



Circular Sanitation

Urine Recycling as a Solution to Decarbonizing Cities and Agriculture

JOHN LANSING, PAE | PAT LANDO, RECODE

Agenda



01

The broken
nutrient
cycle



02

From urine
back to
fertilizer



03

Three-drain
plumbing



04

Existing and
future
applications

London in the 1800s

The "Twycliffe" Patent Syphon W.C. Closet Basin.

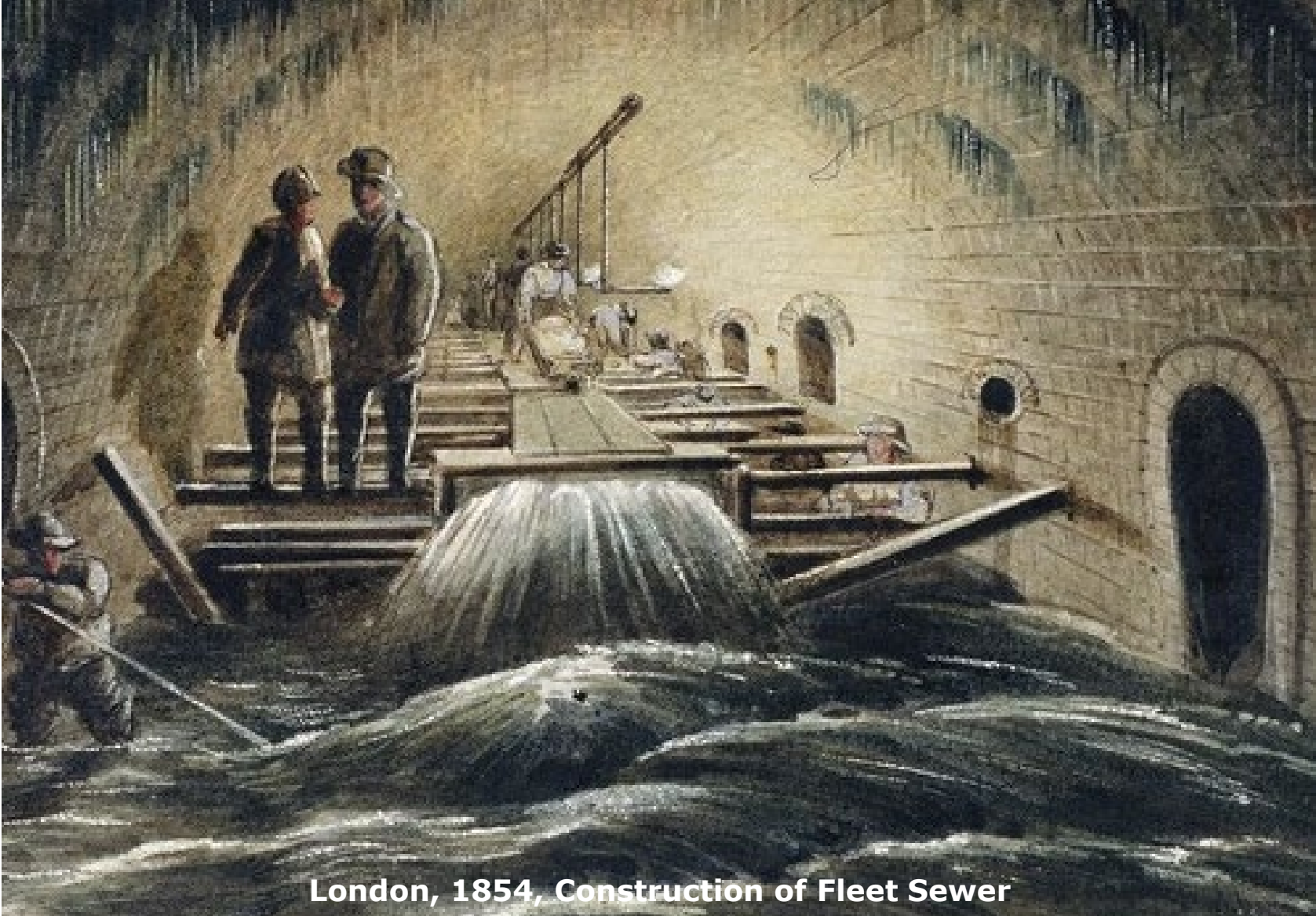


Combining
W.C. BASIN,
URINAL
and
SLOP SINK.

Made
in
ROYAL
C. V.
PEARL
and
IVORY
Porcelain.

THE
TWYCLIFFE
SYPHON
Patent

No. 25—COMPLETE, including Porcelain Basin with Slop Top (see No. 4, page 9.) and Trip in One piece, "Curiethian" Pattern, in Relief, decorated Blue and Gold (see No. 25, page 9.) with Paper Box to match; Brass Connections to Siphon Pipe; Patent Porcelain-Metal Wiped Joint to Outlet and Double Lead Band (unattached); Washery Basin, Slop Quality, with Flap and Brass Brackets, No. 13 Cistern with Porcelain Coating, "Curiethian" Pattern, in Relief, decorated Blue and Gold to match Basin and Brass Brackets; Brass Flush Pipe, 5 ft., and Clogs; Pendant Pull with Knob, 6 1/2 x 1 1/2 in. With Basin, Paper Box and Cistern, "Curiethian" Pattern, in Relief, not decorated. 6/12 1/2 0.



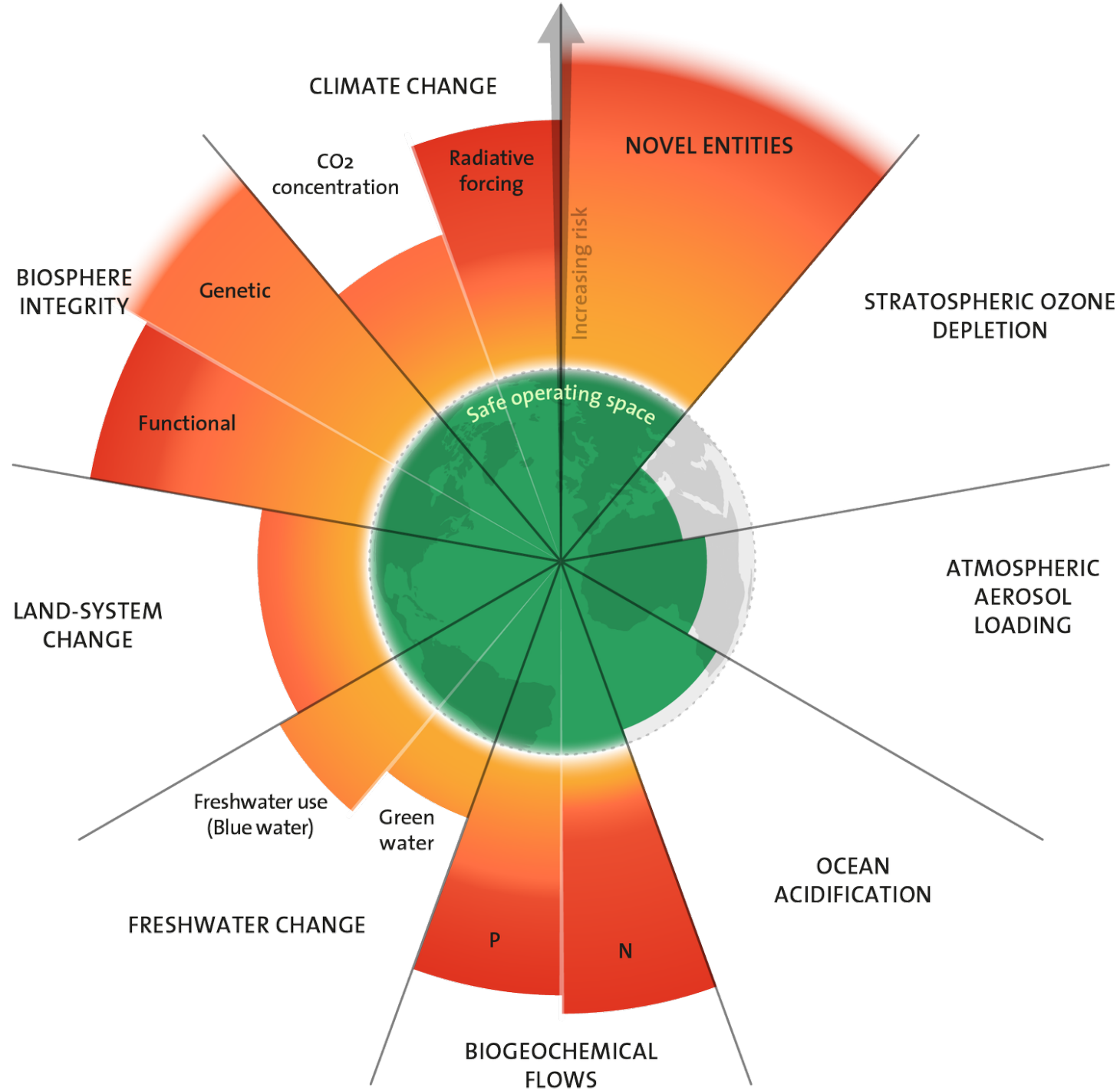
London, 1854, Construction of Fleet Sewer

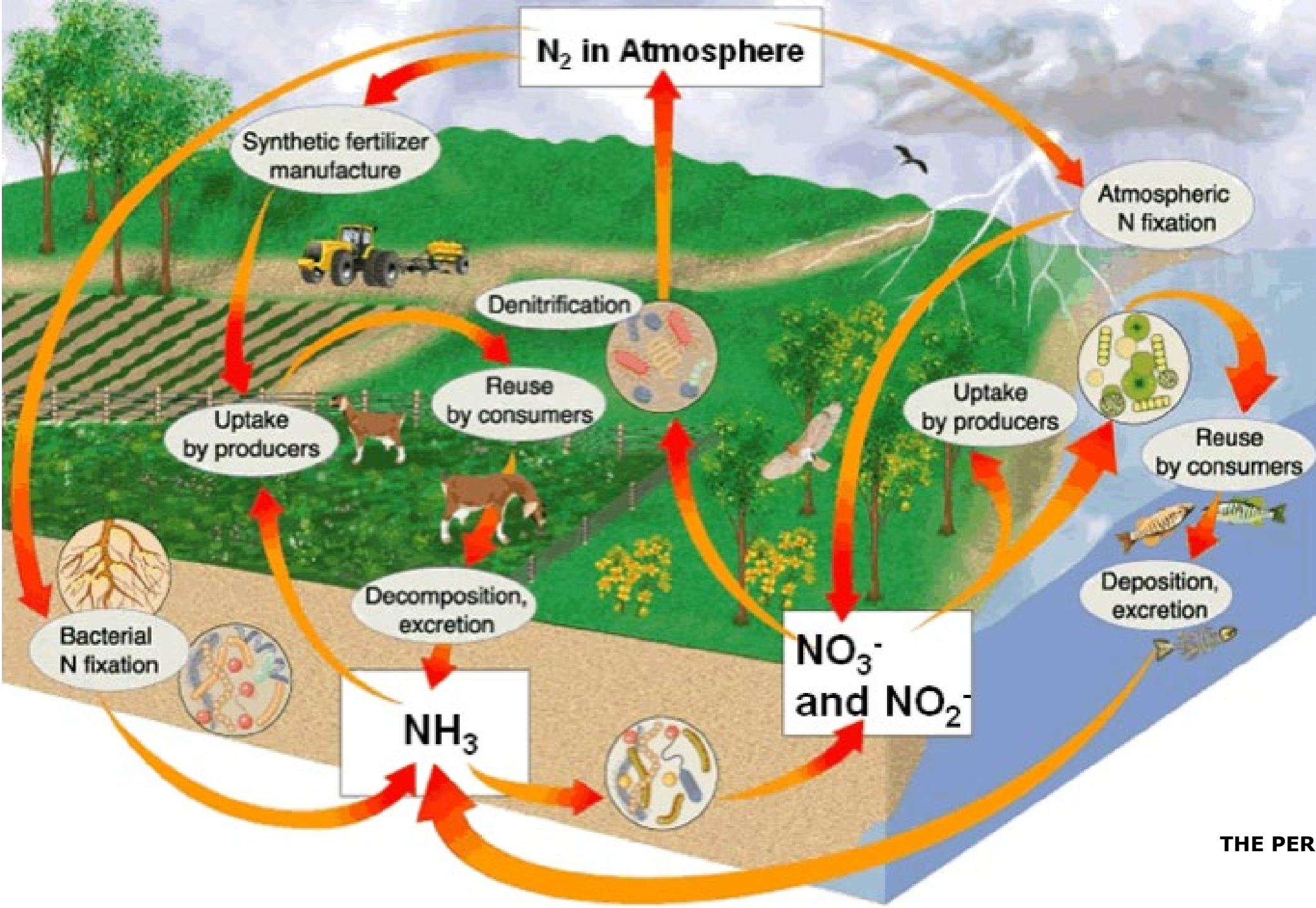
Agricultural Chemist, Justus von Liebig, wrote in his 1842 publication 'Chemistry in its application to agriculture and physiology' that

...it is evident that it would be of much importance to agriculture if none of the human urine were lost. The powerful effects of urine as a manure are well known..

When we consider the immense value of night-soil as a manure, it is quite astounding that so little attention is paid to preserve it. The quantity is immense which is carried down by the drains in London to the River Thames, serving no other purpose than to pollute its waters.

Stockholm
Resilience Centre





THE PERFECT NITROGEN CYCLE

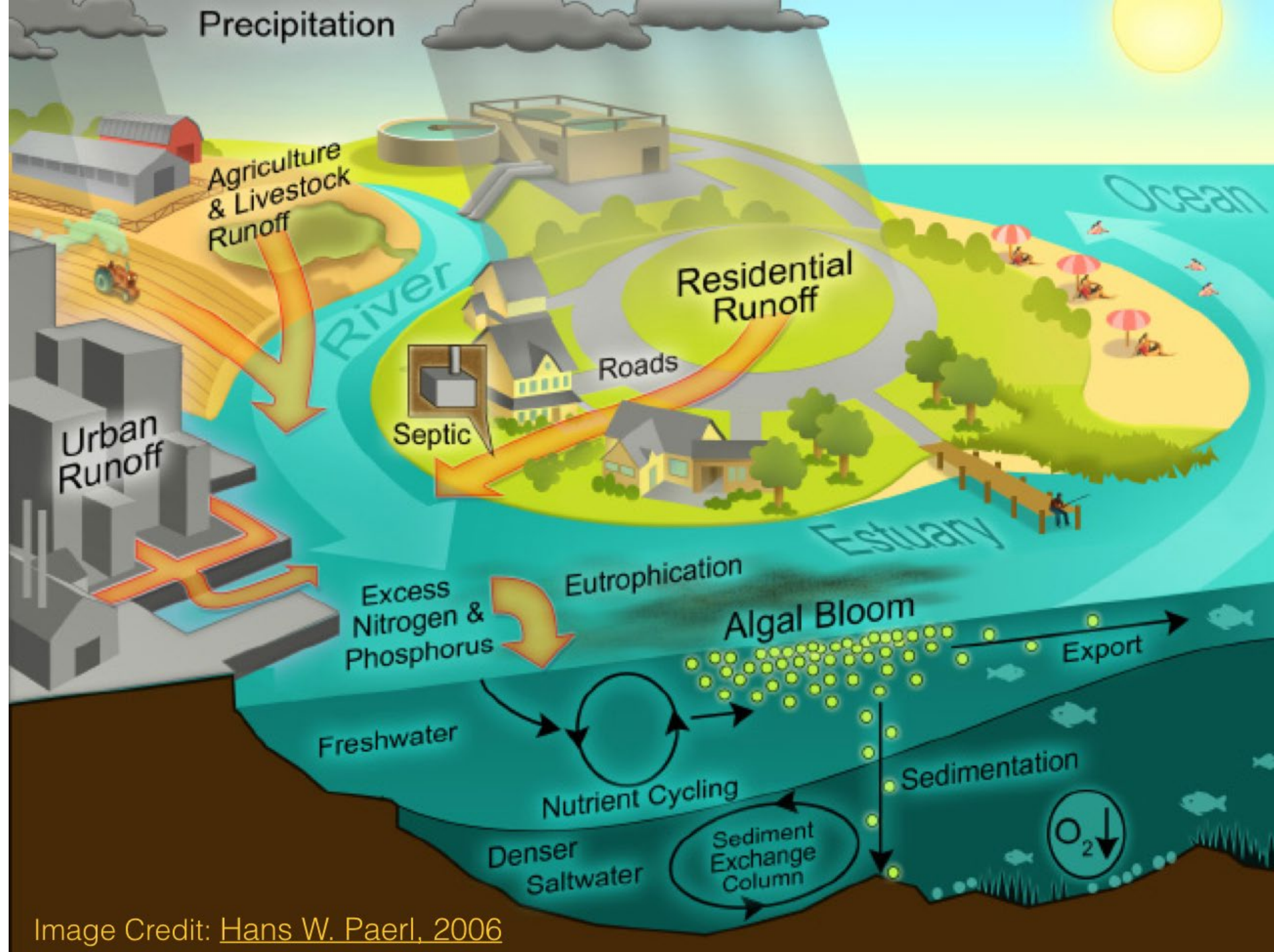


Image Credit: [Hans W. Paerl, 2006](#)



Lake Erie, United States/Canada
Source: New York Times



Image Credit: wikimedia

Net-Zero Nutrients

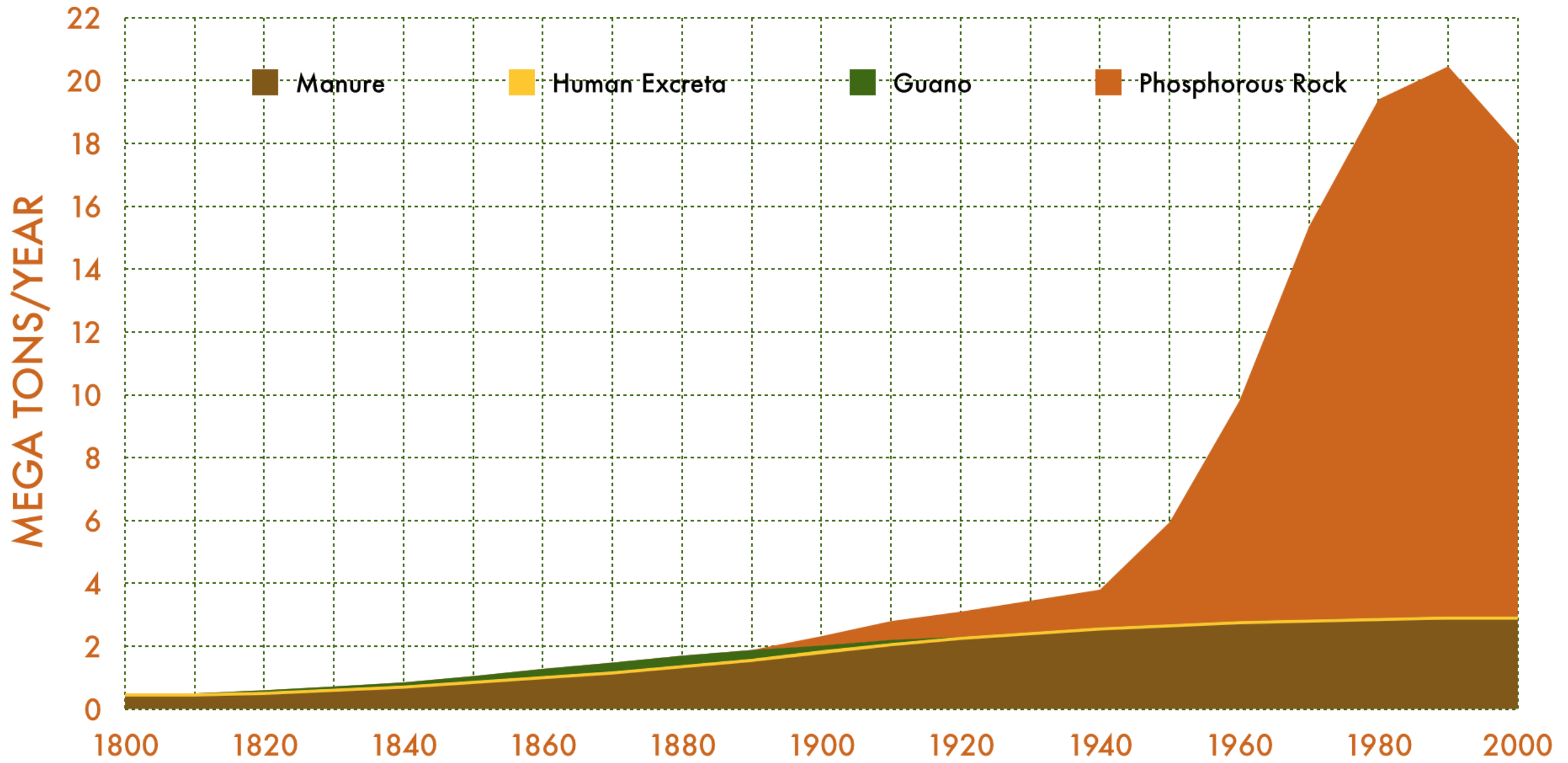
ROCK PHOSPHATE MINING



Image Credit: wikimedia

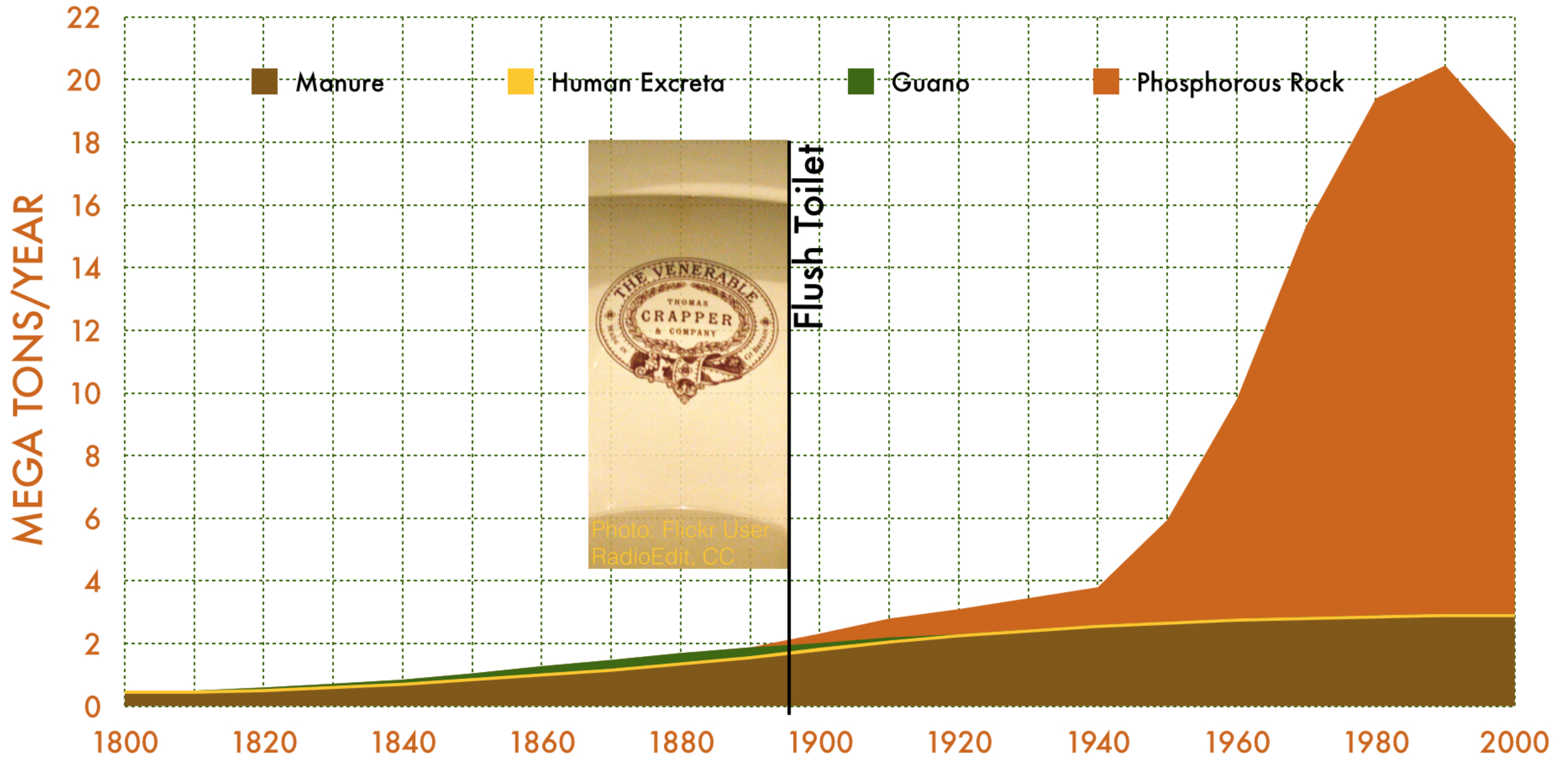
Net-Zero Nutrients

ROCK PHOSPHATE MINING



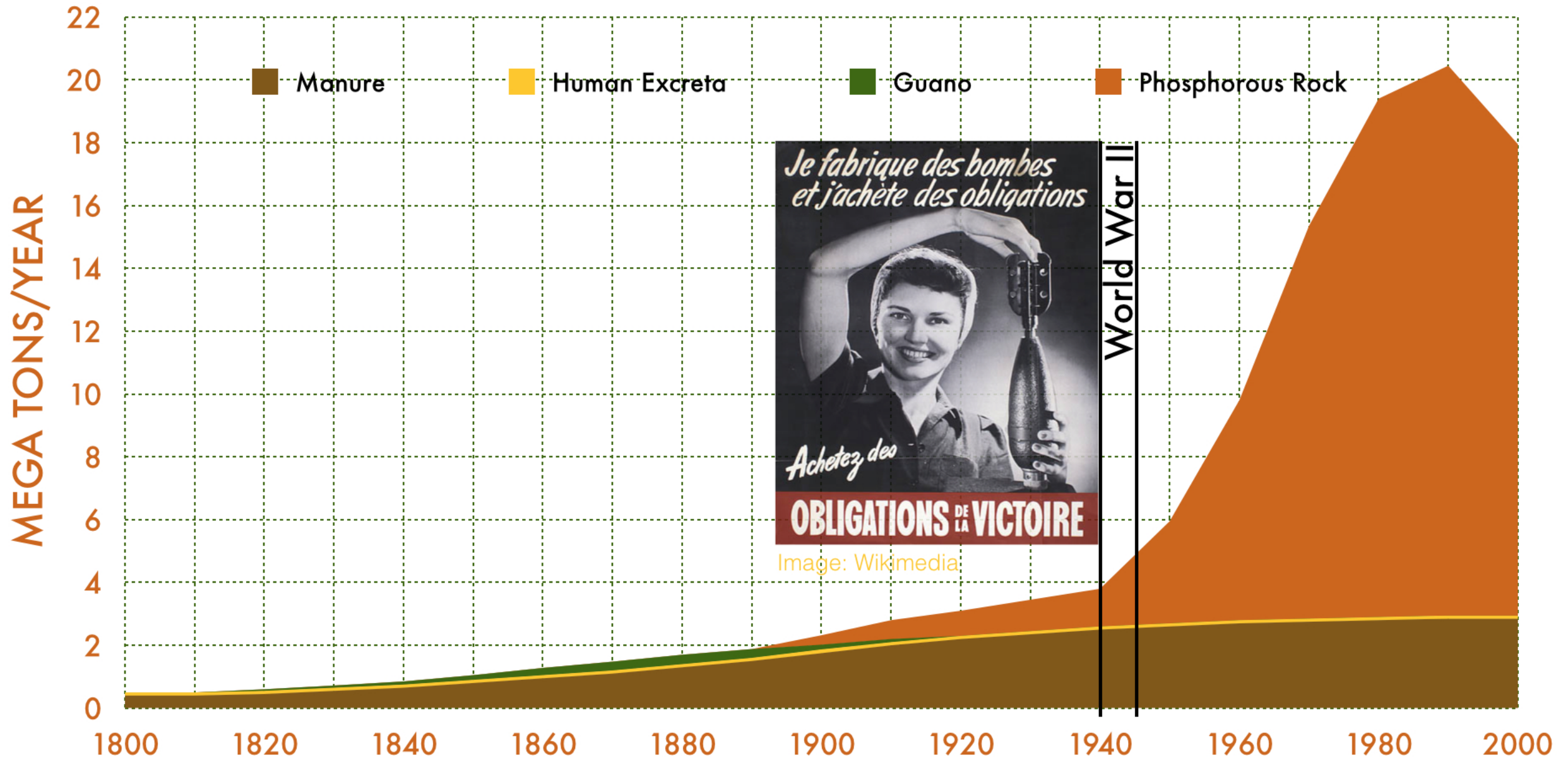
Net-Zero Nutrients

GLOBAL PHOSPHORUS FERTILIZER USE



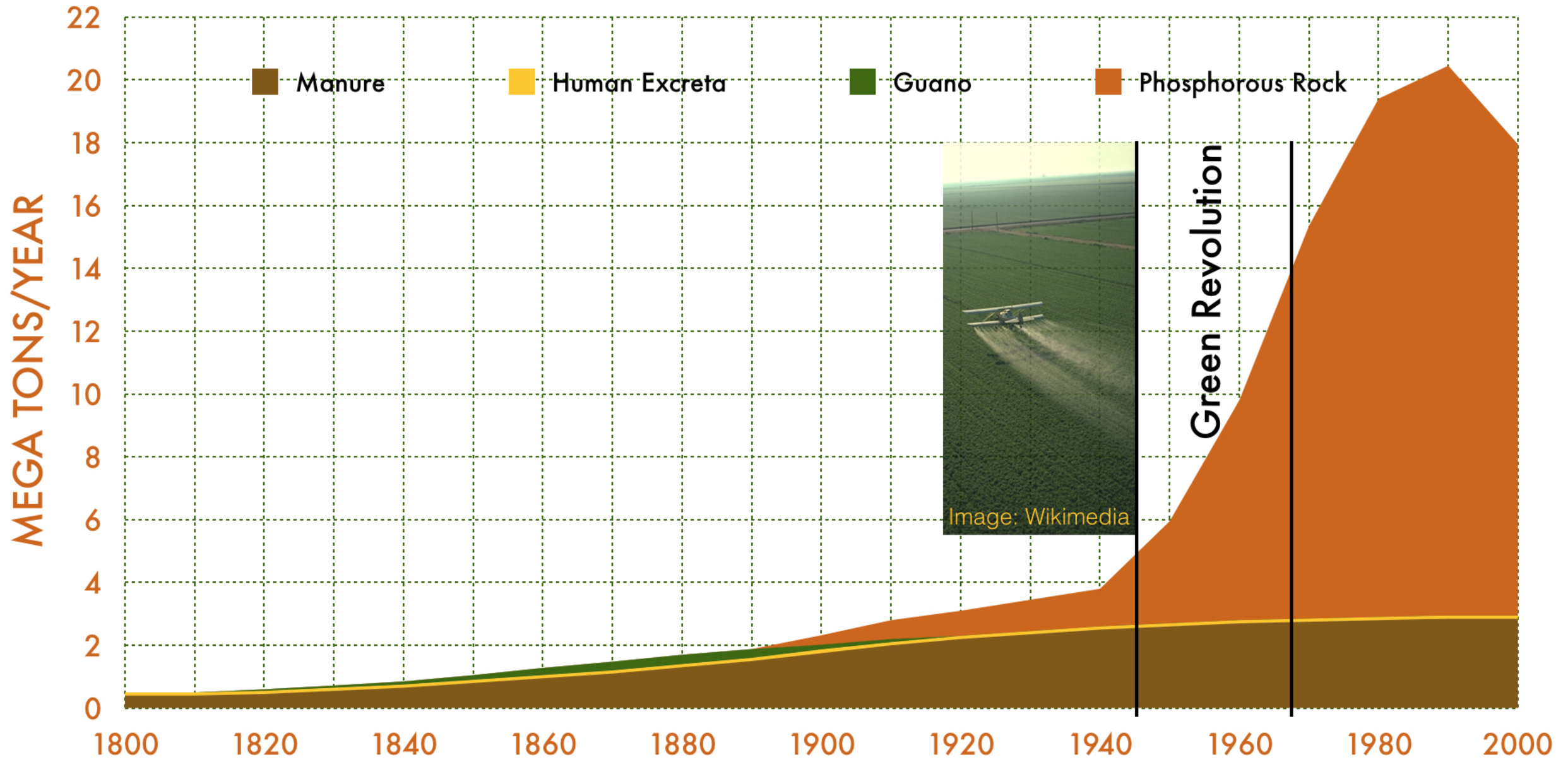
Net-Zero Nutrients

GLOBAL PHOSPHORUS FERTILIZER USE



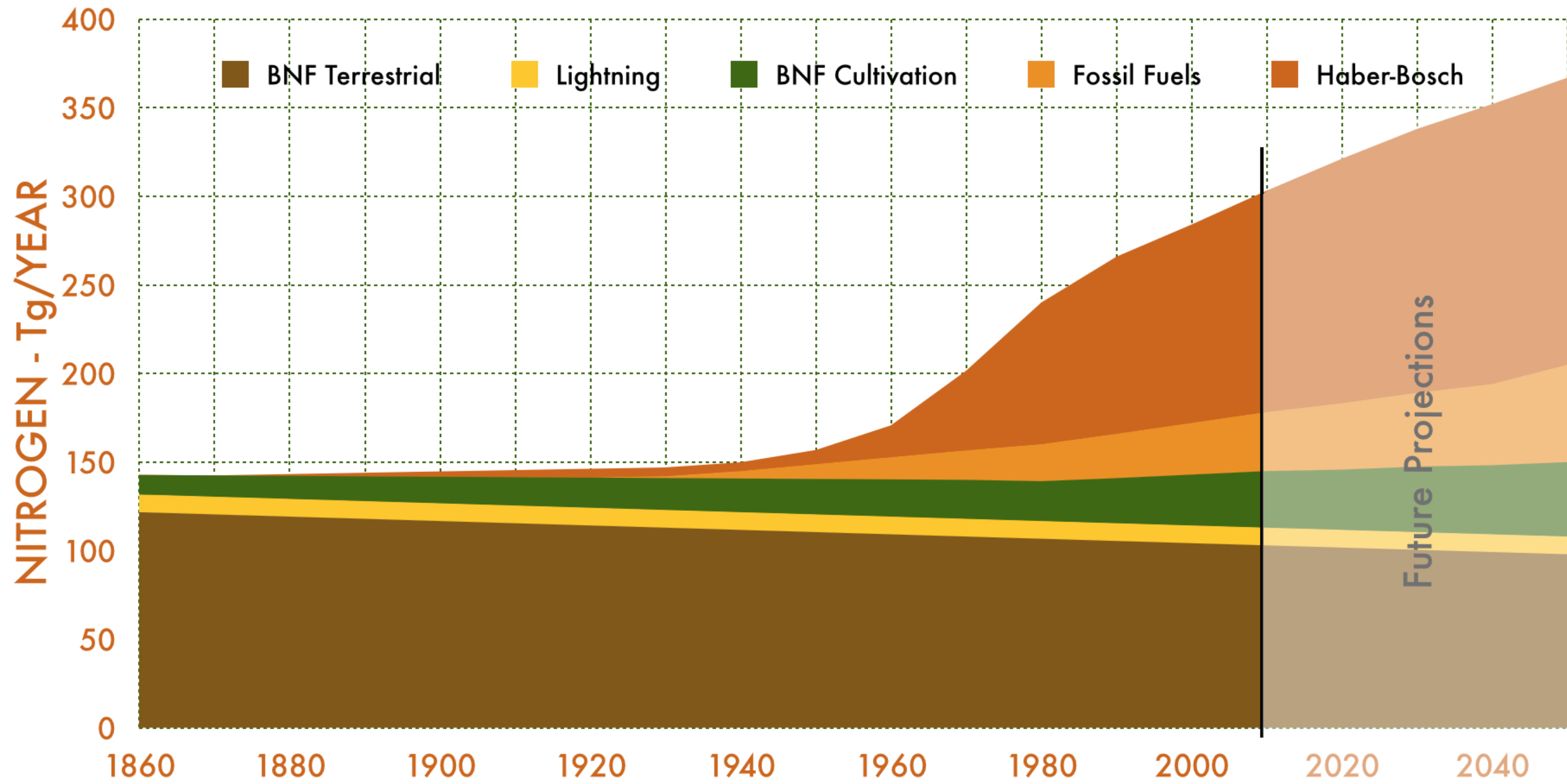
Net-Zero Nutrients

GLOBAL PHOSPHORUS FERTILIZER USE

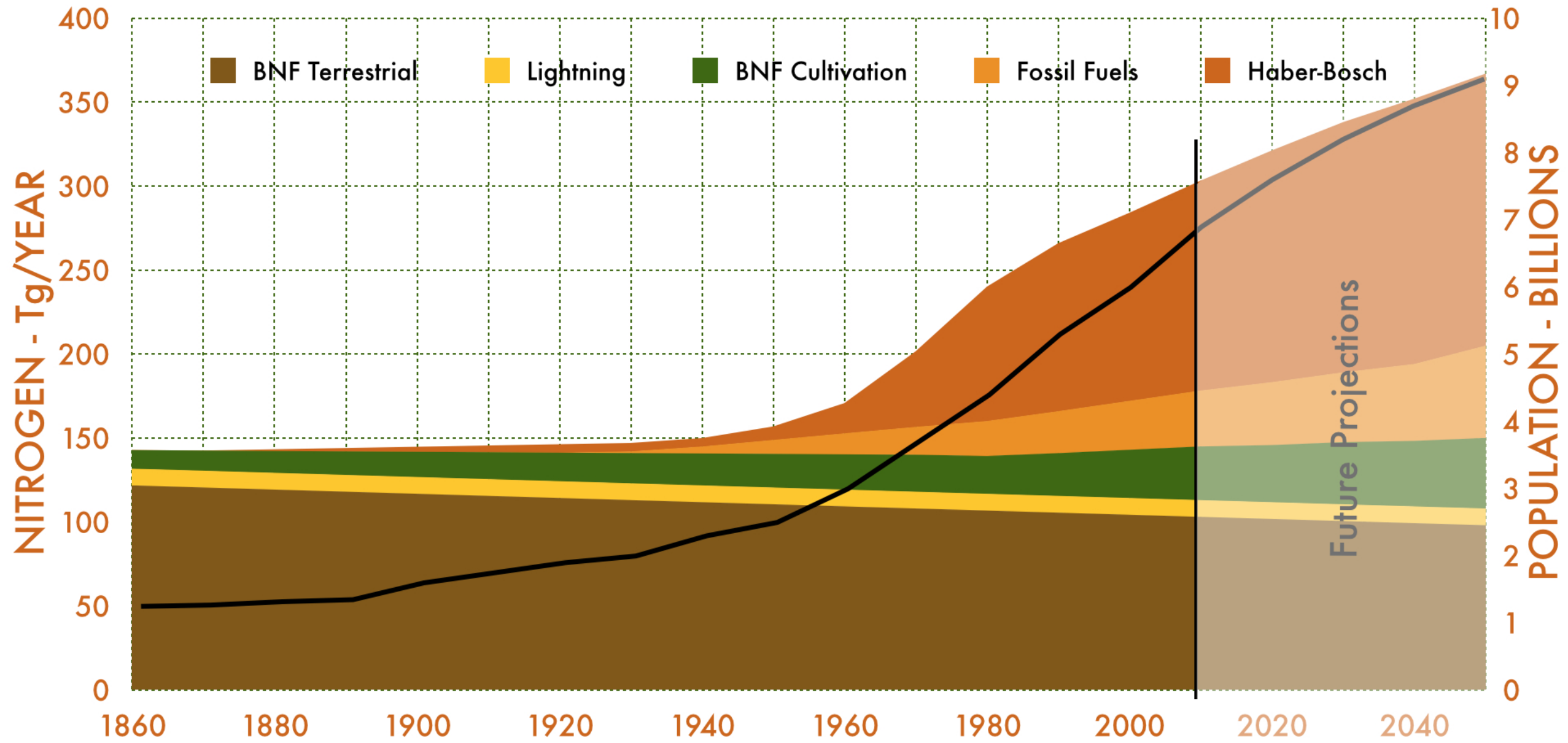


Net-Zero Nutrients

GLOBAL PHOSPHORUS FERTILIZER USE

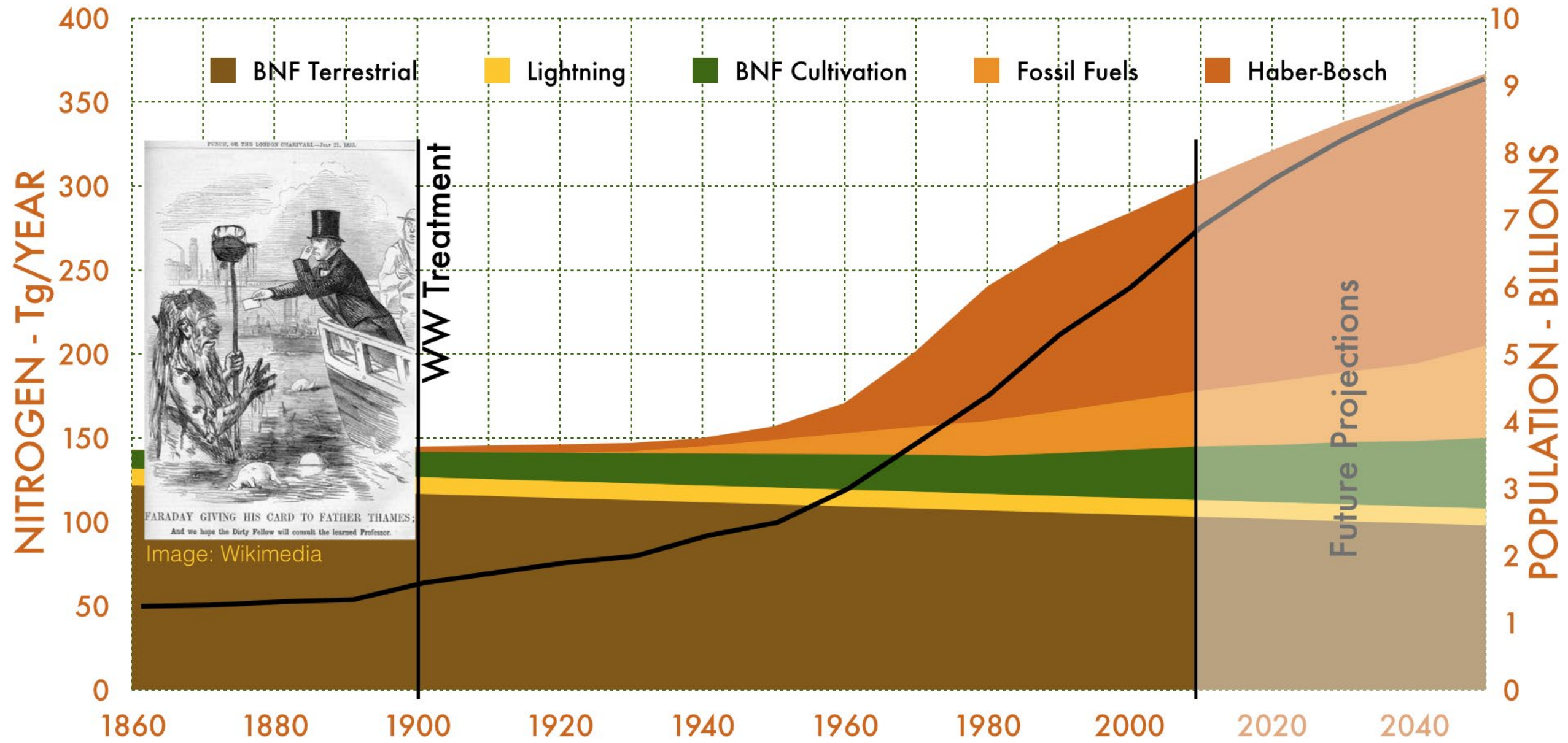


Net-Zero Nutrients GLOBAL PRODUCTION REACTIVE NITROGEN



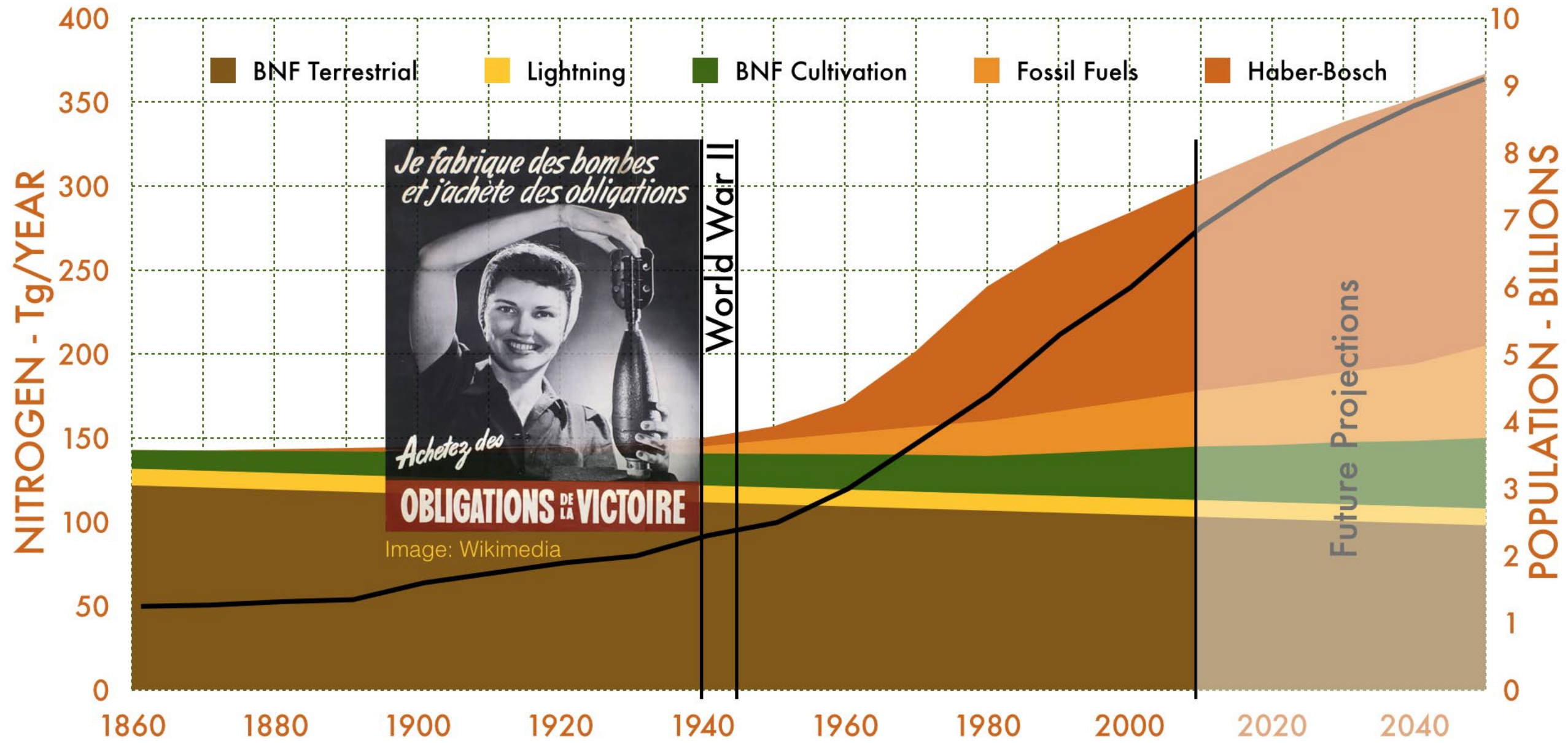
Net-Zero Nutrients

GLOBAL PRODUCTION REACTIVE NITROGEN



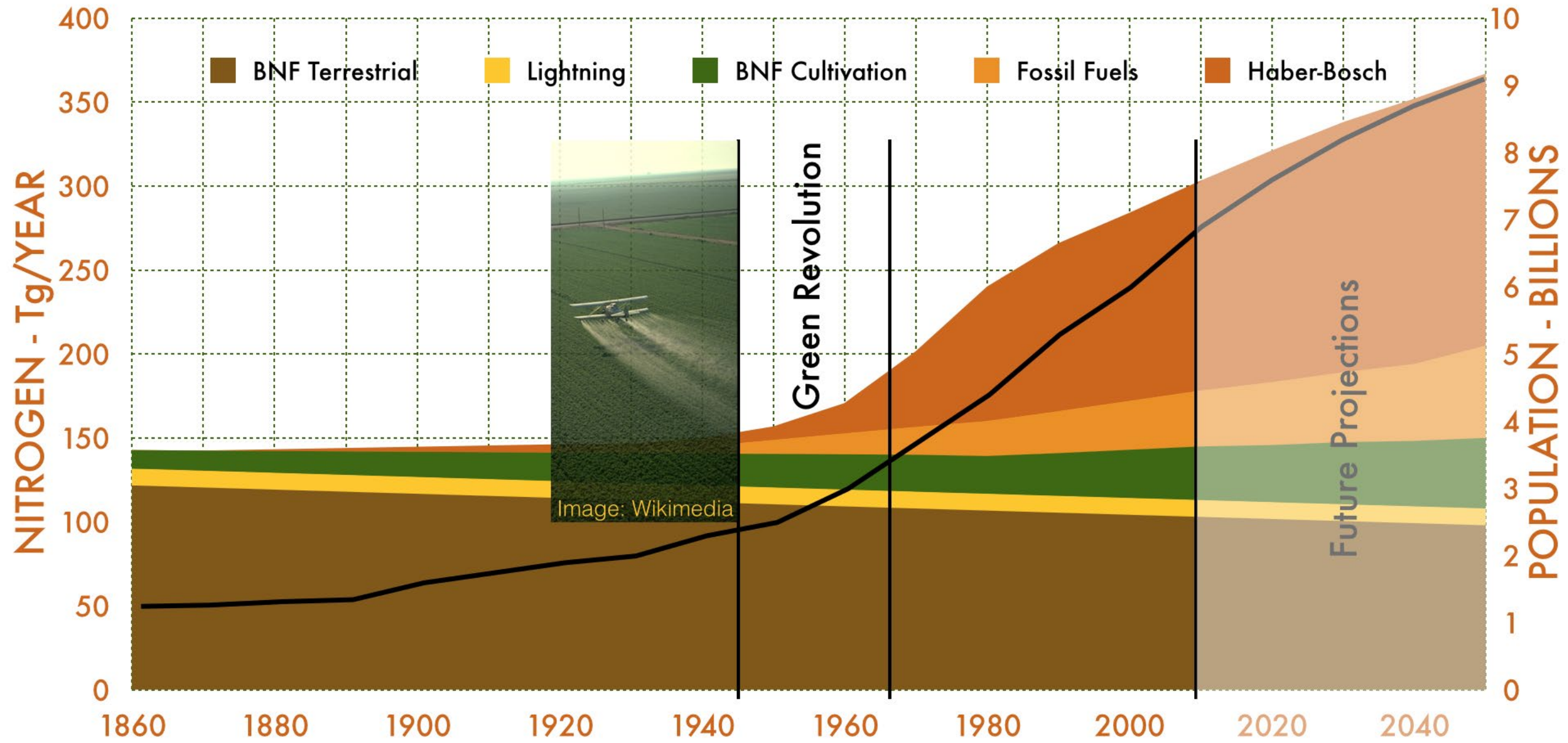
Net-Zero Nutrients

GLOBAL PRODUCTION REACTIVE NITROGEN



Net-Zero Nutrients

GLOBAL PRODUCTION REACTIVE NITROGEN



Net-Zero Nutrients

GLOBAL PRODUCTION REACTIVE NITROGEN

Agenda

A wide-angle landscape photograph showing a body of water, likely a bay or lake, surrounded by lush green mountains under a blue sky with scattered white clouds.

01

The broken
nutrient
cycle

A close-up photograph of a small green seedling with two leaves growing out of a brown, fibrous peat pot filled with dark soil.

02

From urine
back to
fertilizer

A close-up photograph of a chrome faucet with water flowing out in a steady stream, creating a misty spray at the bottom.

03

Three-drain
plumbing

A close-up photograph of a young green plant with a bud-like structure growing from a crack in a light-colored concrete or stone surface.

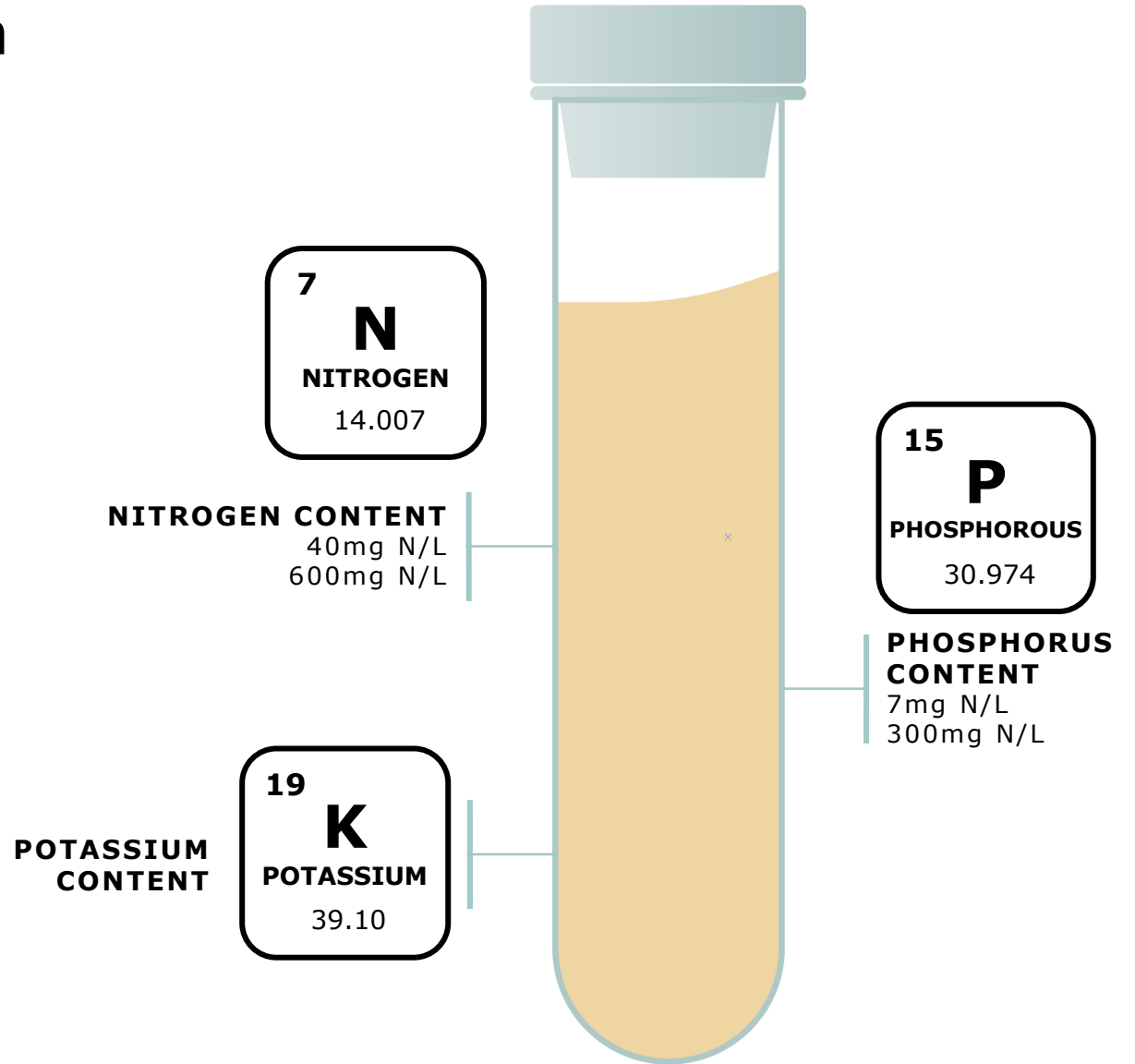
04

Existing and
future
applications

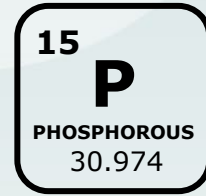
Nutrient Content Breakdown



● GREYWATER ● URINE ● FECES



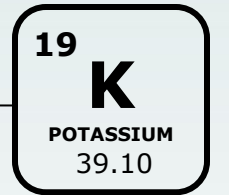
Macronutrients



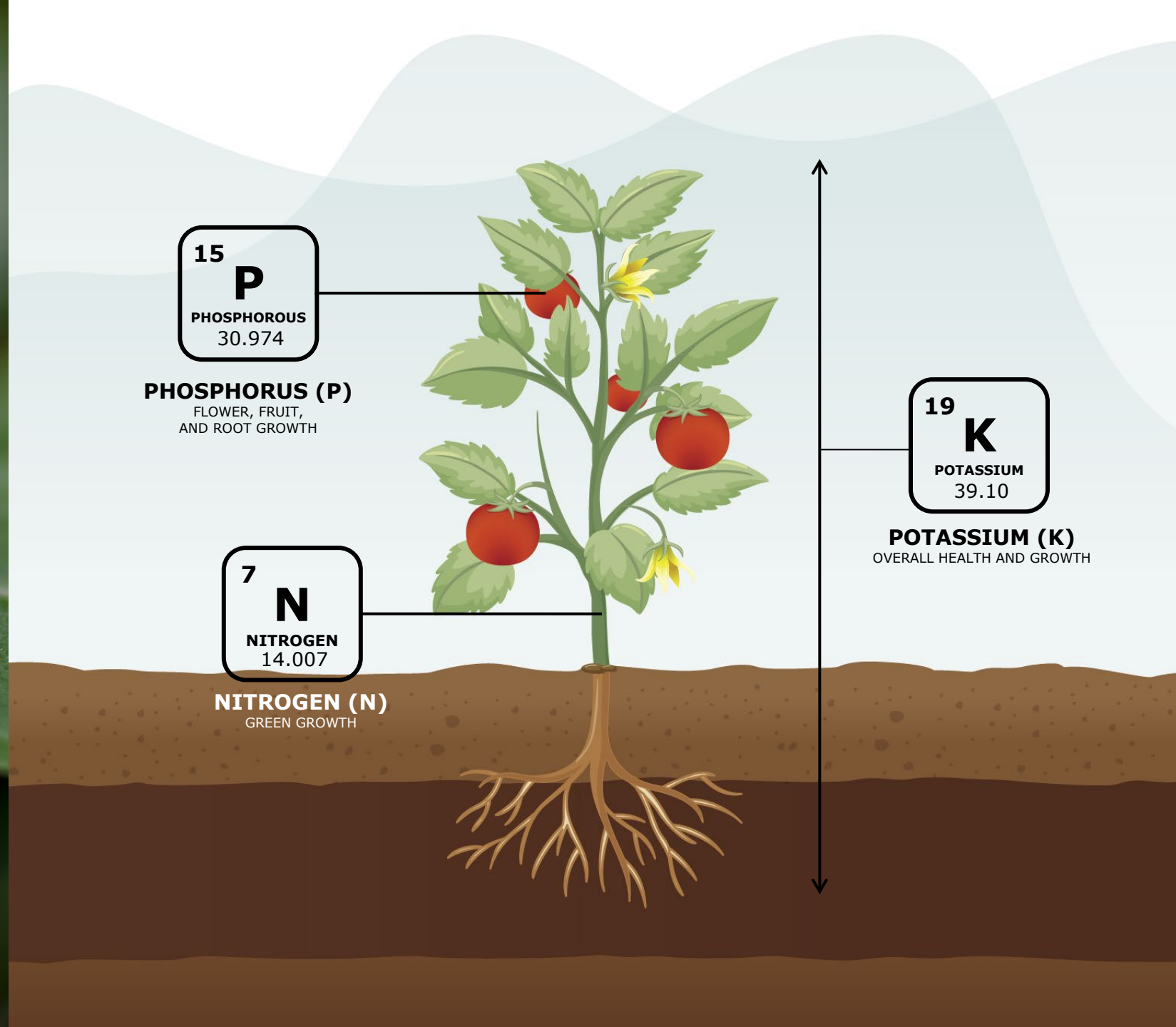
PHOSPHORUS (P)
FLOWER, FRUIT,
AND ROOT GROWTH



NITROGEN (N)
GREEN GROWTH



POTASSIUM (K)
OVERALL HEALTH AND GROWTH



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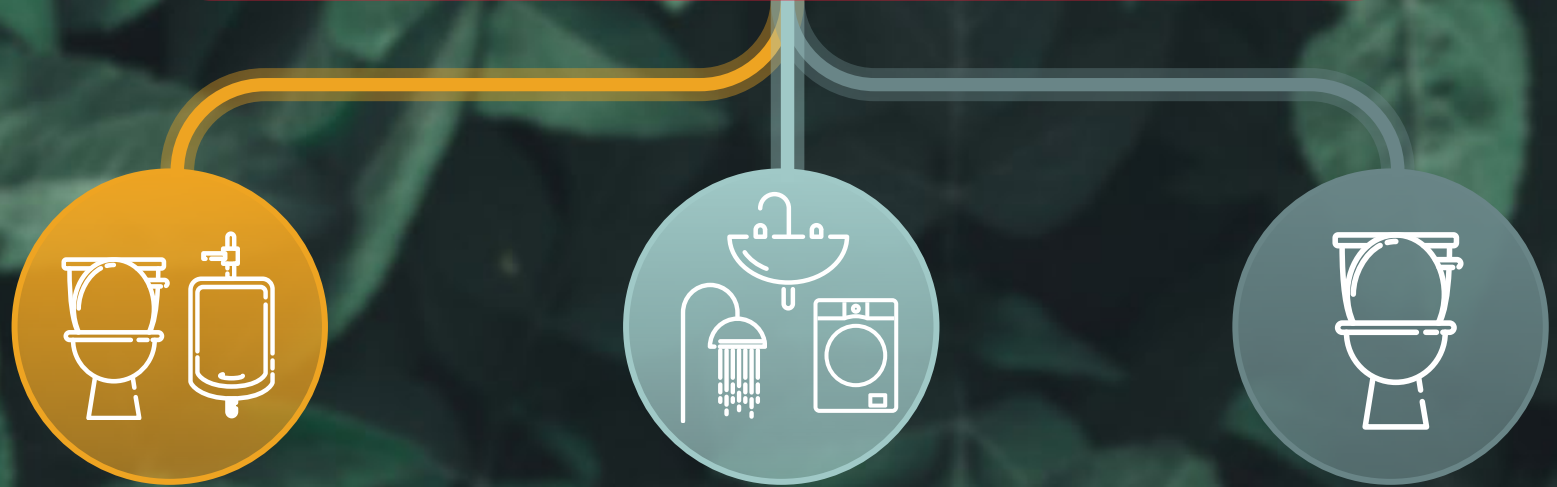
PLASTIC



PAPER



COMPOST



**URINE
DRAIN**

**GREYWATER
DRAIN**

**FECES
DRAIN**

Water closets – Urine diverting



Laufen Gravity-Type



Wostman Gravity-Type



Wostman Vacuum-Type



Laufen Save!

AT EAWAG IN DÜBENDORF,
SWITZERLAND

Urine diverting water closet

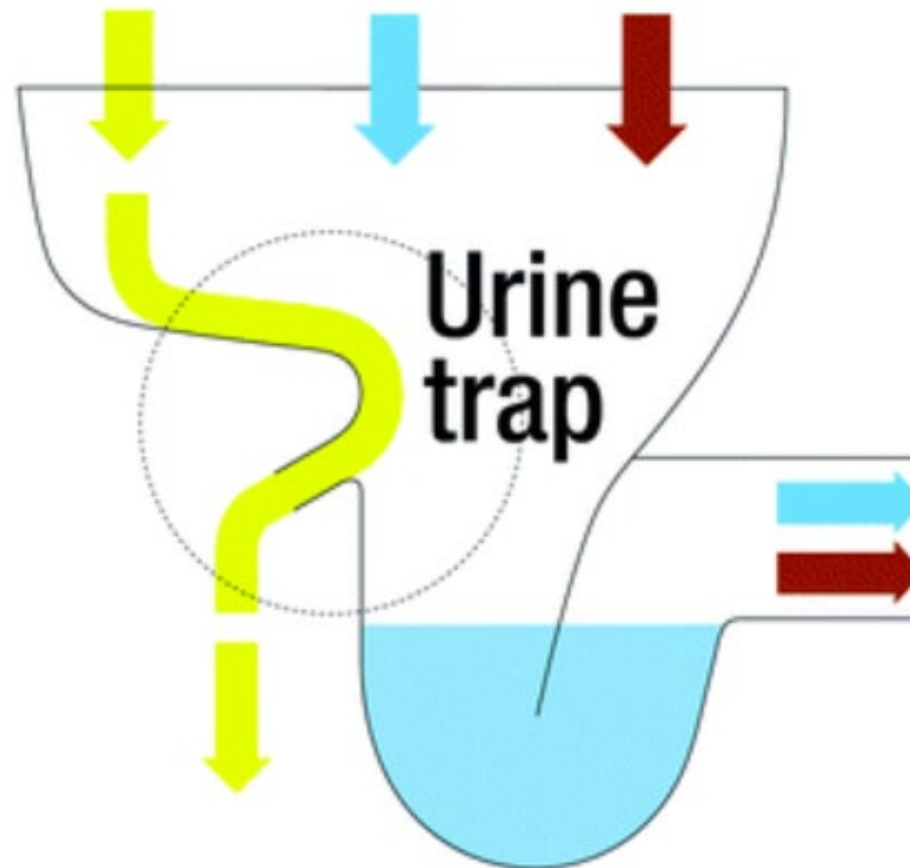
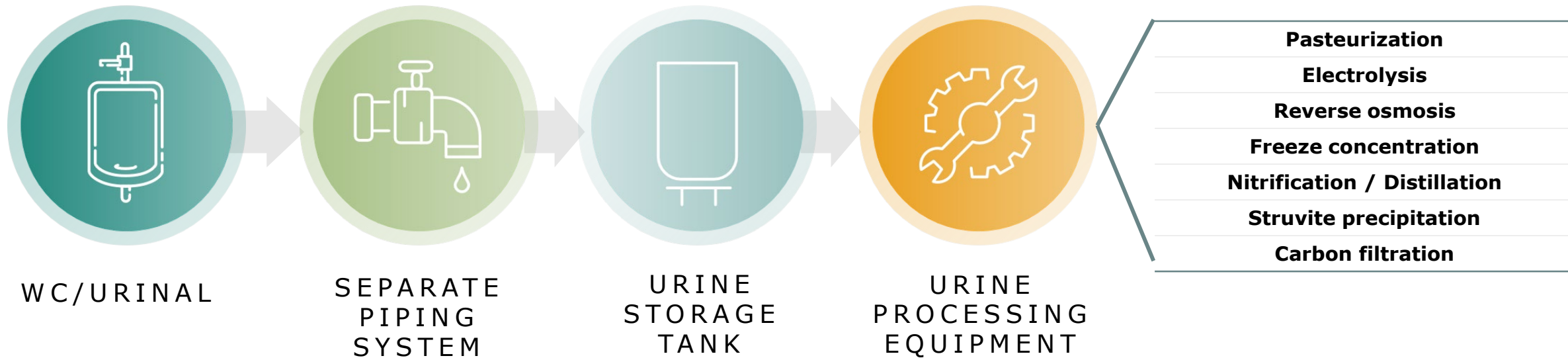


Fig. 2 Basic principle of urine-separating flush toilets using the teapot effect. Copyright EOOS.

Urine diversion for nutrient recovery



Gradient



FECES DRAIN

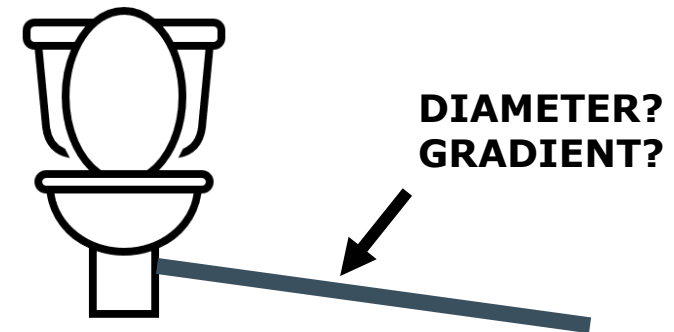
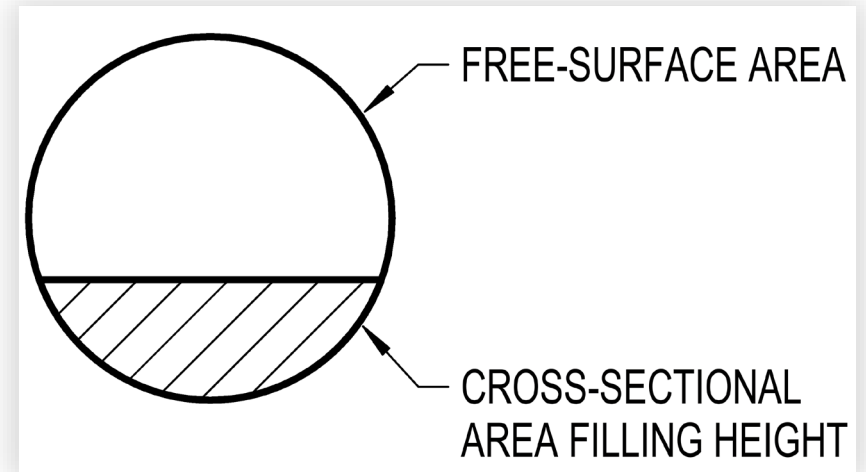
URINE DRAIN 2% TO 4% GRADIENT

Urine Drain Diameter Size

A flow of urine at 10 mL/s to 21 mL/s will achieve a scouring force of 2.5 N/m² in a DN32 drain if installed at a gradient between 4% and 5%

$$S = \frac{\rho g d_h J}{2}$$

Refer to DIN 1986-100 Kommentar for additional information on equation



Key Technical Takeaways

1. Gradient of 2% to 4%
2. Hot water washdown system if gradient cannot be achieved
3. One-way vent terminations with AAVs
4. Plastic piping recommended
5. Tank overflow and tank bypass, and tank vent
6. Cleaning of the piping every few years
7. Inspection and Maintenance procedures
8. Nutrient Management Plan

Key Code Development Takeaways

1. 2014 Redcode developed the model code for ecological sanitation
2. 2017 IAPMO adopted the model code
3. 2024 WE*Stand Update
4. 2024 IAPMO and ICC Proposed adoptions

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Pasteurizer

Brightwater Tools
BRATTLEBORO, VERMONT

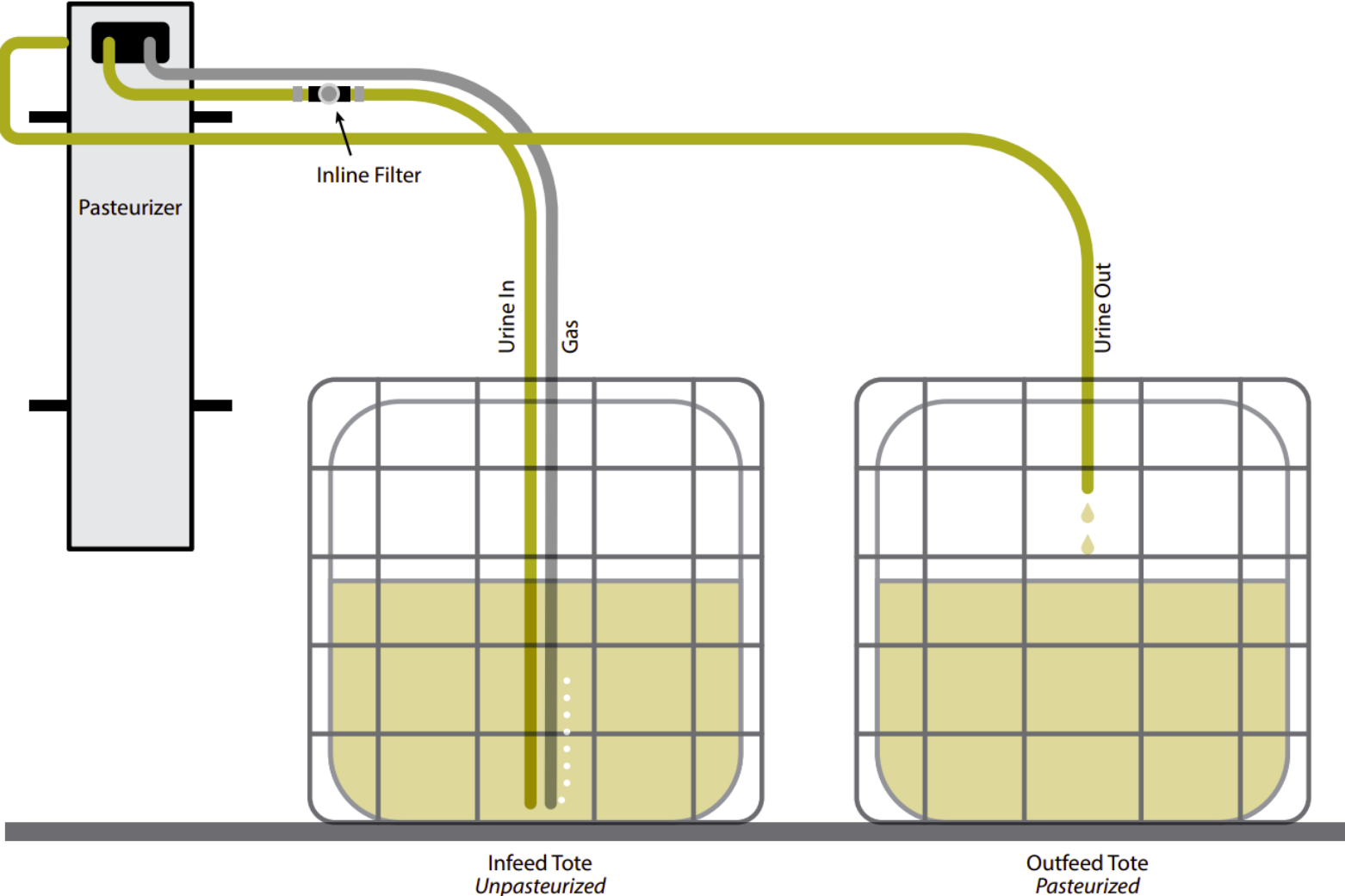


Figure 2. Connect pumps to in/outfeed tanks, main unit

PAE Living Building Portland, Oregon

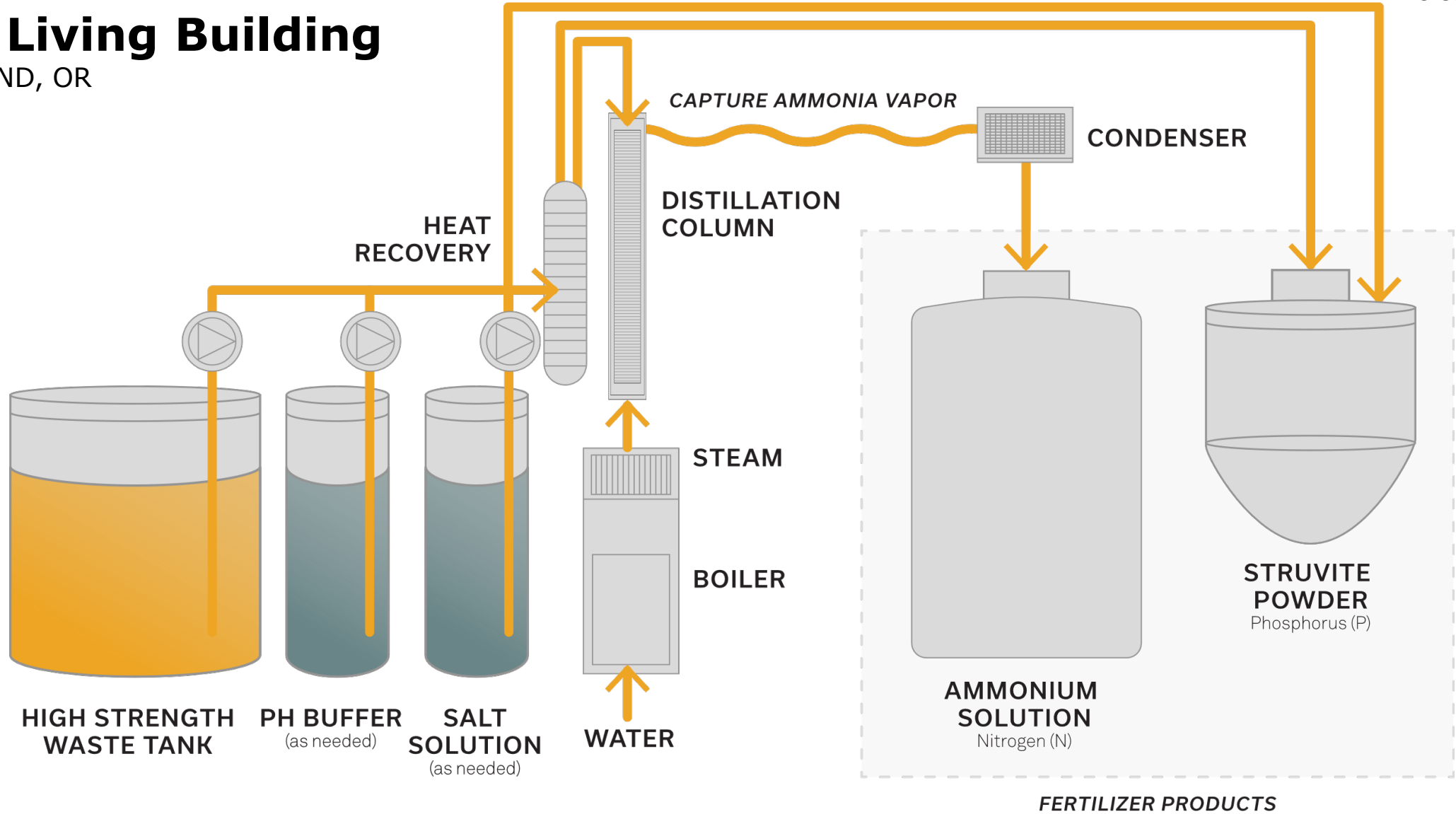


PAE Living Building (office building)



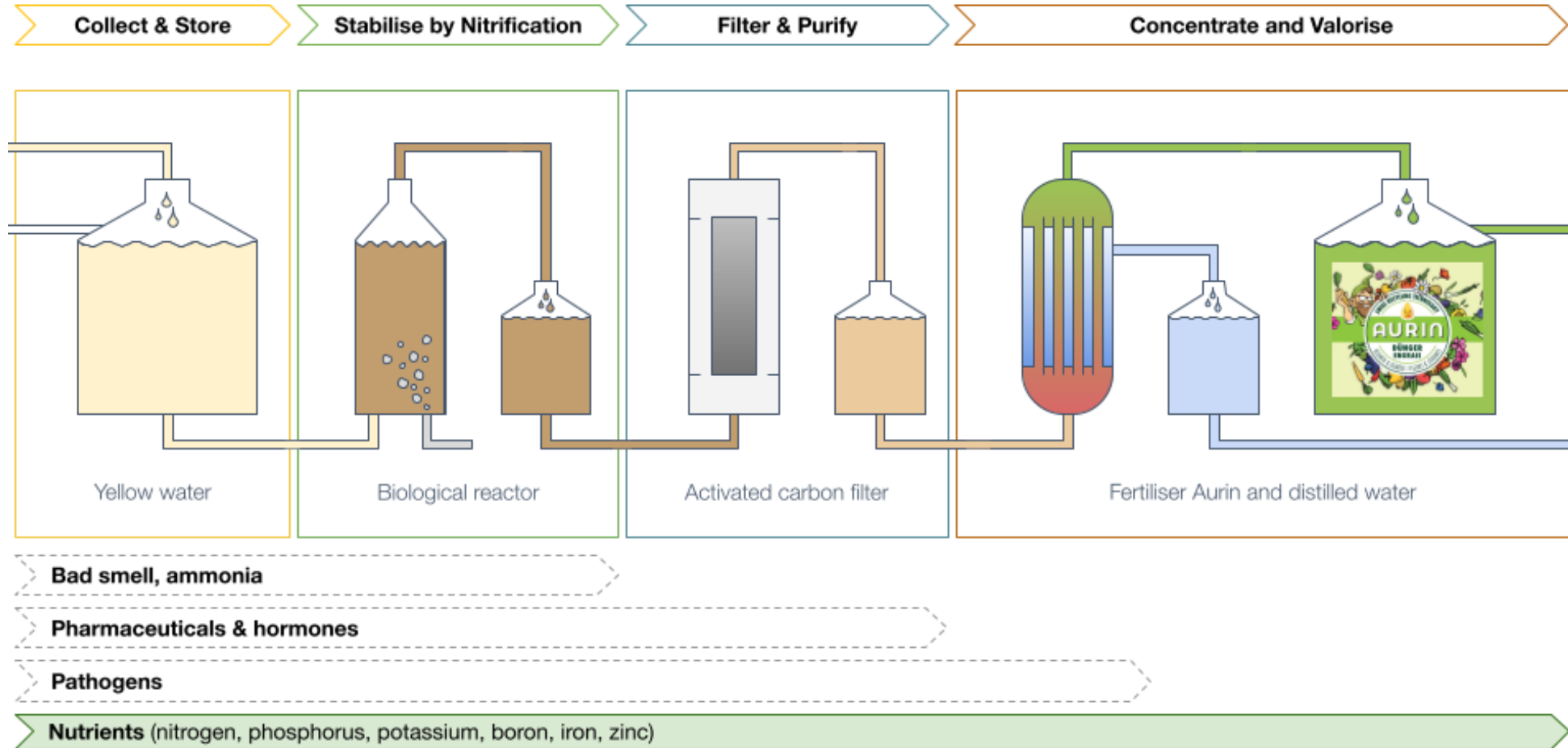
PAE Living Building

PORTLAND, OR



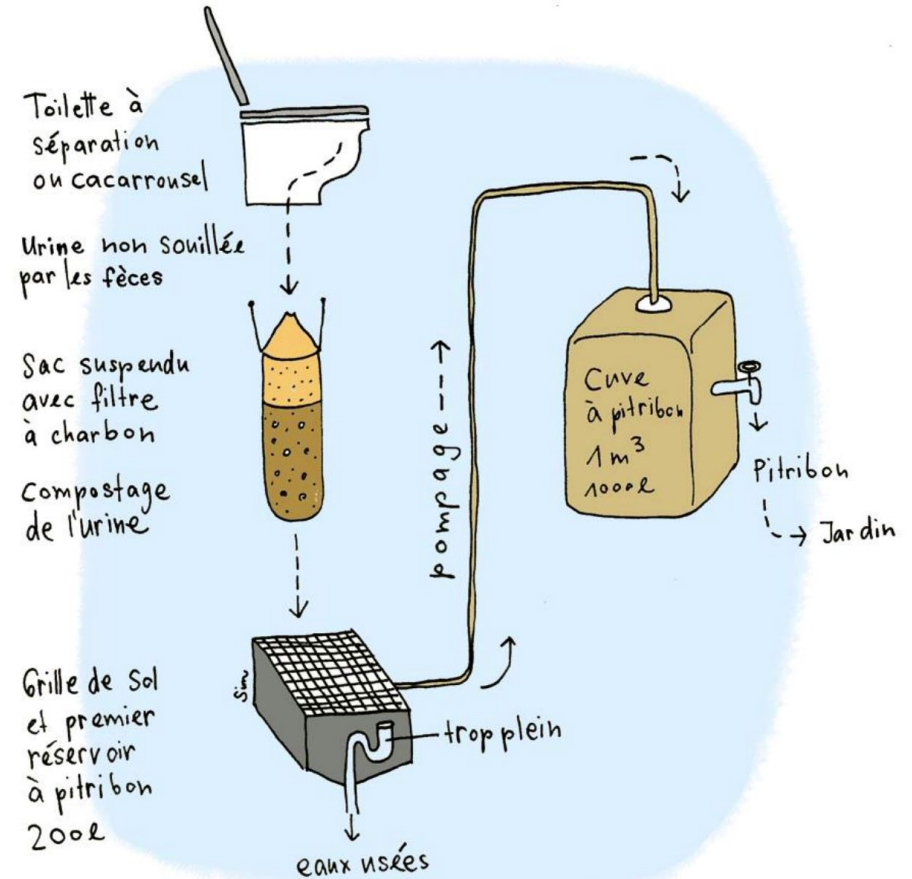
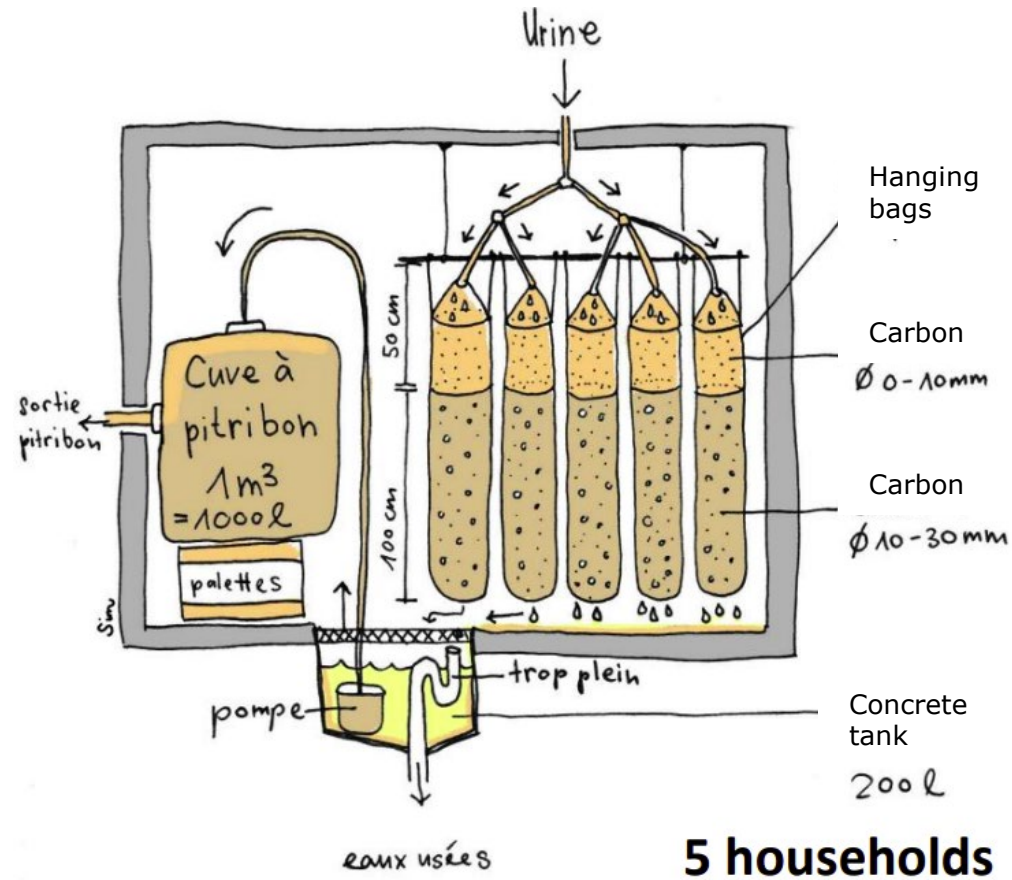
Biological Nitrification

VUNANEXUS
ZURICH, SWITZERLAND



Carbon filtration

ANECO
GENEVA, SWITZERLAND



Compost production
Liquid fertilizer production



Summary

1. Recovering nutrients from urine in buildings is necessary to transition to a post-carbon economy and restore the nutrient cycle
2. When combined with regenerative agricultural practices, the nitrogen in urine is enough eliminate the need for fossil fuel-based fertilizers and industrial mining of phosphorus and potassium
3. Piping and equipment requirements are be much simpler in comparison to water recycling systems, though both water recycling and nutrient recovery are critical elements for plumbing in a post-carbon economy
4. Separating urine at the source allows less resource intensive and lower cost treatment, allowing simpler treatment for feces drainage and greywater.





THANK YOU

Circular Sanitation

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pae-engineers.com |

Emerging Water Technology Symposium May 14-15th, 2024 Scottsdale, AZ

