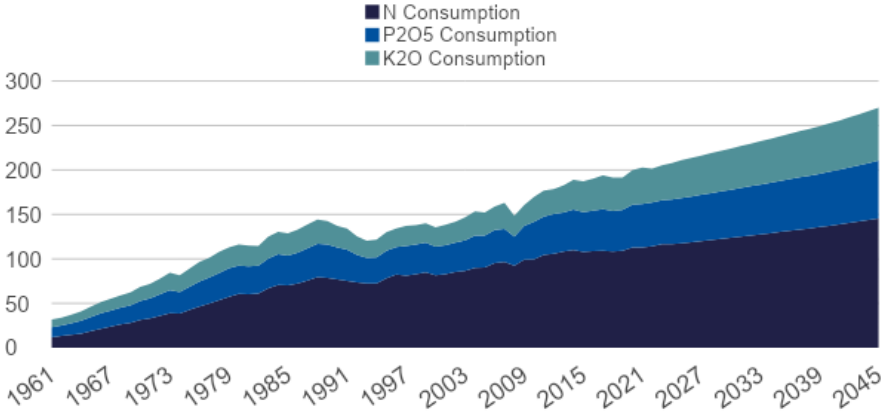




- We do not expect a full recovery of China's exports, but do expect a slight increase compared to 2022
- Some European buyers seem to have begun purchasing Russian fertilizers, but this is likely to be largely limited.
- Prices are expected to come down for the next year or two, however, it's possible they come to a new, higher "normal" as China withdraws from the market.
- Though the extraordinary conditions of 2022 are expected to begin recovering in 2023, it is likely this marks some shift in the industry structure.

Data: CRU

Looking forward in P markets



Demand drivers in the future

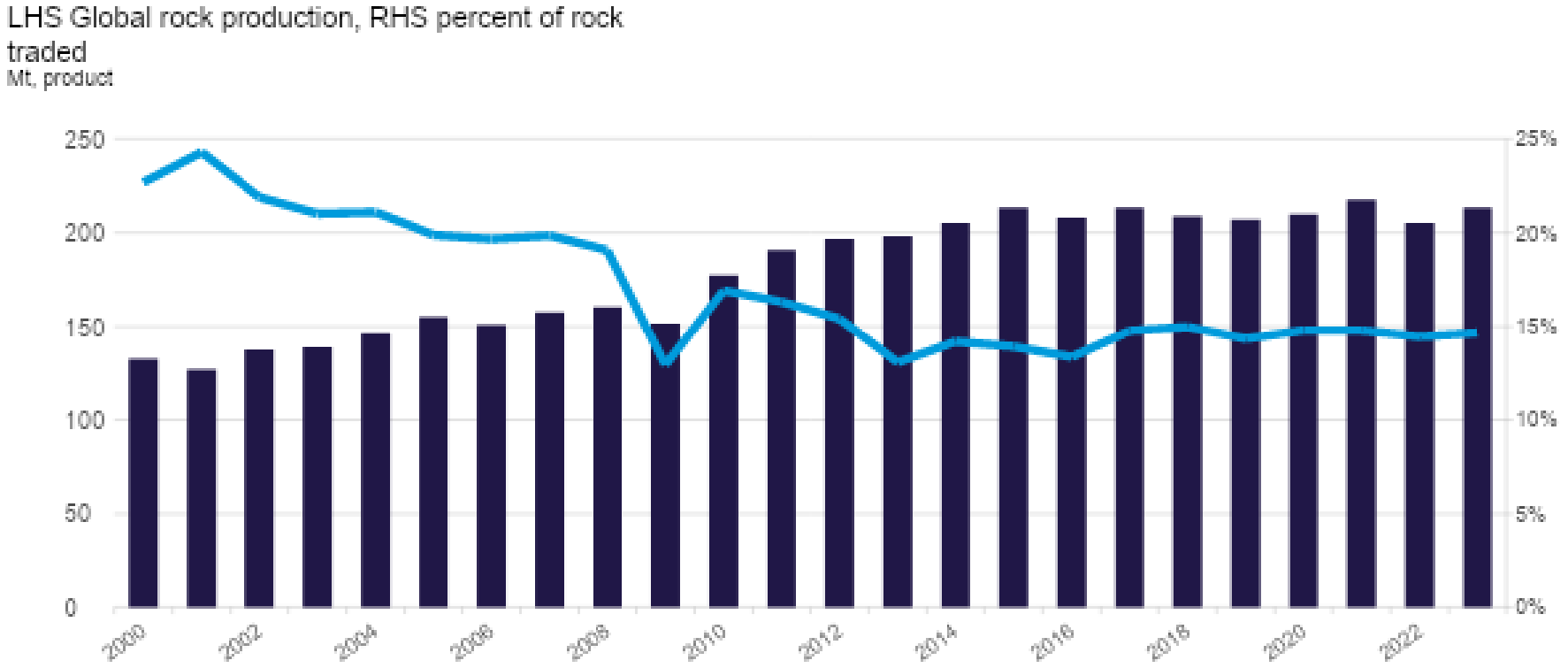
- Meat consumption to rise as part of a global trend
- Africa's demand likely to rise with a growing population and growing industrialization of agriculture
- The rise of LFPs (Lithium Ferro-Phosphate batteries), while a minor demand driver, will still pressure P demand

Production will similarly shift

- China is likely to export less to focus on domestic markets.
- The USA is likely to increase reliance on imports.
- OCP has been rapidly expanding their phosphate capacity.
- Saudi Arabia's Ma'aden has entered the industry and rapidly become a leading exporter

Data: CRU

Phosphate is an increasingly integrated industry



Data:CRU

The bigger picture: drawing lessons from a tumultuous 2022

1. Phosphate trade markets will necessarily change as key producers wind down capacity.
2. Development of global solutions will necessarily need to involve China – the country cannot be treated as a black box. Forging links with China's industry and scientific research will be incredibly important to understanding and developing P sustainability.
3. Growing P demand is inevitable as populations grow, and as meat consumption grows. Solutions to sustainability that focus on limiting P demand can only be based on increasing efficiency
4. A model of agricultural production that relies on cheap fertilizer imports is fragile as markets have proved to be prone to geopolitical difficulty.
5. A trend towards integration of phosphate rock will make phosphate independence more difficult. Phosphate trade will continue to be essential to supply many countries with their P needs. Trade therefore also needs to be sustainable, and less prone to geopolitical difficulty.

Meet the team

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Global Phosphorus Institute

Holistic Vision for Responsible Use of Phosphorus

The Dichotomy in Sustainable Phosphorus Management: Why Do We Need a Convergence?

Kaushik Majumdar

Phosphorus Forum and Sustainable Phosphorus Summit
Raleigh, North Carolina, November 1-4, 2022

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Global Phosphorus Institute

Holistic Vision for Responsible Use of Phosphorus

OUR MISSION

To serve as the global hub for all things phosphorus to strengthen collaborations, boost research and share knowledge in order to:

- Address human and animal nutrition requirements,
- Promote climate-smart and nutrition-sensitive agriculture programs,
- Improve supply-demand chain efficiencies, resolve equity issues, and
- Ensure stewardship and sustainable use of this finite, essential resource.

OUR VISION

Through excellence in collaboration, sharing knowledge, and innovative research, GPI will spark new, phosphorus-related solutions to feed our world and enhance the environment.

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dichotomy noun

di·chot·o·my | \ dī-ˈkä-tə-mē *also* də- \
plural **dichotomies**

a division or contrast between two things that are or are represented as being opposed or entirely different.

Dichotomy is frequently found in the company of the word *false*; a *false dichotomy* is a kind of fallacy in which one is given only two choices when in fact other options are available.

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The Issue: Phosphorus - a finite resource

"phosphate rock . . . may be depleted in 50–100 years" - Cordell et al., 2009

"The estimated world phosphorus reserves increased from 15 billion tons of phosphate rock in 2008 to 71 billion tons in 2011." - Van Kauwenbergh, 2010; Jasinski, 2009, 2012

"estimate . . . of the magnitude of 1000 years for static lifetime 'at most manageable costs.' " - Scholz and Wellmer, 2013

"World resources of phosphate rock are more than 300 billion tons. There are no imminent shortages of phosphate rock." - Jasinski, 2020

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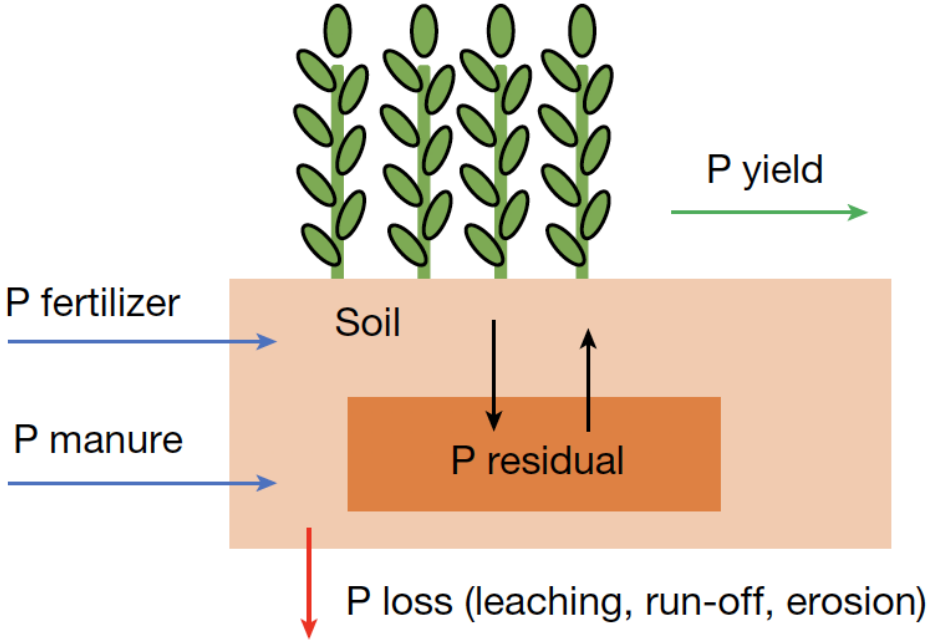
The Issue: Inappropriate use of phosphorus creates environmental challenges



$$\text{P inputs} = \text{P fertilizer} + \text{P manure}$$

$$\text{PUE} = \frac{\text{P yield}}{\text{P inputs}}$$

$$\text{P surplus} = \text{P inputs} - \text{P yield}$$

$$\text{P residual} = \text{P surplus} - \text{P loss}$$

Zou et al., 2022
https://doi.org/10.1038/s41586-022-05220-z

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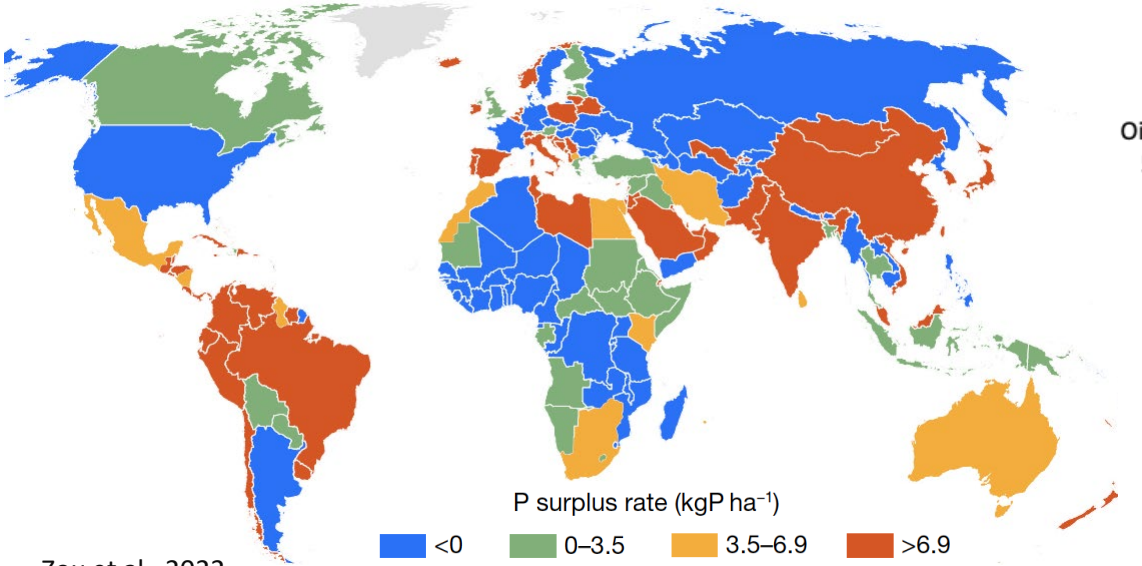
Global **P surplus** and Anthropogenic **P Loads** to Freshwater



Zou et al., 2022
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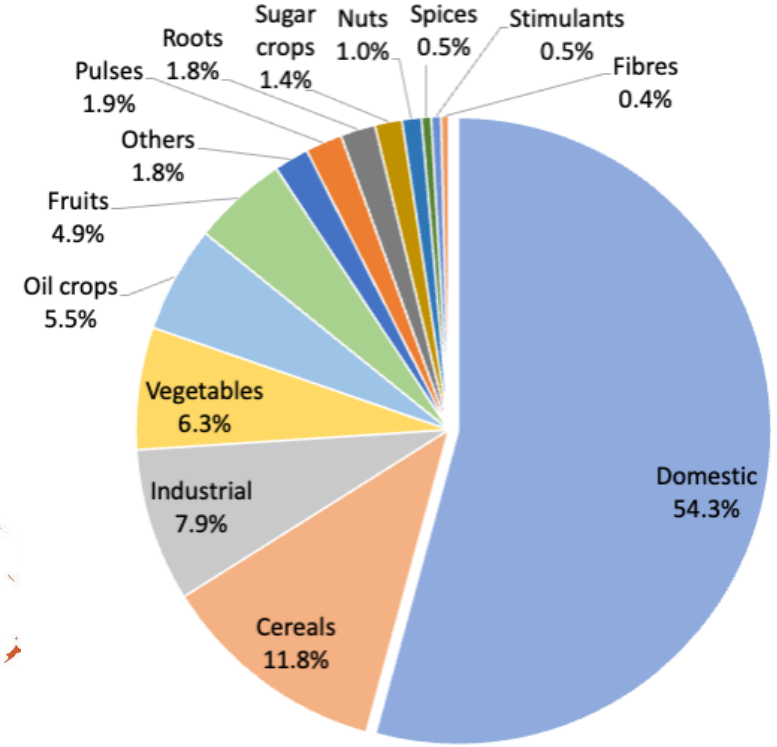

Mekonnen and Hoekstra, 2018
https://doi.org/10.1002/2017WR020448

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The Issue: Phosphorus limitation in global croplands

- 30% of the global cropland area experiences a P deficit (MacDonald et al., 2011)
- Global yield gap due to soil P is estimated at 22, 55 and 26% in winter wheat, maize and rice (Kvakić et al., 2018)
- To achieve target 2.3, five world regions where smallholder farms dominate would require 39% more P application (126 Tg) between 2015 and 2030 (Langhans et al., 2021)
- Agricultural soils worldwide will be depleted by between 4–19 kg ha^{-1} yr^{-1}, with average losses of P due to erosion by water contributing over 50% of total P losses (Alewell et al., 2020)

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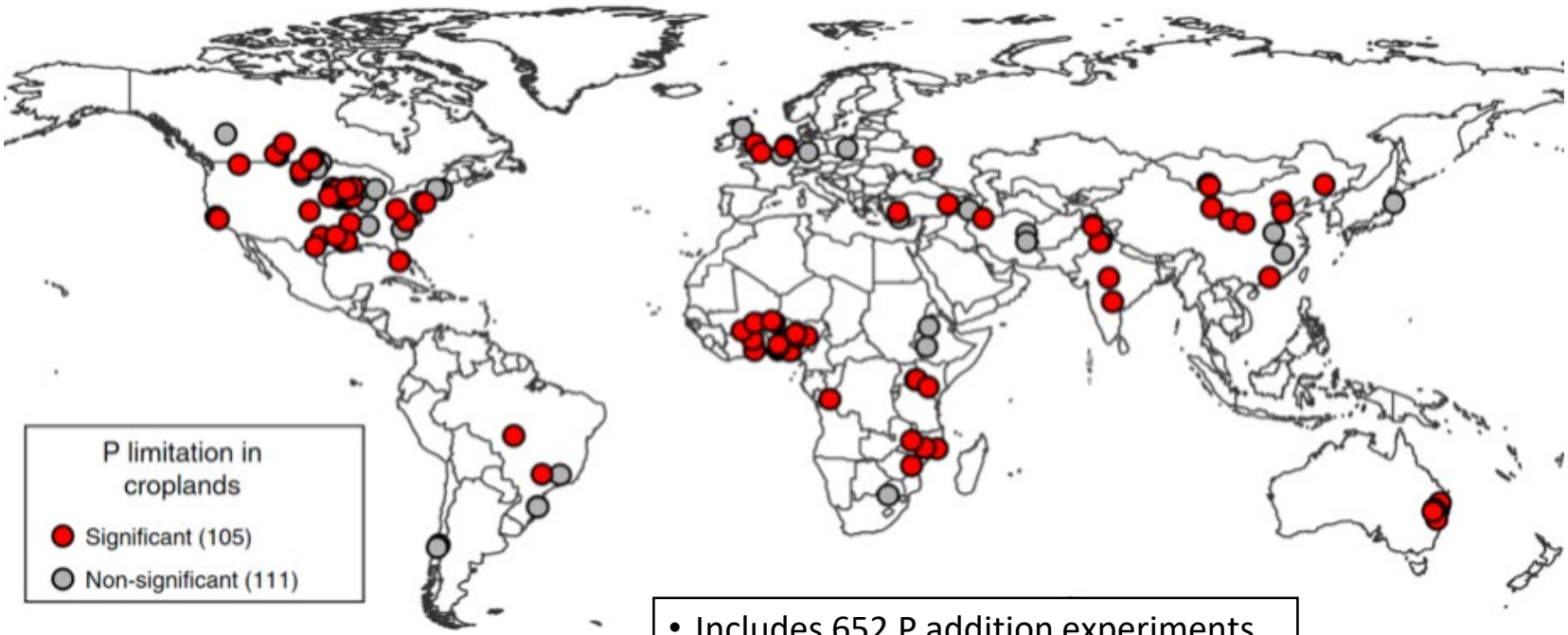
Recent meta-analysis revealed significant P limitation of aboveground plant production in croplands



- Includes 652 P addition experiments conducted between 1955-2017

Hou et al., 2020

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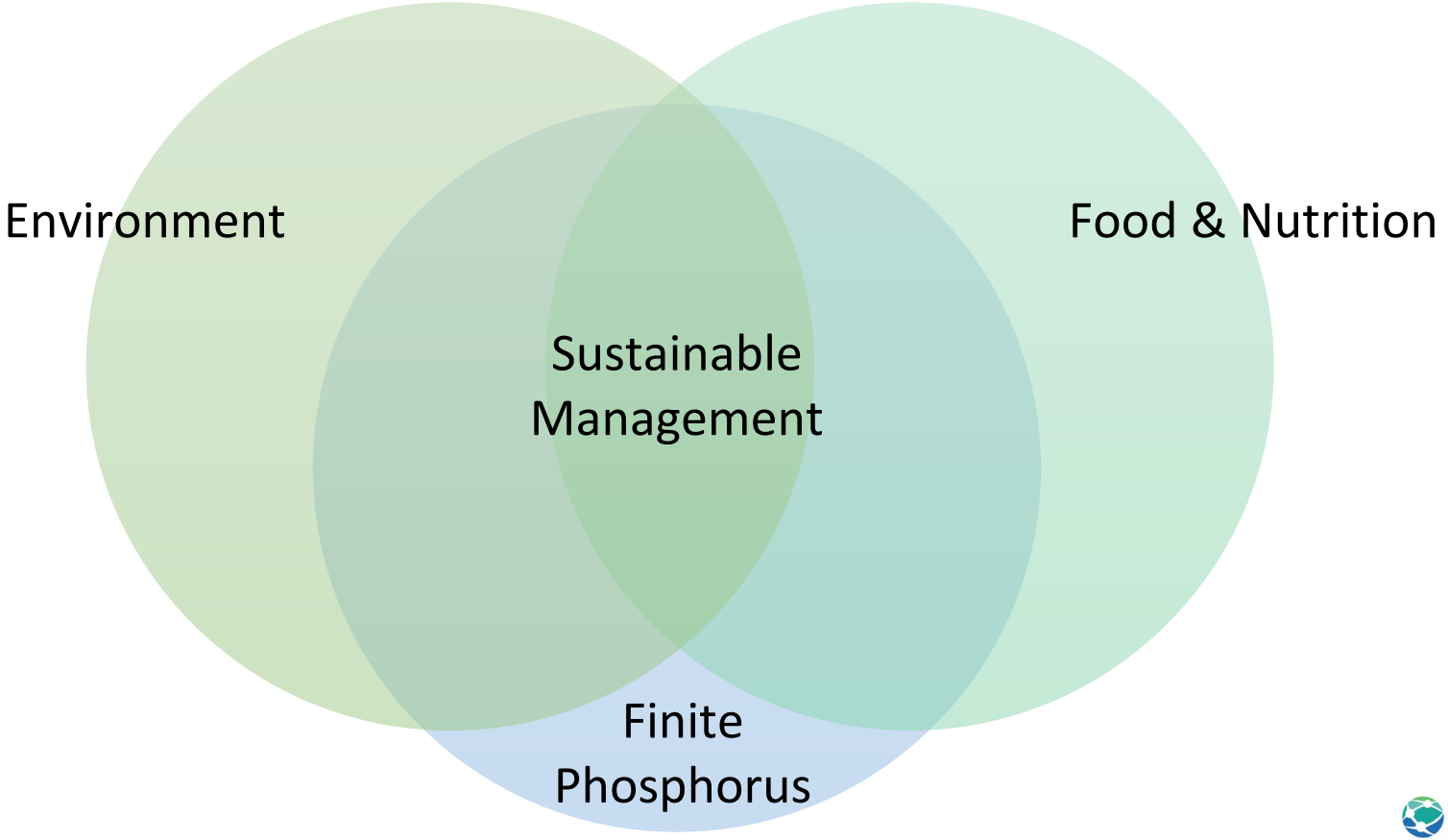
Where is the convergence?



SCIENTIFIC PANEL
ON RESPONSIBLE PLANT NUTRITION

A NEW PARADIGM FOR PLANT NUTRITION

Issue Brief, November 2020

Contents lists available at ScienceDirect

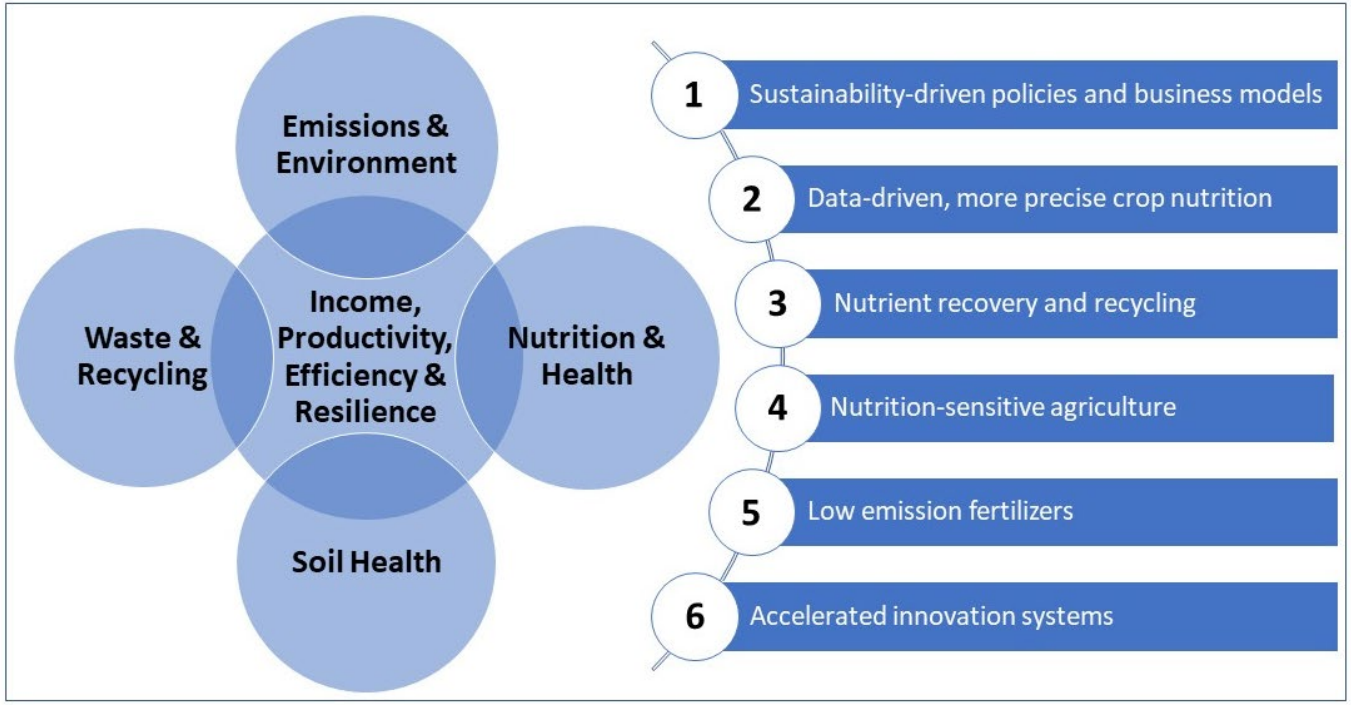
Global Food Security

journal homepage: www.elsevier.com/locate/gfs

ELSEVIER

Responsible plant nutrition: A new paradigm to support food system transformation

Achim Dobermann [a,*], Tom Bruulsema [b], Ismail Cakmak [c], Bruno Gerard [d], Kaushik Majumdar [e], Michael McLaughlin [f], Pytrik Reidsma [g], Bernard Vanlauwe [h], Lini Wollenberg [i], Fusuo Zhang [j], Xin Zhang [k]



SCIENTIFIC PANEL
ON RESPONSIBLE PLANT NUTRITION

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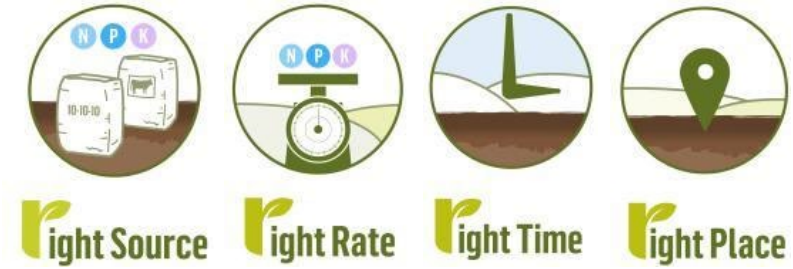
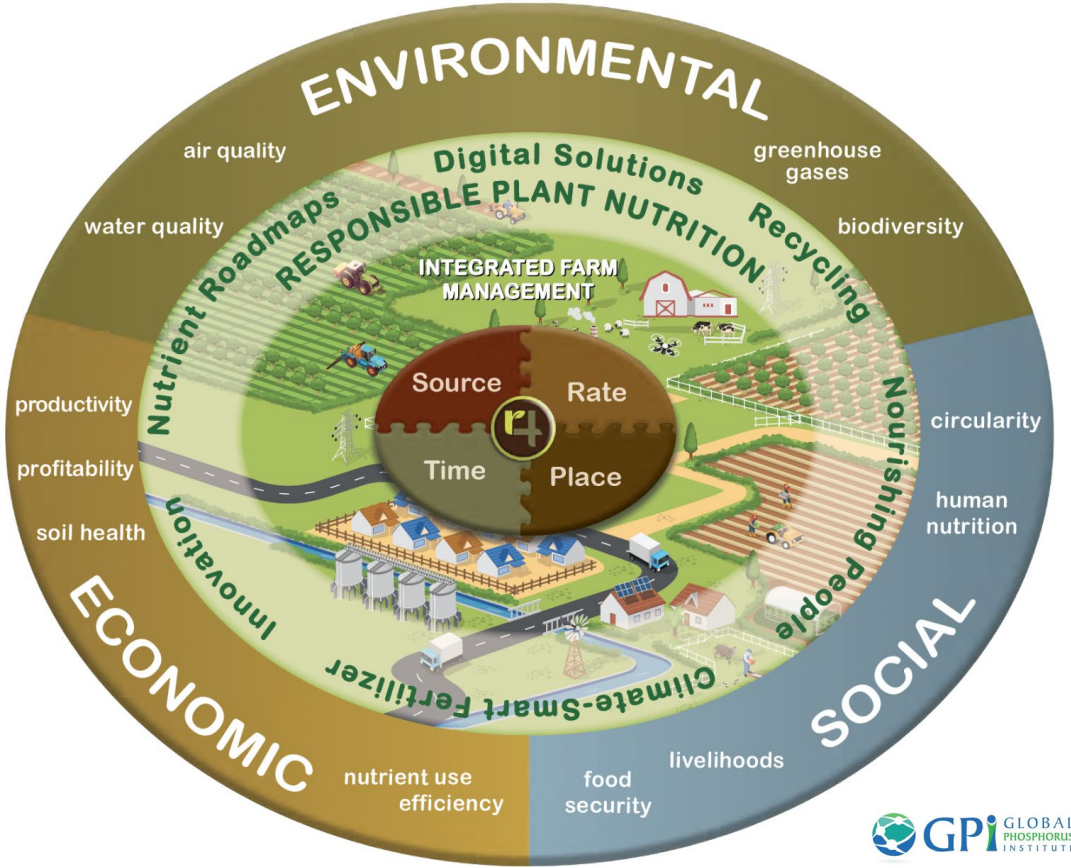
4R Nutrient Stewardship to support the six actions of responsible plant nutrition





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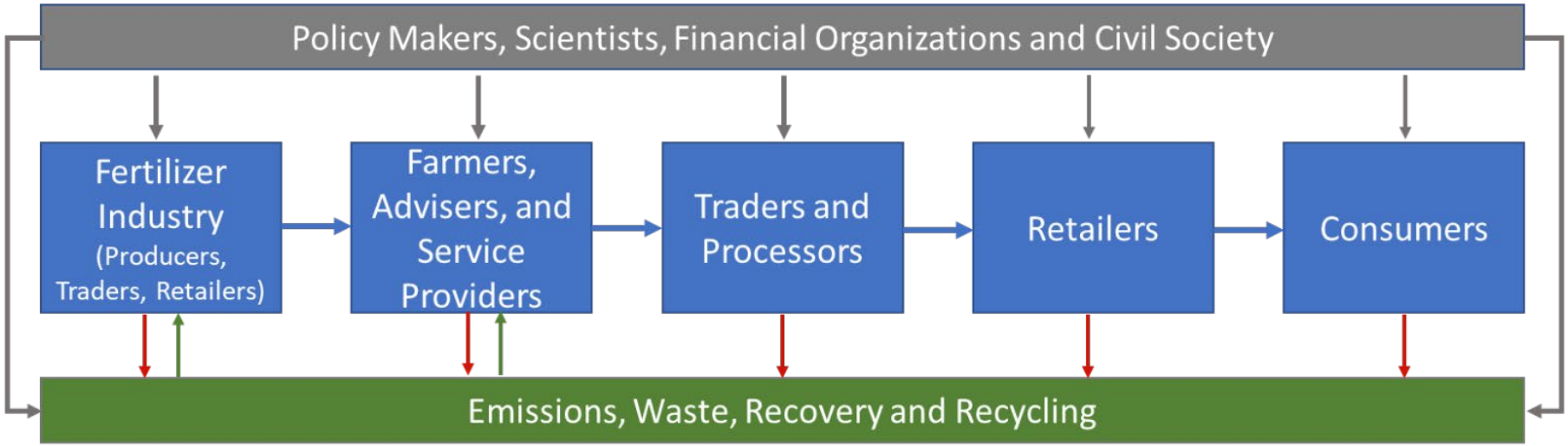
All stakeholders contribute to a new societal optimum for plant nutrition



SCIENTIFIC PANEL
ON RESPONSIBLE PLANT NUTRITION

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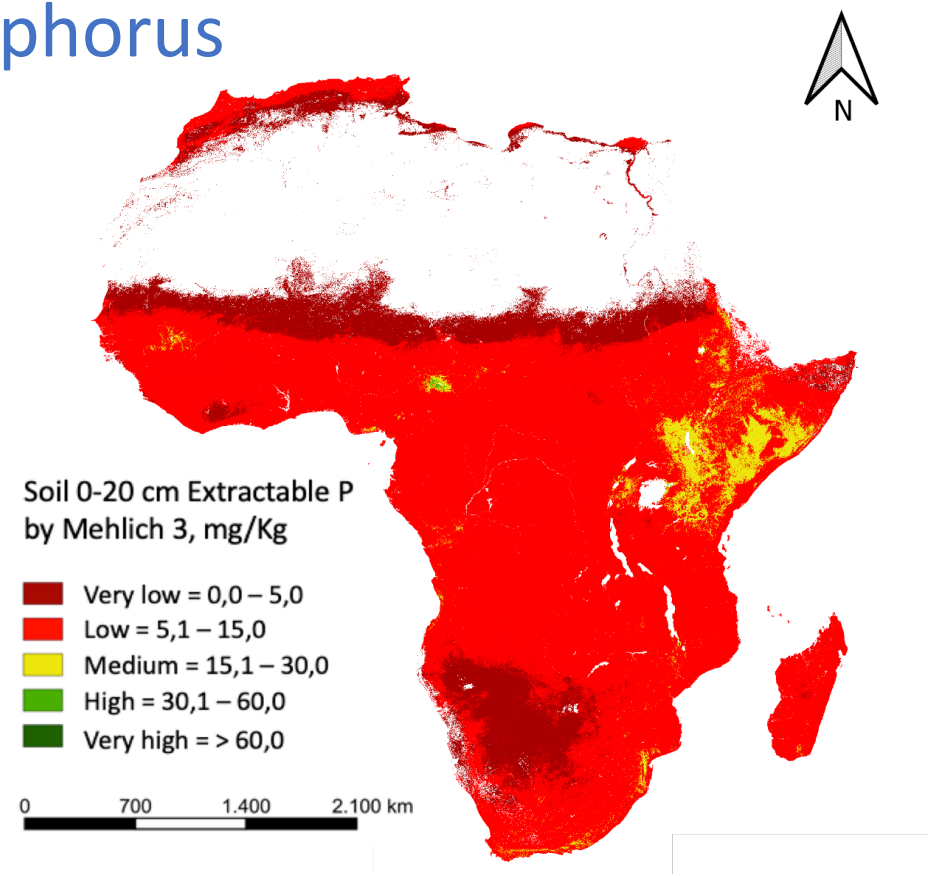
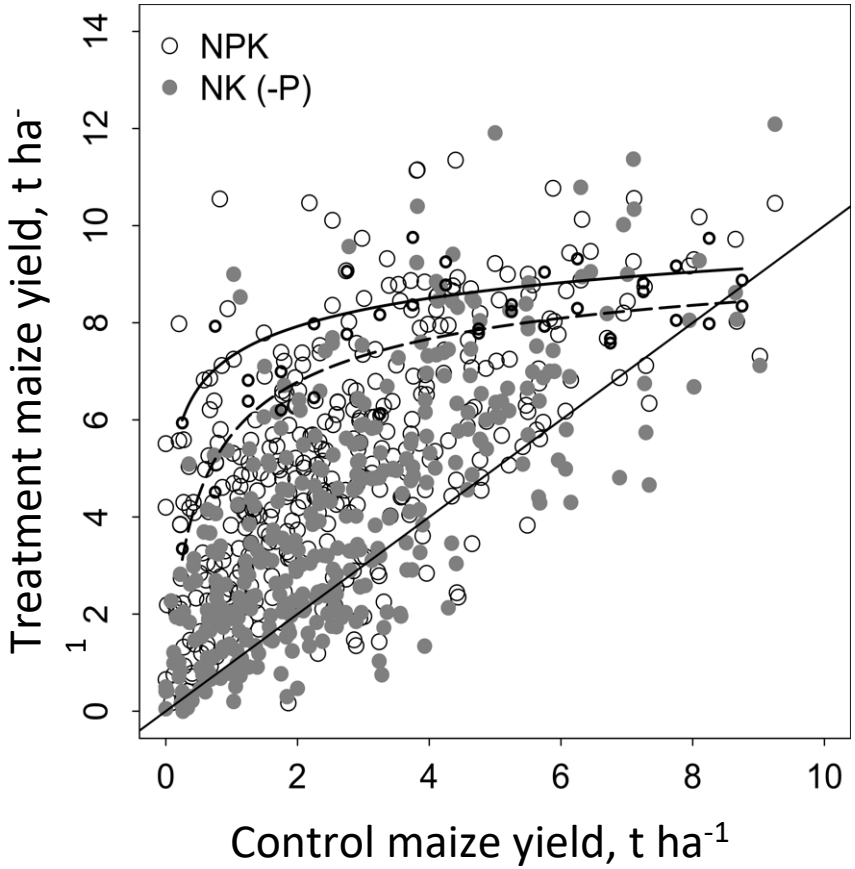
African soils are low in phosphorus



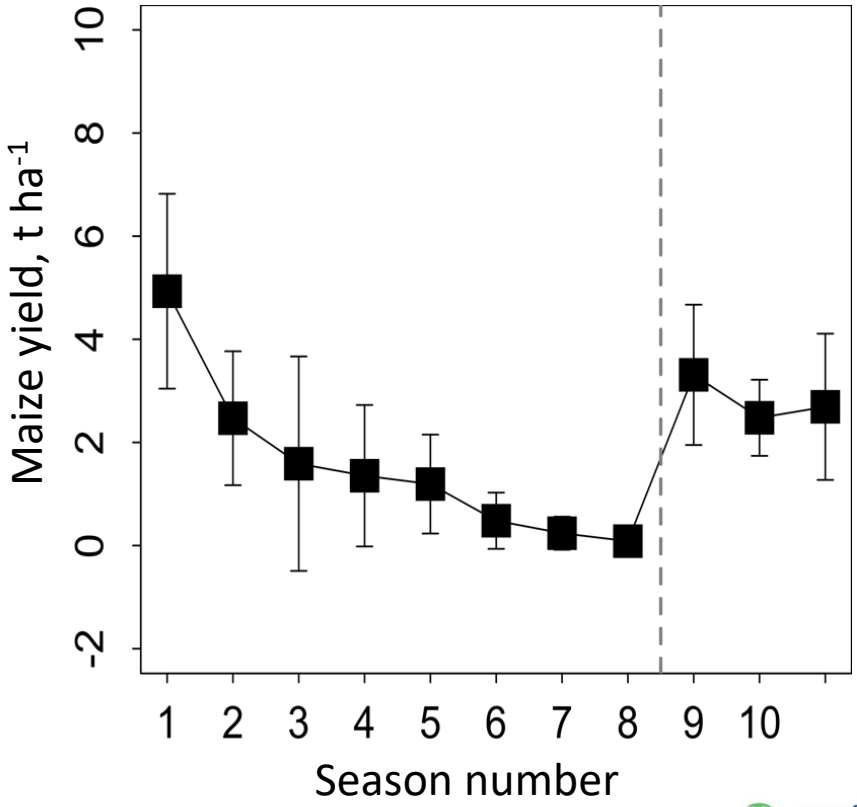
Global Phosphorus Institute, Unpublished, 2022

Modified from Hengel et al., 2021 and iSDA

P deficiency and response to P in African soils



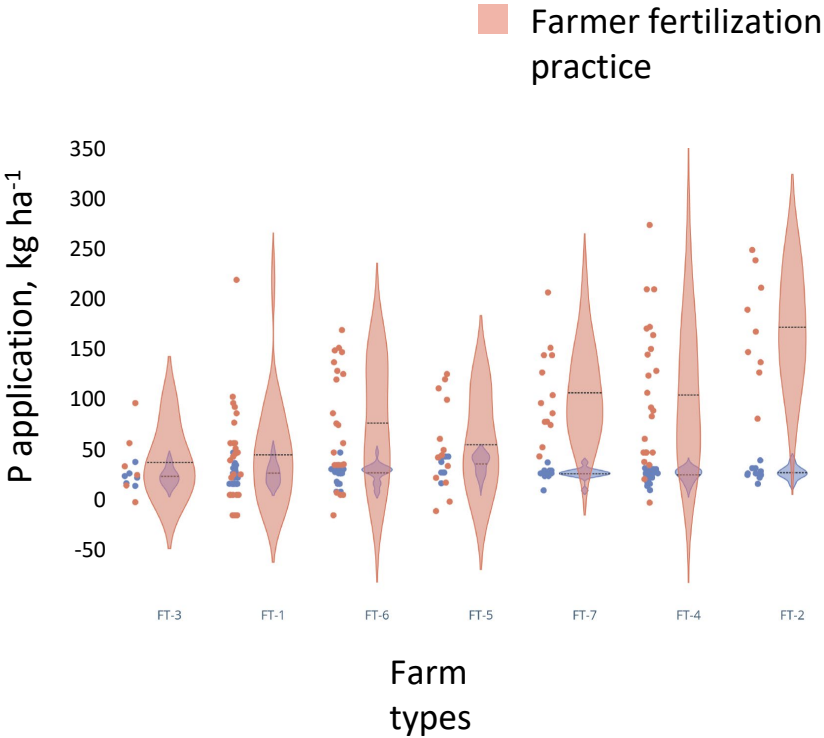
Zingore et al., 2022

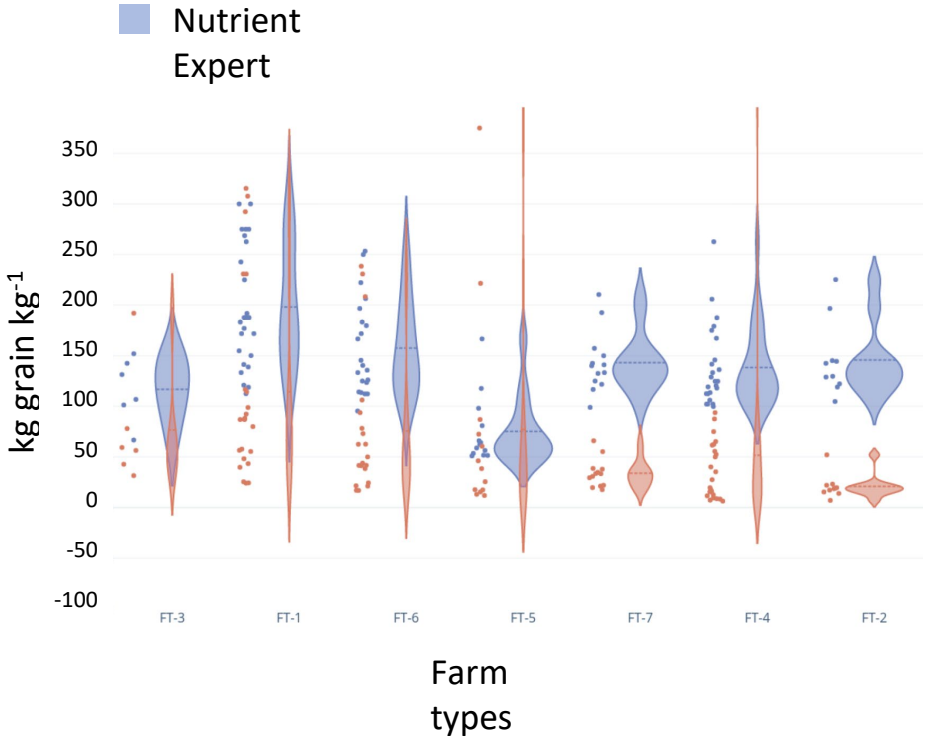


Njoroge et al., 2019

4R management of P and other limiting nutrients:

Converging biophysical & socioeconomic determinants for maize in Asia





Goswami et al., 2022: Submitted for publication

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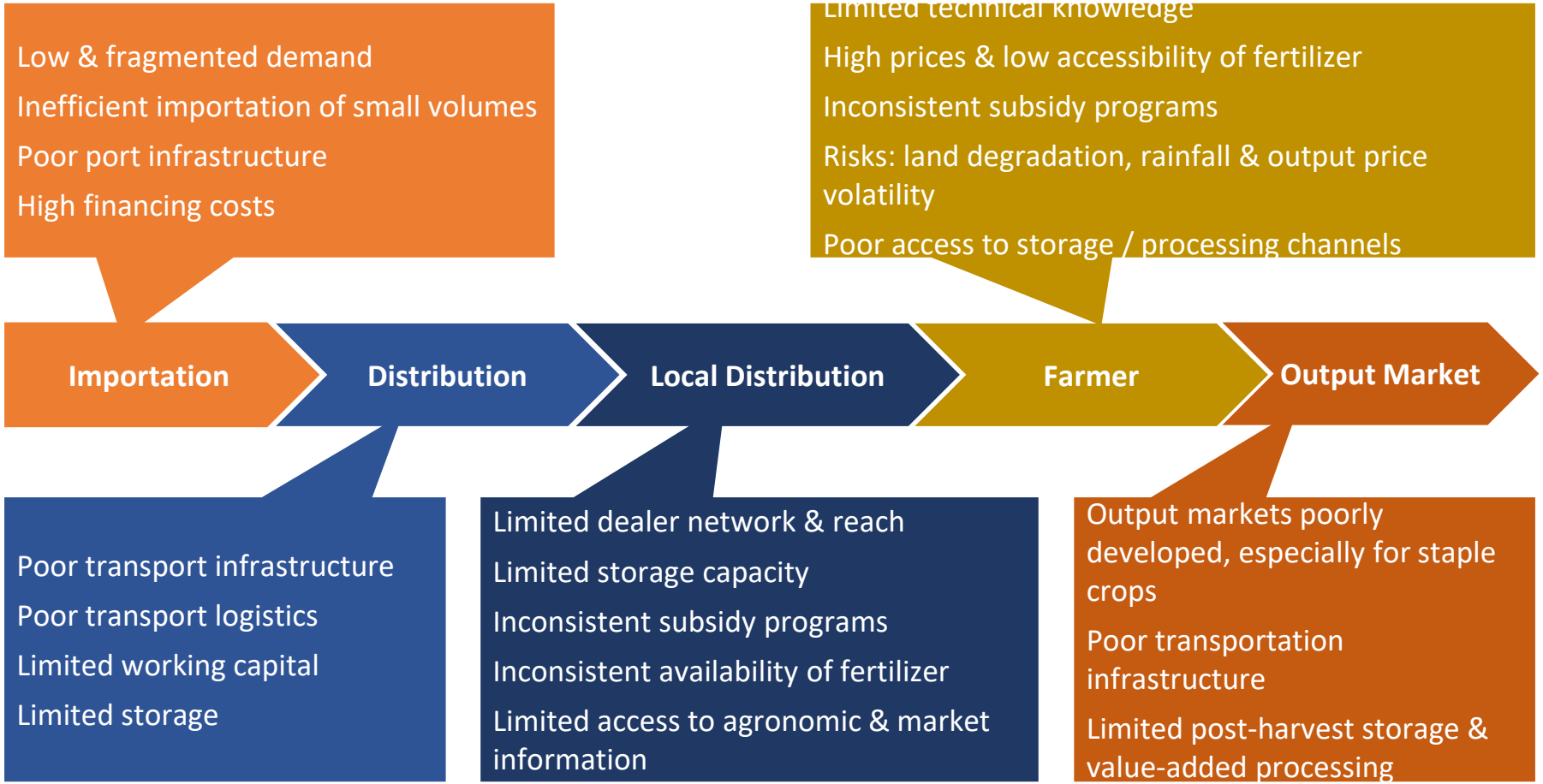
Science to practice: Fertilizer value-chain constraints



Science to practice: Uncertainties faced by farmers

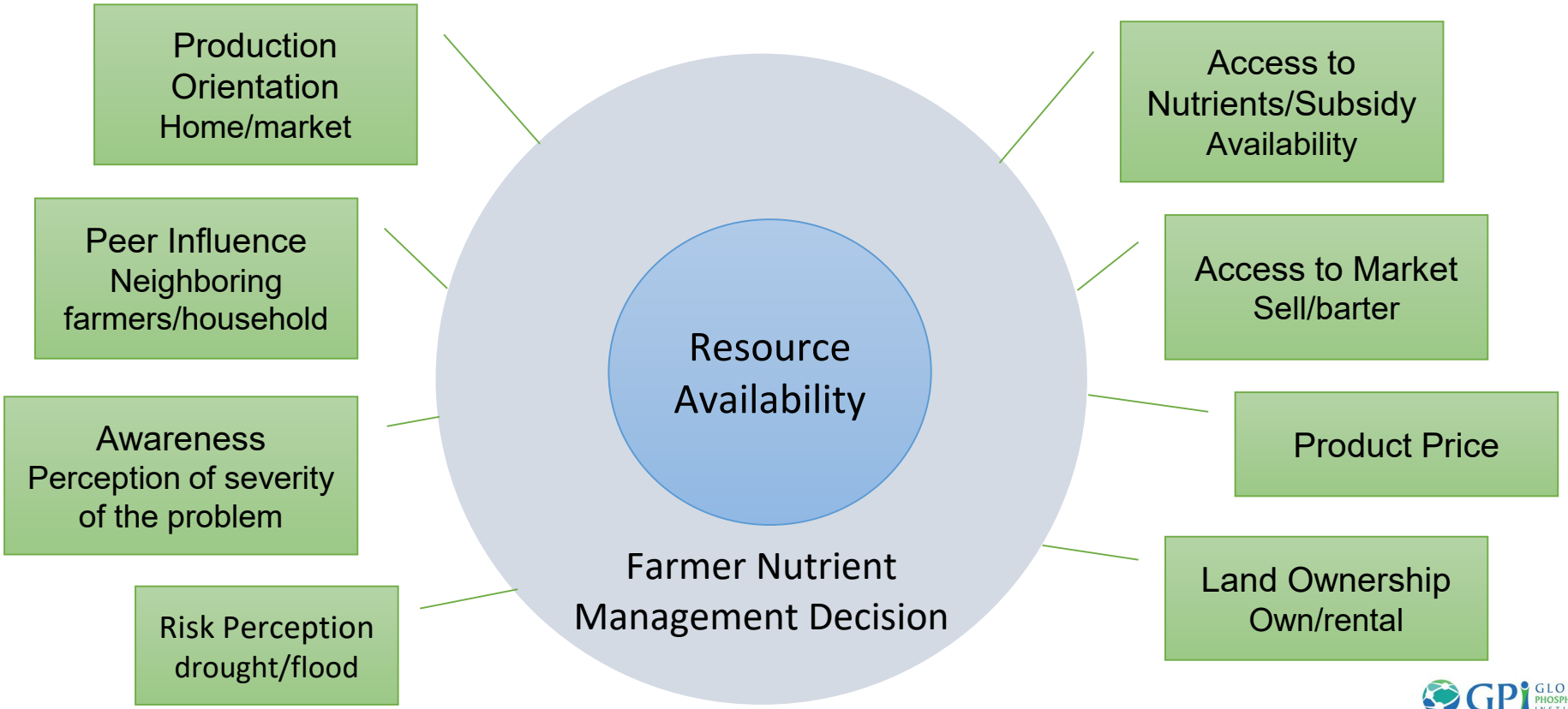
METRIC
Uncertainty about the precision of input to achieve an outcome

TRANSLATIONAL
Uncertainty related to issues external to the decision

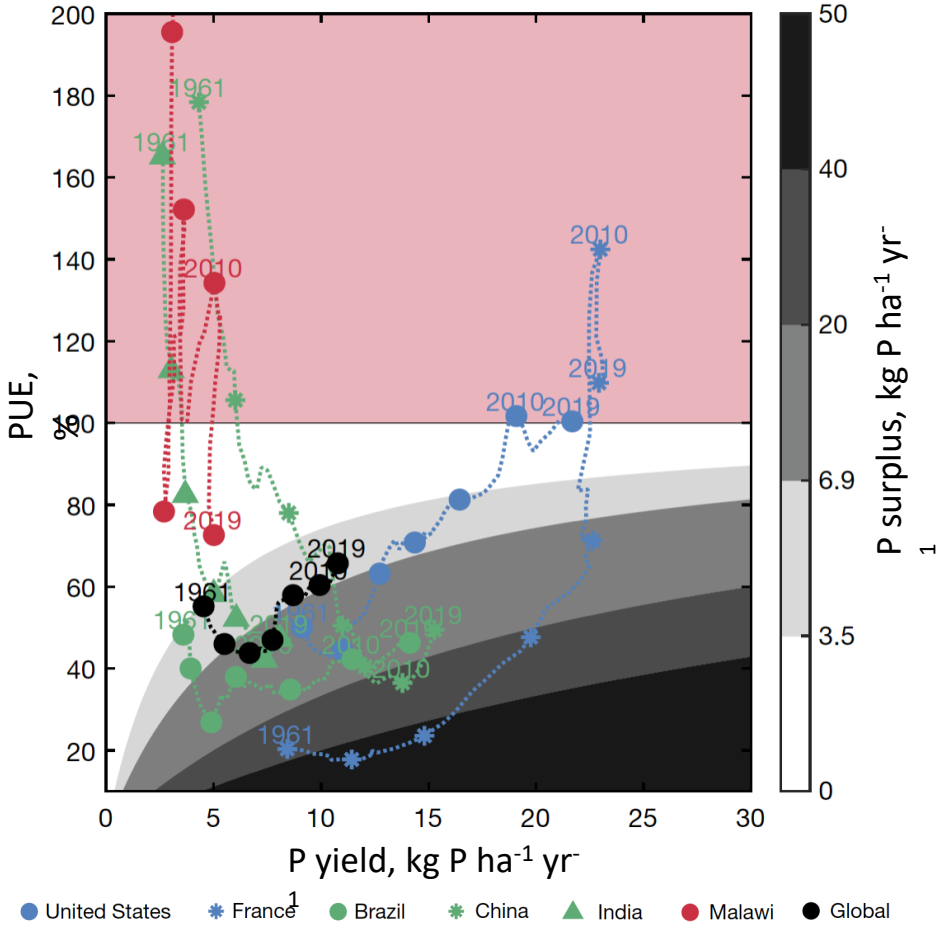
TEMPORAL
Uncertainty related to past / future events

STRUCTURAL
Uncertainty about impact of other internal factors relevant to the decision

Science to practice: Farmers' nutrient management is more resource driven than science driven



Moving towards improved sustainability



- Global PUE after deceasing to a low of 44% in the 1980s, began to increase to around 66% in 2019
- PUE in China and India had declined to around 40% in 2010, and then improved to ~50% by 2019
- By 2019, PUE had steadily increased to 102% and 142% in the US and France, respectively.
- Malawi, has had minimal success in increasing its P yield in the past 50 years, and has relied mainly on mining native soil P.

Zou et al., 2022; https://doi.org/10.1038/s41586-022-05220-z

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Global Phosphorus Institute

Holistic Vision for Responsible Use of Phosphorus

Thank you

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Holistic Vision for Responsible Use of Phosphorus

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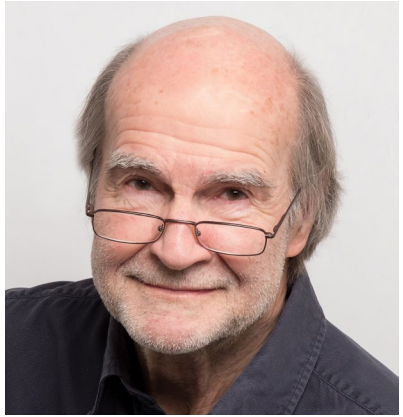

European Sustainable Phosphorus Platform

European Update

Ludwig Hermann, European Sustainable Phosphorus Platform

www.phosphorusplatform.eu

European Sustainable Phosphorus Platform (ESPP)

European Sustainable Phosphorus Platform

European Sustainable Phosphorus Platform

Legal entity,

- *transparency*
- *clear decision making*
- *representation*

- established 2014
- Belgian not-for-profit association
- statutes are public
- EU Transparency Register no. 260483415852-40

100% membership funded

- *credibility, independence*

50+ paying members :

Industries, SMEs,
R&D institutes & projects,
cities & regions

- *Balances the interests of society & industry from the perspective of nutrient conservation*

European Sustainable Phosphorus Platform

What they said …

ILVO	Reduction in fertiliser P use is certainly possible, but it will require decades to reduce soil P and, therefore, P losses. *Fien Amery, ILVO Flanders*
WAGENINGEN UNIVERSITY & RESEARCH	The 50% nitrogen loss reduction target by the green deal is on average required in the EU to protect air and water quality but it varies strongly with location. *Wim de Vries, Wageningen University & Research*
EurEau	The waste water sector is already removing nutrients and supporting reuse of nutrients. We want to extend this in order to contribute to sustainable nutrient management and the Circular Economy. *Sarah Gillman, EurEau*
	DG R&I is working on new, systemic approaches to combat nutrient pollution from all sources and bring nitrogen and phosphorus flows back within Planetary Boundaries. *Katja Klasing, European Commission DG Research & Innovation*
UK Centre for Ecology & Hydrology	It is great to see the Colombo Declaration goal embraced by the EU Farm to Fork Strategy. 'Halving Nitrogen Waste' from all sources will help meet multiple SDGs, saving billions of Euro in fresh nitrogen inputs. *Mark Sutton, UKCEH & INMS*
	In line with the zero pollution ambition of the EU Green Deal, the Commission will propose an integrated nutrient management action plan to address nutrient pollution at source and a better management of N and P throughout their lifecycle. *Andrea Vettori, European Commission DG Environment*
LEIBNIZ SCIENCE CAMPUS PHOSPHORUS RESEARCH ROSTOCK	European policies, such as the CAP, need to be clearly aligned with the targets of the Farm-to-Fork strategy. Major pollutants, particularly intensive livestock farming, have to be addressed. *Jessica Strahwurgh, University of Rostock*
	Nature and the health of ecosystems on which all life depends are under threat. One major reason is agricultural pollution. We must take transformative action to address this crisis. *James Byrne, Wildlife Trusts Wales*
Environment Agency	The workshop provided an excellent overview of the latest policy and science, and showed how the nutrient 'community' must work together to achieve extremely ambitious goals. *Rachel Dils, Environment Agency (England)*
fertilizers europe	We accept the F2F ambition to reduce nutrient losses by 50%. Supporting farmers with innovative solutions is a precondition. Nevertheless, 2030 seems unrealistic for this huge challenge and requires a full impact assessment. *Tiffanie Stephani, Fertilizers Europe*
MTK	Finnish agriculture has already decreased P use by -70% and N use -30%. MTK considers that Farm-to-Fork targets should not fix the same nutrient reduction percentages for all Member States. *Liisa Pietola, Finland farmers and forests organisation*
	Nitrogen and phosphorus boundaries are all too often forgotten as a major environmental

ESPP in action

- ***Decision by consensus***
- ***Mediation rather than advocacy***
  - **enable dialogue between stakeholde**
  - **develop shared policy proposals**
  - **communicate with regulators**
- ***Communication tools:***
  - ***web site www.phosphorusplatform.eu***
  - ***LinkedIn Twitter***
  - ***eNews, Scope Newsletter,***
    82 000 + emailing list

(11 – 14% identified opening rate)

European Sustainable Phosphorus Platform

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EU consultation on "Taxonomy"

P-recovery in EU list of top-100 green activities … but clarifications needed

The EU Taxonomy will classify which economic activities, and when,are considered environmentally sustainable, so eligible for EU Green Deal investment. It may become a key tool for private investors, markets, other public policies. Phosphorus recovery from sewage is one of the 100 activities listed (at the same level as e.g. livestock production, crop production, hotels and accommodation …) but N-recovery or P-recovery from other streams is not cited.

Consultation open to 24th September 2021, 18h00 deadline (not midnight).

The unified EU-wide classification system ("EU Taxonomy") will establish an operational list of economic activities, with technical screening criteria (TSC), determining in which cases each economic activity makes a 'substantial contribution' to an environmental objective. The Taxonomy Regulation (2020/852) defines six eligible environmental objectives: Climate change mitigation, Climate change adaptation, Water and marine resources, Circular economy, Pollution prevention and control, Biodiversity and ecosystems.

The EU has now published a report (over 1 000 pages including the annex) proposing criteria for classifying when a wide range of different industries and activities can thus be considered environmentally friendly, covering (amongst many others) agriculture (both livestock and crop production), sewage treatment, waste management … The report and its annex propose TSC (Technical Screening Criteria for "substantial contribution" to sustainability) and criteria for DNSH (Do No Significant Harm,

SCOPE NEWSLETTER

Sustainable Phosphorus Alliance

European Sustainable Phosphorus Platform

SCOPE Newsletter special issue:
Climate Change, Nutrients and Catchment Management

This is the second SCOPE Newsletter special issue addressing the **links between phosphorus, nutrients and climate change**, in cooperation between the *Sustainable Phosphorus Alliance*, North America, and the *European Sustainable Phosphorus Platform*.

The first issue covered aquatic **methane emissions** (*SCOPE Newsletter n°135*, July 2020).

As is usual for the SCOPE Newsletter, this issue is based on targeted 'layman's' summaries of relevant information from selected recent scientific papers, from which we have tried to draw overall conclusions.

Currently in preparation are further special issues on:

- **interactions between climate change, nutrients and soil carbon**
- **climate change impacts of nutrient recycling and stewardship technologies**

*ESPP wishes to thank for their support and input: **Amin Soltangheisi** (Lancaster University), **Matt Scholz** (Sustainable Phosphorus Alliance) and **Sara Johansson**, all the authors of papers summarised who sent their corrections and comments, and ESPP's members whose support makes this possible.*

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ESPP in action

European Sustainable Phosphorus Platform

EU regulatory and policy dossiers

- Fertiliser supply and food security
- Green Deal
- EU Green Fiance 'Taxonomy'
- Nitrogen recovery & recycling
- EU Critical Raw Materials
- EU Fertilising Products Regulation
- Soil Health
- CAP
- BAT (Industrial Emissions Directive)
- Recycled nutrients in Organic Farming
- Sewage Sludge Directive
- Urban Wastewater Treatment Directive
- Animal Feed Regulation
- R&D

Public consultation to 25/11/22

Public consultation to 24/10/22

Public consultation to 24/10/22

National policies

- Austria proposed sewage P-recovery obligation
- Baltic Nutrient Recycling Strategy (HELCOM)

Nutrient recovery technology catalogue

http://www.phosphorusplatform.eu/techcatalogue

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Process & contact	Input materials	Output products	Process description	Operating status	Photos
Sewage P-recovery: full scale plants operating or under permitting/construction					
Fertiliser industry – E.g., ICL, Borealis ... ***Members of ESPP / DPP / NNP*** http://icl-group-sustainability.com/reports/producing-fertilizers-with-recycled-phosphate/ Contact (ICL): anthony.zanelli@icl-group.com Contact Borealis: wolfgang.hofmair@borealisgroup.com	Input: sewage sludge incineration ash, from sewage works using biological and/or chemical P-removal; animal by-product ash (Cat 2, 3); recovered phosphate salts.	Standards mineral fertilisers. Fertiliser production plant must have operating permit authorising to process waste.	Recovered materials are mixed into the phosphate rock or phosphoric acid based fertiliser production process, either during acid attack of rock, or after this stage where product still has residual acidity (acidulation), so ensuring plant availability of P in ashes. Contaminants in ash are diluted in final product. This is legal under EU regulation on condition that the ash is not classified as "Hazardous". Final fertiliser product is covered by EU Fertilising Products Regulation 'STRUBIAS' annexes as proposed. Recovery rate (P in final product / P in input ash): c. 100% Iron and aluminium in input ash are transferred into final product Heavy metals are not removed.	ICL tested full scale and industrial installations now operation at ICL Netherlands (inaugurated March 2019, photo) and Germany (several hundred tonnes ash and struvite processed to date). Production from 100% ashes (without mixing with phosphate rock) is planned. Borealis Use of ash in fertiliser production has also been tested at Fertiberia Spain (MBM ash at lab scale)	
Ash2Phos (EasyMining) ***Member ESPP, DPP*** http://easymining.se/ Contact: Jan.svard@ragnsells.com	Input: sewage sludge incineration ash, from sewage works using biological and/or chemical P-removal.	Calcium phosphate; can be converted into – superphosphate (SSP), - di-calcium phosphate (DCP), - mono-ammonium phosphate (MAP). Product can be used as feed phosphates (subject to legal provisions): shown to be effective as a feed phosphate, soluble in citric acid and digestible for pigs and poultry. Product can also be used as raw material for NPK fertilizers. Ferric chloride as a coagulant for wastewater treatment	Sewage sludge ash is dissolved in hydrochloric acid (40°C, no pressure). The residue of ash which is not dissolved in acid consists mainly of inorganic silicates, and after separation and washing can be used in the cement or concrete industries (Ottosen et al., 2021). Phosphorus, iron and aluminium compounds are separated from the acid leachate and from each other by specific dissolution and precipitation reactions, in processes characterised by internal recirculation of chemicals. The remaining acid solution is neutralized and treated to remove heavy metals. Most heavy metals end up in a concentrated heavy metal cake (c. 30 kg DM cake per tonne ash input) that can be landfilled or used for further extraction of metals. **Recovery rate (P in final product / P in input ash): >85%**	Pilots in Sweden: Uppsala, 50 kg ash/day ash and Helsingborg, 600 kg/day ash. Full scale plants: - 30 000 t/y ash, Helsingborg, Sweden (permit application submitted), with Kemira - 30 000 t/y ash planned, Schkopau, (permit application ongoing)	 

Nutrient platforms - partners of ESPP

- **Netherlands** 2010 http://www.nutrientplatform.org/
- **Germany** 2015 www.deutsche-phosphor-plattform.de
- **North America** Sustainable Phosphorus Alliance (SPA) 20 (launched as NAPPS in 2015) https://phosphorusalliance.org/
- **Japan** PIDO 2011 (Phosphorus Industry Development Organization of Japan) www.pido.or.jp
- **Global Partnership for Nutrient Management** (UNEP) http://www.unep.org/gpa/what-we-do/global-partnership-nutrient-management
- **Nutrient platform projects: Ireland, Italy, Sweden, …**

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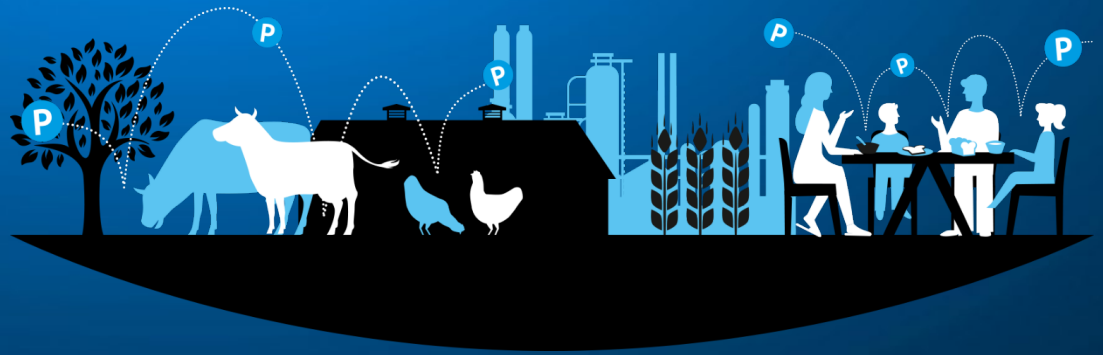
EU (Nutrient) Policy Framework

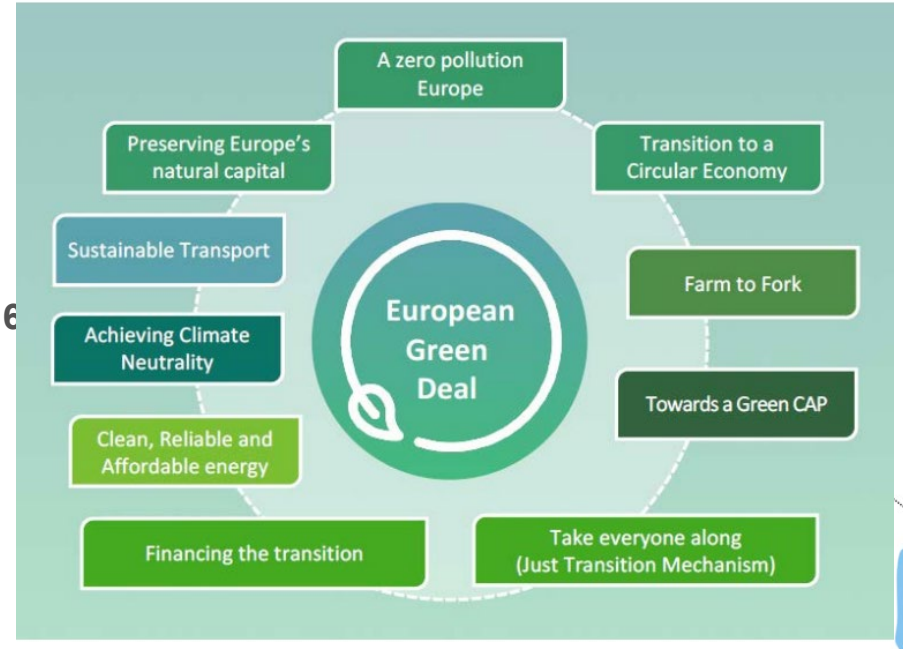


European Green Deal [1]

European Sustainable Phosphorus Platform

- **Farm-to-Fork Strategy [2]**
- **Biodiversity Strategy [3]**
- **Chemicals Strategy [4]**
- **Zero Pollution Action Plan [5]**
- **Circular Economy Action Plan [6]**

Green Deal states possible
"legal requirements to boost the market for secondary raw materials, with mandatory recycled content"



1 = COM(2019)640 https://ec.europa.eu/info/files/communication-european-green-deal_en
2 = COM(2020)381, 20th May 2020 https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1590404602495&uri=CELEX%3A52020DC0381
3 = COM(2020) 380 final, 20th May 2020 https://ec.europa.eu/environment/nature/biodiversity/strategy/index_en.htm
4 = COM(2020)667, 14/10/2020 https://ec.europa.eu/environment/pdf/chemicals/2020/10/Strategy.pdf
5 = https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12588-EU-Action-Plan-Towards-a-Zero-Pollution-Ambition-for-air-water-and-soil/public-consultation
6 =11/3/2020 https://ec.europa.eu/environment/circular-economy/

Farm-to-Fork Strategy Com(2020) 381 final, 20.05.2020

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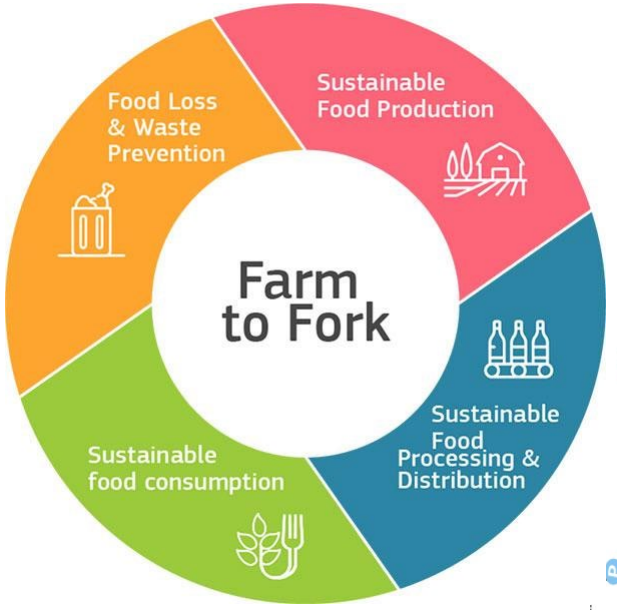
Direct Impact on Nutrients – Fertiliser Use

- Mitigate soil, air and water pollution by increasing nutrient use efficiency (NUE)
  - By reducing nutrient losses by 50% by 2030, leading to using 20% less by 2030
  - By developing an integrated nutrient management plan (COM & Member States)
  - By having 25% of EU agricultural land under organic farming by 2030
- Bio-based fertilisers for organic farming under evaluation
- New green business models (e.g. carbon farming)
- Circular, bio-based economy focusing on nutrient recovery & recycling

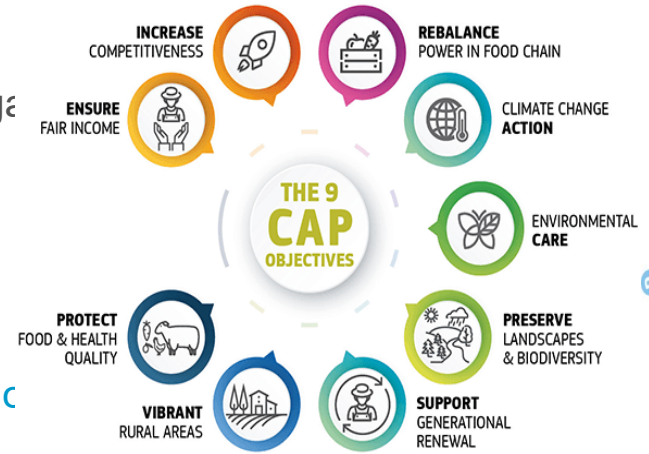


Farm-to-Fork Strategy Com(2020) 381 final, 20.05.2020

European Sustainable Phosphorus Platform

Indirect Impact on Nutrients – Fertiliser Use

- Reduce agricultural GHG emissions: Agriculture emits >10% of GHG of which 70% from livestock
  - Reducing critical feed materials
  - Alternative feed materials: insects, marine feedstock, alga
- New Common Agricultural Policy (CAP)
  - Assigning 25% of 1st Pillar support payments to eco-schemes
  - Farm Sustainability Tool for Nutrients" (FaST)
  - Eco-schemes = sustainable Ag practices such as precisic agriculture, agro-ecology, agro-forestry, enhancing bio-diversity
- Nutrients targets included in the Biodiversity Strategy
- Sustainable aquaculture including nutrient recycling



Other nutrient related EU policies

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Water policy

Water Framework Directive fit for purpose (REFIT) *12/12/2019*

- *https://ec.europa.eu/info/news/evaluation-eu-water-legislation-concludes-it-broadly-fit-purpose-implementation-needs-speed-2019-dec-12_en*

Urban Wastewater Treatment Directive 91/271/EEC evaluation planned

- *https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12405-Revision-of-the-Urban-Wastewater-Treatment-Directive*

Sewage Sludge Directive 86/278/EC public consultation

- Exploratory study on prospective elements = risk posing pollutants

New Circular Economy Action Plan

- 11/3/2020 https://ec.europa.eu/environment/circular-economy/

→ "Food, water and nutrients"

→ Integrated Nutrient Management Action Plan

Chemicals Strategy - for sustainability towards a toxic-free environment

- https://ec.europa.eu/environment/strategy/chemicals-strategy_en

Zero Pollution Action Plan – towards a zero pollution for air, water and soil

- https://ec.europa.eu/environment/strategy/zero-pollution-action-plan_en/

Critical Raw Materials: phosphate rock and P_4 confirmed on 4th CRM List 2/9/2020

- https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0474/

Circular Economy Action Plan

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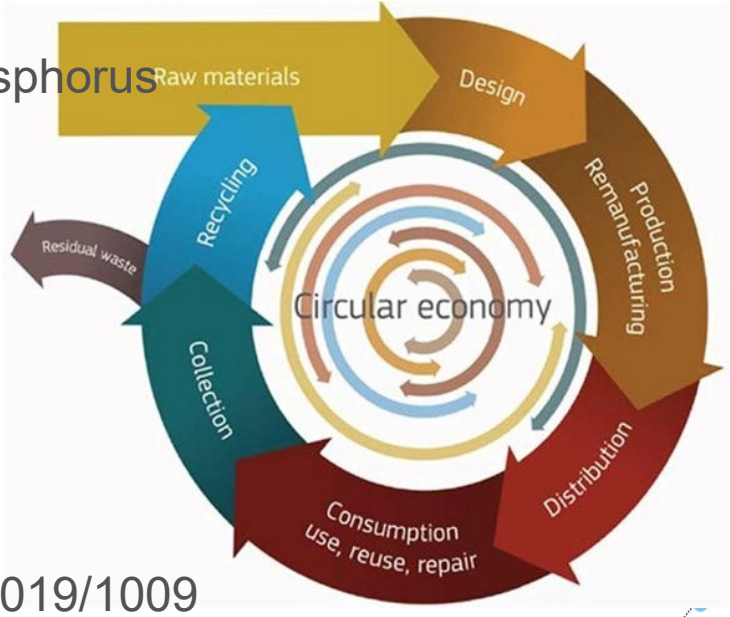
2014 EU Consultative Communication
on Sustainable Use of Phosphorus

Proposals include: Increasing knowledge and research,
P-recycling, risk of soil contamination
by mineral or recycled fertilisers
www.phosphorusplatform.eu/scope107



2015: EU Circular Economy Package
2020: EU Circular Economy Action Plan
11/3/2020 https://ec.europa.eu/environment/circular-economy/

2019: EU Fertilising Products Regulation (EU) 2019/1009
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2019:170:TOC

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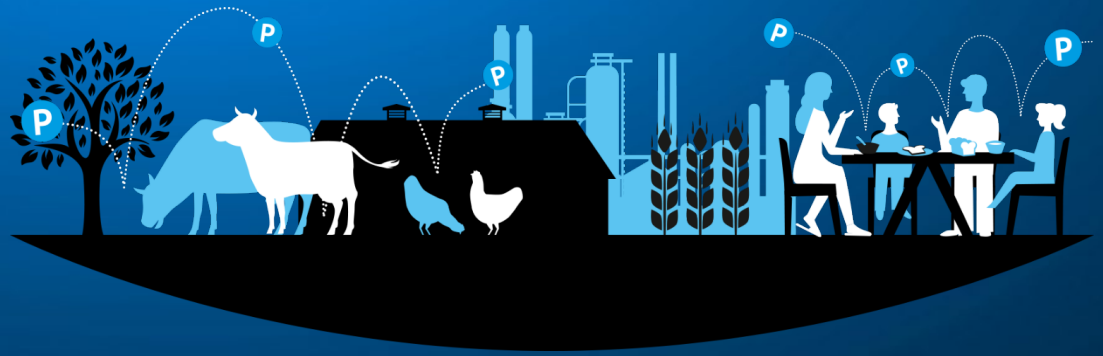
EU Fertilising Products Regulation



EU Fertilising Products Regulation 2019/1009

https://eurlex.europa.eu/eli/reg/2019/1009

CE Mark

Flagship of Commission 'Circular Economy Package':
Opens European market for recycled fertilisers
… and for recycling technologies

Ambitious:

- ***Old EU Fertilisers Regulation (2003/2003) = mineral fertilisers only***
- ***New Regulation (2019/1009) = mineral & organic fertilisers, plant materials, composts & digestates, soil amendments, growing media, biostimulants, liming materials, etc.***

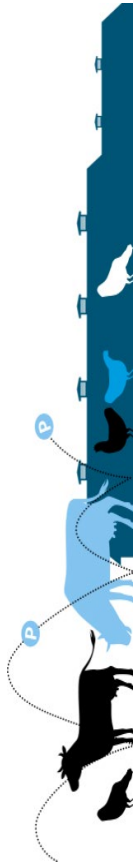
Precedent: first EU Product Legislation to confer EU " End-of-Waste" status

Already a number of amendments: see consolidated version HERE.

"Optional harmonisation"

You can place products on the market

- ***as CE-mark fertilising products***
  (EU Fertilising Products Regulation criteria – and Conformity Assessment)
  - ***transport to and sell in any EU country***
- ***as "national" fertiliser***
  - ***cannot be transported to another EU country***
    (unless "mutual recognition")
- ***or both !***
- ***or spread under national "waste" legislation or similar***
  (traceability, producer responsibility, …)



EU Fertilising Products Regulation
How it works …

A CE-mark product must respect all four of:

- Annex I PFCs
  = Product Function Categories
- Annex II CMCs
  = Component Material Categories
- Annex III = Labelling
- Annex IV
  = Conformity Assessment

If you thought 'CMC's were input materials and 'PFC's were finished products … then you've maybe got it partly right … possibly … but it's not that simple.

Article 6

Obligations of manufacturers

When placing CE marked fertilising products on the market, manufacturers shall ensure that they have been designed and manufactured in accordance with the requirements set out in Annex I for the relevant product function category and the requirements set out in Annex II for the relevant component material category or

ANNEX II

Component Material Categories

A CE marked fertilising product shall consist solely of component materials complying with the requirements for one or more of the Component Material Categories ('CMC') listed below.

EU Fertilising Products Regulation

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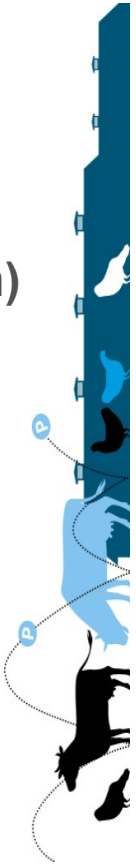
PFCs (Product Function Category)

1. Fertiliser (Organic, Organo-mineral, Inorganic)
2. Liming material
3. Soil improvers: Organic, Inorganic
4. Growing medium
5. Inhibitor
6. Plant biostimulant
7. Blend

CMCs (Component Material Category)

1. Virgin materials
2. Mechanically processed plants
3. Compost
4-5. Digestates
6. Food industry by-products (limited selection)
7. Micro-organisms (biostimulant)
8-9. Nutrient & other polymers
10. Animal by-products - to date: empty box
11. Industrial By-Products (limited selection)
12. Recovered phosphate salts & derivates
13. Ashes & derivates
14. Pyrolysis & gasification materials
15. Recovered Minerals (high purity products) (inc. N-salts from off-gases)



EU Fertilisers Regulation: IN or OUT

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IN? or OUT?	Sewage	Manure + Cat 2 & 3 ABPs	Cat1 ABPs	Plant materials	Food waste / biowaste	Food industry
CMC2: plant materials	✗	✗	✗	✓	✗	✗
CMC3: compost	✗	✓	✗	✓	✓	✗
CMC4: "energy crop" digestate	✗	✗	✗	(✓)	✗	✗
CMC5: other digestate	✗	✓$	✗	✓	✓	✗
CMC6: food-industry by-products	✗	✗	✗	✓	✗	✓ Only plants + certain specified materials
CMC10: animal by-products	CMC10 = empty box. $ = other CMCs: only when ABP 'End Point' defined					
STRUBIAS P-salts (inc. used as fertiliser process ingredient)	✓	✓$	✗	✓	✓	✓
STRUBIAS ashes	✓	✓$	✗	✓	✓	✓

Animal By-Products (ABP) in EU Fertilisers

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At present, no ABP (and no ABP derived product) is allowed, unless + until "ABP End-Points" are added into the EU ABP Regulation 1069/2009

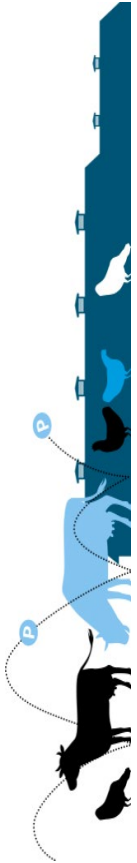
(and for some materials also amendment of 999/2001 TSE transmissible spongiform encephalopathies Regulation)

DG SANTE proposed amendment to 1069/2009 was open to public consultation to 24/10/22

(summarised in ESPP eNews n°70):

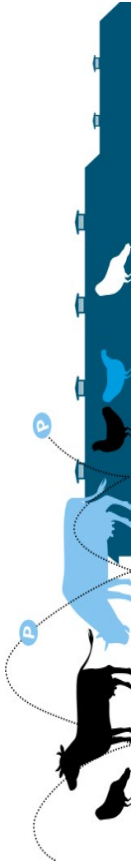
- ***ABPs already cited in FPR but cannot be used until 1069/2009 is amended: compost CMC3, digestate CMC5, ashes (Cat. 2-3) CMC13***
- ***Will require modification of FPR to include into CMC10 (empty box)***

In all cases, authorisation (for the cited materials in this proposal) only where processed under existing "standard" process specifications in annexes of 142/2011 (consolidated version here), NOT under "alternative" specifications in these same annexes



DG SANTE's proposed amendment to the ABP Regulation (of 26/9/2022 published for ***consultation*** ***to 24/10/2022***) would allow **only** the following ABP-derived materials in FPR CE-Mark fertilisers:			*Specifications of processing required * (in Regulation 142/2011)*
Could be used directly, as such, as component materials of CE-Mark fertilisers (subject to respecting the specified existing processing conditions of the ABP regulations)			
Ash from Cat.2 and Cat.3 ABPs (not Cat. 1 ash – see article below on this question)	Already anticipated in FPR texts: ESPP understands no amendment to FPR annexes necessary. But subject to respecting relevant FPR CMC specifications:	CMC13	Annex III. I.e. incineration or co-incineration: ≥850 °C for ≥2 seconds or ≥1100 °C for ≥0.2 seconds (plus various operating and plant requirements).
Compost		CMC3	Annex V, chapters I, II & III
Digestate		CMC5	Annex V, chapters I, II & III
Processed manure and insect frass	Possibly CMC14 for biochars etc. if a relevant pyrolysis process is already specified in the ABP Regulations? Otherwise: CMC10		Annex XI, chapter I ($2 a, b & d): I.e. treatment at ≥70°C for ≥60 minutes and verification by sampling of specified pathogen levels.
Could only be used under conditions: small packaging, dilution with non-feed-list materials			
Glycerine and biofuel residues, Cat.2 and Cat.3	Require addition to CMC10: ESPP understands amendment of FPR Annex II will be necessary		Annex IV, chapter IV
Certain Cat.3 materials			Annex IV, chapter IV
PAP (Processed Animal Protein) Cat.3			Annex X, chapter II
Processed MBM (Meat and Bone Meal) Cat.2. Must also be marked with glyceroltriheptanoate (GTH)			Annex IV, chapter III A I.e. pressure sterilisation ≥133°C for ≥20 minutes and with steam at ≥3 bars
Blood products Cat.3			Annex X, chapter II, §2
Hydrolysed proteins			Annex X, chapter II, §5 D
Dicalcium phosphate and Tricalcium phosphate. *Concerns only DCP and TCP from certain Cat.3 ABPs, not from minerals*			Annex X, chapter II, §6 or §§7
Feathers and down.			Annex XIII, chapter VII C
Horns, hooves.			Annex XIII, chapter XII
** "Standard" (but not "Alternative") specifications of processing (parameters of minimum temperature, time, etc) for each material, as defined in ABPR Implementing Regulation 142/2011, consolidated version 17/4/2022 http://data.europa.eu/eli/reg/2011/142/oj*			

Proposed amendment to 1069/2009 was open to public consultation to 24/10/22 (summarised in ESPP eNews n°70):



The JRC recommends that the scientific knowledge base be further developed in order to demonstrate that the use of EU fertilising products derived from (specific) pyrolysis & gasification materials does not present an unacceptable risk to human, animal or plant health, to safety or to the environment. Article 42 of the EU Fertilising Products Regulation ((EU) 2019/1009) foresees that Annexes I to IV to the Regulation can be amended for the purposes of adapting them to technical progress in the light of new scientific evidence. Therefore, the current proposal to exclude sewage sludge from the eligible input material list for CMC pyrolysis & gasification materials could possibly be revised once robust and extensive techno-scientific evidence underpins the safe use of (specific) pyrolysis & gasification materials derived from sewage sludge.

JRC "STRUBIAS" final report 2019 states (p. 138)
https://publications.jrc.ec.europa.eu/repository/handle/JRC117856

- 250+ proposals for new CMC / PFC received against public consultation.
- Will be prioritised and assessed starting before end of 2022.

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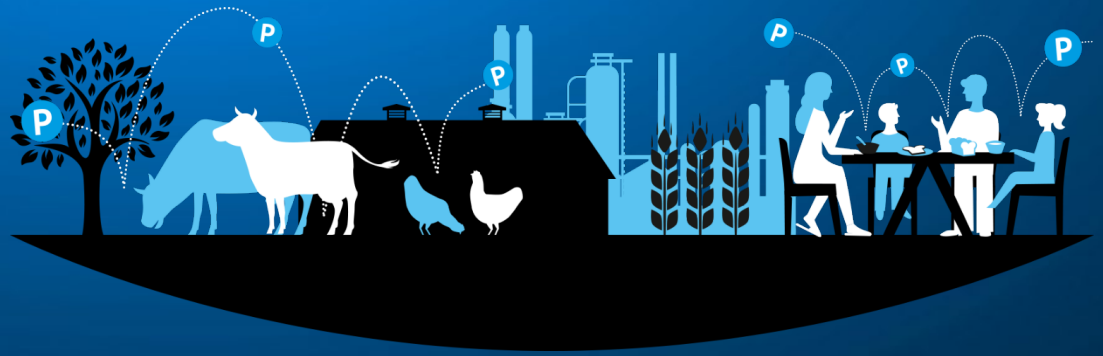
National P Recycling Regulations



European States with P-recycling Obligation

European Sustainable Phosphorus Platform

Switzerland

- 2016 VVEA (waste act), Art 15, makes
  phosphorus recycling becomes obligatory by 2026
  from sewage sludge incineration ash* and meat and bone meal ash
  * Switzerland banned land use of sewage biosolids in 2006

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Germany

- AbfKlärV 2017 (sewage sludge regulation):
  phosphorus recycling from sewage becomes obligatory
  - by 2029 / 2032 years for all WWTPs > 100 000 P.E. / 50 000 P.E.
  if sewage sludge P > 2% of dry matter

Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit

National | Verordnungen | AbfKlärV
Verordnung zur Neuordnung der Klärschlammverwertung
Klärschlammverordnung

Austria (draft for notification)

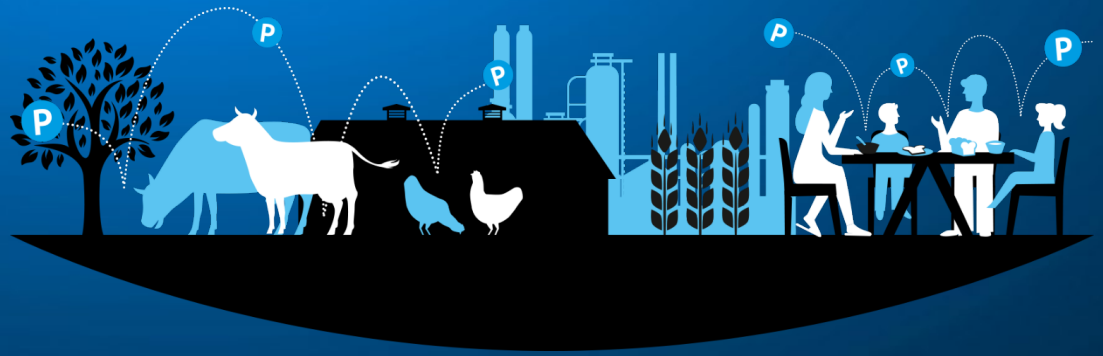
- 2022 AVV Abfallverbrennungsverordnung 2022
  phosphorus recycling becomes obligatory by 2030
  for WWTP >20 000 P.E. from sewage sludge (>60% recovery) or sludge ash (>80% recovery)

Bundesministerium
Klimaschutz, Umwelt,
Energie, Mobilität,
Innovation und Technologie

Under consideration in other countries (e.g., Denmark) and EU (New Sewage Sludge Directive 2023?)
https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12328-Evaluation-of-the-Sewage-Sludge-Directive-86-278-EEC-/public-consultation

European Sustainable Phosphorus Platform

Certified Organic Production (“Organic Farming”)

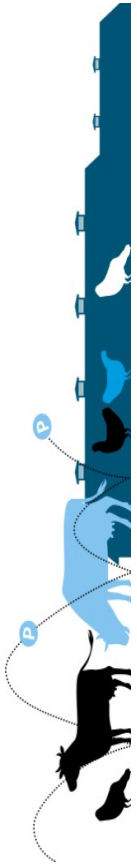


Recycled nutrients authorised in EU "Organic Farming"

EU Implementing Regulation on Organic Farming 2021/1165 Annex II

In some cases with use specification, contaminant limitations or "sustainable origin"

- Materials from **plants or algae**
- **Manure** inc. dried, composted, digestate "**Factory farming origin forbidden**"
- Compost or digestate of separately collected **biowaste**, of **vegetable materials**
- Various specific **animal-by-products**: fish meal, meat meat, bone meal, hydrolysed proteins, dairy, wool, feathers, …
- **Wood by-products and ashes**
- **Shellfish wastes**
- **Egg shells** "**Factory farming origin forbidden**"
- **Biochar from plant materials**



EGTOP Opinion on recycled nutrient materials

EU Expert Group on Organic Production (Opinions here)

European Sustainable Phosphorus Platform

Positive opinions: June 2022 here

- **Struvite** and **precipitated phosphate salts** (EU FPR CMC12 definition)
- **Widen "biowaste"** to include green wastes, catering food wastes (conform to Waste Framework Directive)

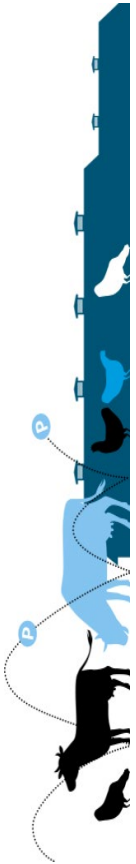
2016 here: **struvite, calcined phosphates from sewage sludge**

Negative Opinions:

- **June 2022 here: "Animal Bone Biochar"**:
  - no advantage but contaminant risks compared to non-pyrolysed bone meal
- 2018 here: (certain) N-salts from ammonia stripping

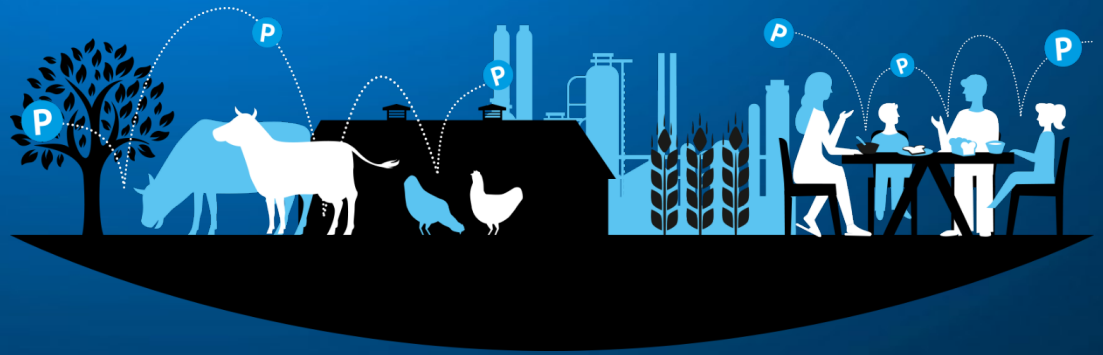
See also : ESPP proposals to authorise further recycled nutrient materials in Organic Production here

FIBL paper on conditions for acceptance of recycled phosphorus materials in Organic Farming here



European Sustainable Phosphorus Platform

Challenges and perspectives



What about more radical, new business models?

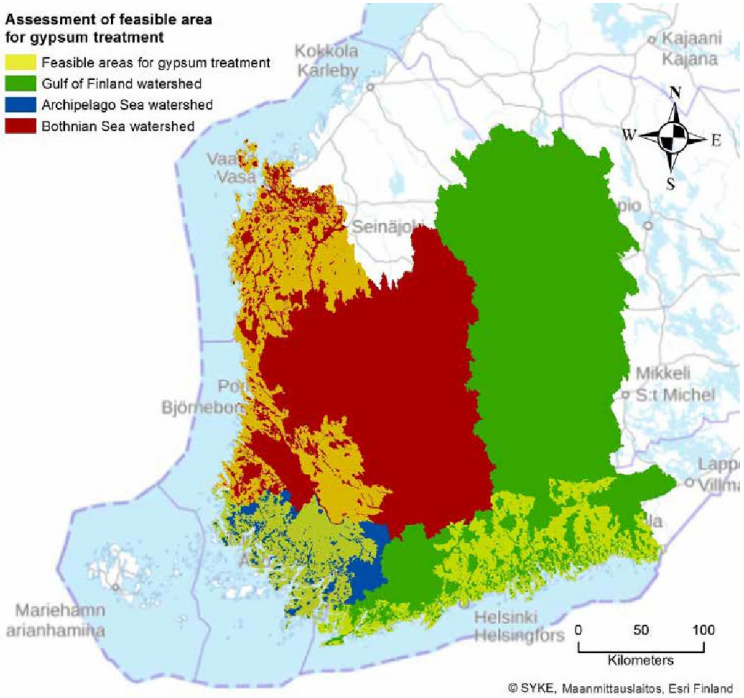
Soil fertility / soil health as a service?

- Fertiliser industry charging an annual lumpsum in the order of current cost of fertilising products for farmers
  - Supplies high nutrient use efficient, low impact speciality fertilisers in lower quantities
  - Selects the most powerful combination of tools (sensors, digital data, models) and practices (precision farming, soil improvers, fertigation) to reduce losses
  - Manages mechanisms for rewarding farmers for carbon sequestration = increasing organic carbon in soils

Picture: EIT Raw Materials

What about using phosphogypsum for abating soil erosion and reducing nutrient losses as shown in Finland? (Ollikainen et al., 2018)

- In Finland 330 t/y of P lost to water can be saved by applying PG on 550,000 ha crop-/grassland in regions as shown
- In the Baltic Sea Region, up to 3,000 t/y of P may be saved if Denmark, Poland and Sweden follow the Finnish model
- In Finland, the amendment costs about 220 €/ha (60% expenses for transport) corresponding to 50-60 €/kg of P saved from loss to water bodies.
- Eligible for agricultural subsidies



What about industry taking a leading role in closing nutrient cycles?

- On top of symbiotic cooperation with the farming sector, cooperating with the wastewater sector and creating a pull factor for nutrient recovery and recycling
- Assessing processes and products for emission and pollution benefits and support the wastewater sector towards selecting the lowest impact, most appropriate technologies
- Contributing to improve recovery and recycling strategies – clear targets, efficient collection and distribution systems, stakeholder involvement, etc.

Policies supporting a circular Farm-to-Fork strategy to real life carbon positive and soil health protecting farming

- EU strategies need to be covered by regulation, incentives, penalisation – compliancy must be rewarded – non-compliance must be penalised
- Stakeholder rewards could be linked to the EU net-zero emission strategy – saving greenhouse gas emissions by recovery (e.g. nutrient recovery), if replacing fossil based products, should receive an EU ETS (EU Emission Trading System) credit for added value in terms of CO_2 emission savings.
- Farmer rewards could be linked to ETS or to CAP

La Cassinazza Farm 2006 & 2018
Courtesy Neorurale Hub, IT

European Sustainable Phosphorus Platform

17-18 January 2023

Brussels & hybrid

Organic fertilisers SOFIEurope 2nd summit

www.phosphorusplatform.eu/SOFIE2023

19 January 2023

Nitrogen Recovery

Brussels & hybrid

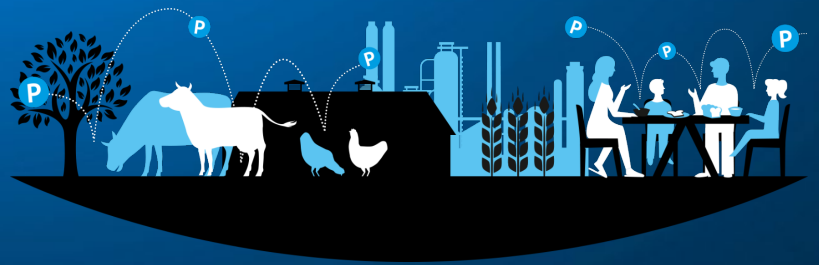
www.phosphorusplatform.eu/NRecovery

European Sustainable Phosphorus Platform

Thank you for your attention!
Questions?

www.phosphorusplatform.eu

Ludwig Hermann (l.hermann@proman.pro)
info@phosphorusplatform.eu



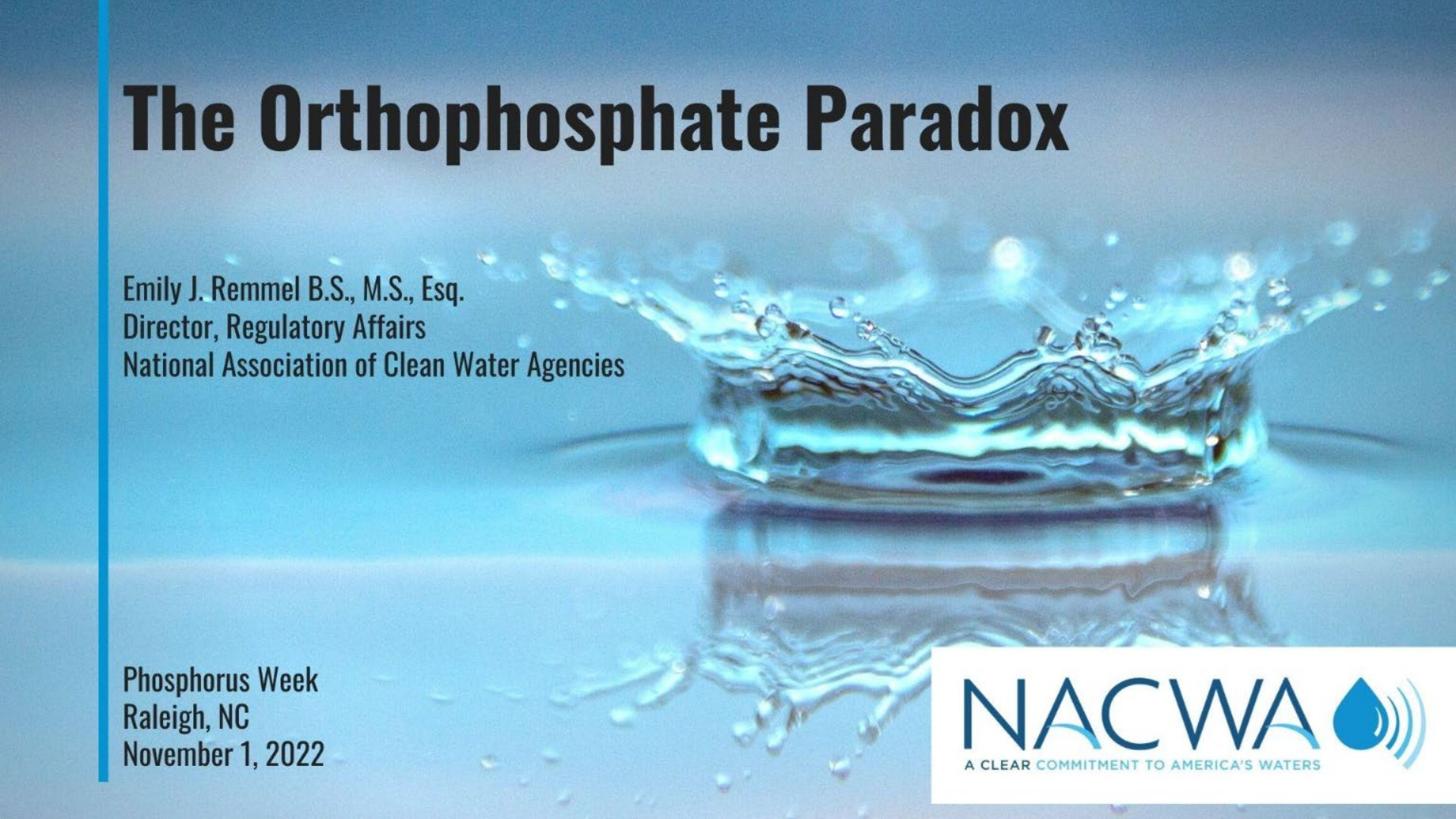
Agenda

12:30 – 1:00	P is for Planet: The Future of Sustainability in Phosphate	Maurício Fortuna, CRU
1:00 – 1:30	The Dichotomy in Sustainable Phosphorus Management: Why Do We Need a Convergence?	Kaushik Majumdar, Global Phosphorus Institute and African Plant Nutrition Institute
1:30 – 2:00	European Update	Ludwig Hermann, European Sustainable Phosphorus Platform (ESPP)
2:00 – 2:30	The Orthophosphate Paradox	Emily Remmel, National Association of Clean Water Agencies (NACWA)
2:30 – 3:00	Facilitated Policy Wrap-Up Discussion	Anna-Maria Marshall, University of Illinois, Urbana-Champaign

The Orthophosphate Paradox

Emily J. Remmel B.S., M.S., Esq.
Director, Regulatory Affairs
National Association of Clean Water Agencies

Phosphorus Week
Raleigh, NC
November 1, 2022



WHO ARE WE?

- NACWA is a national trade association for public wastewater and stormwater utilities
- NACWA represents over 350 public utility members of all sizes nationwide
- NACWA is the recognized leader in legislative, regulatory, and legal advocacy on full spectrum of clean water issues

THE ORTHOPHOSPHATE PARADOX

SAFE DRINKING WATER ACT

CLEAN WATER ACT

THE PROTECTION OF PUBLIC HEALTH AND THE ENVIRONMENT

WHERE NACWA PLAYS

NACWA

Preventing Lead Corrosion

Original Lead and Copper Rule promulgated in 1991

- Maximum Contaminant Level Goal (MCLG) of zero
- Established 15 ug/L action level
- Tap sampling
- Corrosion control if you exceed action level in 10% of consumer taps

Several minor updates through the years (2000, 2007)

- Lead service line replacement
- Community/customer notification
- Public education

Preventing Lead Corrosion

- Public drinking water infrastructure varies in age, material, and level of maintenance
  - Public utilities own
- Water is naturally corrosive depending on water quality factors, including:
  - pH
  - Total alkalinity
  - Dissolved inorganic carbon
  - Calcium
  - Hardness

Because of this variability in source water quality and infrastructure, drinking water utilities have traditionally received flexibility in determining corrosion control methods that best fit a community's site specific water quality needs.

THE ORTHOPHOSPHATE PARADOX

Lead and Copper Rule Revision

Proposed in November 2019; Finalized December 2021

- Introduces a "trigger level" of 10 ug/L (reasoning to "compel actions before an action level exceedance")
- Retains 15 ug/L action level
- Corrosion control: any phosphorus inhibitor must be orthophosphate
  - 1 mg/L orthophosphate residual concentration
  - 3 mg/L orthophosphate residual concentration

Intentional Orthophosphate Dosing

SAFE DRINKING WATER ACT

UPSTREAM ADDITION OF PHOSPHORUS

CLEAN WATER ACT

NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT EFFLUENT LIMITS ON TOTAL PHOSPHORUS

THE PROTECTION OF PUBLIC HEALTH AND THE ENVIRONMENT

More Phosphorus In, More Phosphorus Out

Water systems conducting corrosion control studies would not be able to rule out orthophosphate simply based on the increase in loading to wastewater treatment facilities."

However, "States and water systems can "consider phosphorus removal treatment that may be needed by the receiving wastewater treatment system to meet any phosphorus discharge limits or otherwise prevent impacts to water quality."

The Orthophosphate Paradox

Determining whether treatmetn is optimized can be challenging for individual systems, given the wide variability in distribution system composition, source water characteristics, and approaches to complianing with other National Primary Drinking Water Regulations, such as surface treatment rules."

EPA 2016 LEAD AND COPPER RULE REVISIONS WHITE PAPER, AVAILABLE AT:
HTTPS://WWW.EPA.GOV/SITES/DEFAULT/FILES/2016-10/DOCUMENTS/508_LCR_REVISIONS_WHITE_PAPER_FINAL_10.26.16.PDF

The Costs Associated with Orthophosphate

EPA acknowledges orthophosphate will generate treatment costs for wastewater treatment plants and derived a unit cost of $4.59 per pound of phosphorus for removing incremental phosphorus.

With the unit cost, the estimated incremental cost to wastewater treatment plants annually to remove the additional phosphorus e will range from:

Conservative estimate: $668,000 to $1,066,000
Worst case estimate: $1,203,000 to $1,920,000

A Mile High Case Example

COLORADO
Department of Public
Health & Environment

DENVER WATER

METRO
WATER
RECOVERY℠

A Mile High Case Example

Colorado DPHE requiring the use of orthophosphate for the 64,000 - 84,000 lead service lines in Denver.

Denver water exceeded lead action level in 2012; conducted multi-year study of optimized corrosion control technology and lead lines in service area

- Recommended to CDPHE pH adjustment over orthophosphate

Metro (the wastewater utility) supported this recommendation.

- Low stream flows and dilution factors
- Stringent nutrient limits/controls at play for NPDES permittees
- Would have significant impact on effluent limits and wasteload allocations
- Double investment needed to meet water quality standards for phosphorus

A Regional Solution and Regional Win

Denver Water Lead Reduction Program

- Example of how protection of human health through lead reduction does not have to come at expense of downstream water quality or affordable clean water services
- Suite of strategies
  - Adjusting pH/alkalinity
  - Full lead service line replacement underway

Every year, Denver Metro meets the metrics, Denver Water Recovery contributes $$$ to the lead replacement program

Lead and Copper Rule Improvements

EPA is soon to release (est. early 2023) a proposed rule "improving" the Lead and Copper Rule Revisions

- Attempt to provide greater clarity on the "trigger level"
- Push to reduce 15 ug/L action level to 10 ug/L and eliminate the trigger level
- Orthophosphate required???

Mirror the compliance timeframe:

- Lead and Copper Rule Revisions are effective, yet compliance is not required until 2024
- This proposed rule, if it stays on time, could be promulgated by the time the LCRR compliance is required

Big Picture Takeaways

- Public water systems are not all the same, nor is their source water
- Regulatory flexibility can be protective of public health and the environment
  - No "one-size fits all"
- Orthophosphate dosing means more phosphorus in, more phosphorus out
  - Downstream water quality impacts - eutrophication
- One ratepayer!
- Communities can work together through Clean Water Act tools (e.g., integrated planning) and solve complex problems practically

THANK YOU!

Emily Remmel
eremmel@nacwa.org
202.533.1839

NACWA
A CLEAR COMMITMENT TO AMERICA'S WATERS

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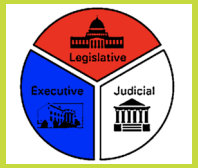
Phosphorus Policy Roundup

Facilitated Discussion:

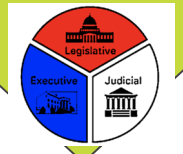
Anna-Maria Marshall
University of Illinois, Urbana -Champaign

FEDERAL



50 STATES

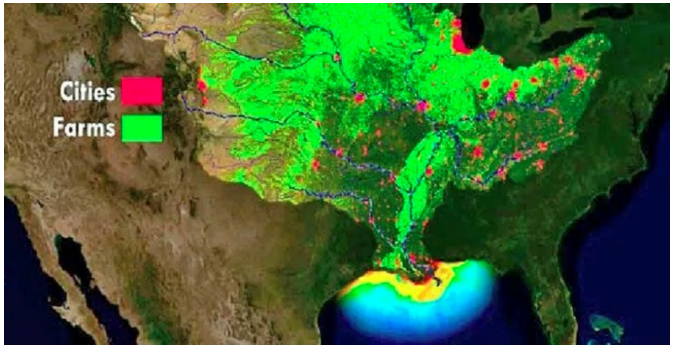
LOCAL



LANDSCAPE OF US POLICY-MAKING

Regulating Phosphorus

- COMMAND AND CONTROL REGULATION
  - STATUTORY
    - Clean Water Act
  - REGULATORY
    - EPA
- PROBLEMS WITH COMMAND AND CONTROL
  - Keeping Up with Science
  - Limited Enforcement
  - Political Obstacles



STEPS Policy-Related Research

- MODELING EFFECTS OF POLICY PORTFOLIOS
- CASE STUDIES ON ADOPTION OF TECHNOLOGIES
  - Policy Constraints and Opportunities
- COLLECTIVE GOVERNANCE
  - Stakeholder Engagement

Your Policy Priorities?

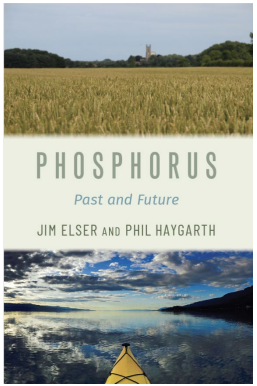
Mining & Fertilizer Production	Animal & Crop Production	Natural Resource Management	Human-Centric Consumption	Waste
Phosphate Rock	Agriculture - Soil	Land & Water Management	Food Processing	Manure
Fertilizer Production	Agriculture - Crops	Recreational Industries	Human Consumption	Food Waste
Other Industrial Uses	Agriculture - Livestock	Real Estate	Restaurants & Groceries	Human Excreta
		Lake Managers		Landfill
		Aquaculture		
		Surface Waters		

Join Us Tomorrow

TIME	SESSION	PRESENTER
8:00 – 8:15	Welcome	Ross Sozzani, NCSU
8:15 – 8:45	Phosphorus Past	Jim Elser, SPA
8:45 – 9:30	Phosphorus Future	Jacob Jones, NCSU
9:30 – 10:00	Coffee and Networking	
10:00 – 11:00	Building the Future of Phosphorus Together	Cary Stickland, RTI; Justin Baker, NCSU
11:00 – 12:00	**Parallel Sessions:** How Do We Achieve Phosphorus Sustainability	Various
12:00 – 1:00	Lunch	
1:00 – 2:00	**Parallel Sessions:** What & Who Do We Need to Achieve Phosphorus Sustainability	Various
2:00 – 3:00	Explore What We've Created	Various
3:00 – 3:30	How We Move Forward Together	Various
3:30 – 4:00	Phosphorus Career Panel	Karl Wyant, Nutrien; Susan White, NCSea Grant; Jonathan Coppess, University of Illinois; Jenny Exum, Cary Water Reclamation Facility
4:00 – 6:00	Reception sponsored by Verdesian Life Sciences	

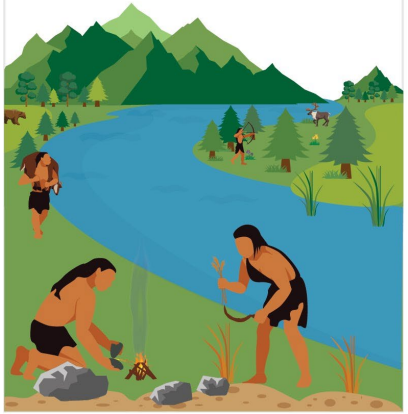
Sustainable Phosphorus Alliance

Concluding Remarks



Stage 1: Hunting and gathering

- Small populations, wild plants and animals
- Patchy, natural soil phosphorus availability from apatite in parent rock
- Concentrated areas of human and animal enrichment from phosphorus excretion
- Semi pristine condition, phosphorus mostly closed system, recycled and sustainable



Stage 2: Beginnings of agriculture

- Herding and confining animals
- Selection of preferred species around dwellings, beginnings of plant domestication
- Recycling of human and animal manure to crops
- Sustainable phosphorus condition

Stage 3: Establishment of modern agriculture and fertilizer

- Development and production of rock phosphate fertilizer, global expansion
- Green Revolution results in the refinement of domestication of animals and plants through breeding and genetics
- Industrialization of agriculture
- Legacy soil phosphorus and fast growing lazy plants (FGLPs)

All of us here, together, are building Stage 4 RIGHT NOW.

Sustainable
Phosphorus
Alliance

PhosphorusAlliance.org