Welcome!

Please Keep Your Video Off

OCP

OSTARA

#Pforum2020

Sustainable Phosphorus Alliance

Welcome!

Founding/Current Members and Strategic Partners

OCP
OSTARA
NACWA
RENEWABLE NUTRIENTS
GreenEdge GreenTechnologies, LLC
THE Water Research FOUNDATION
Biochar Now
THE SUSTAINABILITY CONSORTIUM
FEECO INTERNATIONAL
Consultants Associated With Brookside CAB

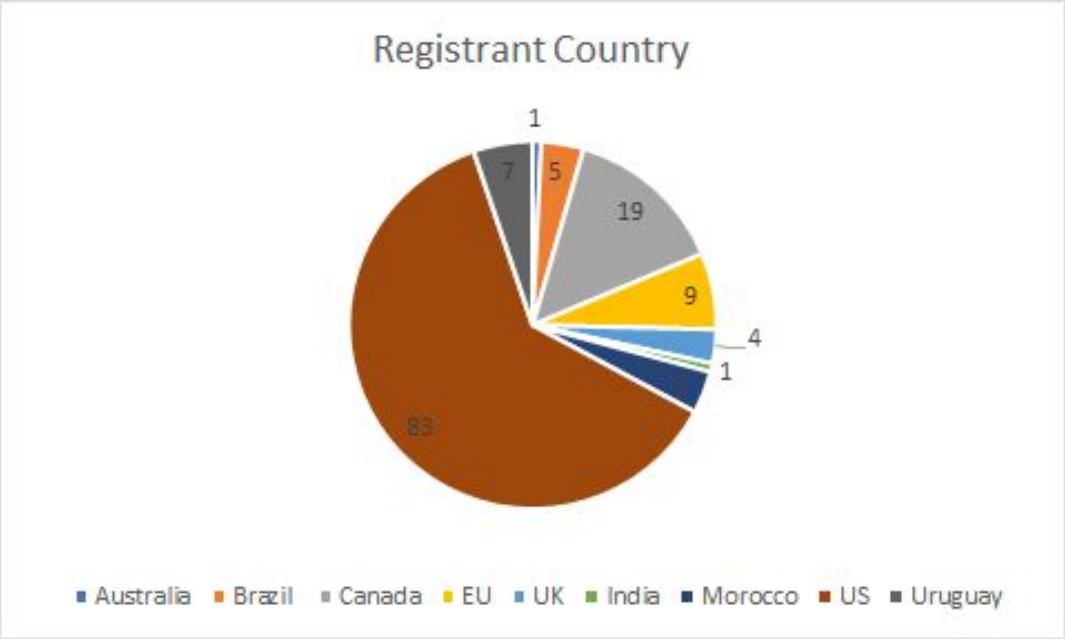
Strategic Partners

AgSTAR
Water Environment Federation
nebra

#Pforum2020

Sustainable Phosphorus Alliance

The Benefit of a Virtual Conference



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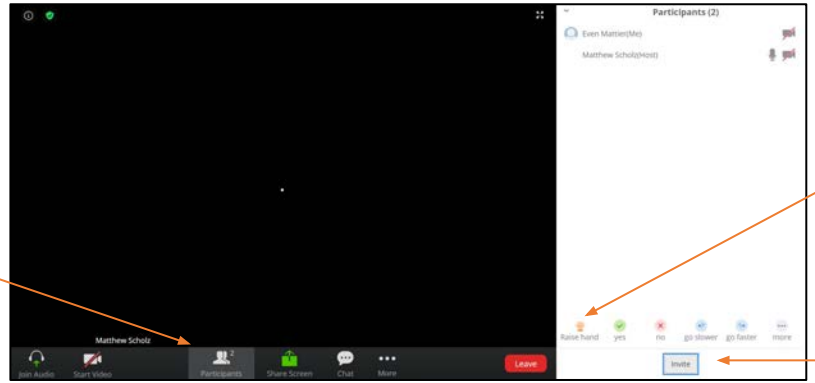
Agenda (all times ET)

12:00-12:20	Welcome from the Alliance (Drs. Jim Elser and Matt Scholz)
12:20-12:40	Mr. Chris Hornback, Deputy CEO, National Association of Clean Water Agencies Regulation of Derived Products for Agricultural Use
12:40-1:00	Dr. Rebecca Muenich, Sustainable Phosphorus Alliance National Inventory of Animal Feeding Operations
1:00-1:45	Panel on the Economics of Small-Scale P Recovery: Mr. Jeff Dawson, CEO, Renewable Nutrients; Dr. Aaron Fisher, Water Research Foundation and Mr. Rick Johnson, Applied Environmental Solutions
1:45-2:05	Mr. Robert van Spingelen, Director of Business Development, and Mr. Matt Kuzma, Vice President, Ostara Resources Reimagined: Enhancing Phosphate Production Through Nutrient Recovery
2:05-2:25	Breakout rooms
2:25-2:45	Closing discussion & raffle!

Meeting Controls

- To avoid chaos, we've muted you and prevented you from sharing screens. Please turn off your video (or we can turn it off for you!) to conserve bandwidth.
- Please use the hand-raise feature to ask a question at the end of each presentation. We will unmute you for your question. We will have ~5 minutes for Q&A after each.
- If you are cut off from Zoom, please try to relaunch from your registration email.
- Note: Meeting is being recorded

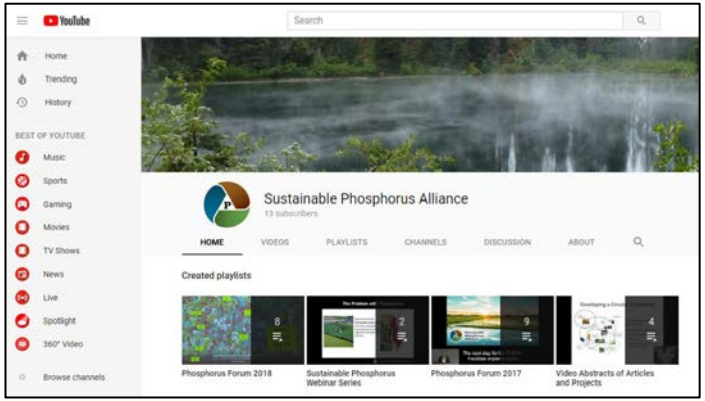
Please click Participants to open side pane to the right and to access hand raise icon



Hand-raise icon is here. Click a second time to lower your hand.

New invitees will not be admitted.

Community Resources



More than 31 hours of coverage including:

- Sustainable Phosphorus Webinar Series
- Phosphorus Science Now!
- Phosphorus Forum event coverage

Membership details for organizations available here!

News Items

Our Symposium at the virtual 2020 ASA-CSSA-SSSA International Meeting, Nov 9-13:
Crop response, watershed loads, and global flows – oh my! Following the yellow-brick future of phosphorus modelling
Featuring: Drs. Josh McGrath, Chad Penn, Carl Bolster, Rem Confessor, David Vaccari, and Céline Vaneeckhaute

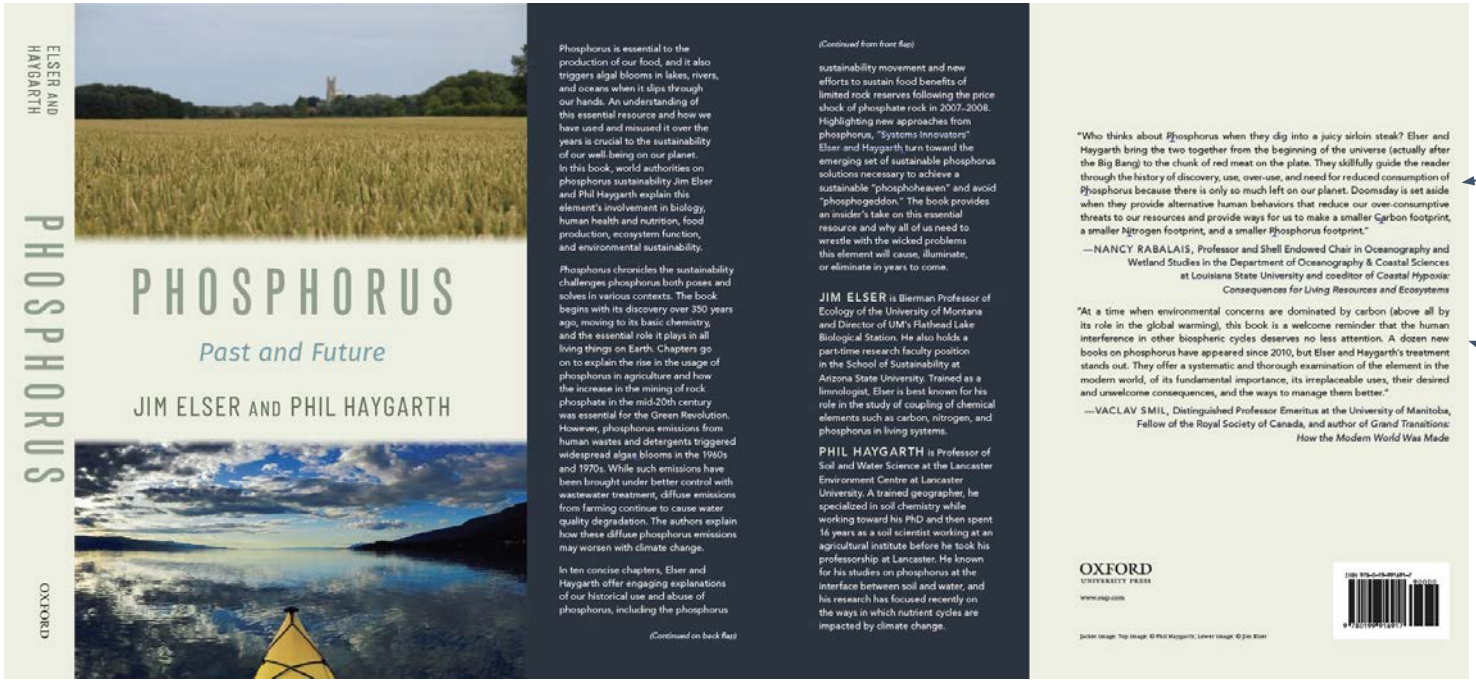
Our Symposium at the virtual AAAS 2021 Annual Meeting, Feb 8 at noon ET
Phosphorus and Climate Change: A Vicious Circle
Featuring: Drs. Jim Elser, Matt Scholz, Laura Johnson, John Downing, and Mr. Ahren Britton

ESPP SCOPE Newsletters on phosphorus and climate change
One to come soon and one online now at
https://phosphorusplatform.eu/scope-in-print/scopenewsletter/1984-july-2020-scope-135#

Jim's Book! *Phosphorus: Past and Future*

***Our Phosphorus Future* Report**

Welcome and news from Phosphorus-land!



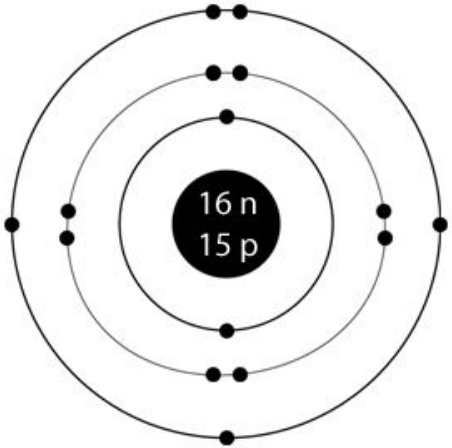
blurb from Dr Nancy Rabalais

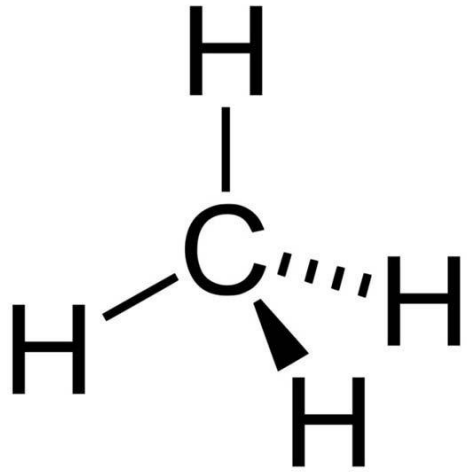
blurb from Dr Vaclav Smil

Now available for pre-order!

Welcome and news from Phosphorus-land!

Phosphorus meets Methane!





Welcome and news from Phosphorus-land!

Phosphorus meets Methane!

SCOPE NEWSLETTER

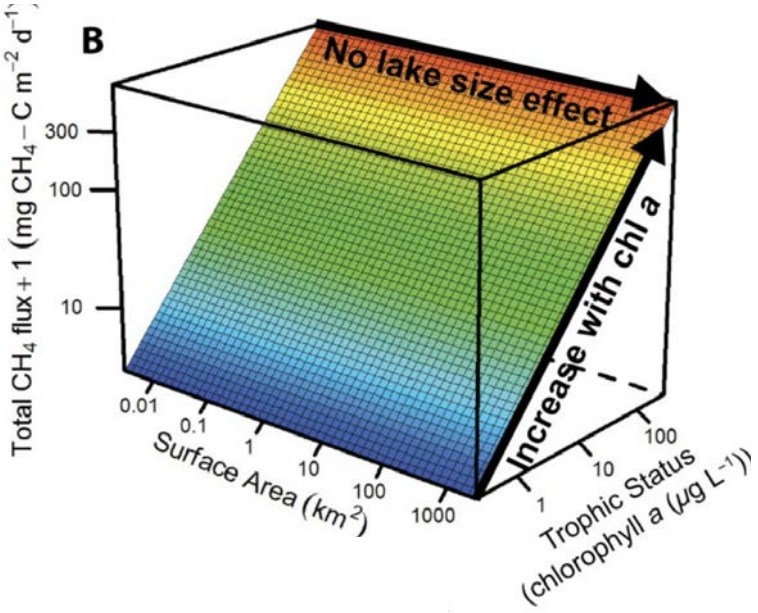
European Sustainable Phosphorus Platform

SCOPE Nutrients and Climate Change: (1) – Aquatic Methane Emissions

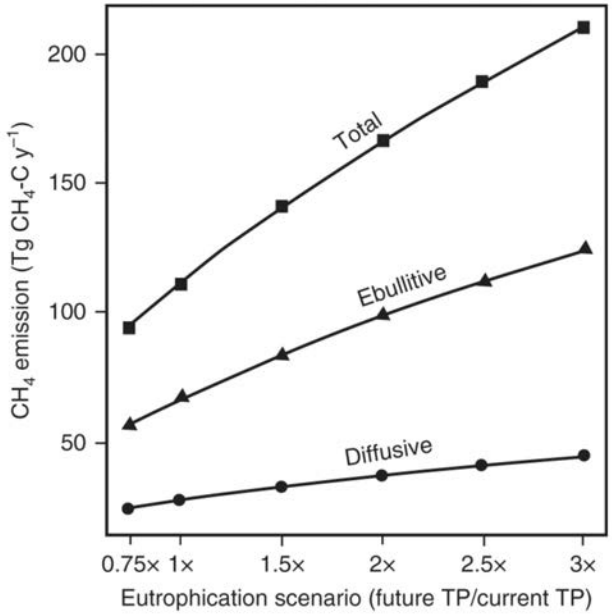
Co-produced by ESPP (Chris Thornton) and SPA (Matt Scholz, Jim Elser)

Phosphorus meets Methane!

Greenhouse gas emissions from lakes and reservoirs represent around 1/5th of those from fossil fuel combustion, and 75% of this impact is from methane.



DelSontro, T., Beaulieu, J.J., Downing, J.A., 2018. Greenhouse gas emissions from lakes and impoundments: Upscaling in the face of global change: GHG emissions from lakes and impoundments. Limnology and Oceanography Letters 3, 64–75.



Beaulieu, J.J., DelSontro, T., Downing, J.A., 2019. Eutrophication will increase methane emissions from lakes and impoundments during the 21st century. Nature Communications 10.

Phosphorus meets Methane!

SCOPE Nutrients and Climate Change: (1) – Aquatic Methane Emissions

This is the first of several **SCOPE Newsletter** special issues addressing the **links between phosphorus, nutrients and climate change**. These special issues are produced in cooperation between the Sustainable Phosphorus Alliance, North America, and the European Sustainable Phosphorus Platform.

As usual for SCOPE Newsletter, this issue is based on short 'layman's' summaries of selected recent scientific papers. We have also tried to draw overall conclusions from these papers.

Currently in preparation are further special issues on:

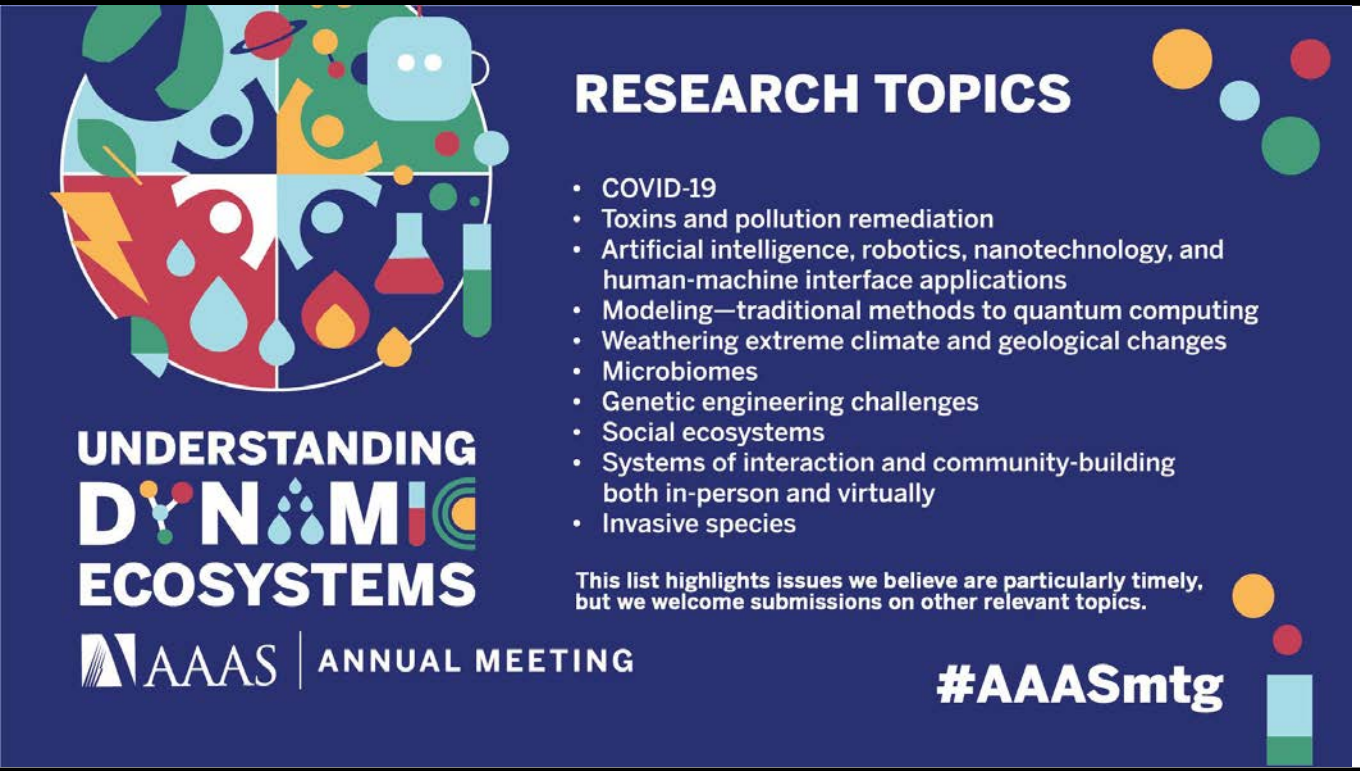
- **climate change, nutrient losses and eutrophication**
- **interactions between climate change, nutrients and soil carbon**
- **climate change impacts of nutrient recycling and stewardship technologies**

With special thanks to Matt Scholz, Sustainable Phosphorus Alliance, who led the authorship of this issue on nutrients and freshwater methane emission

P ➡ eutrophication ➡ climate change

climate change ➡ P ➡ eutrophication

Phosphorus meets methane at 2021 AAAS meeting!



Symposium

"Phosphorus and Climate Change: A Vicious Circle"

Featuring

Moderators

Jim Elser & Matt Scholz (SPA)

Speakers

John Downing (NOAA)
Laura Johnson (Heidelberg U.)
Ahren Britton (Ostara, Inc.)

OUR PHOSPHORUS FUTURE

Brownlie, William (Principal Investigator)
Spears, Bryan (Co-Principal Investigator)
Howard, Clare (Co-Principal Investigator)
Heal, Kate (Co-Principal Investigator)
Sutton, Mark (Co-Principal Investigator)
Johnes, Penny J (Co-Investigator)

The 'Our Phosphorus Future' project

The 'Our Phosphorus Future' project is a two year project (concluding in March 2019), funded by the Natural Environment Research Council (NERC) international opportunities fund, with additional support from UN-Environment and the European Sustainable Phosphorus Platform (ESPP). The project is currently being delivered by the Centre for Ecology and Hydrology and the University of Edinburgh, Scotland, UK.

Funding

NERC SCIENCE OF THE ENVIRONMENT

UN environment

European Sustainable Phosphorus Platform

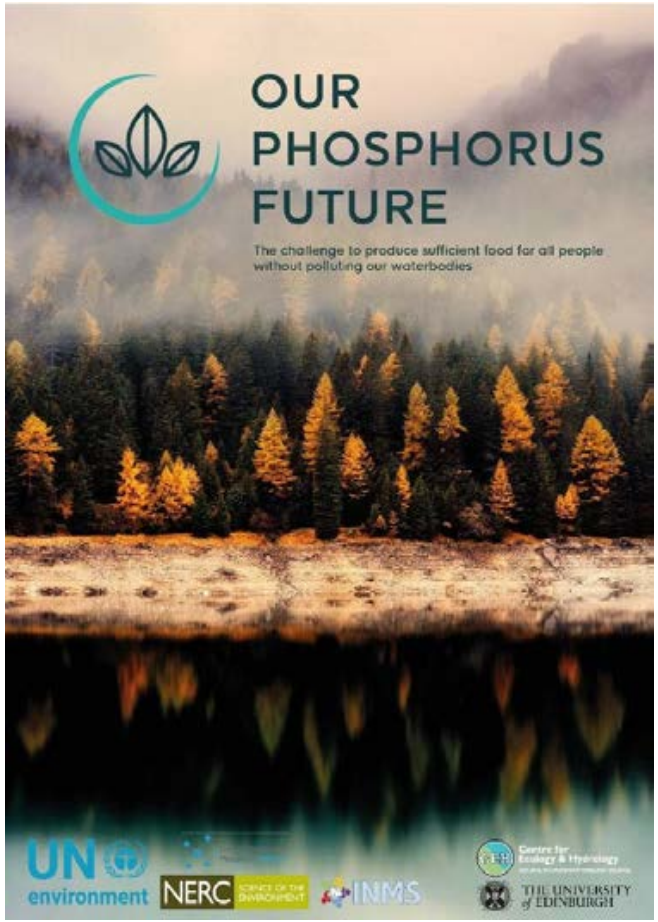
INMS

Executing partners

UK Centre for Ecology & Hydrology

THE UNIVERSITY of EDINBURGH

80+ Authors/Contributors
20 countries



SYNTHESIS REPORT:. Concise, highly visual, easily accessible/readable. (~150 pages),

AUDIENCE: policy makers, environment agencies, with supporting media for the public and the media

- Setting the scene
- The challenges
- The solutions/benefits
- Regional perspectives
- The way forward

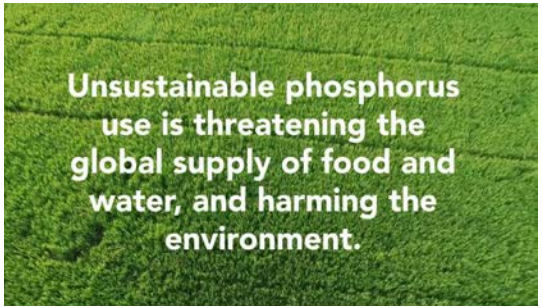
Increasing awareness: different formats, for different audiences, to maximize impacts.

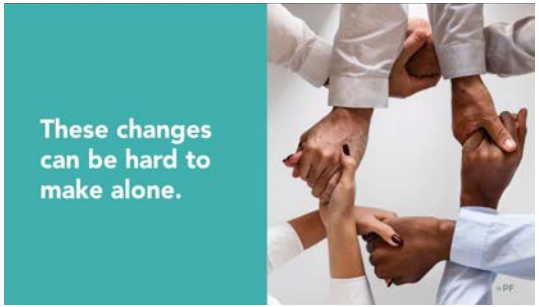
1.30 mins	Explainer video
10 mins	Scrolling story
15-20 mins	Full chapter
Full document	




OUR PHOSPHORUS FUTURE

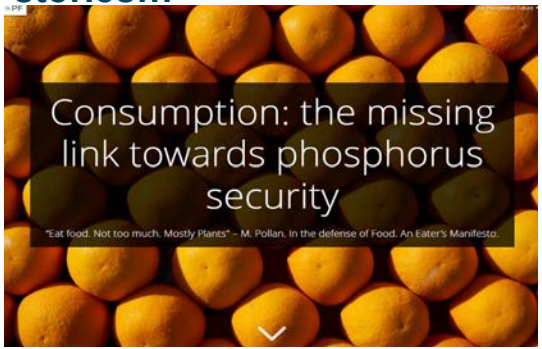
Stills taken from one of the 10 explainer videos…

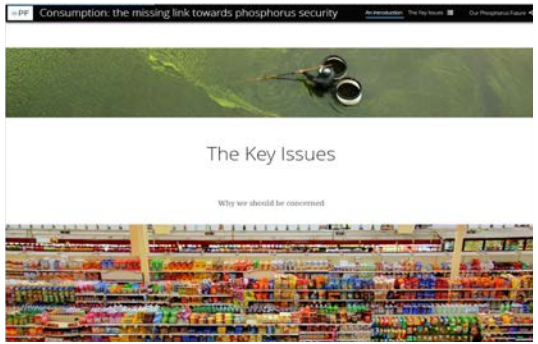


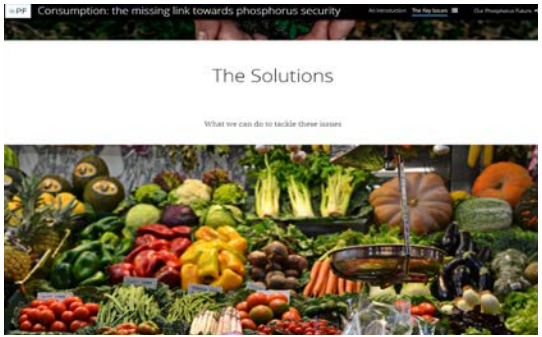


OUR PHOSPHORUS FUTURE

Stills taken from one of the 10 scrolling stories…





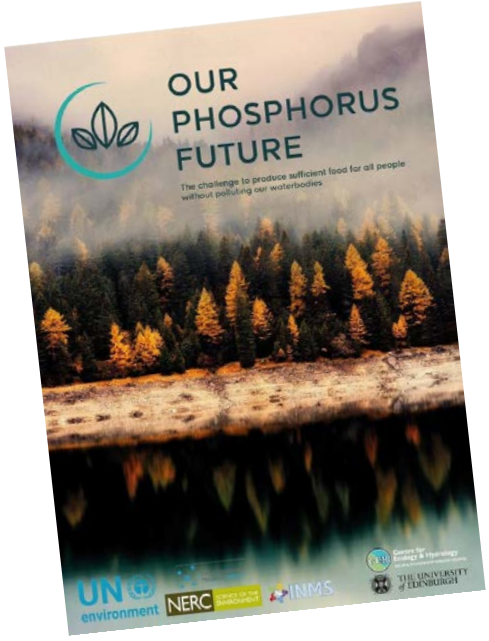


OUR PHOSPHORUS FUTURE

Stills taken from one of the animated social media videos…

OUR
PHOSPHORUS
FUTURE

Chapters
:



The transition to food systems that provide nutritious food for everyone, sustainably, is not possible without significantly improving the sustainability of our phosphorus use. Simply put, we cannot achieve food security without addressing phosphorus security. Phosphorus security includes:

-**Fertiliser security** - ensuring farmers have access to nutrients/fertilisers;
-**Nutritional security** - ensuring people have access to healthy diets with optimal phosphorus intake;
-**National security** - countries have reliable access to phosphorus resources;
-**Water security** – aquatic ecosystems are protected from the damage caused by excess phosphorus.

Food systems need to transform to grow more nutritious foods with lower environmental footprints (hence shifting from diets, with public health implications), shorter food value chains and increased food access. Climate change, obesity and the non-communicable food-related disease epidemic (i.e. diabetes and cardio-vascular health, cancers) means 'business as usual' agricultural growth of commodity-crop based agriculture is not an option. Growing nutritious food in sustainable ways can reduce the burdens of malnutrition and environmental impacts generally.

As reflected in the Sustainable Development Goals (SDG), reducing poverty (SDG1) and hunger (SDG2) are among the critical challenges facing humanity. Most of the world's hungry are rural smallholder farmers, therefore supporting farmer livelihoods by investing in family farmers and rural women can simultaneously address poverty and hunger. For phosphorus, such investment could include extension services to improve productivity such as phosphorus use efficiency; improved access to credit, insurance and loans for fertilisers/nutrients in addition to other inputs; and employment diversification for vulnerable farmers (e.g. to less phosphorus vulnerable crops or off farm employment such as agri-tourism). Importantly, change is needed across the whole food system, not just in the agricultural sector, such as shifts to low phosphorus-footprint diets and improvements in the capacity to recover and reuse phosphorus from organic waste streams.

THE PROBLEMS

- Food production in nearly every country is reliant on phosphate imports from only a few countries. Five countries control ~85% of the world's phosphate rock reserves, leaving food systems in most countries dependent on phosphorus imports and vulnerable to fertiliser price fluctuations and geo-political instabilities in producing countries.

- In many regions, a lack of phosphorus inputs to soils restricts crop production. Like water, carbon and nitrogen, phosphorus is vital for growing the crops that underpin food systems. Of the approximately 800 million people who face the risk of frequent hunger, some 80% are smallholder farmers in the developing world (FAO 2015). The same group are most vulnerable to phosphorus scarcity: 1 in 7 farmers lack access to phosphorus fertilisers (Cordell and White 2014a; UNSTD 2008).

- Fluctuation in phosphate fertiliser price is a risk to food security in the short term. In 2008, the phosphate fertilizer price spiked by 800%. This affected the livelihood of many of the world's poorest farmers, resulting in farmer debt and reports of farmer riots, for example, in Mali and India. This spike was the result of many factors, including the introduction of US Ethanol policy in 2007, which saw a sharp rise in demand for fertilising fast-growing biofuel crops.

- The increasing cost of mining our planets finite phosphate rocks reserves and extracting ever-more phosphates is a risk to food security in the long term. Depletion of high quality, 'easy to mine' phosphate reserves will force mining of reserves that are 'hard to get to' and of lower quality, with additional processing costs potentially transferred to farmers and consumers.

- Long food value chains, based on globalised commodity based agriculture, have led to low phosphorus use efficiency. Four-fifths of the mined phosphorus used in agriculture is wasted or lost in the food chain between mine, farm and fork (Cordell et al. 2009). Much of this ends up in rivers, lakes and oceans where it can cause toxic algal blooms, in turn destroying aquatic ecosystems and costing the fisheries and recreation industries billions.

- Nutritional insecurity is complex: more people are obese in the world today than underweight. Obesity is often associated with poverty and a reliance on calorie-dense but nutrient-poor foods. Malnutrition in all its forms occurs in every country in the world (FAO IFAD UNICEF WFP and WHO, 2017). Human dietary phosphorus intake in the developed world is at double the recommended levels and maybe harming some vulnerable people. In the developing world, lack of accessibility to adequate phosphorus inputs is undermining both food quantity and quality.

THE SOLUTIONS

Achieving food security will require transforming food systems to grow more nutritious foods with lower environmental footprints, making the food system more efficient (such as reducing food wastes) with shorter food value chains and increased food access. This means explicitly shifting from a production-oriented paradigm to one that seeks to incentivise low waste, coupled with healthy eating of sustainably produced food.

For phosphorus, this means ensuring resource security for all parts of the food system:

- fertiliser security - farmers have financial and physical access to phosphorus fertilisers;
- soil security - soil phosphorus is maintained at optimal levels in plant-available forms;
- national security - countries have reliable access to phosphorus resources underpinning food supply;
- nutritional security - people have access to balanced diets including optimal phosphorus intake; and
- environmental security – avoiding dangerous eutrophication, climate change, and food chain waste.

- Implementing change across the whole food value chain – not just within agriculture. This will include: improving phosphorus-use efficiency, reducing waste, improving food processing and distribution efficiency, producing food closer to end markets, improving recycling of food waste streams and more stringent cadmium limits in food. This means producing low phosphorus-demanding foods, supporting

OUR PHOSPHORUS FUTURE

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Sutton, Mark (Co-Principal Investigator)
Johnes, Penny J (Co-Investigator)

Current status: just completed internal peer review; going out for review by partners
Target release: December 2020 / January 2021

Funding

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Next Speaker

Mr. Chris Hornback
Deputy CEO
National Association of Clean Water Agencies (NACWA)

Chris joined the National Association of Clean Water Agencies in 2001 and currently serves as the Association's Deputy CEO. He has nearly 25 years of experience working on a range of environmental issues for NACWA and the private sector.

Regulation of Derived Products for Agricultural Use

Chris Hornback
Deputy, CEO

NACWA: A Clear Commitment to Our Nation's Waters

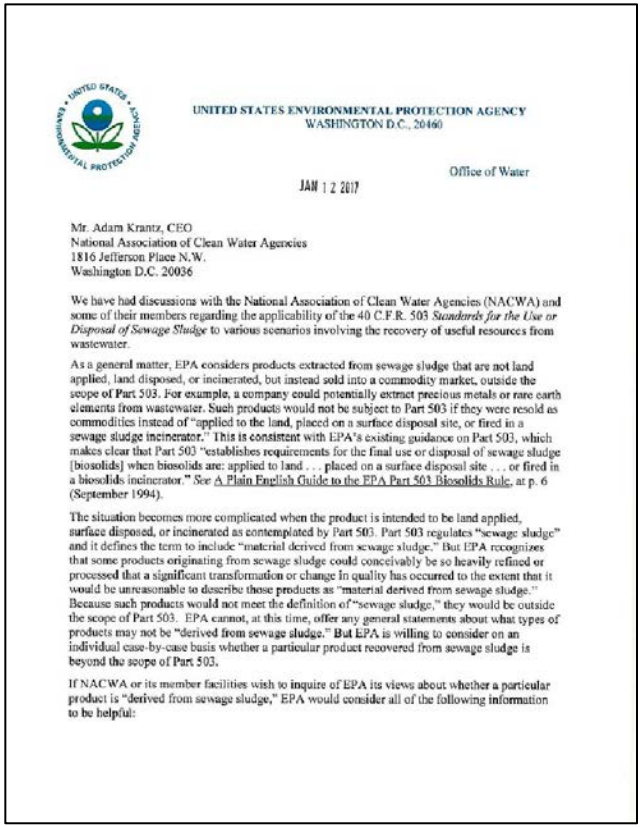
- National trade association for public wastewater & stormwater utilities in the United States
- Represent over 330 public utilities of all sizes from around the country
- Focused on legislative, regulatory, legal & communications advocacy on the full spectrum of clean water issues

Uncharted Territory?

- The “Utility of the Future” Mindset: Wastewater Treatment = Resource Recovery…BUT
  - How are PRODUCTS recovered from a waste treatment process regulated?
  - What if that waste treatment process is highly-regulated under a Federal statute like the Clean Water Act?
  - And what if that statute was written before the PRODUCTS were even conceived of and provides no pathway for those PRODUCTS to fall out of regulation?

Where we have been…

- Discussion at NACWA started in late 2011/early 2012
- NACWA engaged EPA and its attorneys in 2013 and provided a detailed legal rationale in 2014
- Discussions around product quality continued, with additional requests for more data/information
- January 2017 EPA Letter
  - PRODUCTS sold as commodities and not land applied, land disposed or incinerated = outside the scope of Part 503
  - Otherwise - Case by Case



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C., 20460

Office of Water

JAN 12 2017

Mr. Adam Krantz, CEO
National Association of Clean Water Agencies
1816 Jefferson Place N.W.
Washington D.C. 20036

We have had discussions with the National Association of Clean Water Agencies (NACWA) and some of their members regarding the applicability of the 40 C.F.R. 503 *Standards for the Use or Disposal of Sewage Sludge* to various scenarios involving the recovery of useful resources from wastewater.

As a general matter, EPA considers products extracted from sewage sludge that are not land applied, land disposed, or incinerated, but instead sold into a commodity market, outside the scope of Part 503. For example, a company could potentially extract precious metals or rare earth elements from wastewater. Such products would not be subject to Part 503 if they were resold as commodities instead of "applied to the land, placed on a surface disposal site, or fired in a sewage sludge incinerator." This is consistent with EPA's existing guidance on Part 503, which makes clear that Part 503 "establishes requirements for the final use or disposal of sewage sludge [biosolids] when biosolids are: applied to land . . . placed on a surface disposal site . . . or fired in a biosolids incinerator." *See* A Plain English Guide to the EPA Part 503 Biosolids Rule, at p. 6 (September 1994).

The situation becomes more complicated when the product is intended to be land applied, surface disposed, or incinerated as contemplated by Part 503. Part 503 regulates "sewage sludge" and it defines the term to include "material derived from sewage sludge." But EPA recognizes that some products originating from sewage sludge could conceivably be so heavily refined or processed that a significant transformation or change in quality has occurred to the extent that it would be unreasonable to describe those products as "material derived from sewage sludge." Because such products would not meet the definition of "sewage sludge," they would be outside the scope of Part 503. EPA cannot, at this time, offer any general statements about what types of products may not be "derived from sewage sludge." But EPA is willing to consider on an individual case-by-case basis whether a particular product recovered from sewage sludge is beyond the scope of Part 503.

If NACWA or its member facilities wish to inquire of EPA its views about whether a particular product is "derived from sewage sludge," EPA would consider all of the following information to be helpful:

Current Landscape

- Case by Case letter remains in place, though has not been tested

- Trump Administration Regulatory Reform Effort
    - NACWA urges regulatory revisions to create a clear ‘off ramp’ for derived products

- Office of Water – current leadership has been engaged on the issue; their legal team has been evaluating – other issues have taken priority

- Federal regulations are not the only obstacle to additional growth of struvite recovery at the nation’s water resource recovery facilities

NACWA

CELEBRATING FIFTY YEARS

OF CLEAN WATER SUCCESS

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Next Speaker

Dr. Rebecca Muenich
Assistant Professor, Arizona State University
Research Scientist, Sustainable Phosphorus Alliance

Becca is an Assistant Professor of Environmental Engineering at Arizona State University. Her expertise is in watershed and environmental modeling to evaluate trade-offs in management and engineering solutions for water and water quality.

Phosphorus Forum:
September 30, 2020

Under the Radar

The Need for and Approach to Develop a National Animal Feeding Operations Inventory

Rebecca Logsdon Muenich

Sustainable Phosphorus Alliance

Ira A. Fulton Schools of Engineering
Arizona State University

MUENICH LAB GROUP

Background

Background

- The desire for meat, dairy and other animal products has increased over time (worldwide)
- Trend towards larger operations
- Operations concentrated with respect to animals per farm **and** in space
- These large farms or clusters of large farms can produce the same amount of waste per year as cities

Background

- Known impacts of large animal operations
  - Air quality issues
  - Water quality (nutrients, pathogens, metals, ARG/B)
  - Ecosystems
  - Human health
  - Environmental justice
  - More…

Background

But these operations are also a great place to recover organic matter, nutrients, and even water!

Goal

Create a national inventory of ALL regulated and non-regulated animal feeding operations

Background - Regulatory

- Animal feeding operations vs. CAFOs?
  - Animals confined for 45 days or more in a 12-month period
  - Crops, vegetation not sustained in normal growing season over any portion of lot facility
  - Concentrated Animal Feeding Operation (CAFO)
    - *Meets above AND meets animal size numbers* or actively discharges via pipe, ditch, etc. to WOTUS

Background - Regulatory

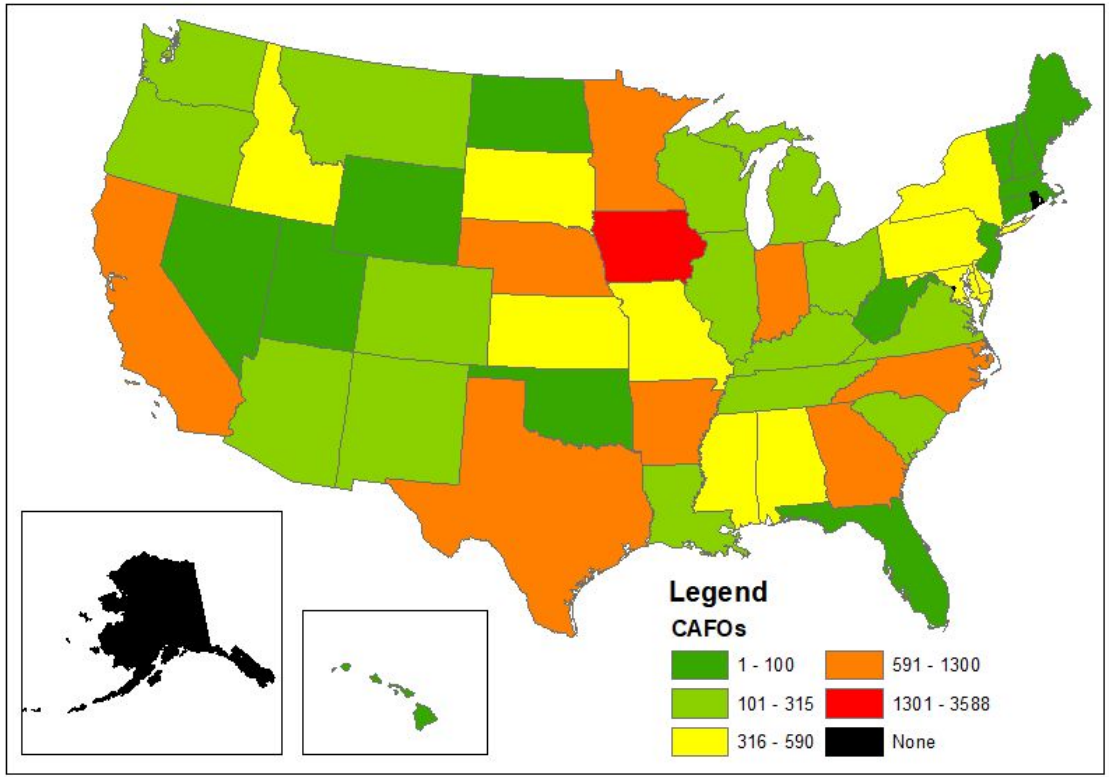
- Example CAFO numbers

Animal Sector	Size Thresholds (number of animals)		
	Large CAFOs	Medium CAFOs[1]	Small CAFOs[2]
cattle or cow/calf pairs	1,000 or more	300 - 999	less than 300
mature dairy cattle	700 or more	200 - 699	less than 200
veal calves	1,000 or more	300 - 999	less than 300
swine (weighing over 55 pounds)	2,500 or more	750 - 2,499	less than 750
swine (weighing less than 55 pounds)	10,000 or more	3,000 - 9,999	less than 3,000
horses	500 or more	150 - 499	less than 150
sheep or lambs	10,000 or more	3,000 - 9,999	less than 3,000
turkeys	55,000 or more	16,500 - 54,999	less than 16,500
laying hens or broilers (liquid manure handling systems)	30,000 or more	9,000 - 29,999	less than 9,000
chickens other than laying hens (other than a liquid manure handling systems)	125,000 or more	37,500 - 124,999	less than 37,500
laying hens (other than a liquid manure handling systems)	82,000 or more	25,000 - 81,999	less than 25,000
ducks (other than a liquid manure handling systems)	30,000 or more	10,000 - 29,999	less than 10,000
ducks (liquid manure handling systems)	5,000 or more	1,500 - 4,999	less than 1,500

[1]Must also meet one of two "method of discharge" criteria to be defined as a CAFO or may be designated.
[2] Never a CAFO by regulatory definition, but may be designated as a CAFO on a case-by-case basis.

Background - Regulatory

State CAFO numbers*

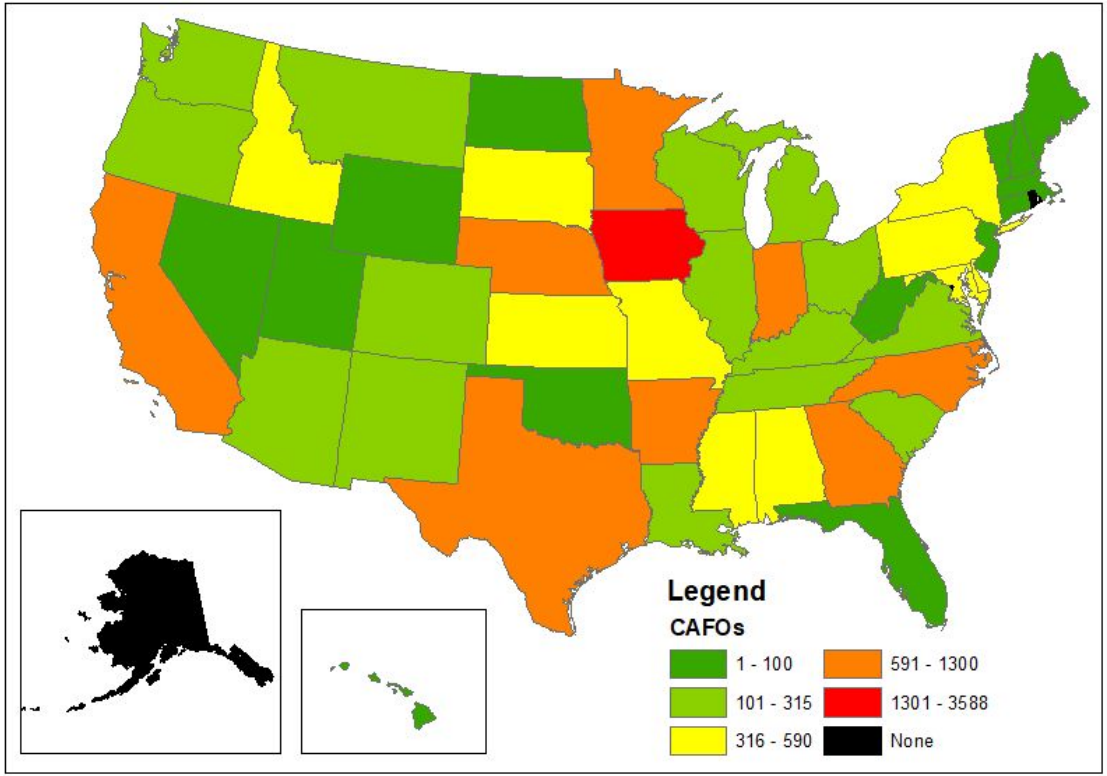


*Per federal definition of a Large CAFO

Regulatory Complexities

- CAFOs are regulated by National Pollutant Discharge Elimination System (NPDES) under the Clean Water Act
  - In 40 CFR Part 122 and 40 CFR Part 412
- Recent rule changes and interpretations of federal CAFO regulations has led to more focus and emphasis at the state and local level
  - Not all CAFOs are required to get NPDES permits

Regulatory Complexities

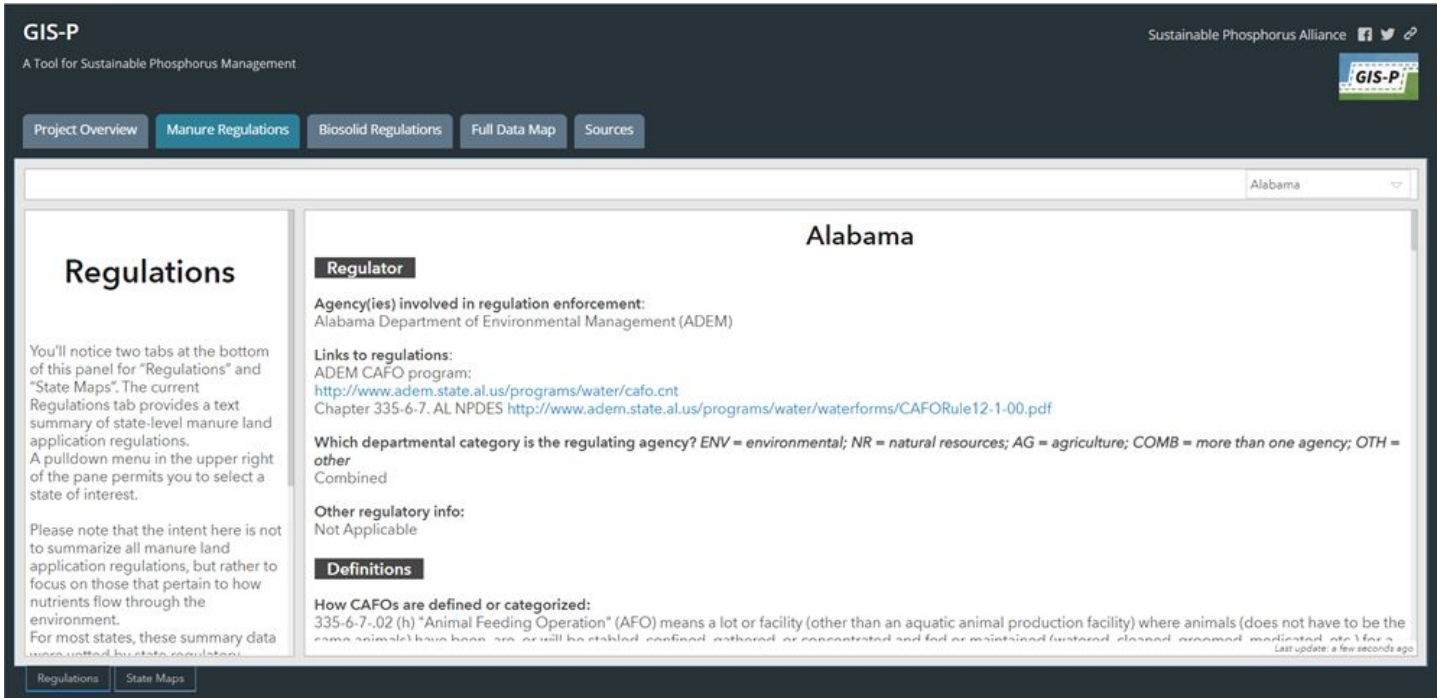


262 CAFOs in Ohio, 30 with NPDES permits

Regulatory Complexities

These matter because it controls what data are publicly available…this is why there is not a nationwide inventory of CAFOs

Regulatory Complexities



https://phosphorusalliance.org/gis-p

Rauh E, Muenich RL, Scholz M. Policy Landscape for Recycled Fertilizers in the US: Implications for land application of biosolids and CAFO manure. In review.

Sustainable Phosphorus Alliance

Other Reg. Considerations

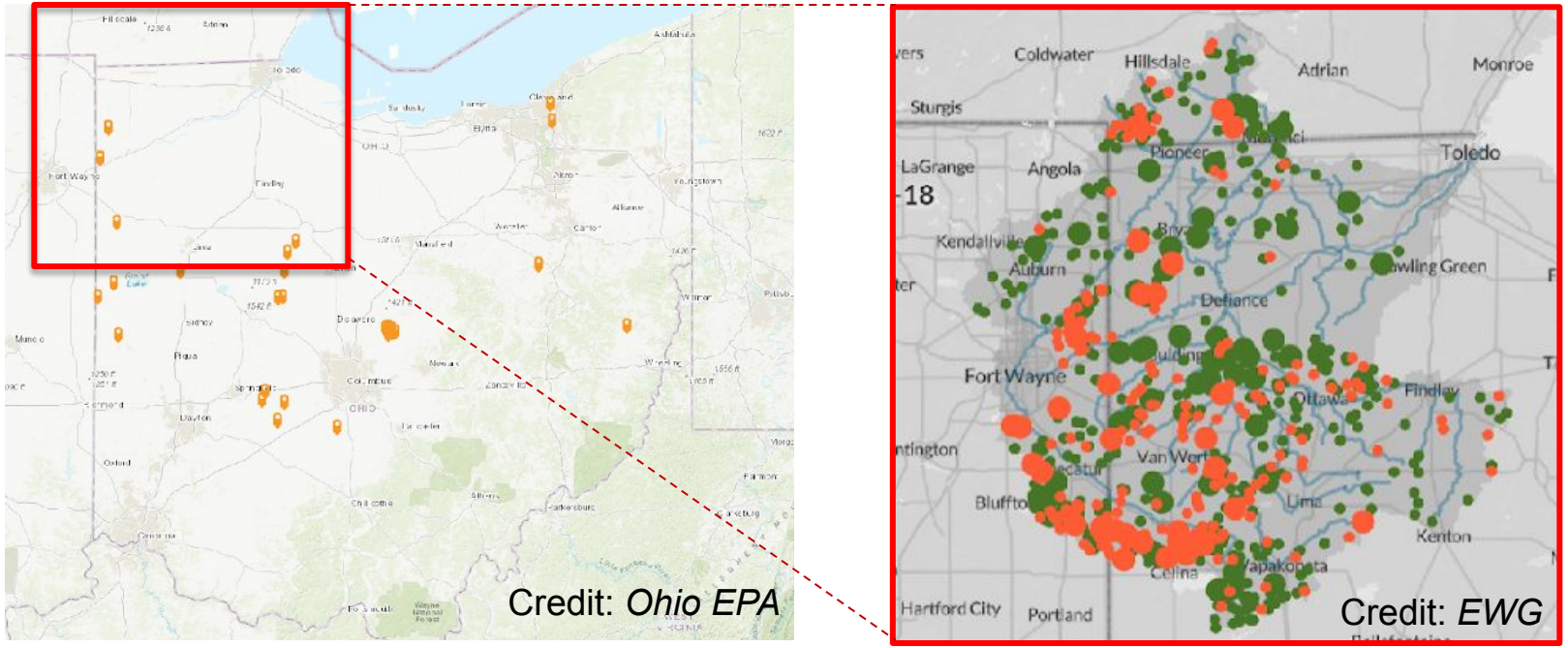
- Many farms may operate just below Large CAFO animal numbers to avoid regulation
  - In this case, a state-provided list of regulated operations would miss these
- Sometimes it's not about the *number* of animals, but:
  - Number of animals per land available
  - Animals/farm per sensitive environmental conditions
  - Number of farms within certain vicinity

…So we need maps of <u>all</u> farms

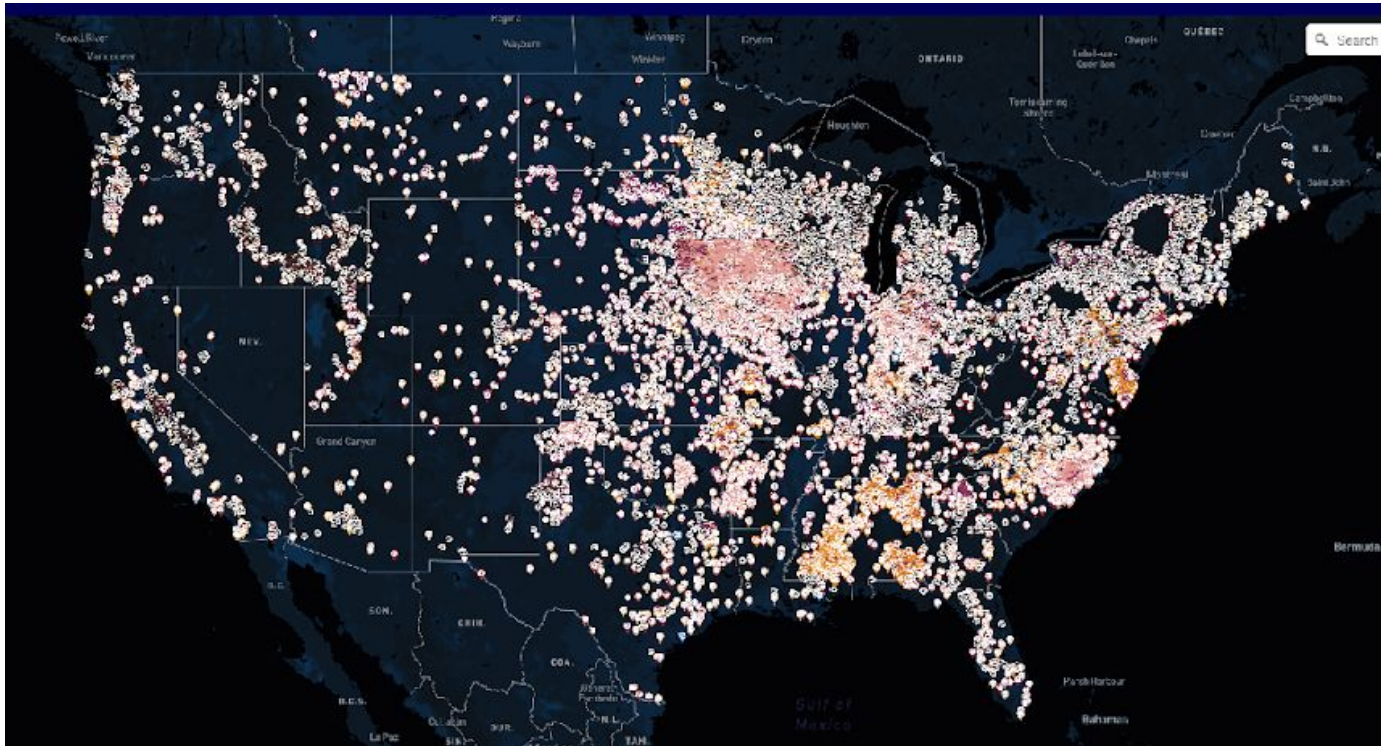
Current Approaches to Mapping

Manual Approaches

Digital Image Review by Humans



Citizen Science

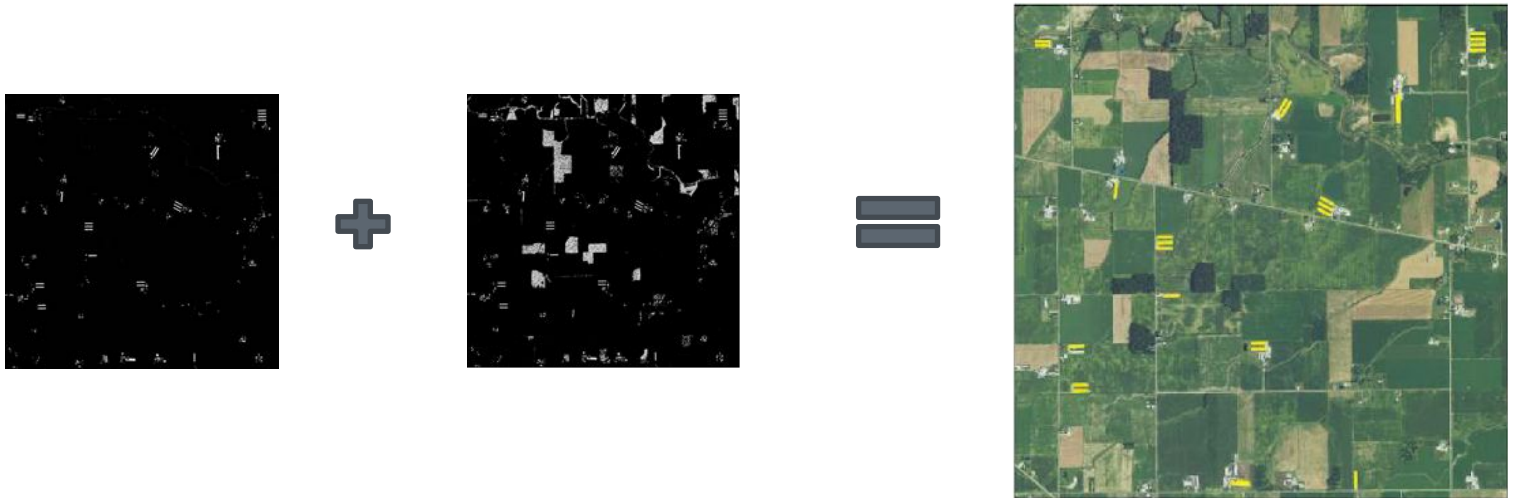


Credit: Project Counterglow https://map.counterglow.org/

Automatic Approaches

Approach – Remote Sensing

- Combine NDVI (vegetation information) with LiDAR (height data) to identify barns
- Use object-oriented classification to create barn shapes



Long CM, **Muenich RL**, Scavia D. Using Remote Sensing to Identify Locations of Large Animal Operations in the Maumee River Watershed. International Association for Great Lakes Research Annual Conference, Toronto, Ontario, Canada, June 18-22, 2018.

Approach – Deep Learning (AI)

nature sustainability

SUPPLEMENTARY INFORMATION

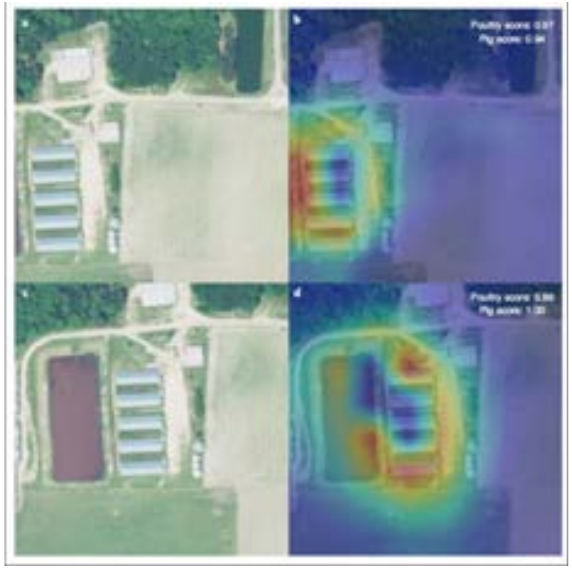
https://doi.org/10.1038/s41893-019-0246-x

In the format provided by the authors and unedited.

Deep learning to map concentrated animal feeding operations

Cassandra Handan-Nader[1,2] and Daniel E. Ho[1,2,3]*

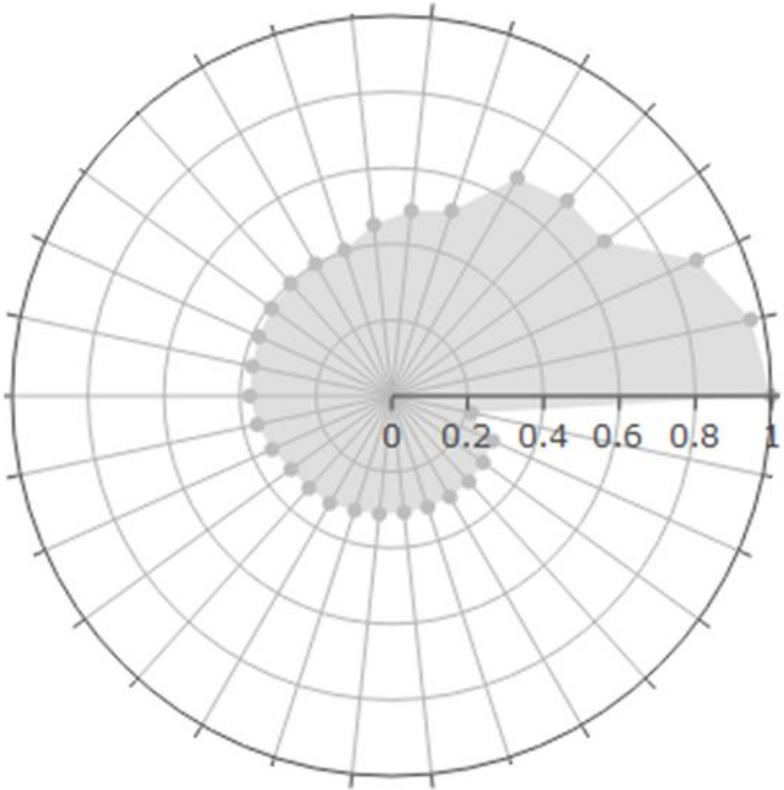
[1]Stanford Law School, Stanford University, Stanford, CA, USA. [2]Department of Political Science, Stanford University, Stanford, CA, USA. [3]Stanford Institute for Economic Policy Research, Stanford, CA, USA. *e-mail: dho@law.stanford.edu



Stanford: Handan-Nader and Ho (2019)

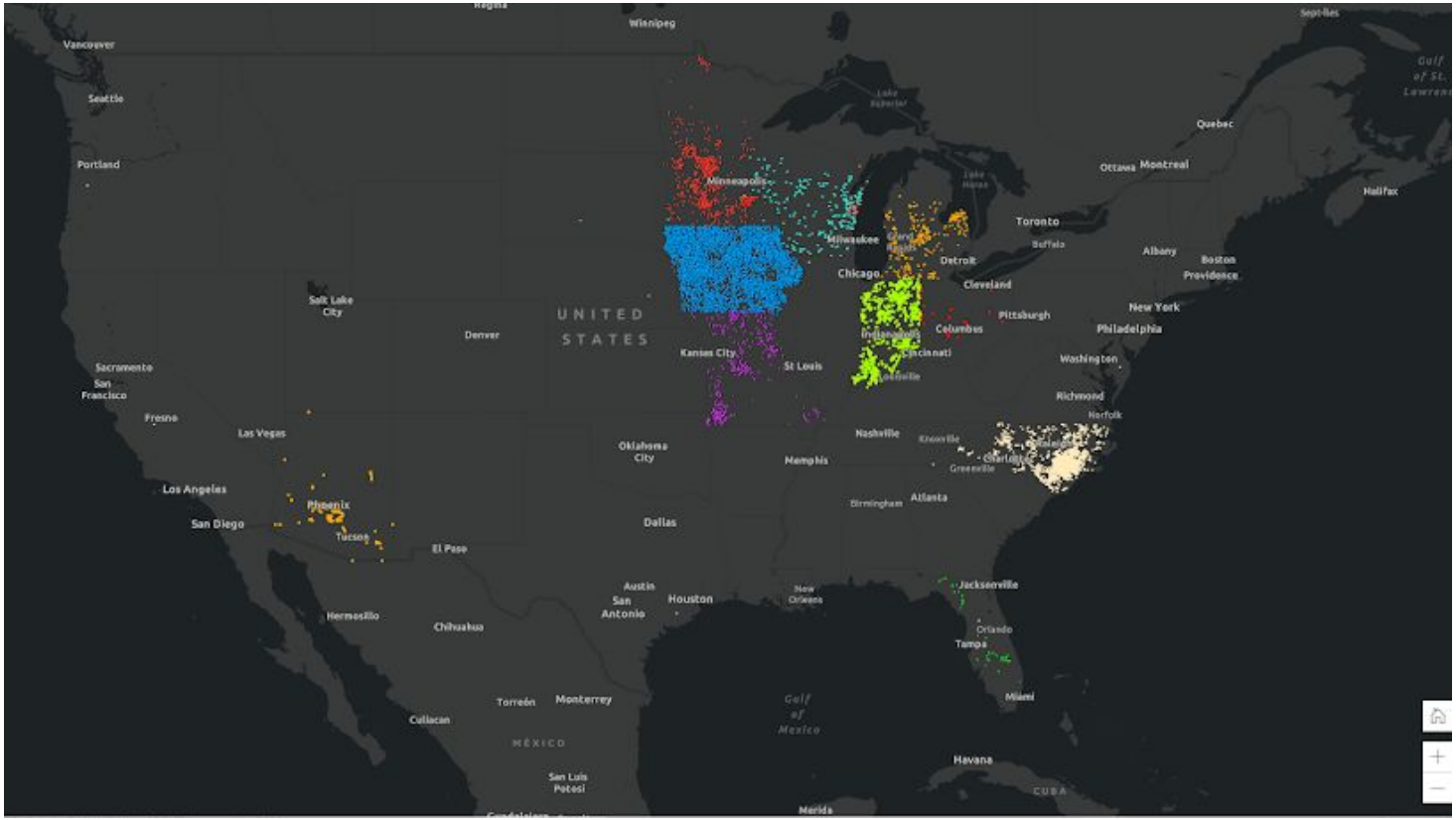
Approach – Machine Learning (AI)

- Transitioning to new data for machine learning algorithms that allow for assessment across AFO types and regions
  - e.g. not specific to one AFO animal type or one region



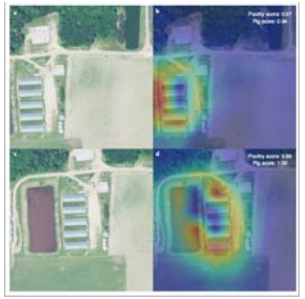
Continuing the Work

Database of Known CAFOs

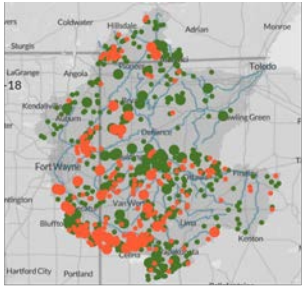


Unfunded Working Group

- Teaming up with other groups to improve methods and move towards a nationwide database
  - Stanford Group (Dr. Daniel Ho's Lab)
  - Environmental Law & Policy Center
  - Others? Please contact us if interested
- Comparing methods, sharing resources, combining efforts



Stanford: Handan-Nader and Ho (2019)



Environmental Law & Policy Center

Sustainable Phosphorus Alliance

Concluding Thoughts

- **Animal agriculture accounts for a large portion of recoverable P**
- **To be able to accurately account for them in environmental models or identify recovery options, *we need to know where they are***
- **Methods available and motivated group working on it – need funding**

Agenda (all times ET)

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2:05-2:25	Breakout rooms
2:25-2:45	Closing discussion & raffle!

Panel Discussion

Mr. Jeff Dawson, CEO, Renewable Nutrients
Jeff brings to Renewable Nutrients more than 15 years of experience in the investment and capital markets industry. As CEO, Jeff is responsible for overseeing the development and strategic planning of the company, including market exploration and opportunities for expansion.

RENEWABLE NUTRIENTS

QUICK WASH®

- Renewable Nutrients is commercializing a new combined Phosphorus & Ammonia recovery technology.
- The new technology is currently under the design construction phase at a large midwest US municipal waste facility.
- The new Renewable Nutrients technology was recently awarded the national FLC award for excellence in technology transfer.
- Renewable Nutrients is also expanding into the separations market by creating and manufacturing its own technical membrane for use in the new joint Phosphorus and ammonia technology.

Panel Discussion

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Mr. Rick Johnson, Director of Commercial Development, Applied Environmental Solutions
Prior to founding AES, Rick retired from a growing tertiary treatment technology provider focused on phosphorus recovery and has held a number of senior level research and commercial development positions with several Fortune and Global 500 Corporations. In addition, he owns and operates a small family farm in NE Ohio and is a graduate of the US Naval Academy.

Dr. Aaron Fisher, Technology & Innovation Manager, Water Research Foundation.
Aaron is responsible for identifying and evaluating innovative water technologies for their suitability to the LIFT program. He previously worked as a contractor to the U.S Department of Energy, authoring the interagency document: Energy-Positive Water Resource Recovery Facility Workshop Report and founded a start-up commercializing polymer-based lithium batteries.

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Next Speakers

Mr. Robert Van Spingelen, Director of Business Development EMEA, Ostara

Robert has over 20 years of experience in the global turf, landscaping and horticulture market, most recently leading product and brand development in the Turf & Landscape segment at ICL Group after its acquisition of the Scotts Miracle-Gro Company. He has managed global sales for B2B clients in Southern Europe, Scandinavia, the Mediterranean, Japan and Africa

Mr. Matt Kuzma, Vice President, Nutrient Recovery Solutions, Ostara

Matt has more than 25 years of water/wastewater management experience, heavily focused on resource recovery technologies. Companies range from large multinational corporations such as Veolia, to technology start-ups in both North America and Europe. He is currently Ostara's commercial lead for deployment of nutrient recovery technologies at Ostara.

Resources Reimagined™

Enhanced Phosphate Fertilizer Production through Nutrient Recovery

Presented at:
Sustainable Phosphorus Alliance – Annual Phosphorus Forum 2020

INSIGHT

We may be able to substitute nuclear power for coal, and plastics for wood, and yeast for meat, and friendliness for isolation – but for phosphorus there is neither substitute nor replacement.

Isaac Asimov, Author and professor of Biochemistry, Boston University

Take. Make. Dispose. The Linear Phosphorus Cycle Today

How we manage this indispensable & limited available nutrient will have a direct impact on global water resources and our collective ability to feed the growing population.

OSTARA

Recover. Regenerate. Reimagine. The Value-Added Future of Phosphorus & Nitrogen.

- Pearl Technology Implementation
- Customer Offtake Revenue
- Reduced Operational Costs

Crystal Green from PEARL is :

- 99% pure mineral
- <1 % organic carbon
- No heavy metals
- No organic contaminants

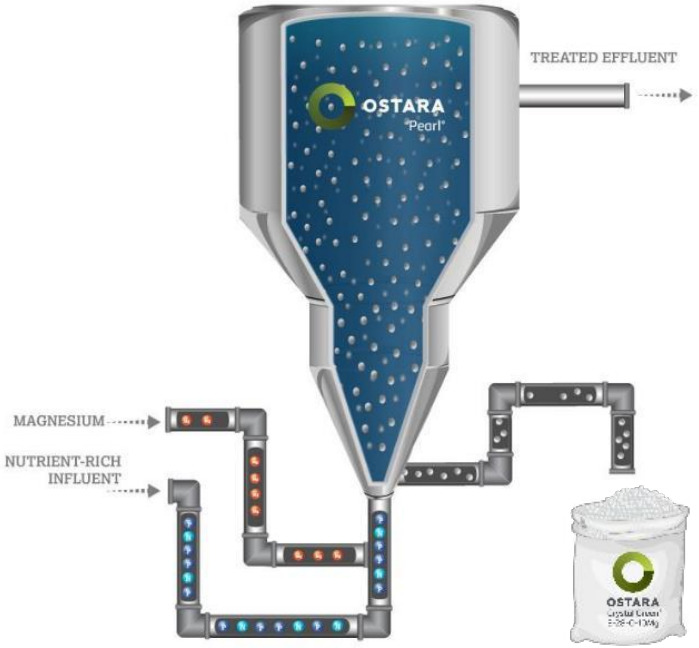
Triple Bottom Line:

- ✓ Environmental Impact
- ✓ Social Impact
- ✓ Economic Impact

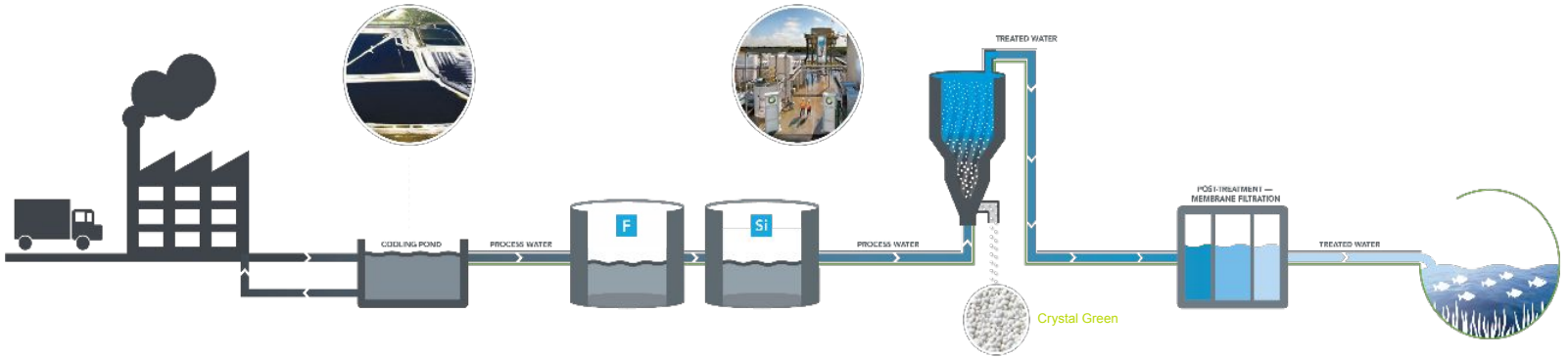
Product Technology: Pearl Process

Ostara recovers struvite (magnesium ammonia phosphate) – the core of Crystal Green based products - from process water using patented Pearl technology

- Phosphorus, nitrogen, and magnesium are crystallized as a 99% pure form of struvite from nutrient rich water sources in a pH-controlled environment.



Phosphate Production Site Closure Scenario: Turning A Cost Center Into A Profit Center



1 **Process Water Influent**

Phosphogypsum ponds can contain up to 2 or 3 billion gallons of process water. Before it can be reused or discharged, water must be treated to raise pH levels and to address the dilute mixture of phosphoric, sulfuric, and fluosilicic acids.

2 **Pre-Treatment FLORIDE & SILICA REMOVAL**

Ostara's pre-treatment process significantly reduces the volume of sludge that requires handling

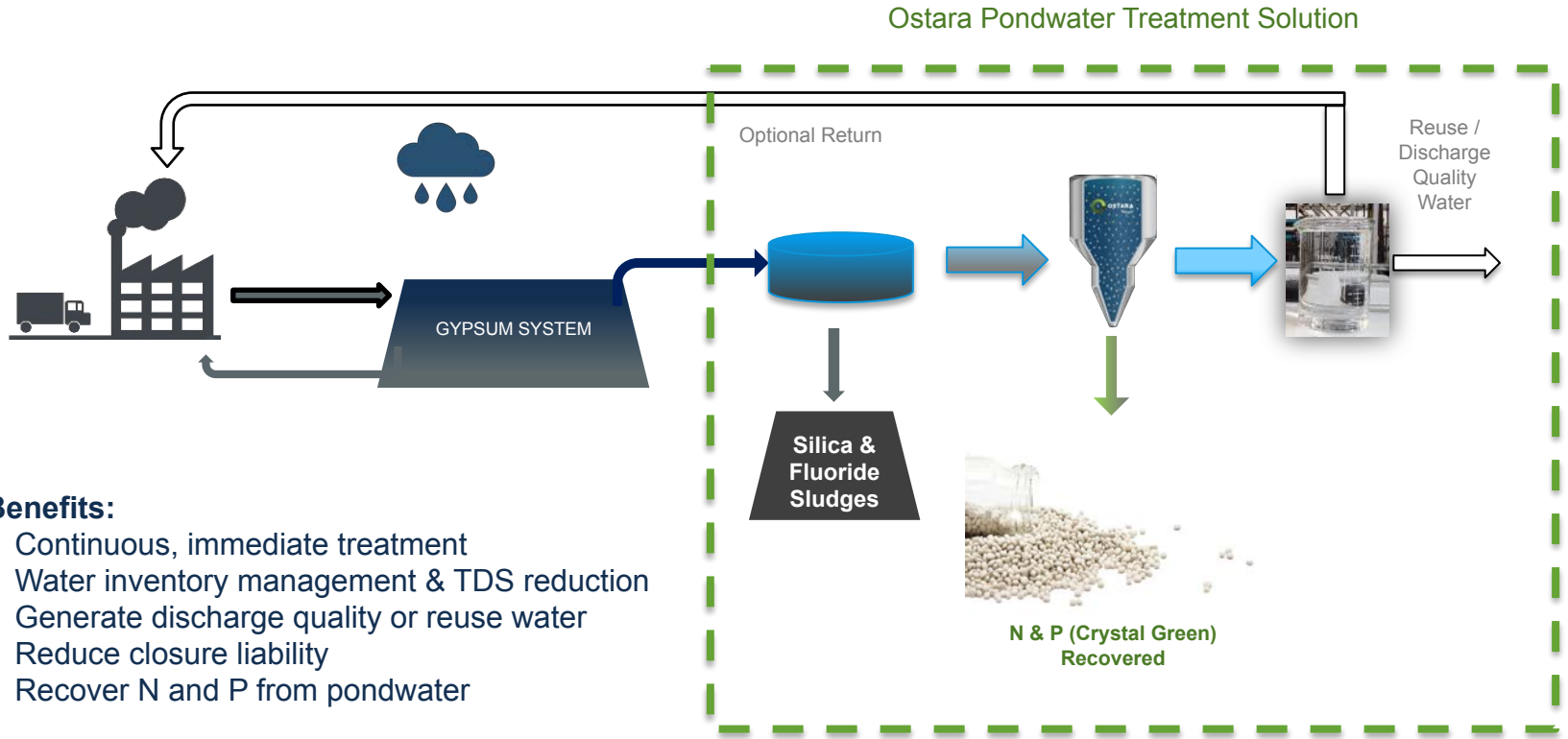
3 **Nutrient Recovery PHOSPHORUS & NITROGEN REMOVAL**

Ostara's proprietary Pearl® technology uses a fluidized bed crystallization reactor to precipitate phosphorus and ammonia from used water streams by adding magnesium. Up to 65% of process water P2O5 can be recovered

4 **Post-Treatment MEMBRANE FILTRATION**

The Ostara solution consistently produces water that exceeds regulatory requirements, suitable for re-use within the plant or discharged to receiving waters.

Phosphate Production Site Operating Scenario: Production Facility Integrated with Ostara Treatment



Benefits:

- ✔ Continuous, immediate treatment
- ✔ Water inventory management & TDS reduction
- ✔ Generate discharge quality or reuse water
- ✔ Reduce closure liability
- ✔ Recover N and P from pondwater

Discharge Water Quality Exceeding Regulatory Requirements

A cost-effective solution for managing pond water inventories and solids disposal while producing water that meets exacting regulatory challenges.

Parameter	Process Water Influent	Pre-Treatment (F & Si removal)	Pearl Effluent (P & N removal)	Post-Treatment* (membrane filtration)
pH	1.4	6.7	8.1	6.0-8.5
Conductivity (uS/cm)	43,000	32,000	29,000	300
TSS (mg/L)	NA	NA	NA	<1
Ammonia (mg/L as NH_3-N)	1,000	1,000	200	<1
Fluoride (mg/L)	9,000	100	100	<5
Phosphorus (mg/L)	12,000	2,000	400	<3

* Post-Treatment discharge quality depends on NF/RO installation used and depends on the local regulatory requirements

Proven Commercialization of Phosphogypsum Process Water Treatment

Experience:

- ✔ Successfully commissioned & operated full-scale demonstration nutrient recovery facility at operational fertiliser production facility

Demonstrated Benefits:

- ✔ Proactively reduce pond water inventory
- ✔ Strong regulatory, social responsibility and environmental benefits
- ✔ Eliminate double-liming closure costs

Triple Benefits of Ostara Solution

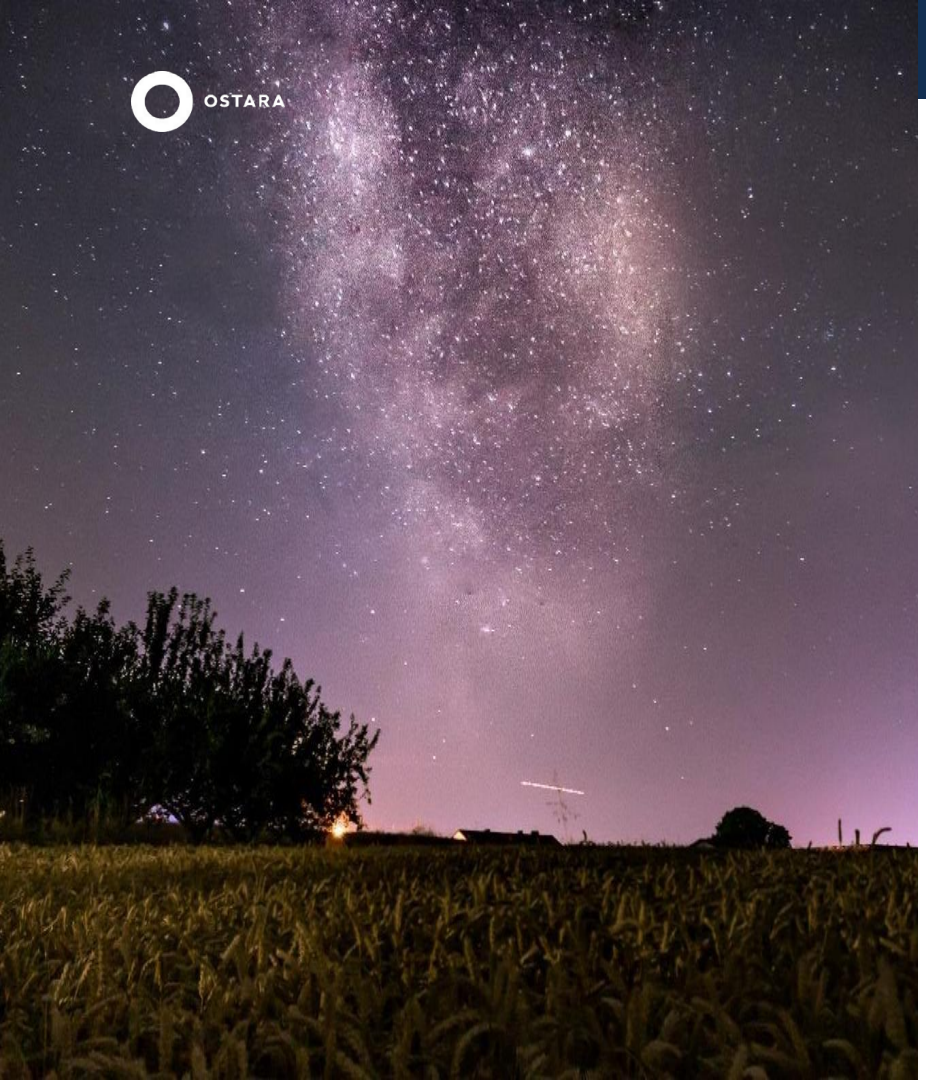
Status: Plant Closure

- ✔ Proactively & safely manages pondwater volumes and gypsum stack leachate
- ✔ Reduce sludge volumes
- ✔ Proactively meets water discharge quality standards
- ✔ Eliminate double liming closure costs
- ✔ Recover N and P from pond water with guaranteed offtake agreement

Status: Operational

- ✔ Continuous & immediate treatment solution
- ✔ Reduce water inventory management & total dissolved solids
- ✔ Produce discharge quality or re-use water
- ✔ Reduce closure liability
- ✔ Recover N and P from pond water with guaranteed offtake agreement

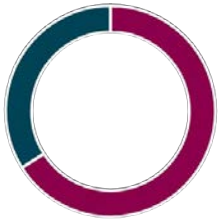
Photos: Demonstration facility at Mosaic, Riverview



EU “Green Deal” Leading the Way

- Cadmium Limits and other heavy metal limits
- Mandated Recovery of up to 50%
- Amendments to regulations adding recovered phosphate salts to the fertilizer regulations (CMC 12)
- Bans on Microplastics (polymer coatings)
- Cutting CHG emissions,
  Emergy as value, lower CO_2footprint

Consumers Trends Are Changing Food & Farming Practices



66% of global consumers are willing to pay more for sustainable goods (Nielsen, 2016)

80% of millennials (born 1975-1995), are keen to learn more about how their food is produced (Nielsen, 2016)

73% of consumers say they would definitely change their consumption habits to reduce their environment impact (Neilson, 2016).

INSIGHT

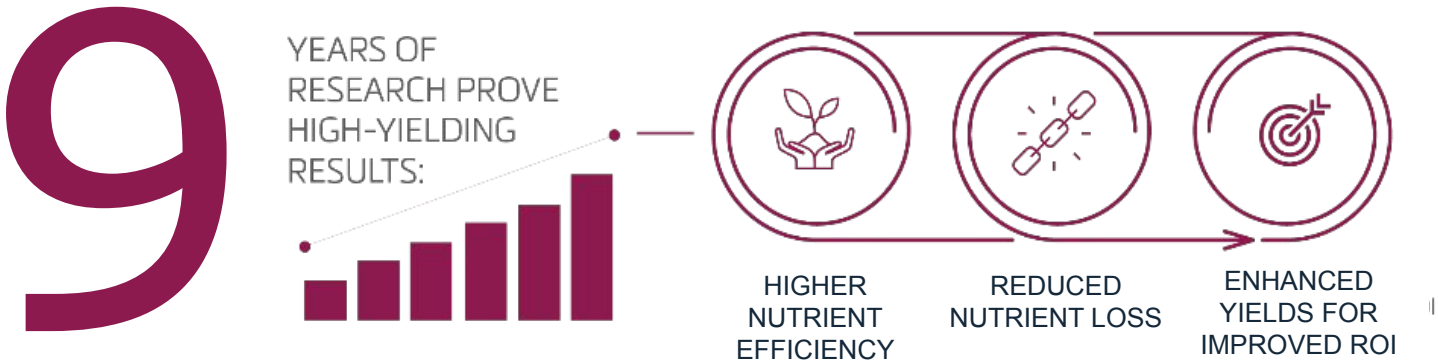
“My son will be the 5th generation [farmer], but none of that will be possible if we don’t utilize new knowledge and products that help us better use our resources.

It’s not just fertilizer.”

Canadian Canola Grower, Crystal Green Customer

Validated Research Key to Proving Value

Crystal Green is high-quality struvite, made with sustainably recovered phosphorus, nitrogen and magnesium in one powerful continuous release granule (5-28-0-10Mg). Backed by more than 9 years of university and independent field trials globally.



OSTARA
CrystalGreen®

Crystal Green is high-quality struvite made with recovered nutrients (5-28-0-10Mg) and backed by more than 9 years of university and independent field trials globally.

- Phosphate fertilizer
- Root-Activated™ (Citrate Soluble)
- Crystalline, granular
- Lowest Salt Index of any P source

Putting Plants In Control: Solubility Drives Improved Nutrient Use Efficiency

How Does Crystal Green Dissolve?

Mined from water, struvite (magnesium ammonium phosphate) is a phosphate mineral that is not soluble in water, but rather in acidic solutions.

4% Water Soluble
96% Citrate Soluble

Crystal Green

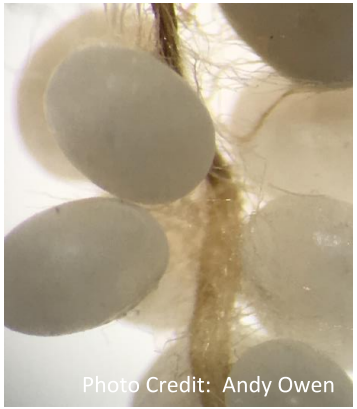
90% Water Soluble
10% Citrate Soluble

MAP

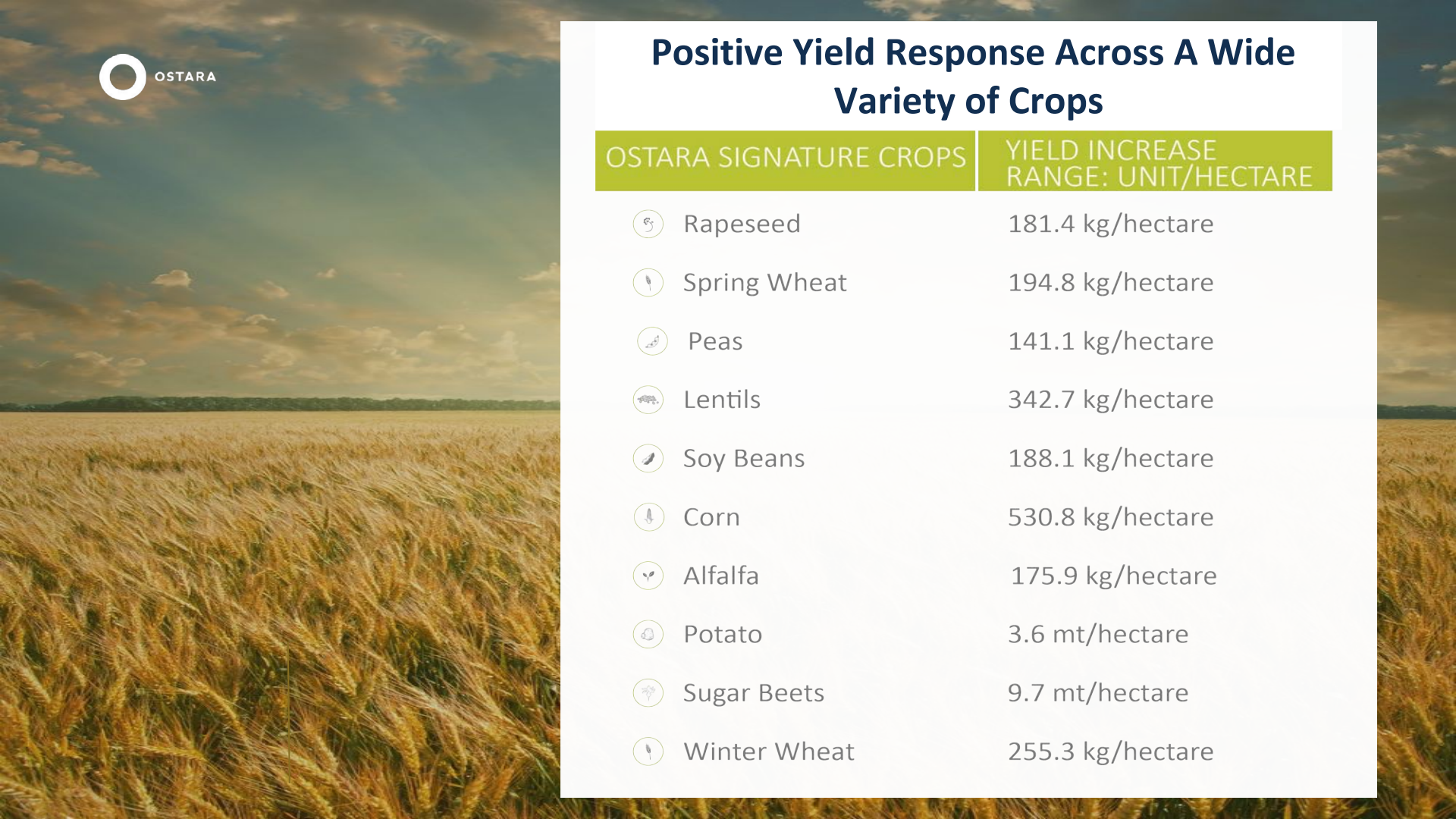
Solubility and Low Salt Ensure Seed & Root Safety; Optimized Yield

Canola root mining into Crystal Green after 7 days.

Turf roots growing directly into Crystal Green



Turf seeds growing on substrate of 100% Crystal Green.



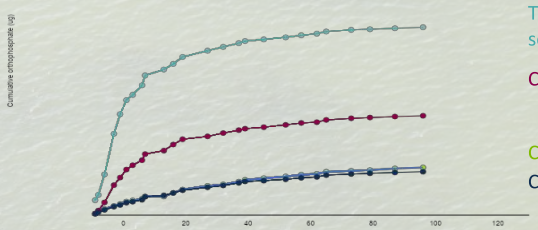
Positive Yield Response Across A Wide Variety of Crops

OSTARA SIGNATURE CROPS	YIELD INCREASE RANGE: UNIT/HECTARE
Rapeseed	181.4 kg/hectare
Spring Wheat	194.8 kg/hectare
Peas	141.1 kg/hectare
Lentils	342.7 kg/hectare
Soy Beans	188.1 kg/hectare
Corn	530.8 kg/hectare
Alfalfa	175.9 kg/hectare
Potato	3.6 mt/hectare
Sugar Beets	9.7 mt/hectare
Winter Wheat	255.3 kg/hectare

OSTARA

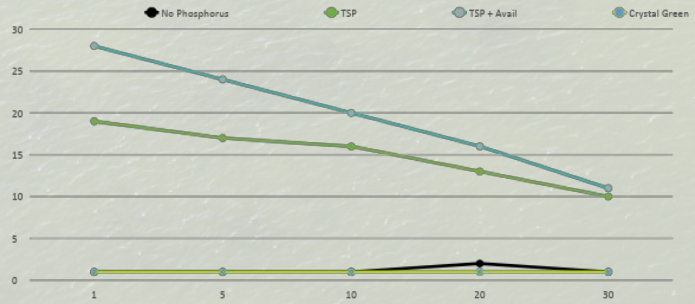
CRYSTAL GREEN SOLUBILITY: **REDUCES ENVIRONMENTAL IMPACT OF RUNOFF**

Reduce Leachate from Phosphorus



Cumulative Orthophosphate in Leachate as Affected By P Source Auburn University 2014

Eliminate Surface P Runoff



Concentrations of phosphorus in runoff during a 30-minute rainfall event after receiving water soluble (TSP) phosphorus, slowly available (Crystal Green) phosphorus and a fertilizer additive (TSP+Avail). Loddington, UK P-Link Project

Thank you

Ostara Nutrient Recovery Technologies Inc.
690 - 1199 West Pender Street
Vancouver, BC V6E 2R1

mkuzma@ostara.com
rvanspingelen@ostara.com

ostara.com | crystalgreen.com

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2:05-2:25	Breakout rooms
2:25-2:45	Closing discussion & raffle!

Breakout Groups

You will be split into rooms of 7-8 for 20 minutes.

Please identify a facilitator from among your group.

Tasks:

1. Introductions: Name, affiliation, very short description of area of interest, and what is the first thing you will do after a covid vaccine?
2. Identify as a group the **most provocative idea you've heard today** regarding nutrient recovery and reuse? Discuss and vote.
3. Try to develop **forward action items** to support this idea. Think about who needs to be involved, how they could be motivated, where the money would come from, barriers and opportunities, how the conference attendees and the Sustainable Phosphorus Alliance might help.
4. Take notes and **paste answers to #2 and #3 in the chat box**.

Report Out

1. What did you vote your **most provocative idea**?
2. What are your **forward action items**?

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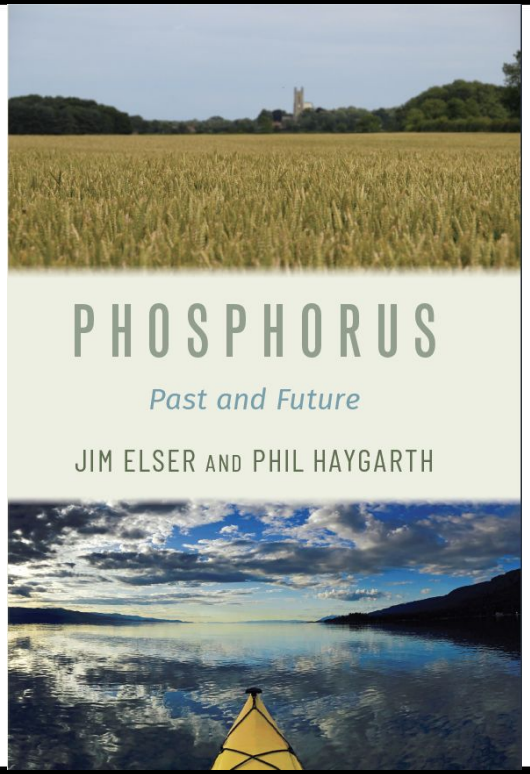
Raffle!


PHOSPHORUS
Past and Future
JIM ELSER AND PHIL HAYGARTH


ENTER TO WIN!

Concluding Remarks: Don't forget Day 2!

12:00-12:20	Welcome from the Alliance (Drs. Jim Elser and Matt Scholz)
12:20-12:40	Dr. Don Boesch, Professor and President Emeritus, University of Maryland Climate Change and Coastal Eutrophication
12:40-1:00	Mr. Kerry McNamara, CEO, OCP North America Perspective on Phosphorus Sustainability
1:00-1:45	Dr. Jon Winsten, Agricultural and Environmental Economist, Winrock International Pay-for-Performance Program for Nutrient Pollution Mitigation
1:45-2:05	Drs. Carl Bolster and Barret Wessel, USDA-ARS Phosphorus Transport Modeling Group Report
2:05-2:25	Breakout rooms
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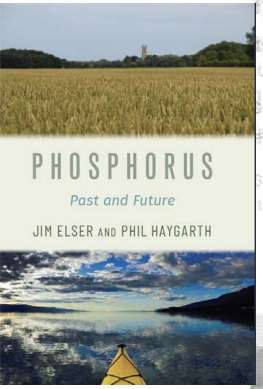
OCP

OSTARA

https://phosphorusalliance.org/phosphorus-forum/

Concluding Remarks: Day 1



- animals, people, & crops segregated

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

Thanks for coming!

Sustainable Phosphorus Alliance

PhosphorusAlliance.org