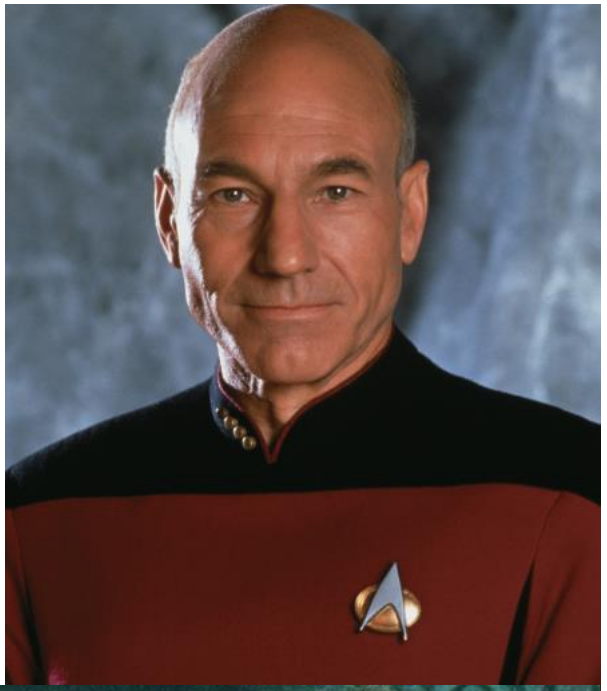
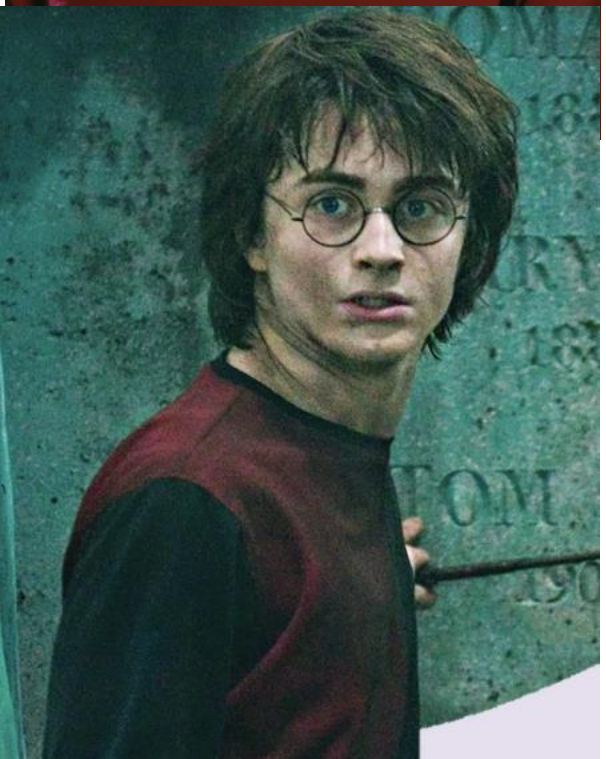




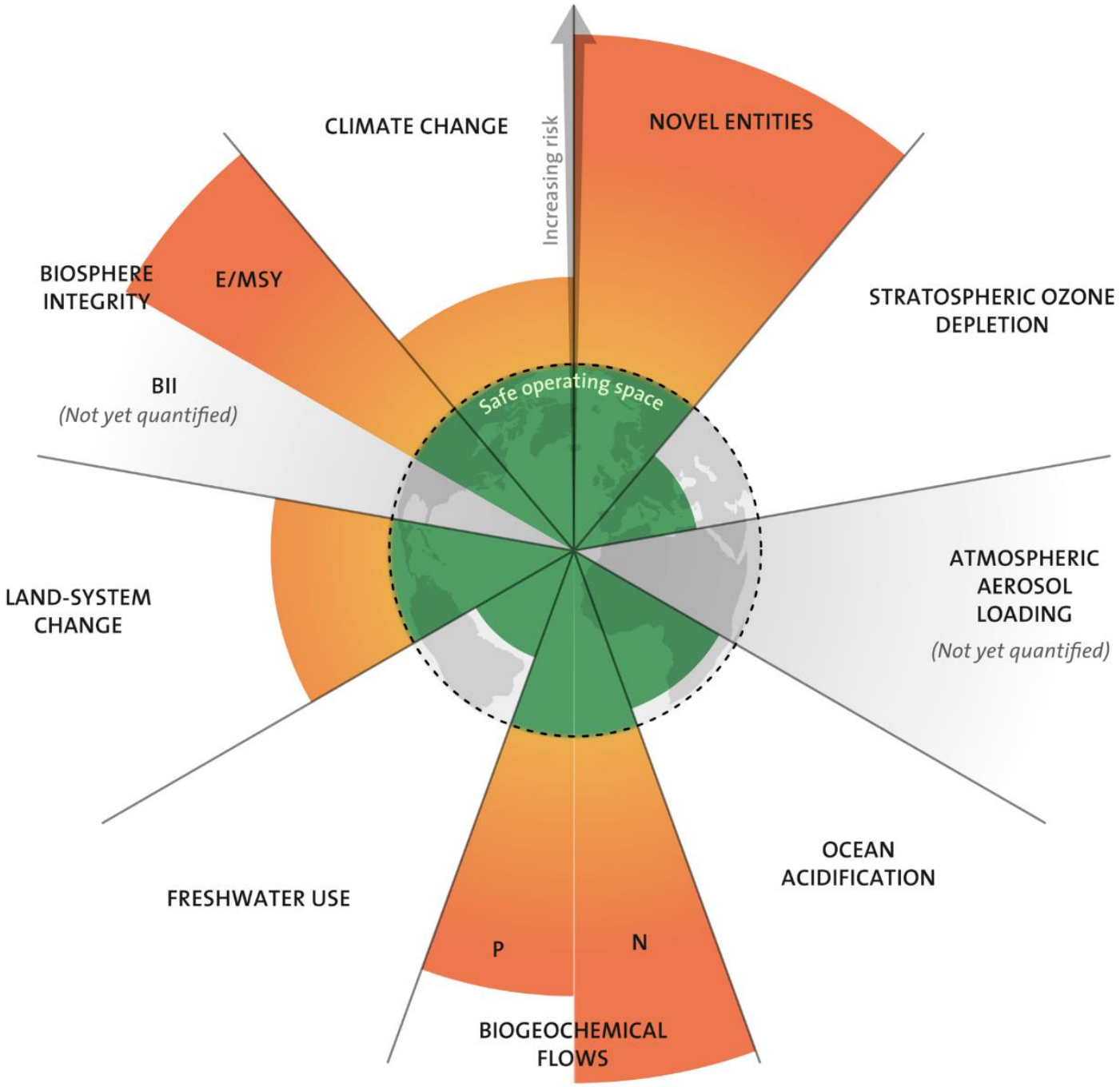
Too often we forget which category we fall into:

The Role of Biosolids in Environmental Stewardship

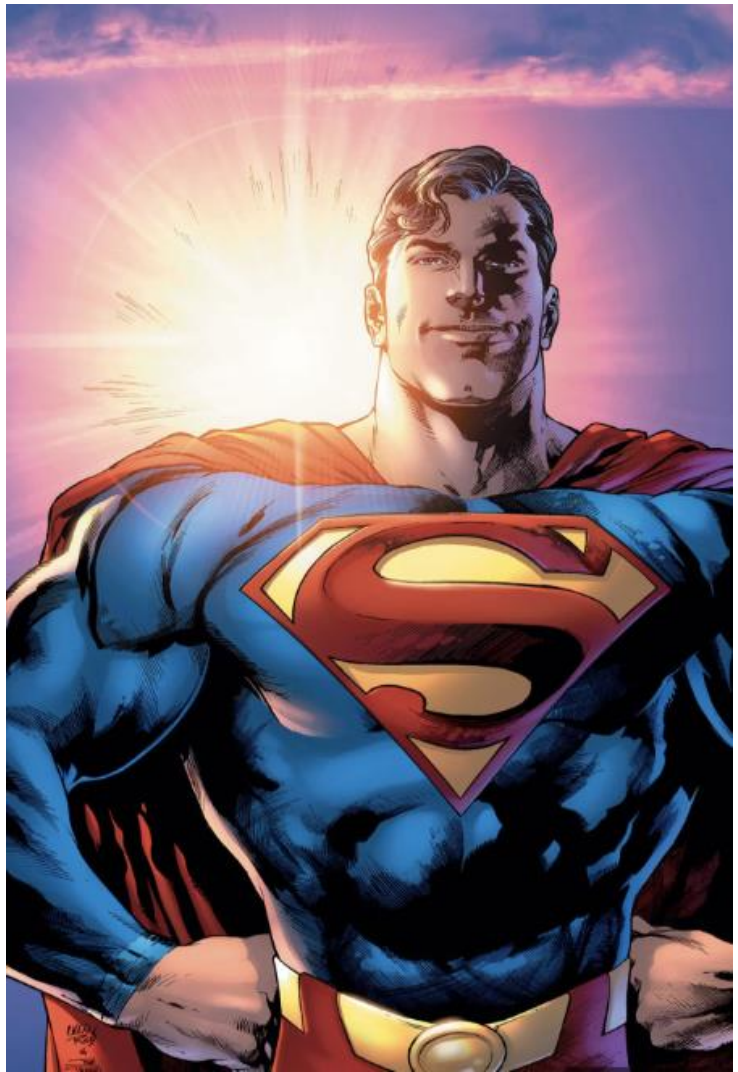
Sally Brown
slb@uw.edu

Let's see where we fit (Steffen et al., 2015)

- Novel entities
  - Anthropogenic chemicals/ compounds
- Biogeochemical flows
- Land system change
- Climate change



Like many superheroes (and I KNOW that is what we are) - we have our kryptonite equivalent



Novel Entities For biosolids-

- It seems like PFAS is the equivalent to the proverbial :

Our unequal earth

‘I don’t know how we’ll survive’: the farmers facing ruin in Maine’s ‘forever chemicals’ crisis

Maine faces a crisis from PFAS-contaminated produce, which is causing farms to close and farmers to face the loss of their livelihoods

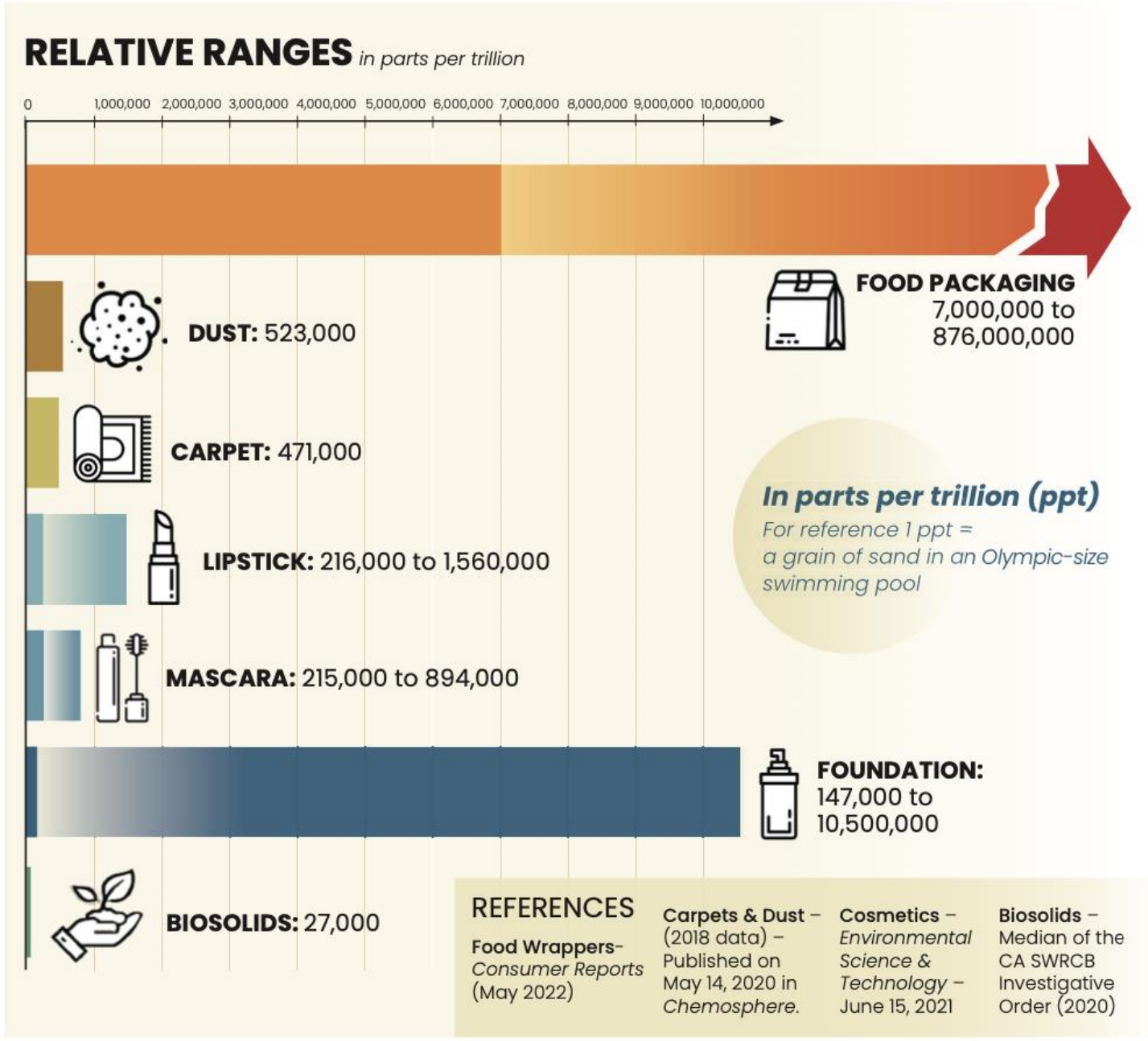
by Tom Perkins with photographs by Tristan Spinski

Fred Stone, a third-generation dairy farmer, is co-owner of Stoneridge Farm in Maine.

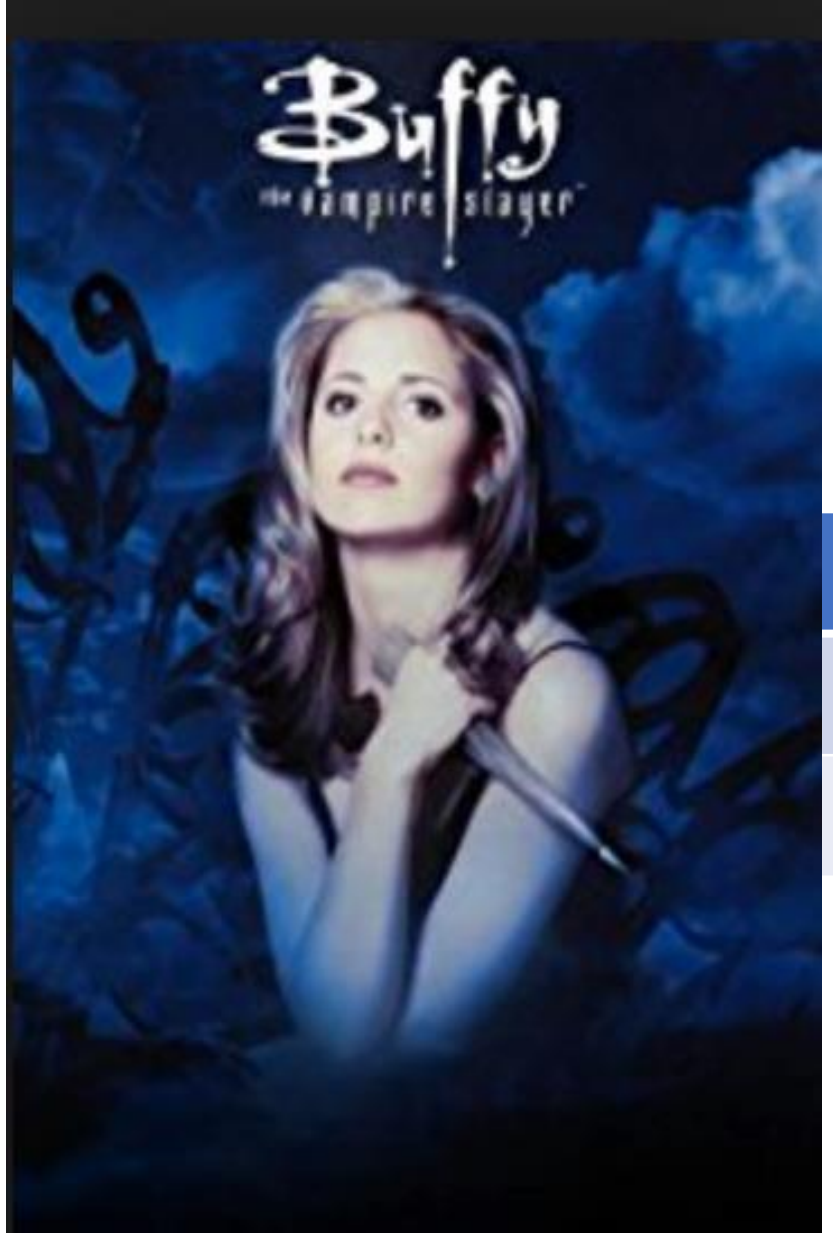
https://www.theguardian.com/environment/2022/mar/22/i-dont-know-how-well-survive-the-farmers-facing-ruin-in-americas-forever-chemicals-crisis

They brag, we cower

Helpful graphic from CASA



Serving 69 million daily worldwide



Human Blood ppb

CDC Data

	PFOA	PFOS
1999	5	30
2012	2	6

Note that these are only measures of the banned compounds, they do not include the full suite of PFAS compounds

Ban the biosolids or the dental floss?

As a result of concerns about perfluorinated compounds in biosolids many states are considering bans on their use-

The concentration of perfluorinated compounds in many dental floss products is 16 ppb

The concentration of perfluorinated compounds in the biosolids was 48 ppb

A recent study showed a direct correlation between use of fluorinated dental floss and increased body burden of these compounds

No such correlation has been seen for biosolids or composts

Which cake would you rather eat?

As a result of concerns about perfluorinated compounds in biosolids many states are considering bans on their use-

The FDA recently sampled a range of food products for PFAS compounds. The chocolate cake tested had concentrations of 17 ppb

The concentration of perfluorinated compounds in biosolid, often referred to as ‘cake’ was 48 ppb

As this comparison shows, home exposure to these compounds is far greater than any potential exposure from biosolids

Fecal Excretion of Perfluoroalkyl and Polyfluoroalkyl Substances in Pets from New York State, United States

Jing Ma, Hongkai Zhu, and Kurunthachalam Kannan*

85 +/- 94 ng g (ppb)

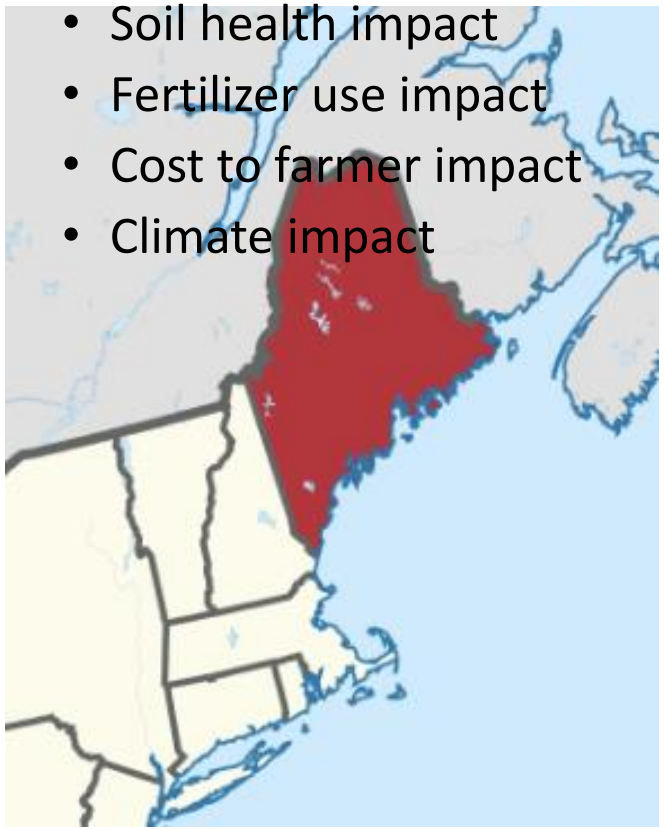
- What are likely sources?

CASA biosolids 27 ppb

- How much biosolids would Soph have to eat?

A tale of two states

- Maine aka Ground zero
  - Banned land application
    - Doubled or > costs of biosolids
    - Soil health impact
    - Fertilizer use impact
    - Cost to farmer impact
    - Climate impact

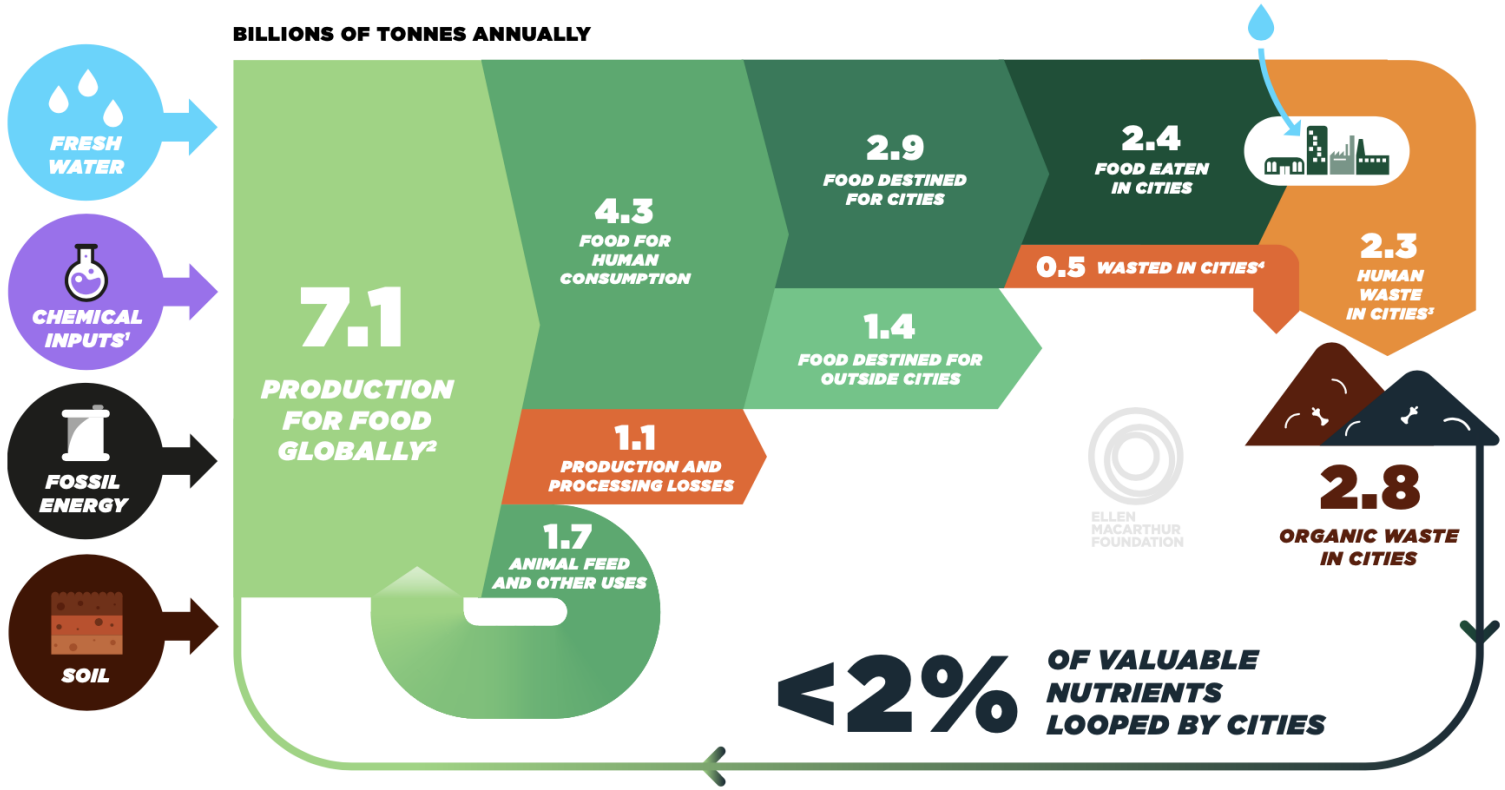


- Michigan
  - Required municipalities test
    - If above a background level required source control
    - If below a background level BAU
    - Source control has been effective in reducing # of plants with > background biosolids

Nutrient flows
Wastewater is chock full of them

FIGURE 2: THE FLOW OF MATERIALS IN THE FOOD SYSTEM IS OVERWHELMINGLY LINEAR.

In the linear food system, a very high proportion of food flows into cities where it is processed or consumed, creating organic waste in the form of discarded food, by-products or sewage. In cities, only a very small proportion (<2%) of the valuable nutrients in these discarded organic resources gets looped back to productive use.



Here we go back to basics

- Look at what we treat
- How it flows within the plant
- How much of an impact resource capture can make

How much do we need Nitrogen?

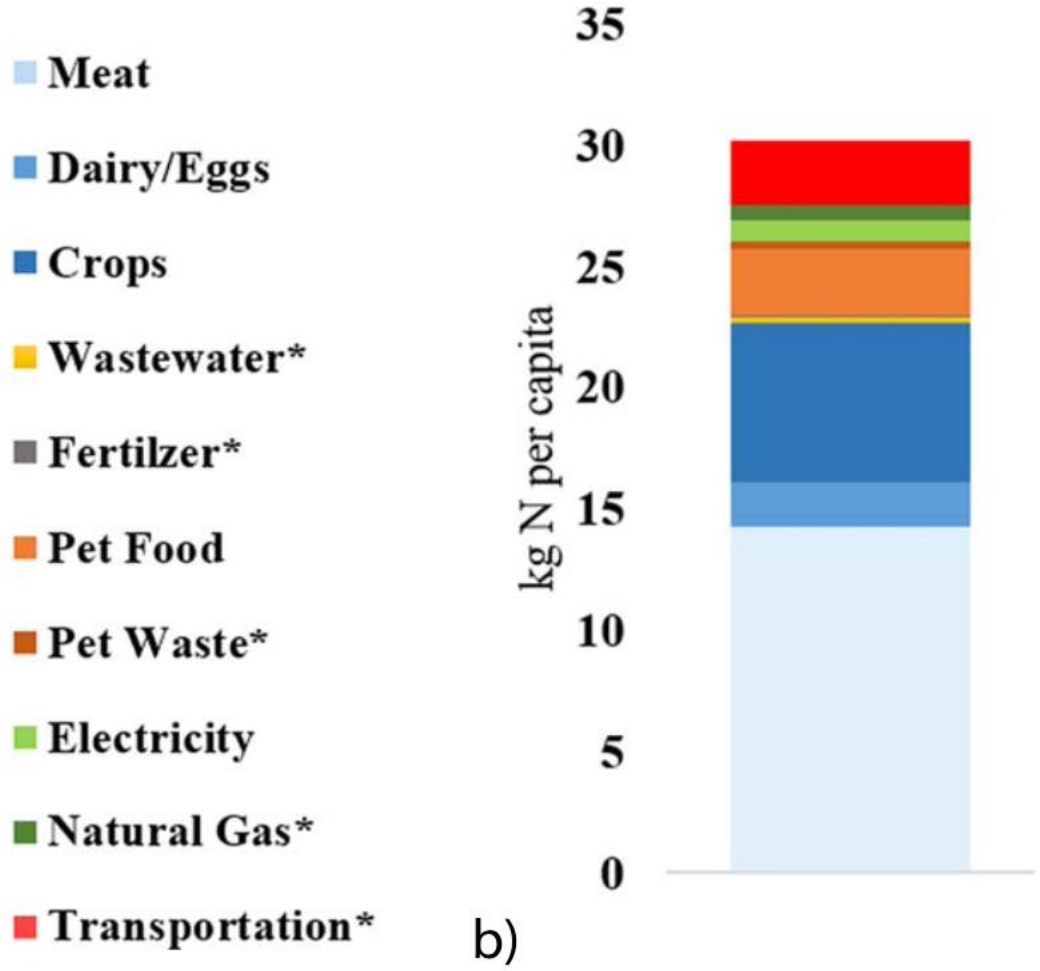
(Dukes et al., 2020)

- 30 kg N per person per year
- 47% meat
  - 0.47*30=14.1

6% dairy and eggs

0.06*30= 1.8

- 22% crops
  - 0.22* 30 = 6.6 kg



How much do we need Phosphorus?

(Metson et al., 2020)

- 4.4 kg P per person per year (for food production)
- 70% meat and dairy
  - 0.70*4.4 = 3.1kg

30% crops

0.30* 4.4 = 1.3 kg

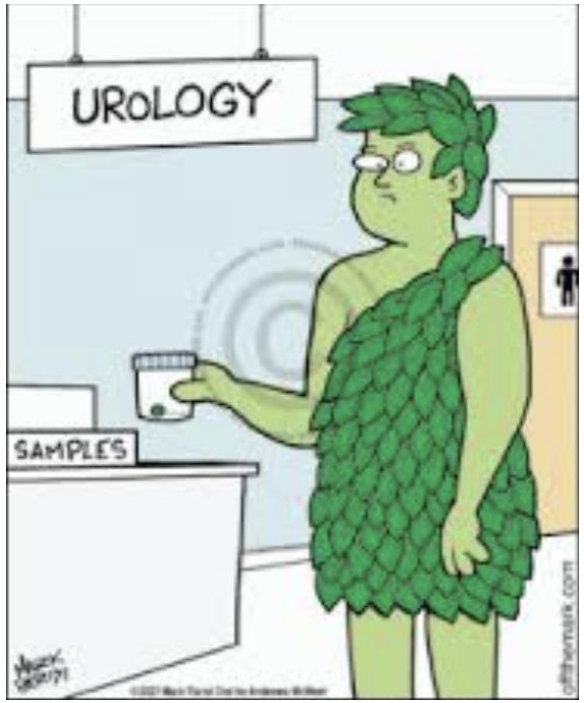
Let's talk #2
(Rose et al., 2015)

- Wet mean 128 g per person per day
- Dry mean 29 g per person per day
- 25-54% dead microbes
- Remainder is undigested food

- Phosphorus 0.35-2.7 g per person per day
- Nitrogen 1.8 g (0.9-4.9) g per person per day
- Carbon 44-55% of dry solids

#1

- Wet mean 1.42 L (0.6-2.6) per person per day
- Dry mean 4.7-10.4 g per person per day
- N (as urea) 11 g per person per day
  - 8.12 g L
  - Higher for carnivores
- How much P is in pee?
  - 350- 2500 mg L
  - Also higher for carnivores



+

=

13 g N per person per day
13 g * 365 days = 4 745 g per year
4745/1000 = 4.75 kg N per year

2 g N per person per day

11 g N per person per day

+

=

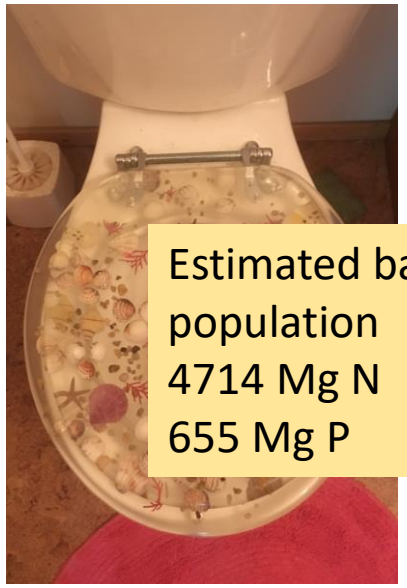
2.75 g P per person per day

2.75 g * 365 days = 1 004 g per year

1004/1000 = 1.0 kg P per year

1.5 g P per person per day

1.25 g P per person per day



Estimated based on population
4714 Mg N
655 Mg P

Measured in plant influent
7250 Mg N
840 Mg P

In biosolids
688 Mg N
180 Mg P

Measured in plant effluent
3581 Mg N
358 Mg P

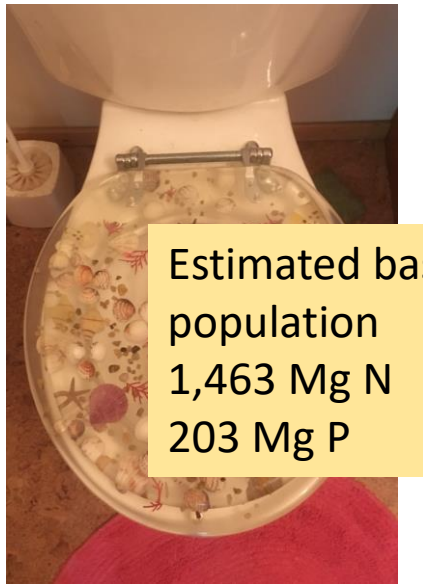
Measured in plant influent
7250 Mg N
840 Mg P

Measured in plant effluent
3581 Mg N
358 Mg P

In biosolids
688 Mg N
180 Mg P

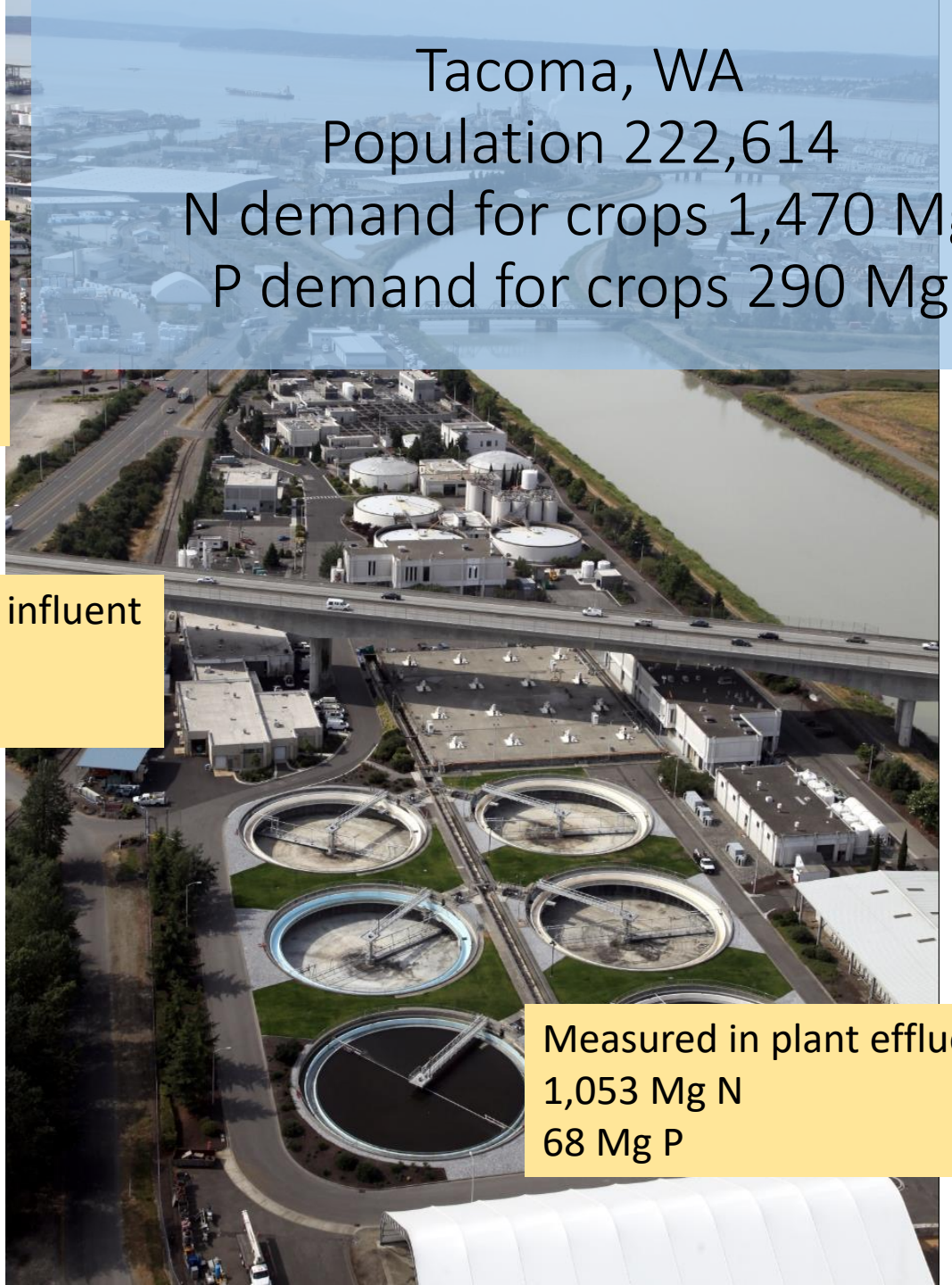
IF reclaimed water is used = 60% recovery of both N and P

IF biosolids is burned/ landfilled + water is discharged = 0% recovery of N and P



Estimated based on population
1,463 Mg N
203 Mg P

Tacoma, WA
Population 222,614
N demand for crops 1,470 Mg
P demand for crops 290 Mg



Measured in plant influent
1,182 Mg N
149 Mg P

Measured in plant effluent
1,053 Mg N
68 Mg P

In biosolids
371 Mg N
169 Mg P

You can estimate

How much N and P come into your plant

- 4.75 kg N per person
- 1.0 kg P per person

If you serve 10 000 people

- 4.75 kg N * 10 000 = 47 500 kg or 47.5 tons N
- 1.0 kg P * 10 000= 10 000 kg or 10 tons P

King County, S Plant

Land use change

- Land use change is driven by growing population and the need for everybody to eat
- If you can feed more people with less land or use urban land- you are winning the battle

Biosolids use in an urban context

- Study looking at soil health/ plant health for urban soils with residual based amendments

  (Una et al., 2022)

-/+ compost
Case of famine versus feast

- Total C
  - 10.1 ± 2.3
- Total N
  - 0.6 ± 0.1
- Bulk density
  - 0.6
- POX-C
  - 1265

- Total C
  - 3.24 ± 1.1
- Total N
  - 0.2 ± 0.06
- Bulk density
  - 1.1
- POX-C
  - 632

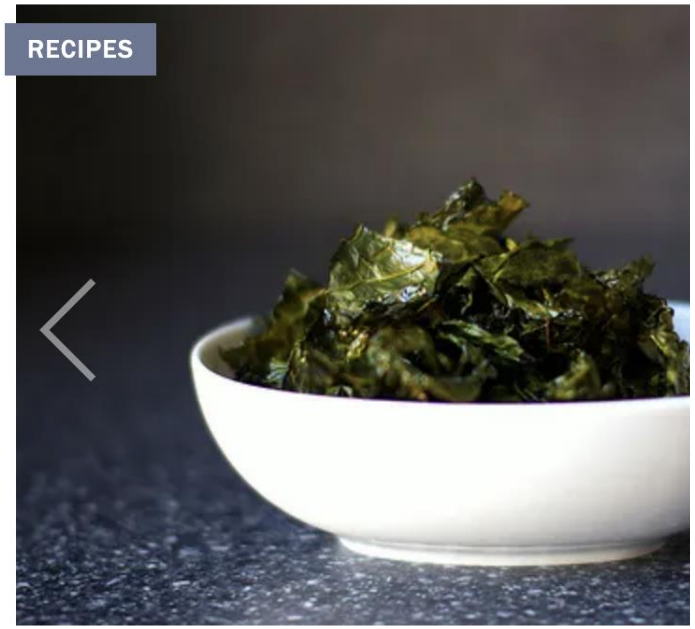
How many people could you feed per ha?
(1 portion kale per person per day)

Fertilizer control- 15

Biosolids potting soil- 736

If you use biosolids in a disturbed urban soil and grow kale

https://smittenkitchen.com/



baked kale chips

kale salad with pecorino and walnuts

kale and caramelized onion stuffing

Man does not live by kale alone

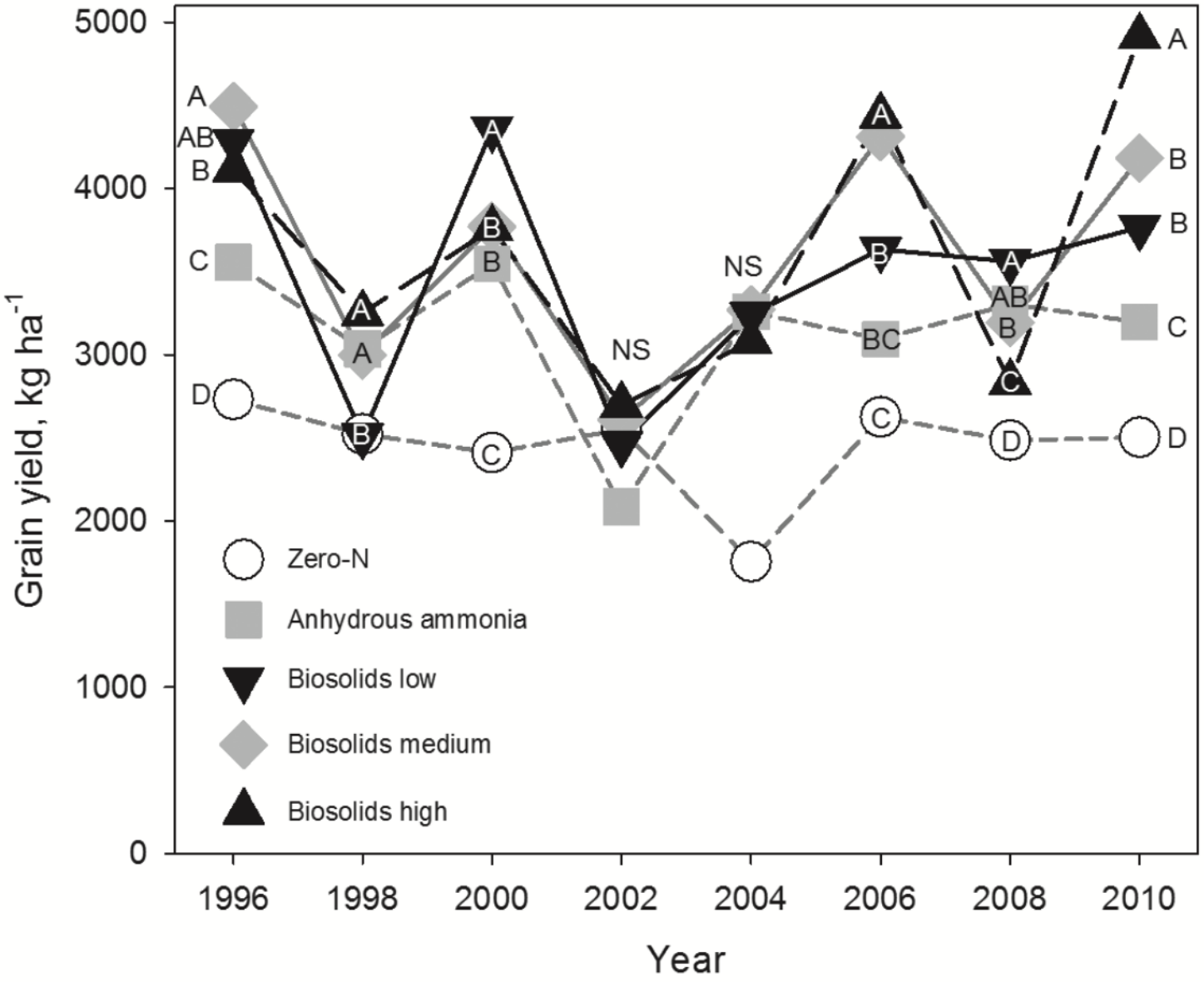
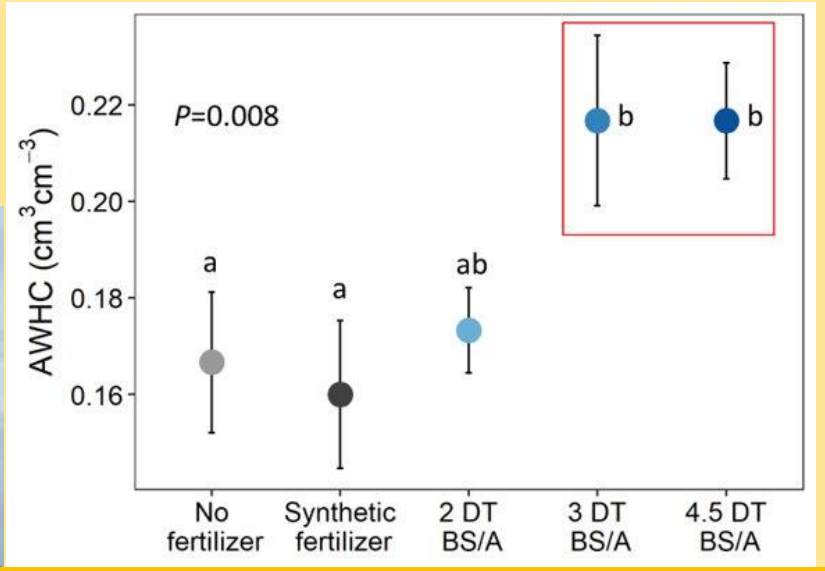


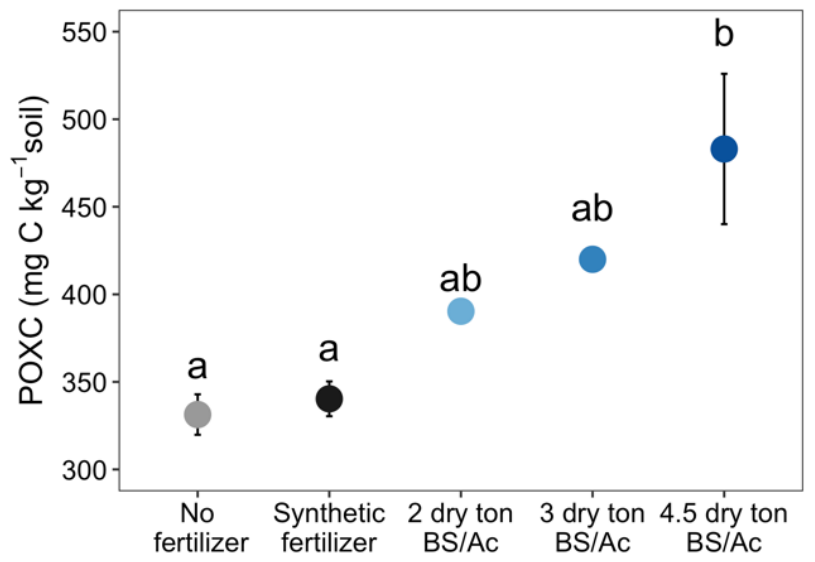
Fig. 1. Winter wheat grain yield by harvest, 1996 to 2010. The first crops following biosolids applications were in 1996, 2000, 2004, and 2008. The second crops following biosolids applications were in 1998, 2002, 2006, and 2010.

Deirdre Griffin La Hue
Washington State University

Biosolids make the soil healthier



Available water holding capacity (AWHC) results from the biosolids experiment in Douglas Co.



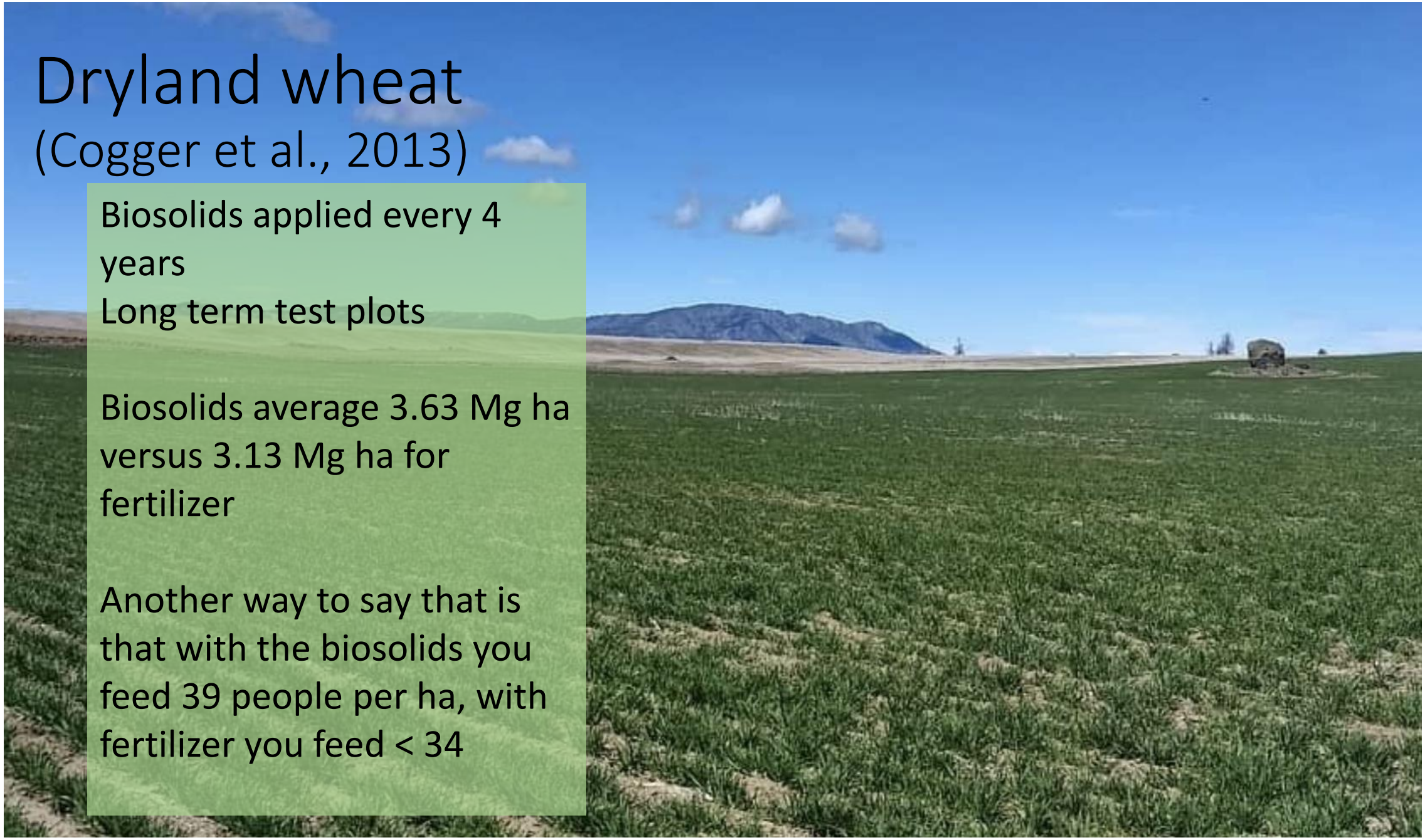
POX-C values from the long-term biosolids trial in Douglas Co., WA

Dryland wheat
(Cogger et al., 2013)

Biosolids applied every 4 years
Long term test plots

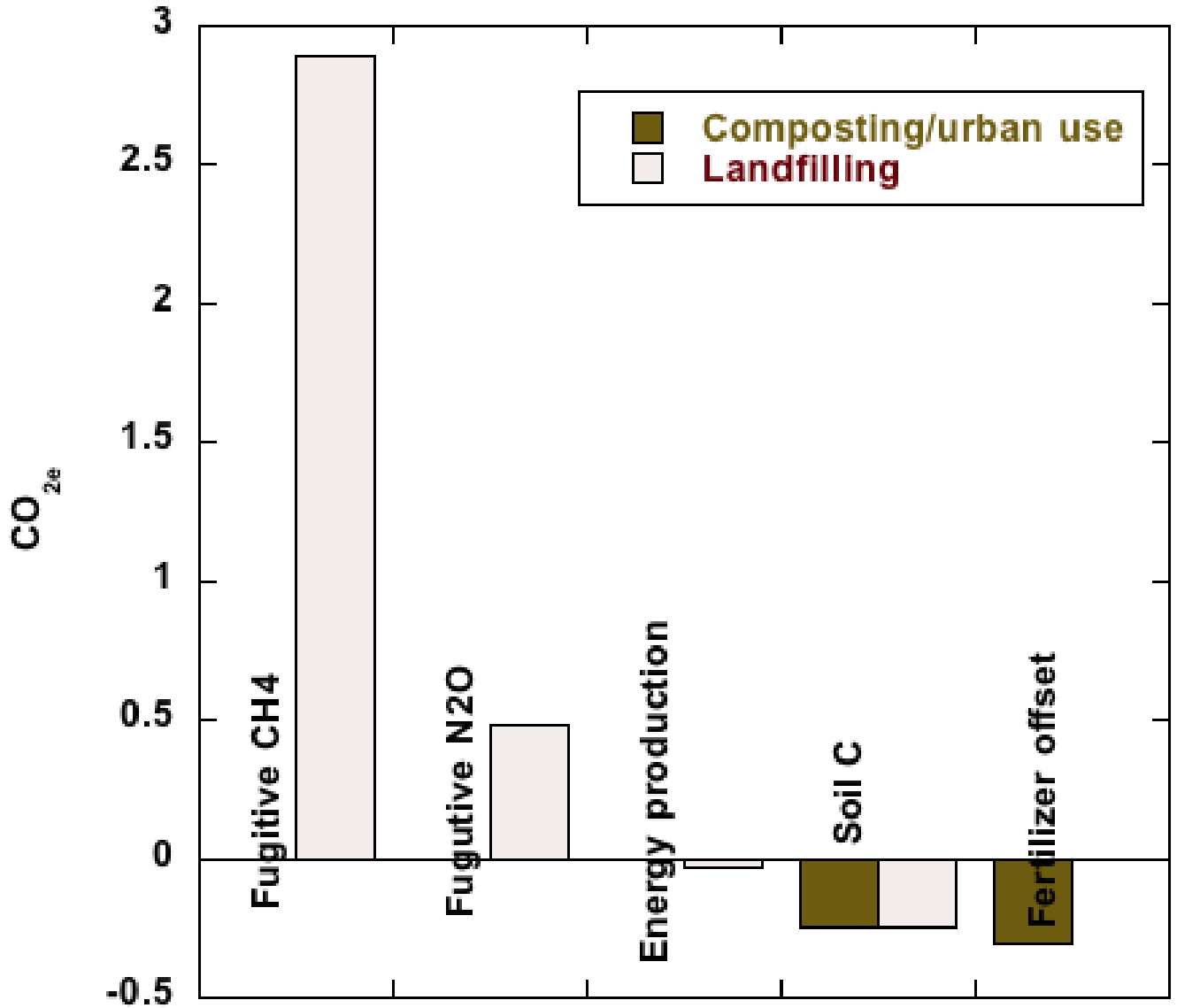
Biosolids average 3.63 Mg ha versus 3.13 Mg ha for fertilizer

Another way to say that is that with the biosolids you feed 39 people per ha, with fertilizer you feed < 34



Climate impacts- 1 ton biosolids
3.23 (landfill) versus -0.38 (land apply)

Default values



Brown et al., 2010

Forest application
(Leonard et al., 2021)


25m
ROTTNE RK 90

Carbon Balance

Above ground biomass
- Increase in tree growth
- Commercial plantation
  - **40 year rotation**
  - **Does not qualify**

Transport and application
- 224 km haul distance
- 30 ton capacity truck
- Application by self loading vehicle

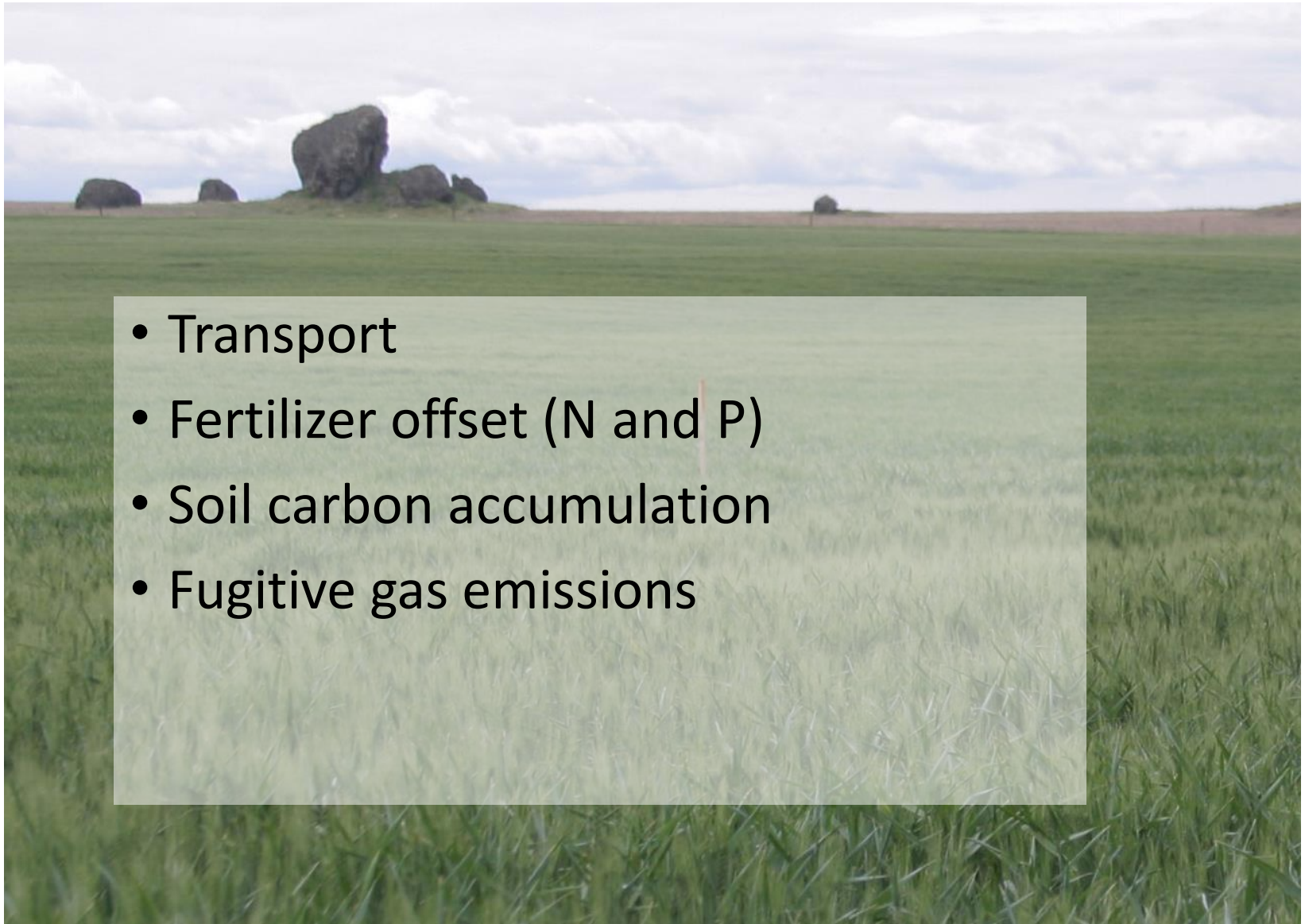
0.05 Mg CO_2 per dry ton

Soils
- Fertilizer value of material
  - **-0.245 Mg CO_2 per dry ton**
- Increase in soil carbon
  - **-5.15 Mg CO_2 per dry ton Tokul soil**
  - **No change Klaus soil**

Tokul soil balance = 0.05- 0.245- 5.15 = -5.3 Mg CO_2 per dry ton biosolids

Klaus soil balance = 0.05-0.245 = -0.2 Mg CO_2 per dry ton biosolids

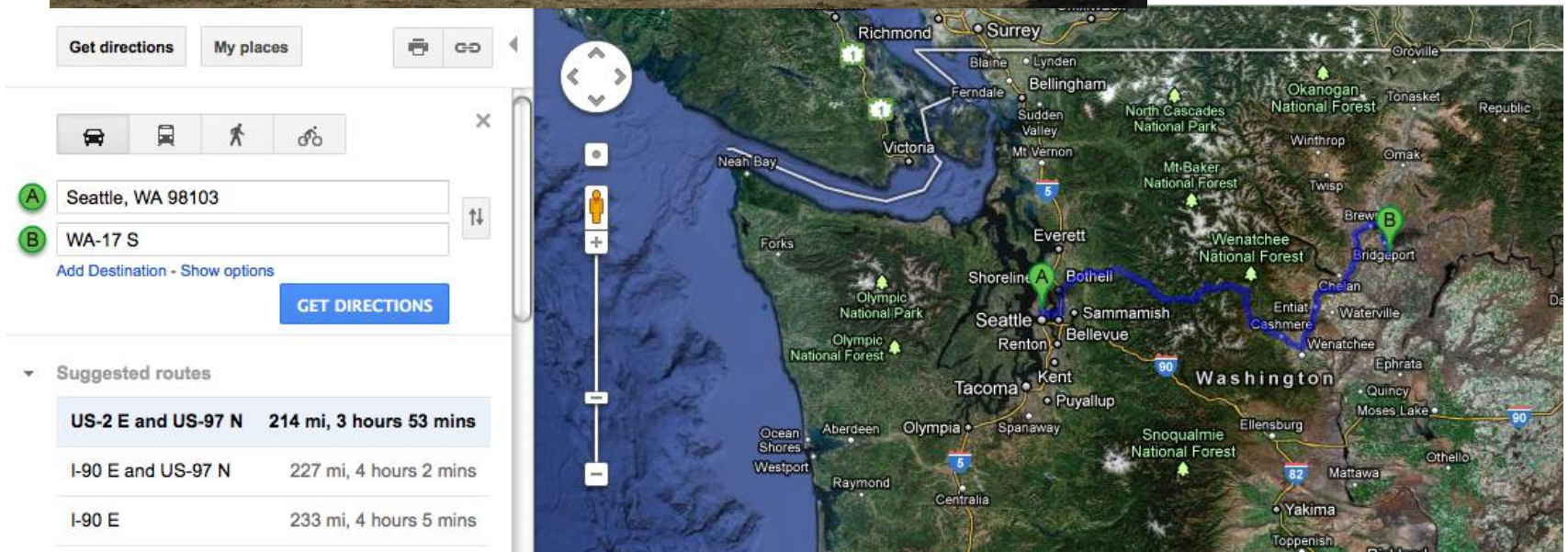
Boulder Park
Dryland wheat- 50-60% of total production



- Transport
- Fertilizer offset (N and P)
- Soil carbon accumulation
- Fugitive gas emissions

Significant haul distance

0.3 kg/dry ton biosolids/ mile transport = 0.12 Mg CO_2 per dry ton transported



Soil- debits/credits

CO_2 per dry Mg biosolids

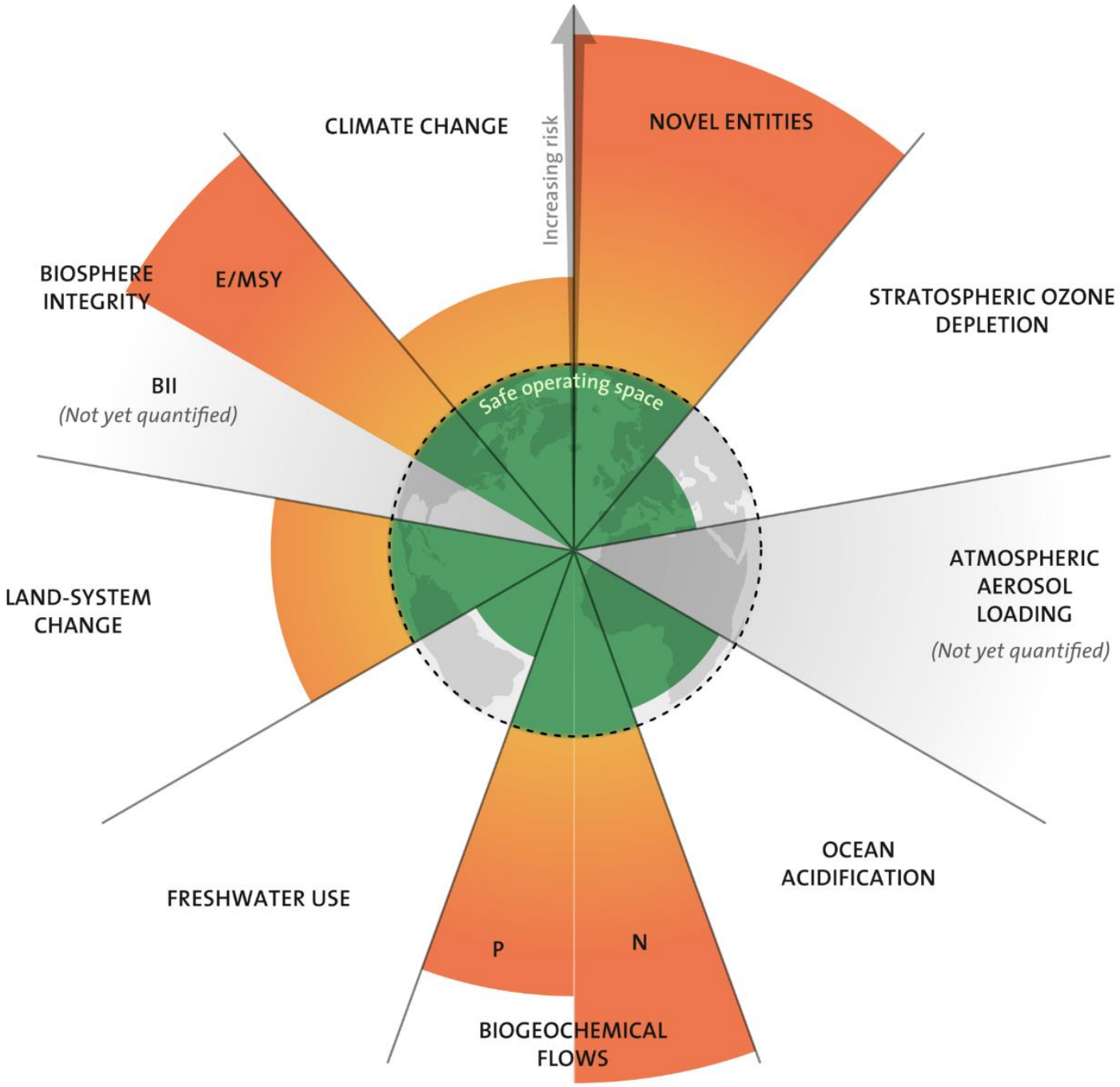
- Soil
  - 1.4
- Fertilizer offsets
  - 0.27
- Fugitive gas emissions
  - None detected

Dryland wheat- does not include increased yields

- Credits=
  - 1.67
- Debits=
  - 0.12
- Total =
  - 1.55 Mg CO_2 per Mg biosolids

We are a part of the solution

- Novel entities
  - Anthropogenic chemicals/ compounds
- Biogeochemical flows
- Land system change
- Climate change



Why it's time to talk about poo

By Lina Zeldovich 30th August 2022

The nutrients in human waste are drifting into our oceans and landfills instead of back into soils. But there are much better uses for human poo than flushing it down the drain

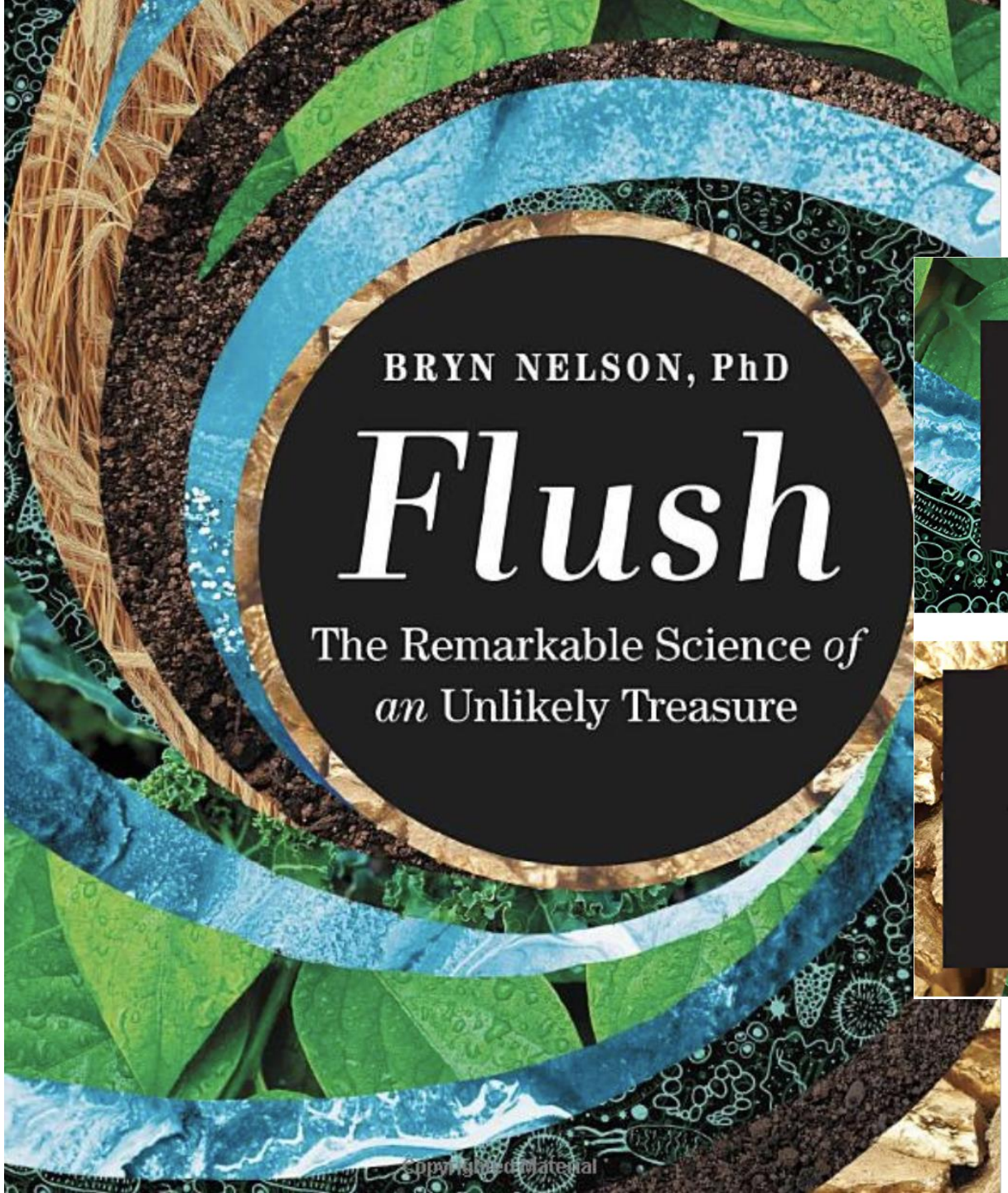
https://www.bbc.com/future/article/20220830-the-new-science-of-recycling-human-poo

DC Water recently changed their treatment process and has a Class A biosolids product as a result
They followed the lead of Tacoma and King County for branding and outreach

Why it's time to talk about poo

The fertiliser product Bloom is made from the output of sewage plants in Washington DC (Credit: Lina Zeldovich)

https://www.bbc.com/future/article/20220830-the-new-science-of-recycling-human-poo


BRYN NELSON, PhD
Flush
The Remarkable Science of an Unlikely Treasure
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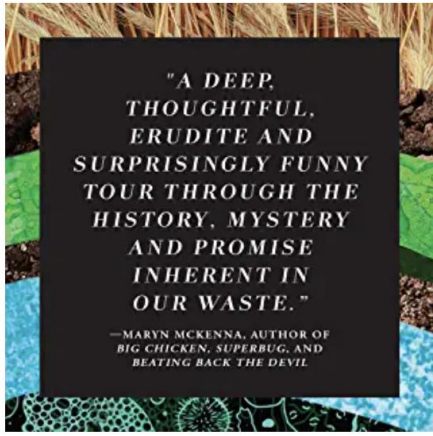
"BRYN NELSON LOVES NEARLY ALL THINGS SCATOLOGICAL, FROM FARTS TO POOP, INPUT AND OUTPUT. AND HE'LL CONVINCE YOU THAT WHAT COMES FROM YOUR BODY, AND EVEN YOUR PHYSICAL SELF AFTER DEATH, JUST MIGHT SAVE THE PLANET."
—LAURIE GARRETT, PULITZER PRIZE WINNER, WRITER, AND AUTHOR OF THE COMING PLAGUE AND BETRAYAL OF TRUST


"THIS IS POP SCIENCE DONE RIGHT."
—PUBLISHERS WEEKLY (STARRED REVIEW)

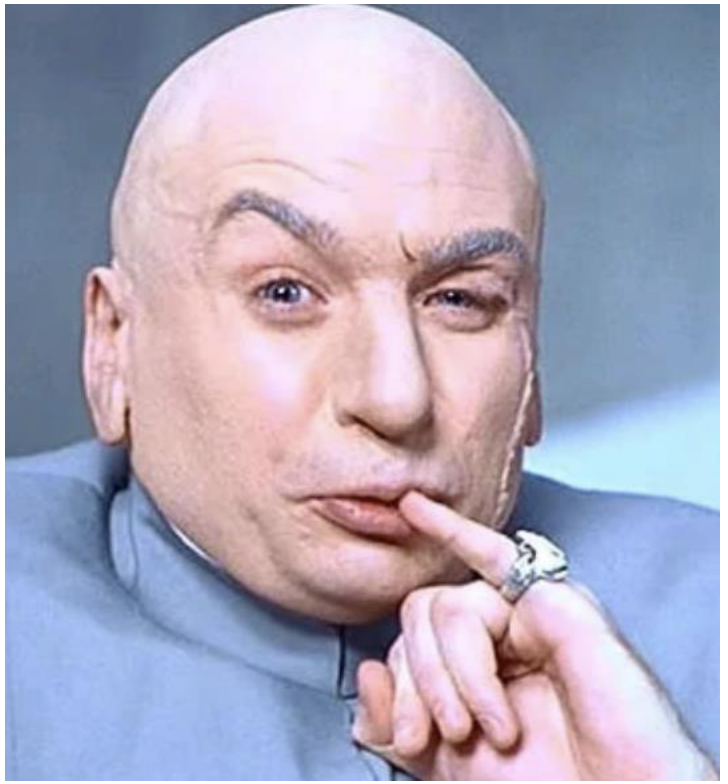

"FLUSH IS A TABOO BREAKER AND A FECAL FANTASIA."
—CAITLIN DOUGHTY, NEW YORK TIMES BESTSELLING AUTHOR OF SMOKE GETS IN


"A DEEP, THOUGHTFUL, ERUDITE AND SURPRISINGLY FUNNY TOUR THROUGH THE HISTORY, MYSTERY AND PROMISE INHERENT IN OUR WASTE."
—MARYN MCKENNA, AUTHOR OF BIG CHICKEN, SUPERBUG, AND BEATING BACK THE DEVIL

Grossly ambitious and rooted in scientific scholarship, *The Other Dark Matter* shows how human excrement can be a life-saving, money-making resource—if we make better use of it.

I asked some of the professionals I know to talk about what they do and where they fit in

(a sense of humor can be helpful in our field)



SYLVIS

sylvis.com

Our Vision: Make Waste History

We research, recommend and implement beneficial residuals management

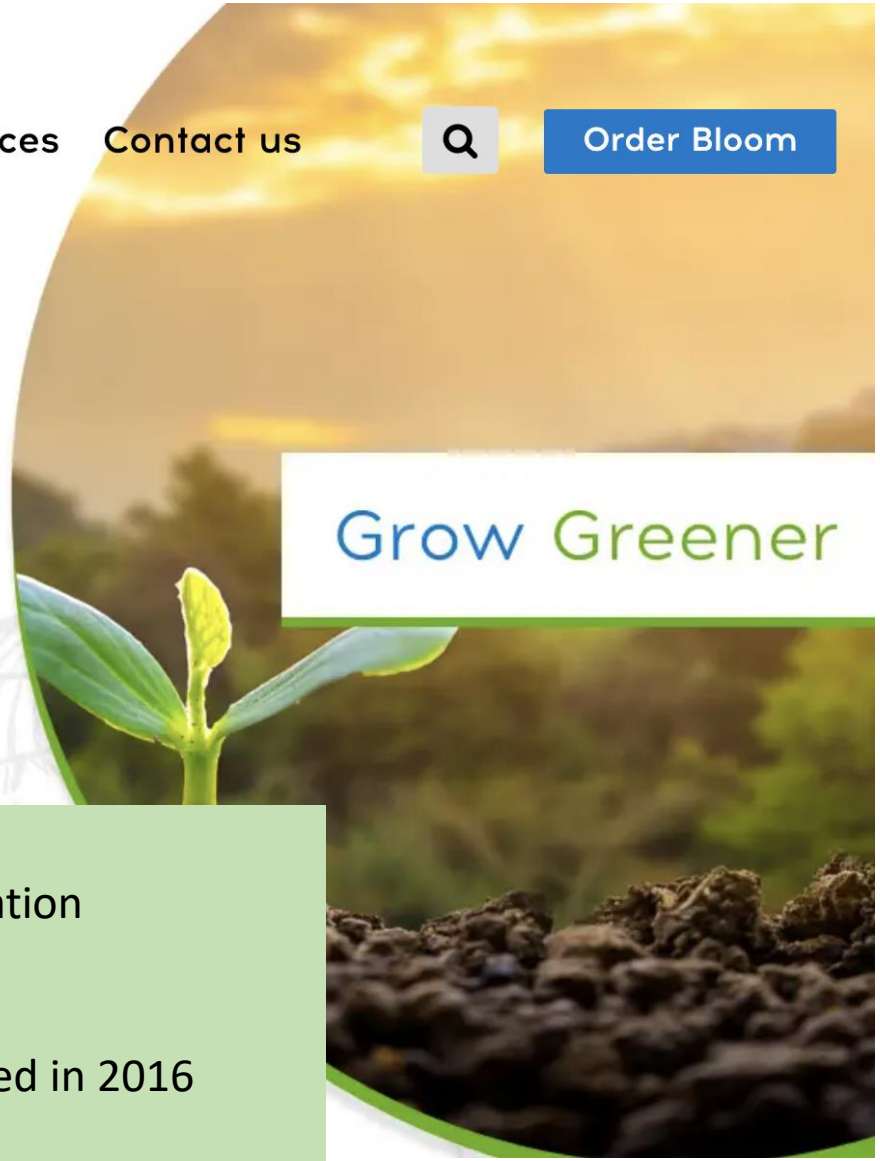
"SYLVIS exists because I believe our sustainability is dependent on the innovative management of our waste"

Mike Van Ham

President and Senior Environmental Scientist
SYLVIS Environmental

BLOOM®

Home What is Bloom? News Resources Contact us Order Bloom



Sustainable, local, recycled.

Using Bloom helps sequester carbon, generate clean energy and recycle 450 tons of biosolids a day. Inquire about a purchase today!

What is Bloom?

56,310 tons of Bloom sold this past year.

- $1.4M in savings over traditional land application contracting
- $320K in Bloom revenue last year
- Over $1.1M in Bloom revenue since we started in 2016

60,000 MWhrs of green electricity and 50,000 thermal equivalent MWhrs of green heat energy recovered last year

Chris Peot (DC Water)

Biosolids reuse offers an enormous opportunity to recycle a wildly underutilized asset. While we won't solve the climate crisis alone with our work, we can contribute to the solution. This work allows me to sleep very well at night, knowing we are turning the tide of public perception from disposal of a waste toward recovery of a valuable resource. There is no such thing as waste, only wasted resources!

Dan Thompson

TAGRO
City of Tacoma

- In my role as a biosolids manager I am not only conserving resources and improving the environment by providing high quality fertilizer from what were considered waste products but I am bringing people together and creating community.

- Biosolids recycling is not only the most basic of recycling endeavors it also is an excellent tool for creating and sustaining community. Biosolids have played a big part in Tacoma's community gardening program which has fostered improved community relations, better access to healthy food, and an improved sense of citizenship where these gardens have been built.

Dan Eberhardt
Tagro, Tacoma

- Feeding the soil that feeds you. (One flush at a time) Thousands of TAGRO customers can’t be wrong!!!

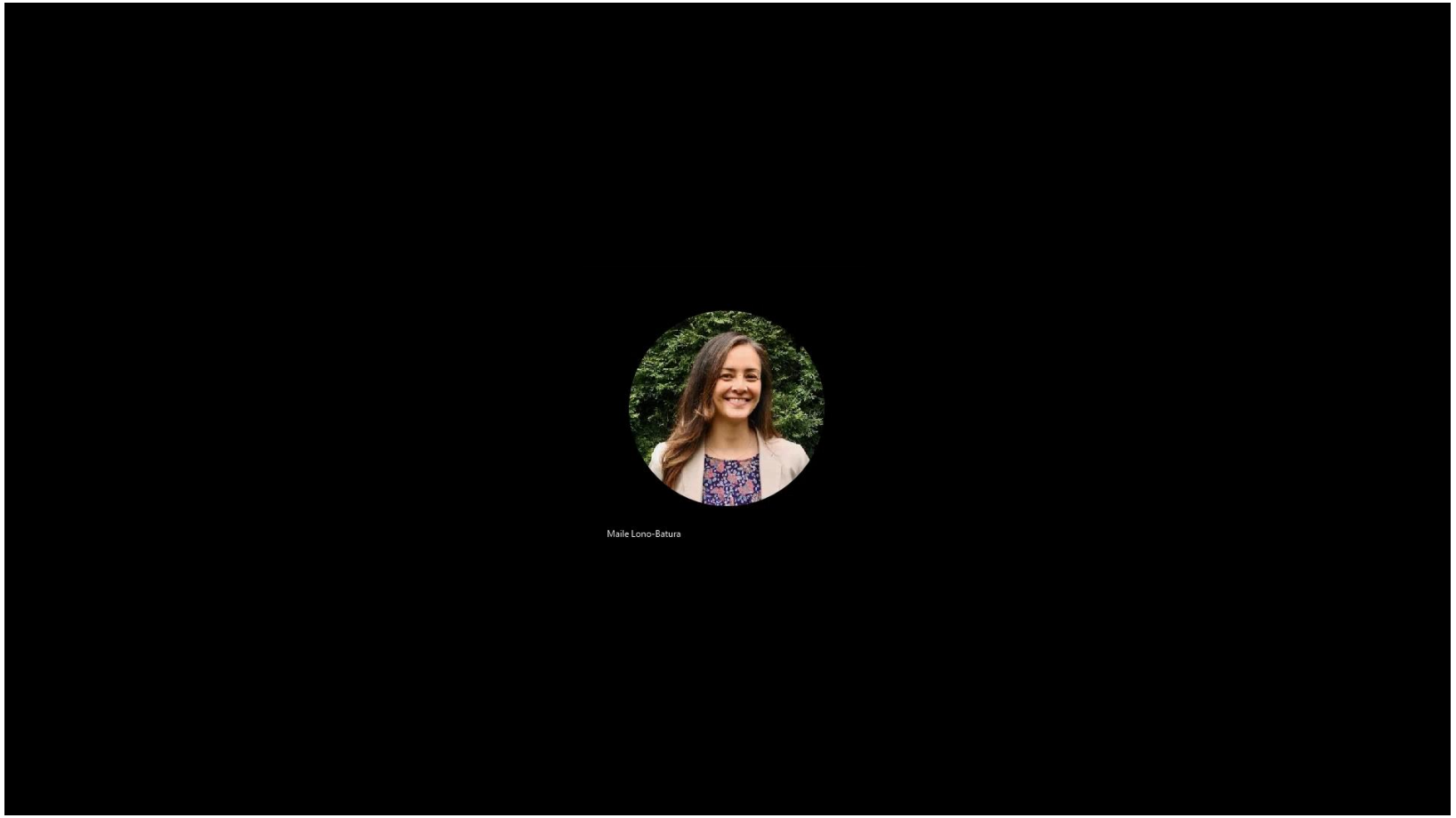
Rebecca Singer, Lead Resource Recovery King County WA

- Wastewater treatment facilities are community hubs that offer climate resiliency. We don't seem to value what they are capable of because we continue to define them as waste, but if we take a deeper dive into what their capable of, you may be surprised at what they offer. From the moment that you flush your toilet, take a shower or wash laundry, you have created a resource.
- We are not doing ourselves or the planet any favors by viewing biosolids as a waste. We should be maximizing our use of all organics to protect our valuable soils.
- I do what I do, because protecting our soils is key to our survival.

Maile Lono- Batura

Sustainable biosolids programs

Water Environment Federation®
the water quality people®



Take pride in product and take pride in what you do

Our thrones may lack in majesty
But they are as real as they come