Improving water quality under processing vegetable rotations on sandy soils

Steven Hall, et al.
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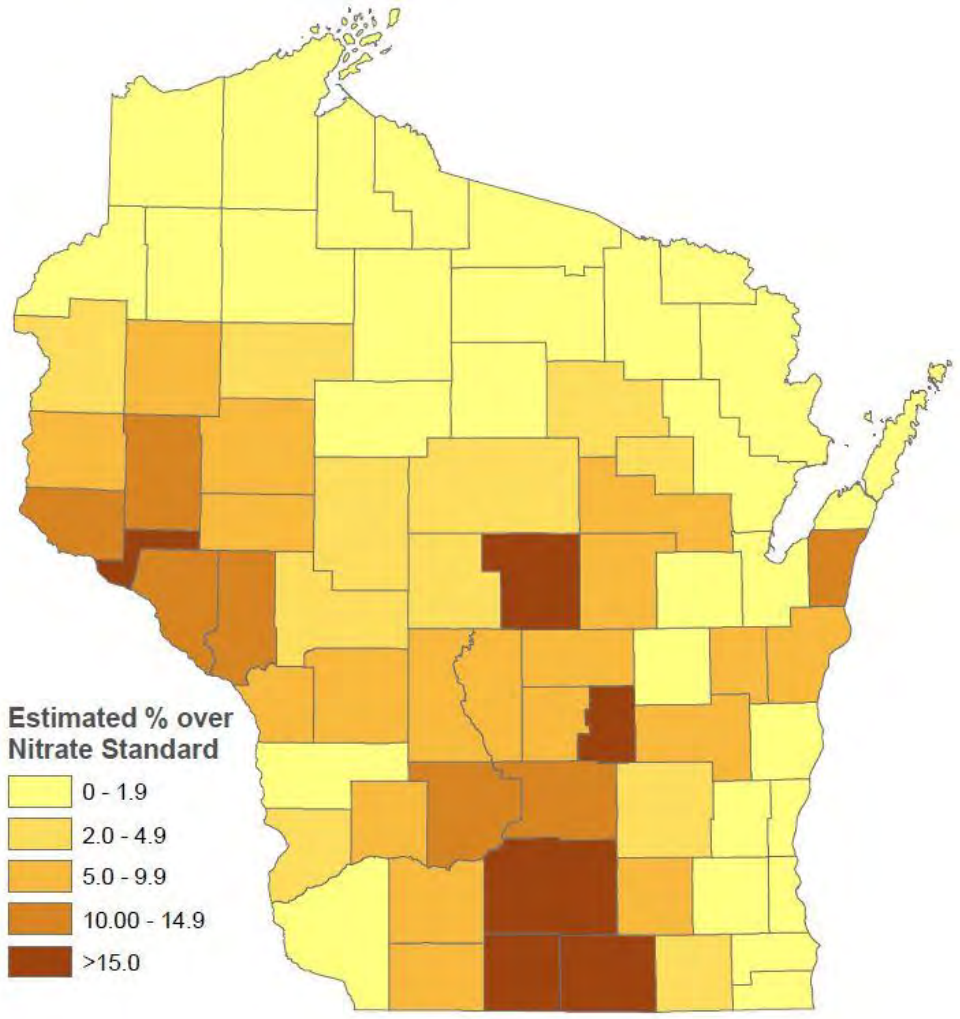
Widespread groundwater nitrate contamination throughout Wisconsin



Map of Estimated Percentage of Private Wells over Nitrate Standard by County (Jan. 2022 through June 2023).

Source: WI groundwater coordinating council, 2023

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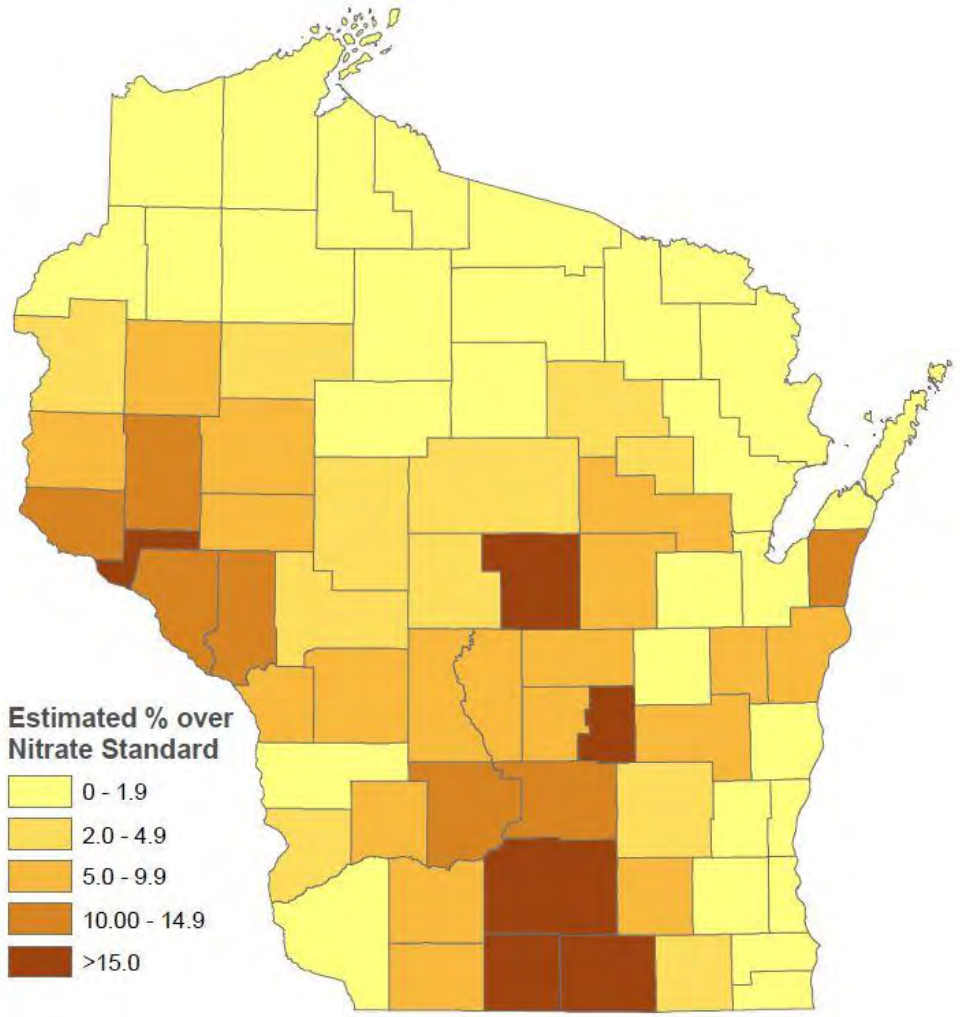

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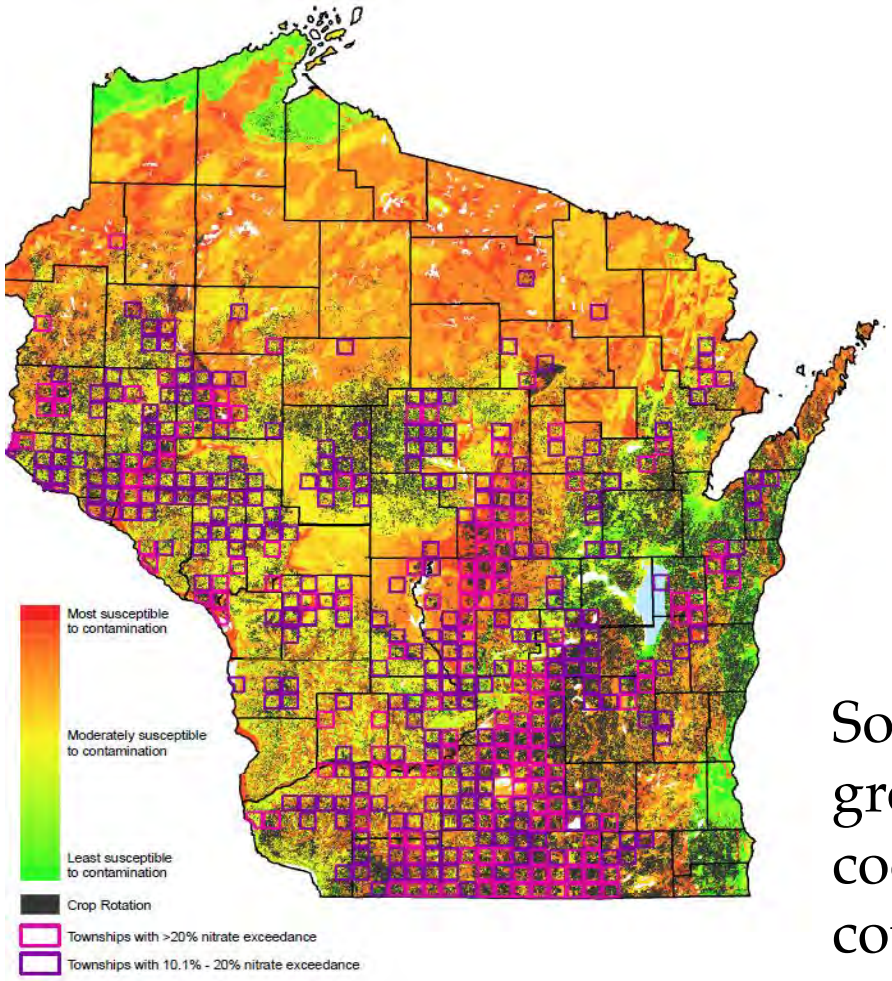
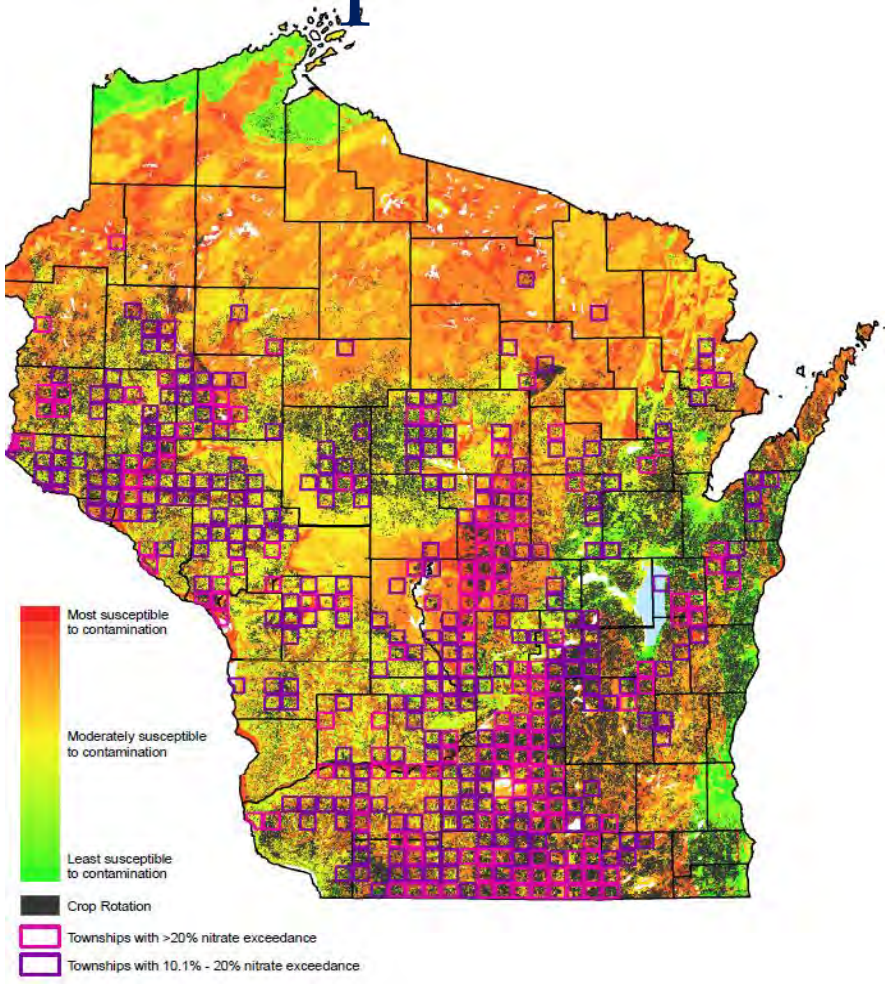


Sensitivity of Wisconsin's groundwater versus agricultural land use and nitrate impacts to private wells.

Source: WI groundwater coordinating council, 2023

Opportunity:
Wisconsin Rural Partnerships Institute

- Funding from USDA to support research and outreach in Wisconsin's rural communities
- Our project focuses on addressing nitrate in the Central Sands
- Project leader: Jed Colquhoun
- Participants: Paul Mitchell, Steven Hall, Yi Wang, Matt Ruark, Matt Digman, Kevin Masarik, Amber Radatz, Guolong Liang, Chris Kucharik, Jeff Hadachek, Mallika Nocco



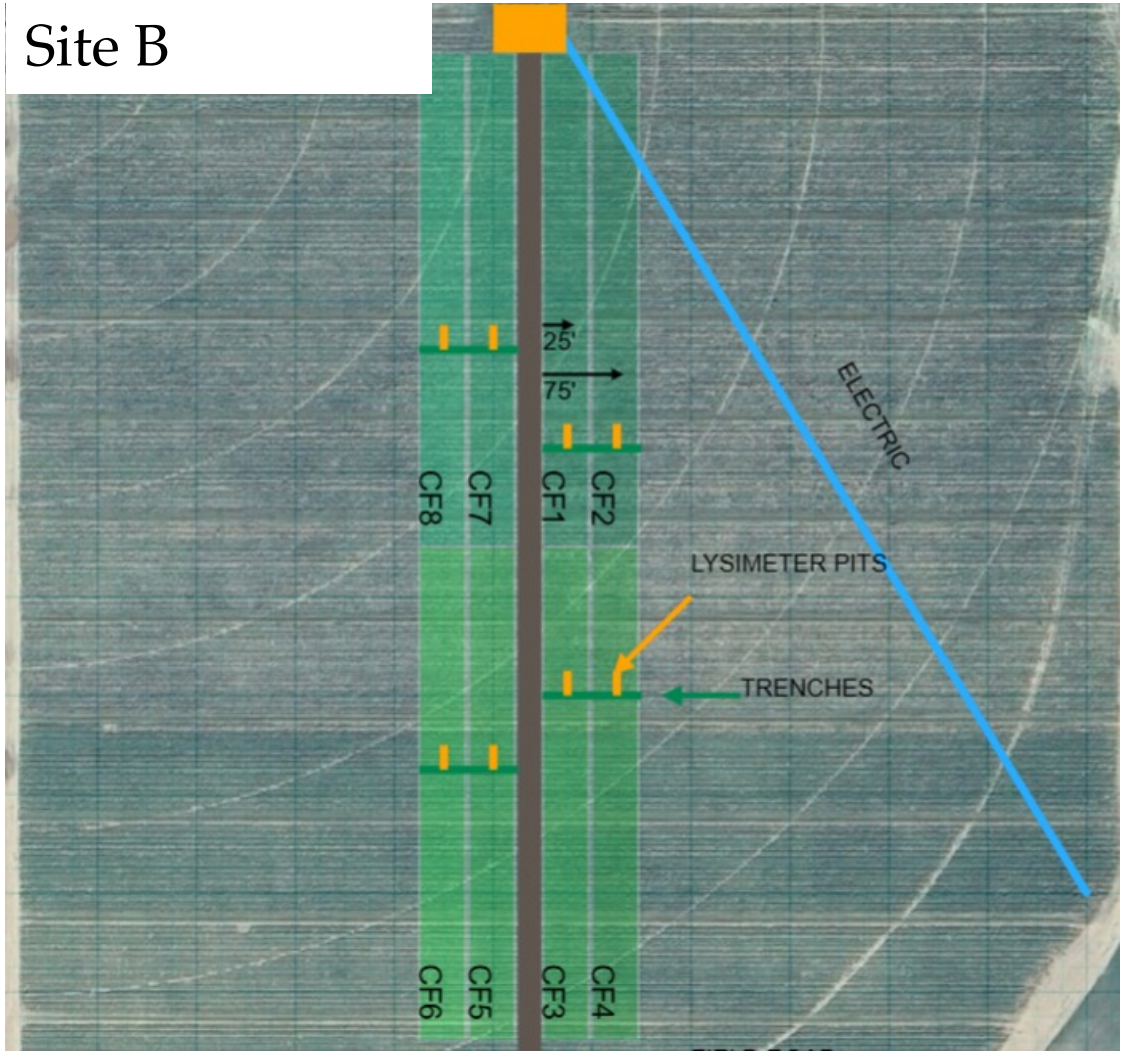
Sensitivity of Wisconsin's groundwater versus agricultural land use and nitrate impacts to private wells.

Goals of our work

- Tackle the challenge of nitrate leaching from multiple perspectives
- Test conventional and off-the-wall approaches to decrease nitrate leaching
- Assess what combination(s) of practices could actually be implemented
- Monitor impact and improve implementation

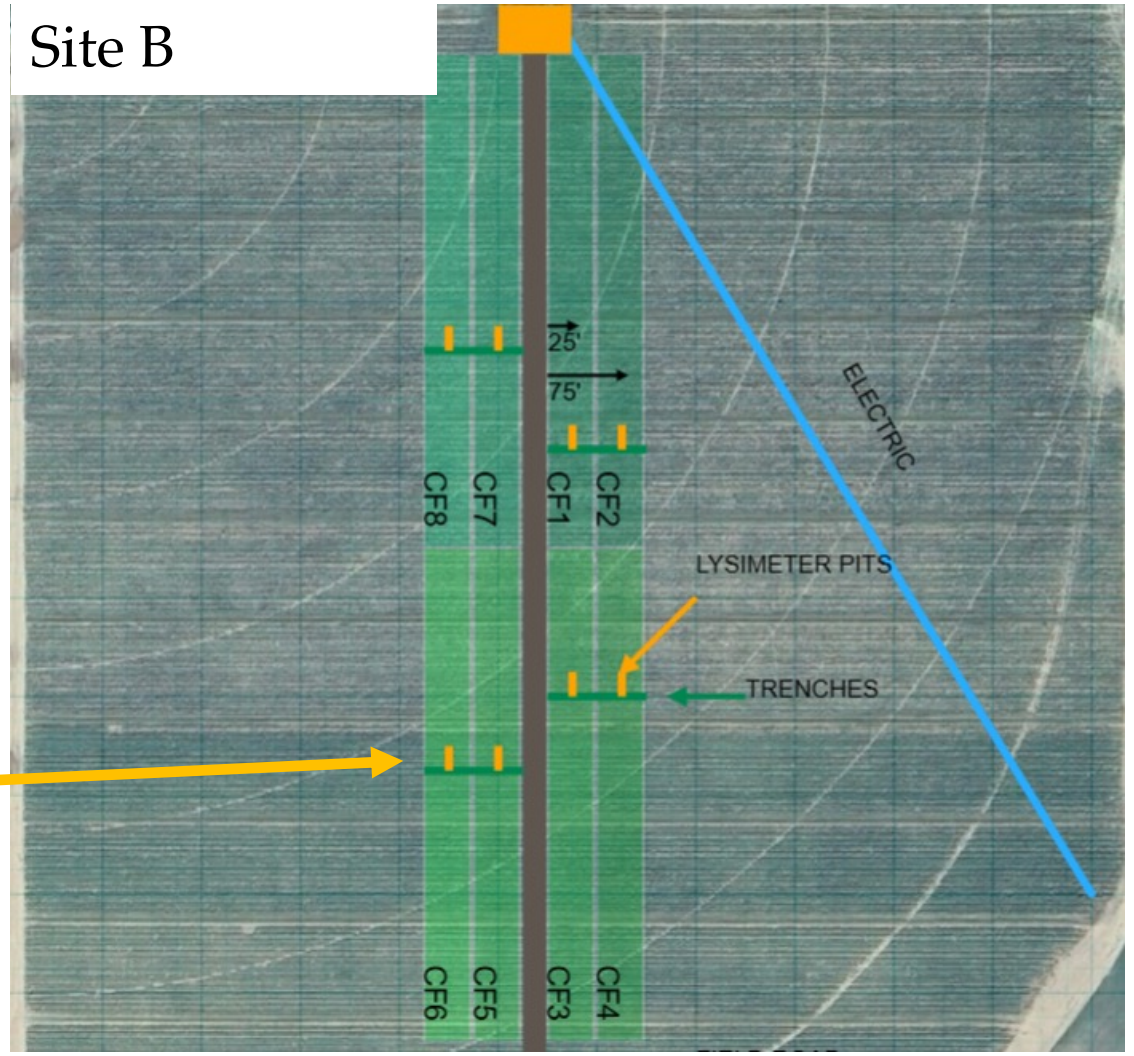
Water Stewards Innovation Farms

- Three leading potato/vegetable growers are participating in on-farm research to improve water quality
- Test "business-as-usual" vs. new practices to test water quality benefit
- Examples:
  - Decreased N fertilizer rate
  - Banded fertilizer, polymer-coated urea
  - Intercropping with rye/mustard
  - Relay cropping (e.g. winter camelina)

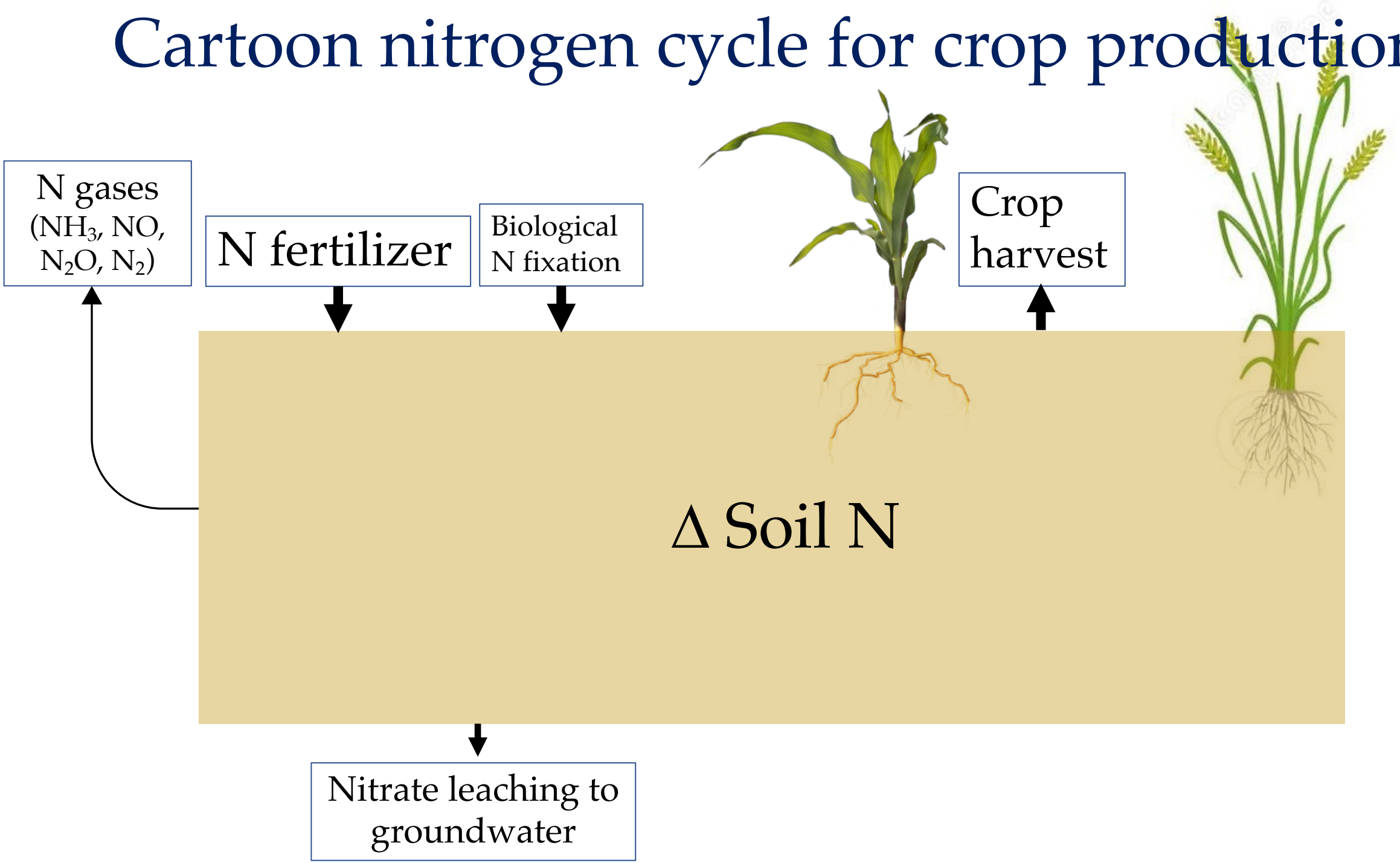


Water Stewards Innovation Farms

Equilibrium tension lysimeter



Cartoon nitrogen cycle for crop production



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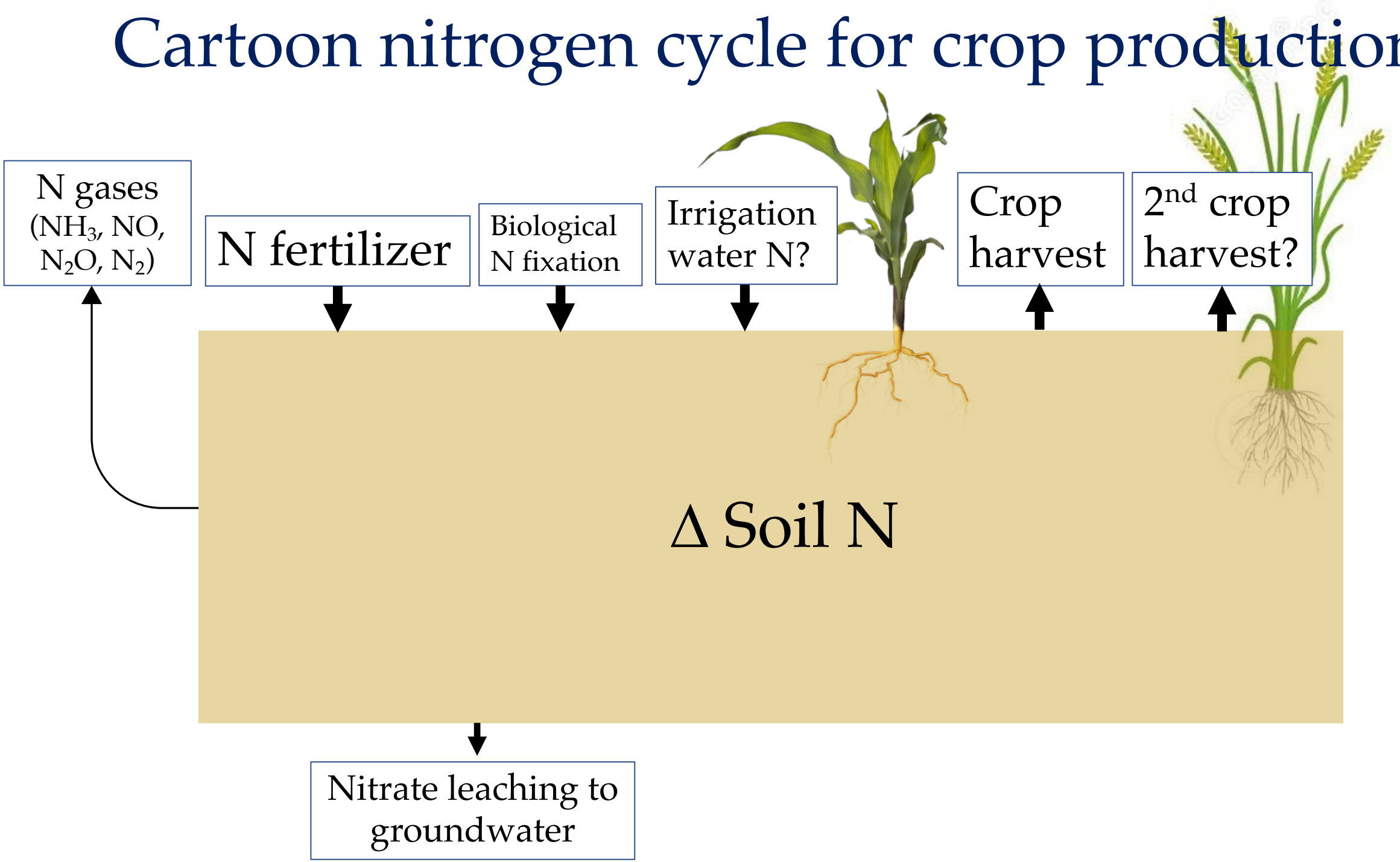
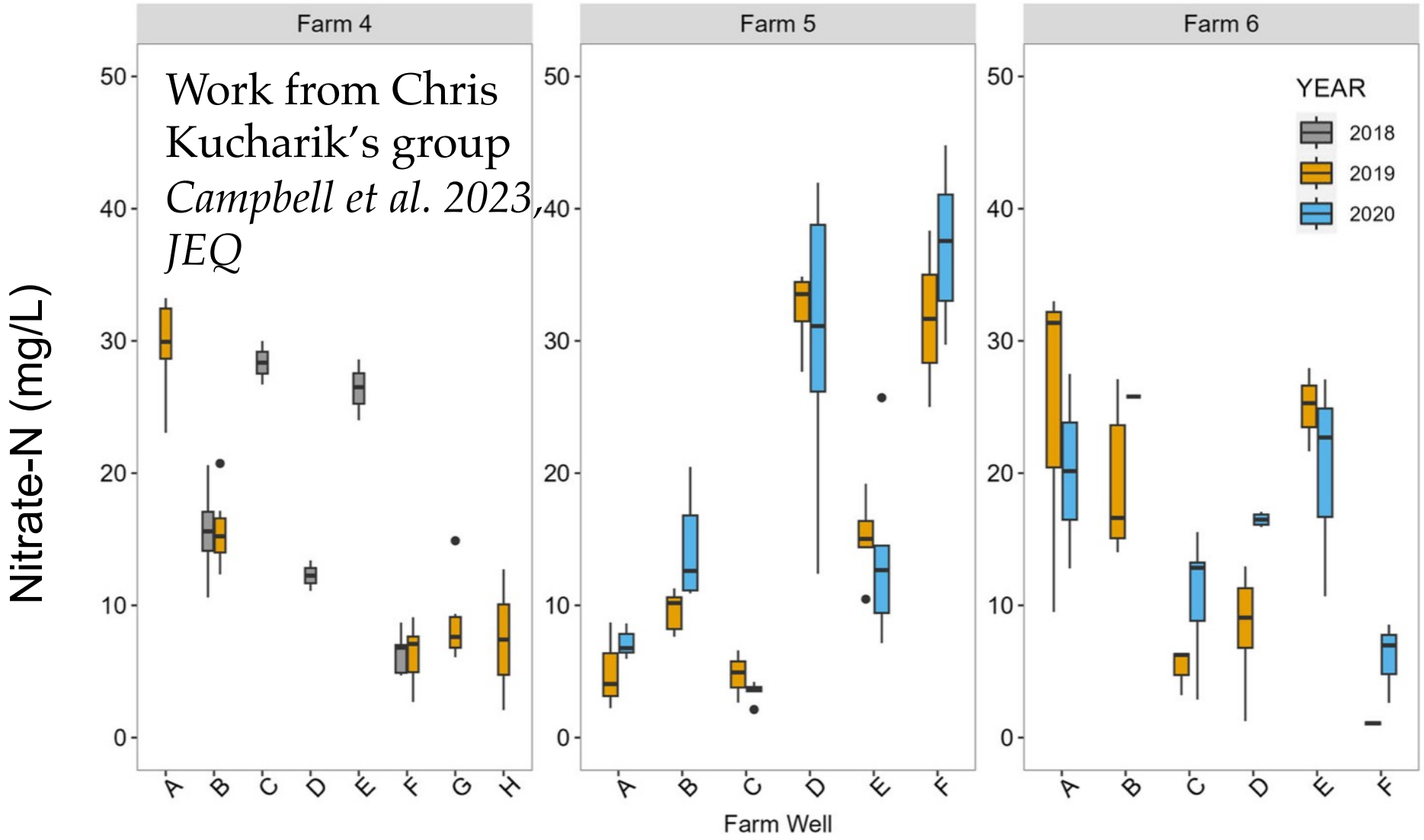
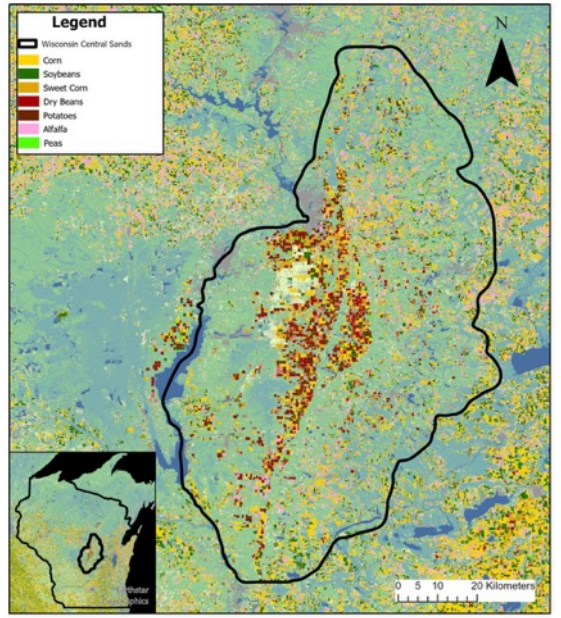


Irrigation water:
an untapped source of N credits?

Photo credit: UW Extension





- Wells from different fields had consistently different nitrate concentrations
- >8-fold variation in well nitrate among fields from a single farm!

How to account for field-specific variation in well-water nitrate?

- **Conventional viewpoint:** it doesn't matter, because well-water nitrate is already accounted for in standard fertility guidelines
- **Nuanced approach**: credit irrigation N applications in fields with *unusually* high well-water NO_3…

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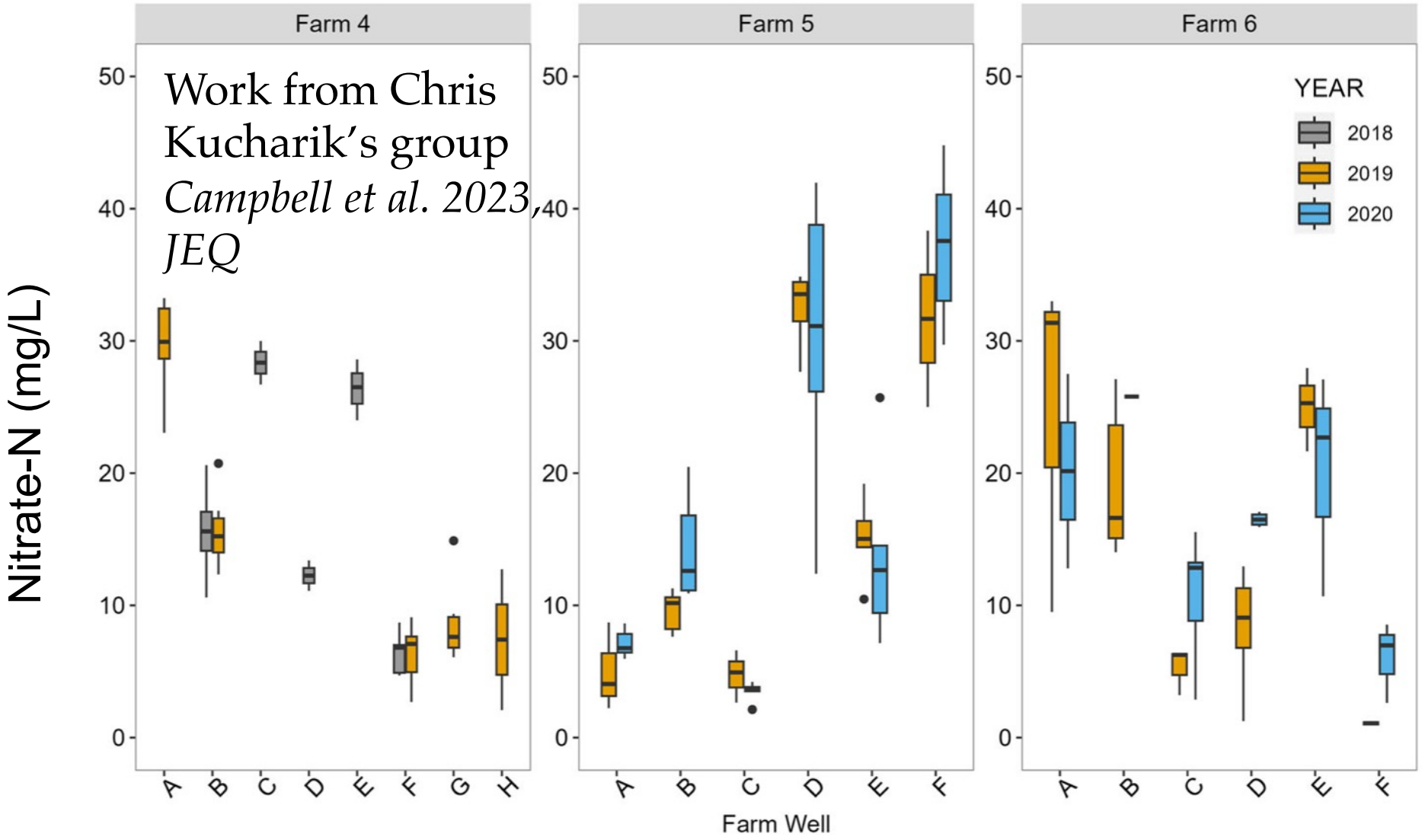
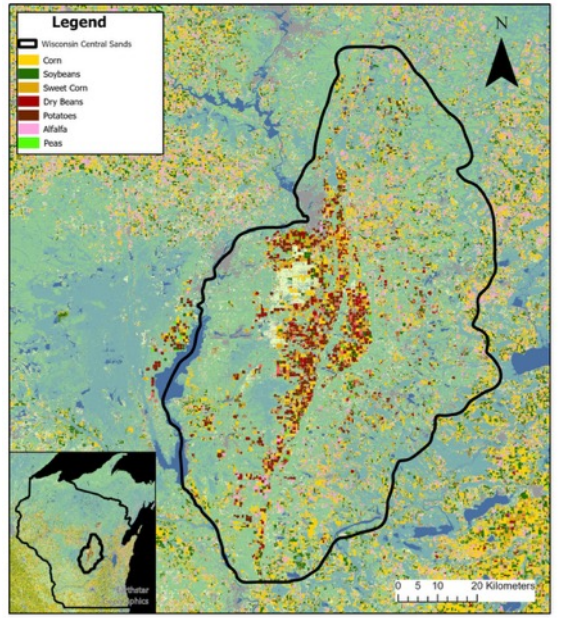
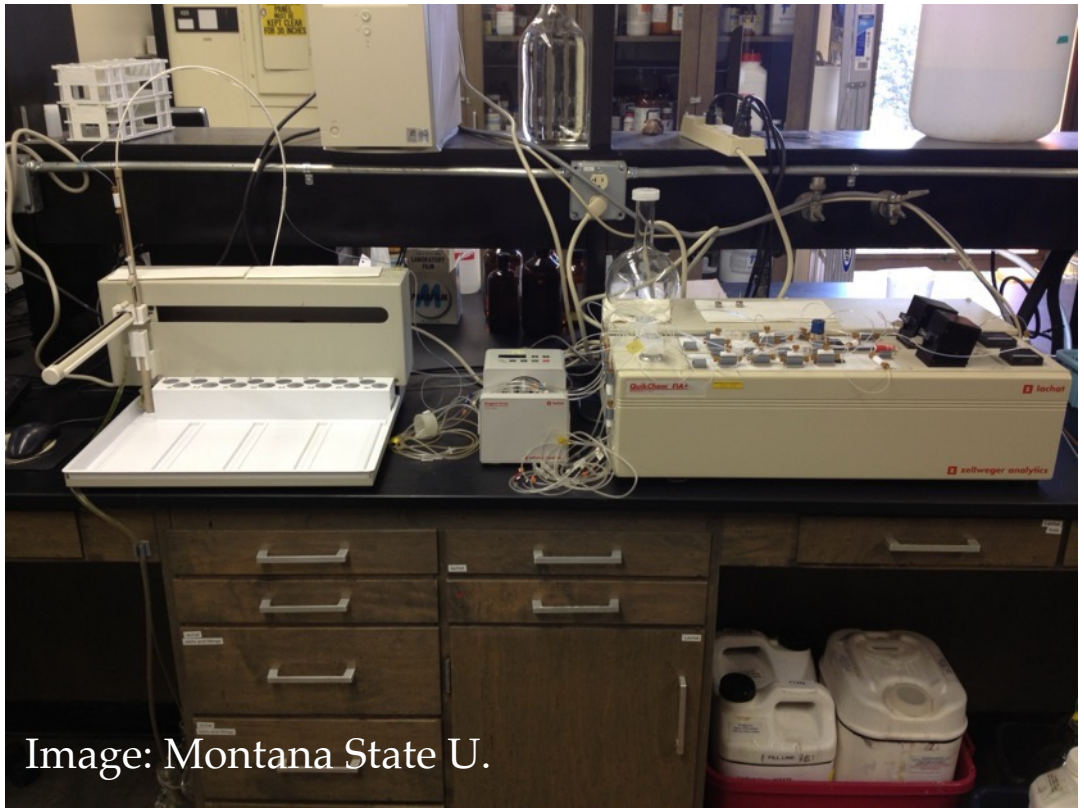
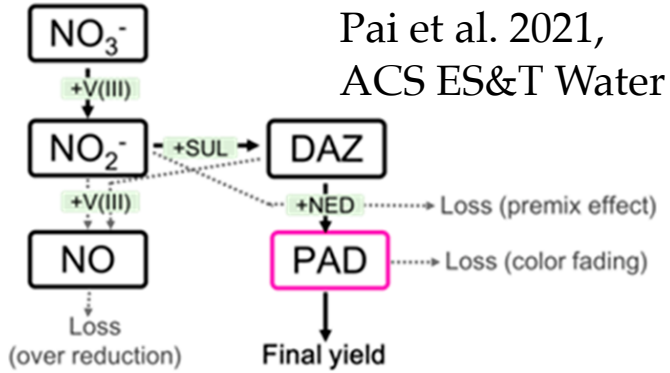
  - **Difference: 41 lb/ac of potential N credit**





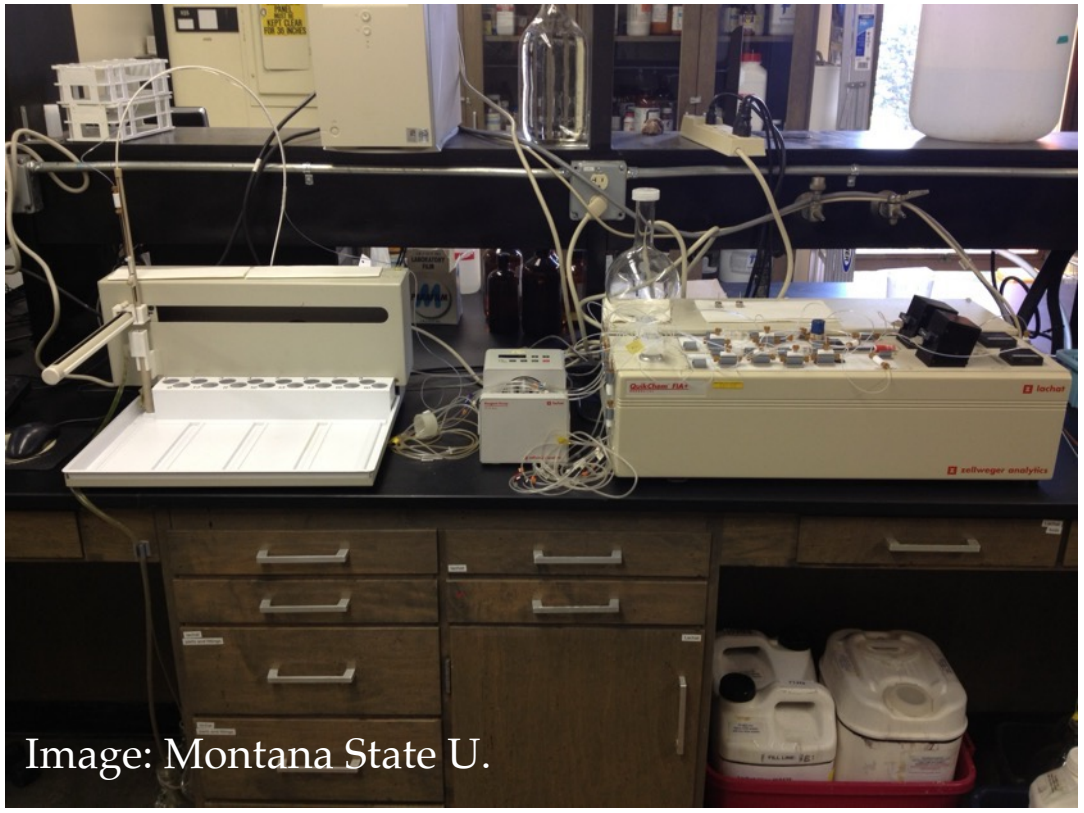
- **Challenge**: we can't yet predict spatial variation in well-water nitrate… *but we can measure it*!

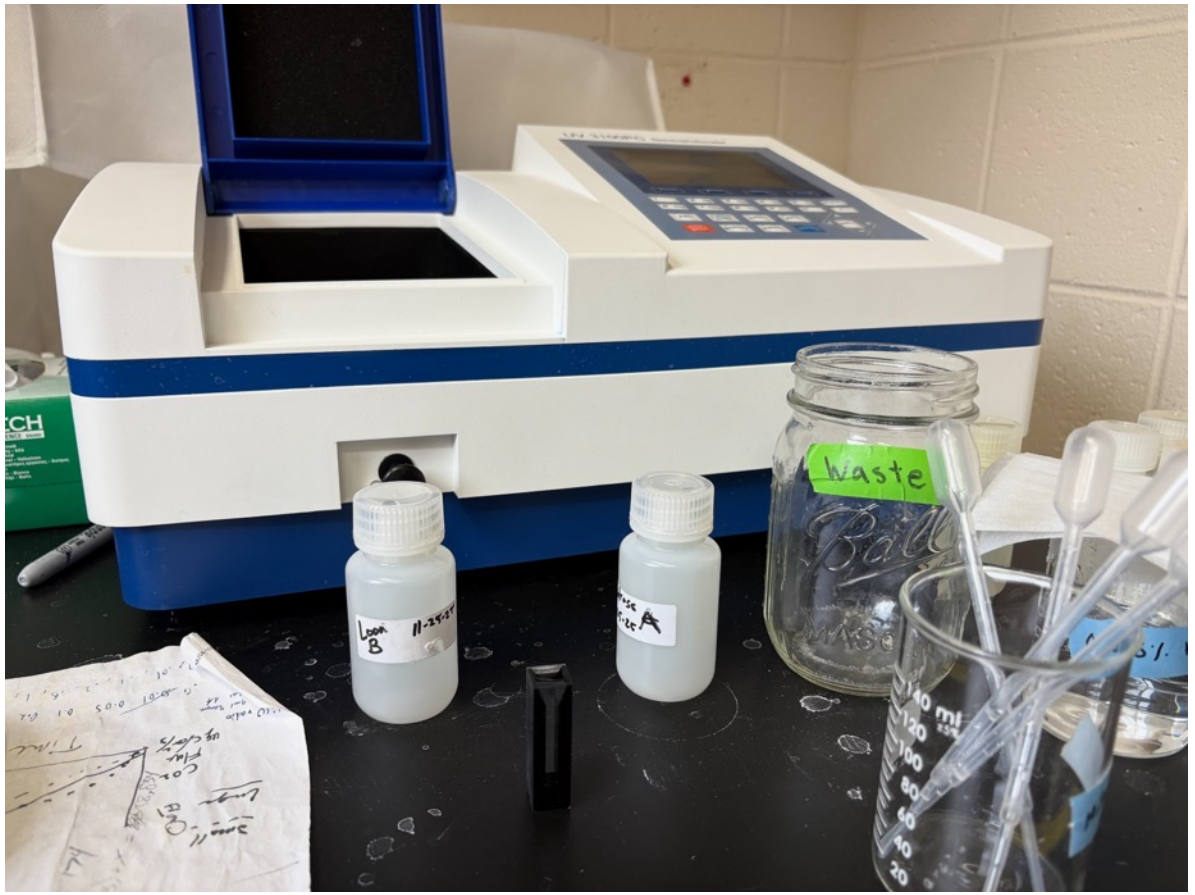


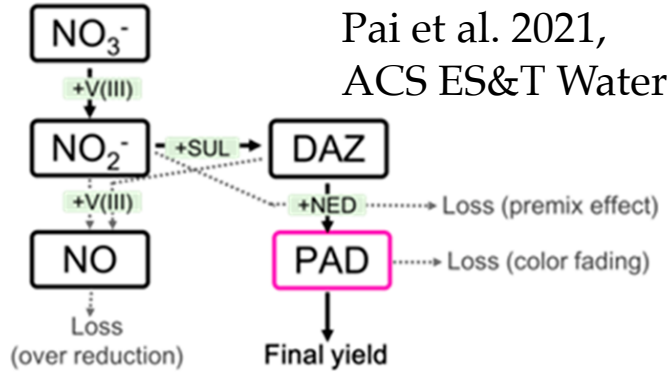


Pai et al. 2021,
ACS ES&T Water

- Traditional nitrate measurement
- Expensive, toxic waste, troublesome instruments







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Scanning UV spectroscopy enables direct measurement of nitrate in water samples
(Crumpton et al. 1992, Limnol. Ocean.)

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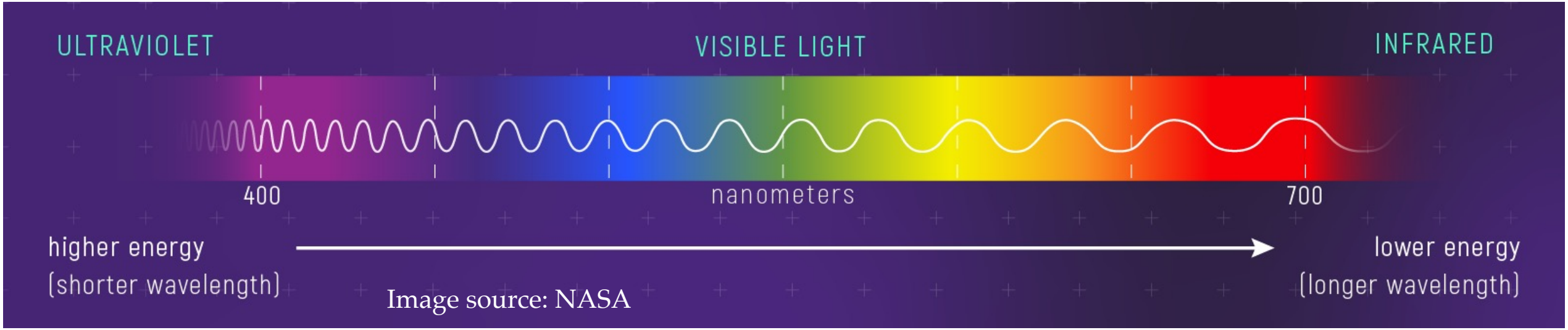
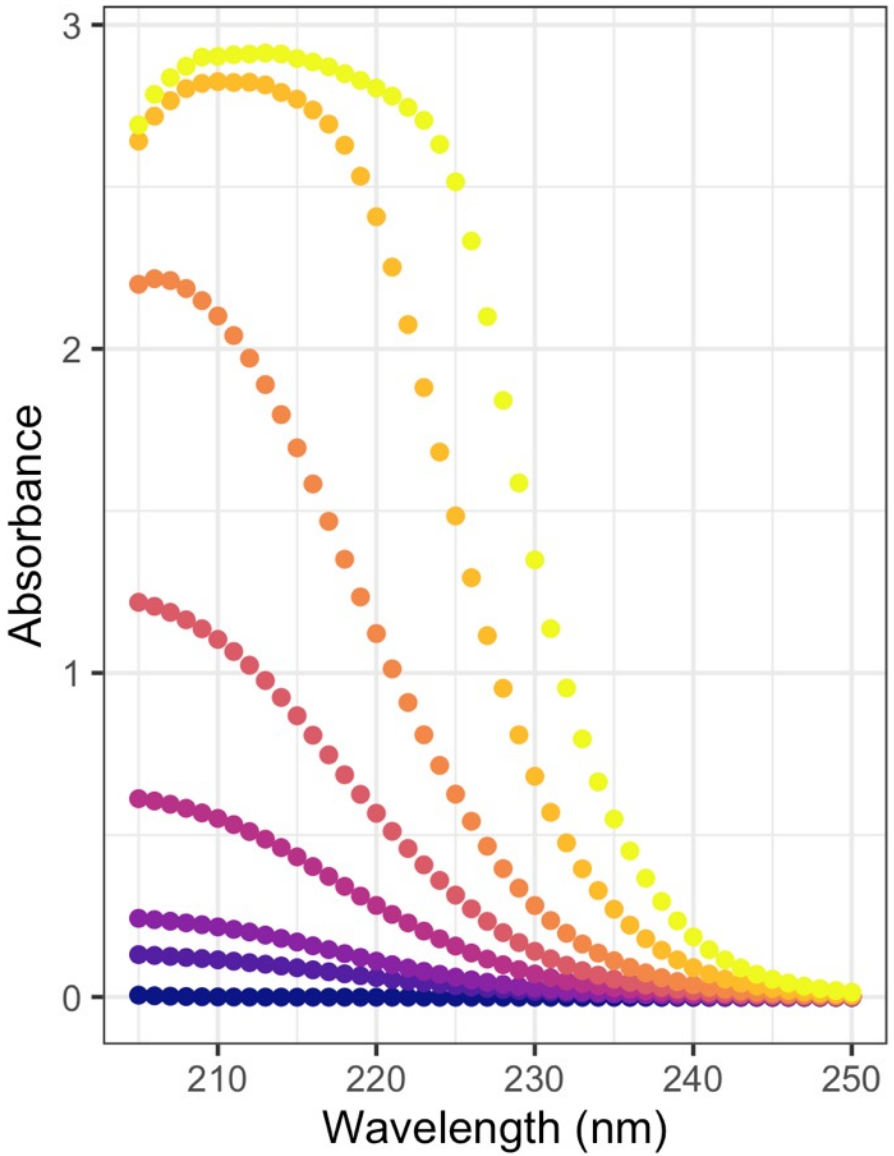
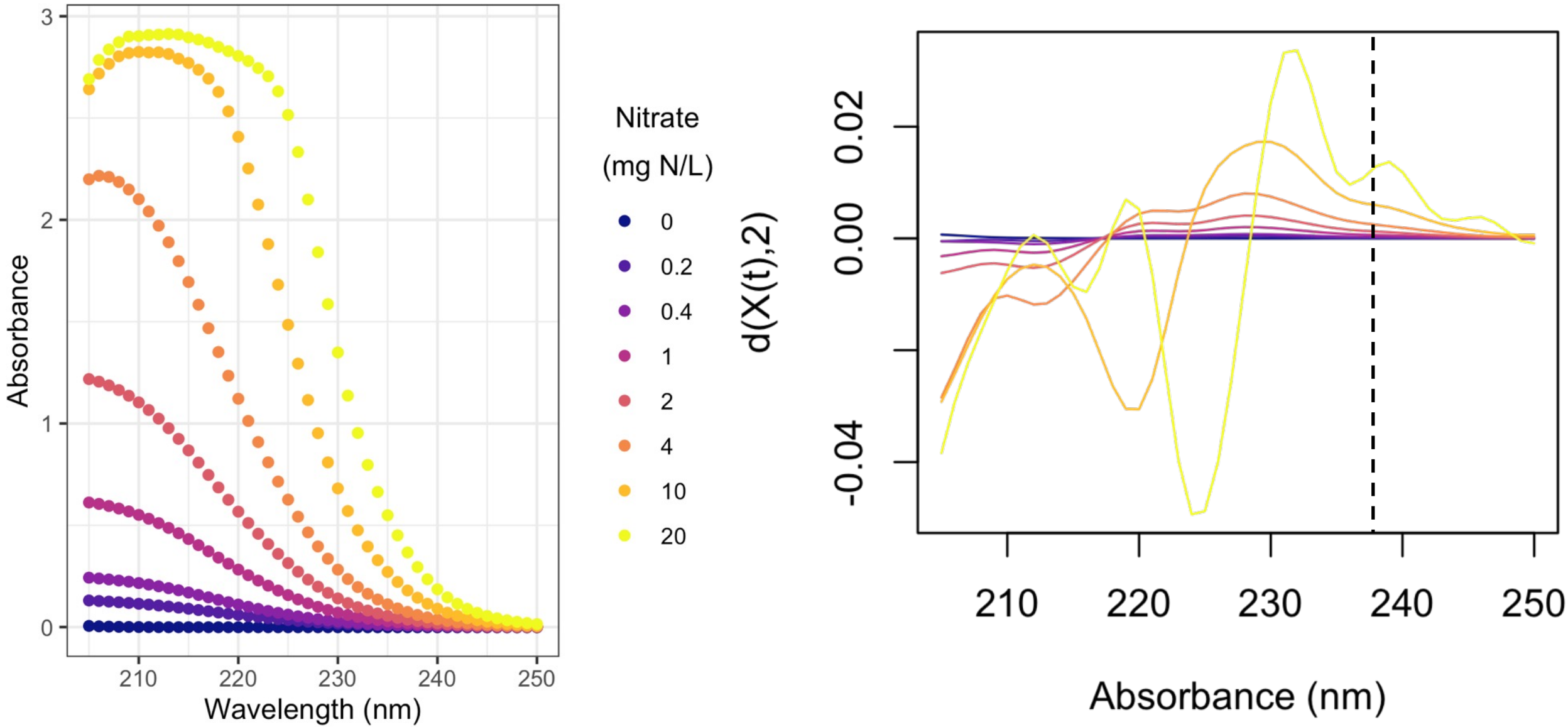


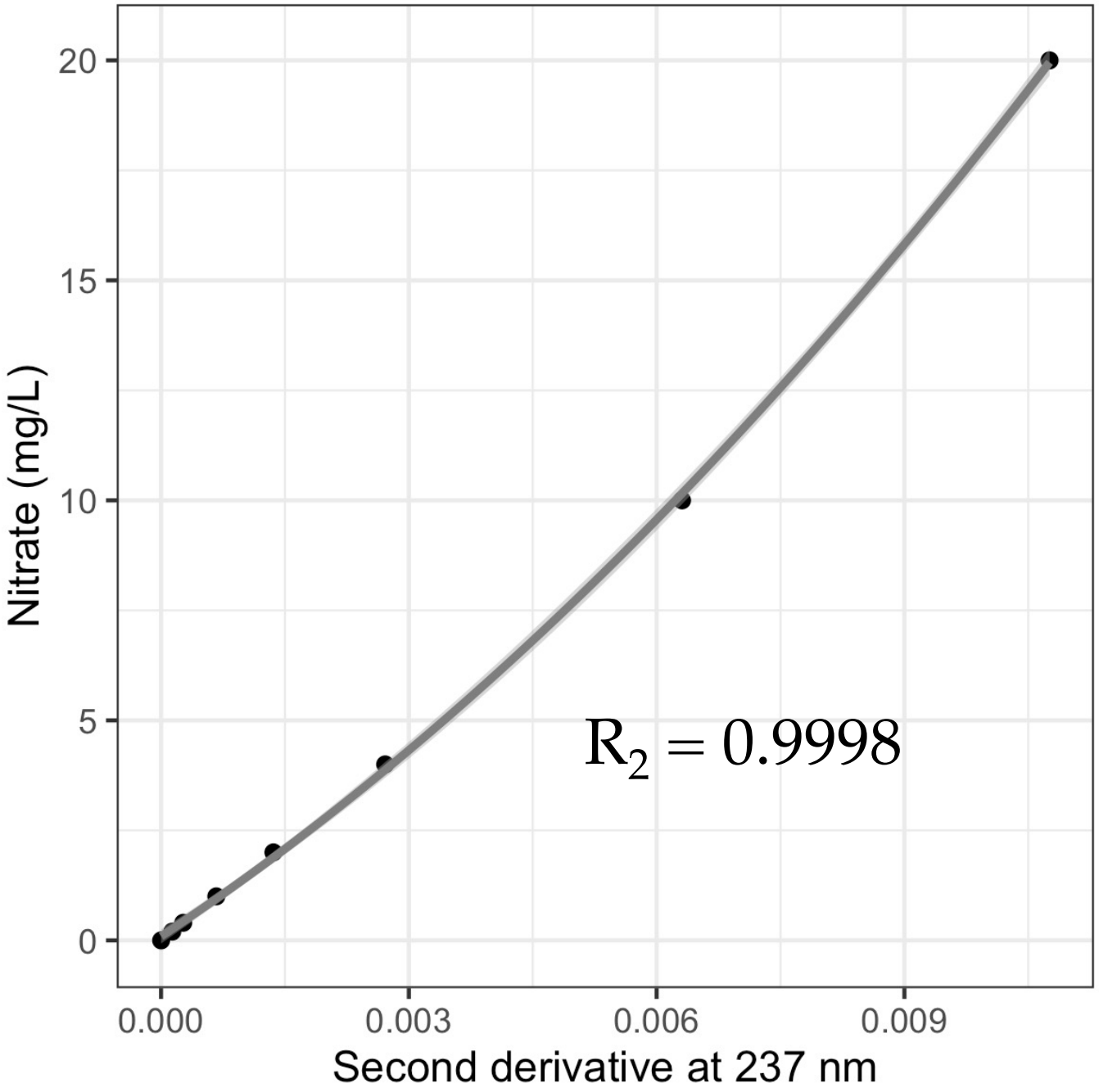
Image source: NASA



Nitrate
(mg N/L)

- 0
- 0.2
- 0.4
- 1
- 2
- 4
- 10
- 20

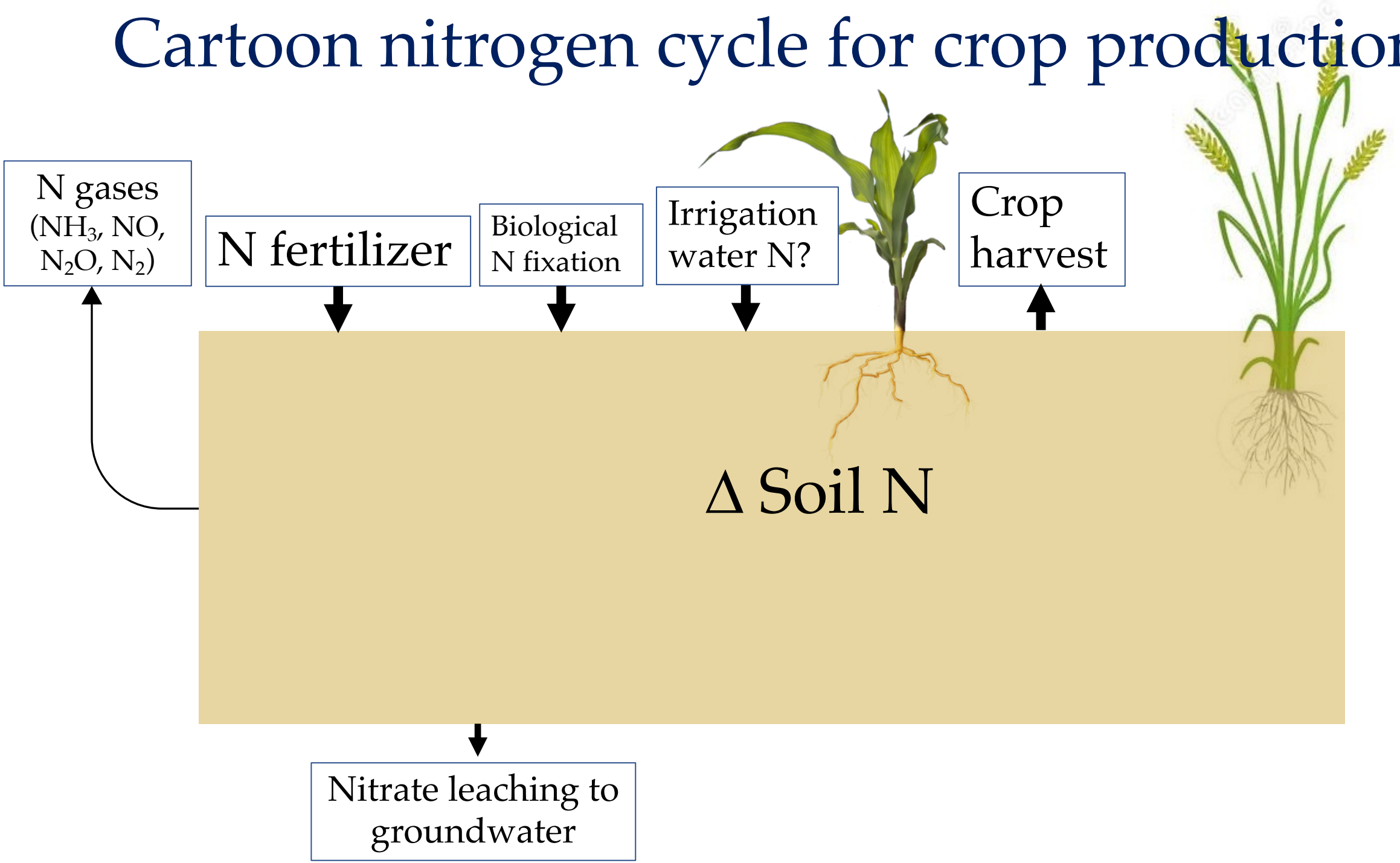

Absorbance
Wavelength (nm)
Nitrate
(mg N/L)
0
0.2
0.4
1
2
4
10
20
d(X(t),2)
Absorbance (nm)


20
15
10
5
0
Nitrate (mg/L)
0.000
0.003
0.006
0.009
Second derivative at 237 nm
$R_2 = 0.9998$


50 ml
40
30
20
GRAD APPROX.

- **Goal**: bring *inexpensive* optical measurements to the field to enable real-time nitrate measurement
- Inform real-time budgeting of N in irrigation water
- Work by Digman and Nocco's teams at UW-Madison

Cartoon nitrogen cycle for crop production



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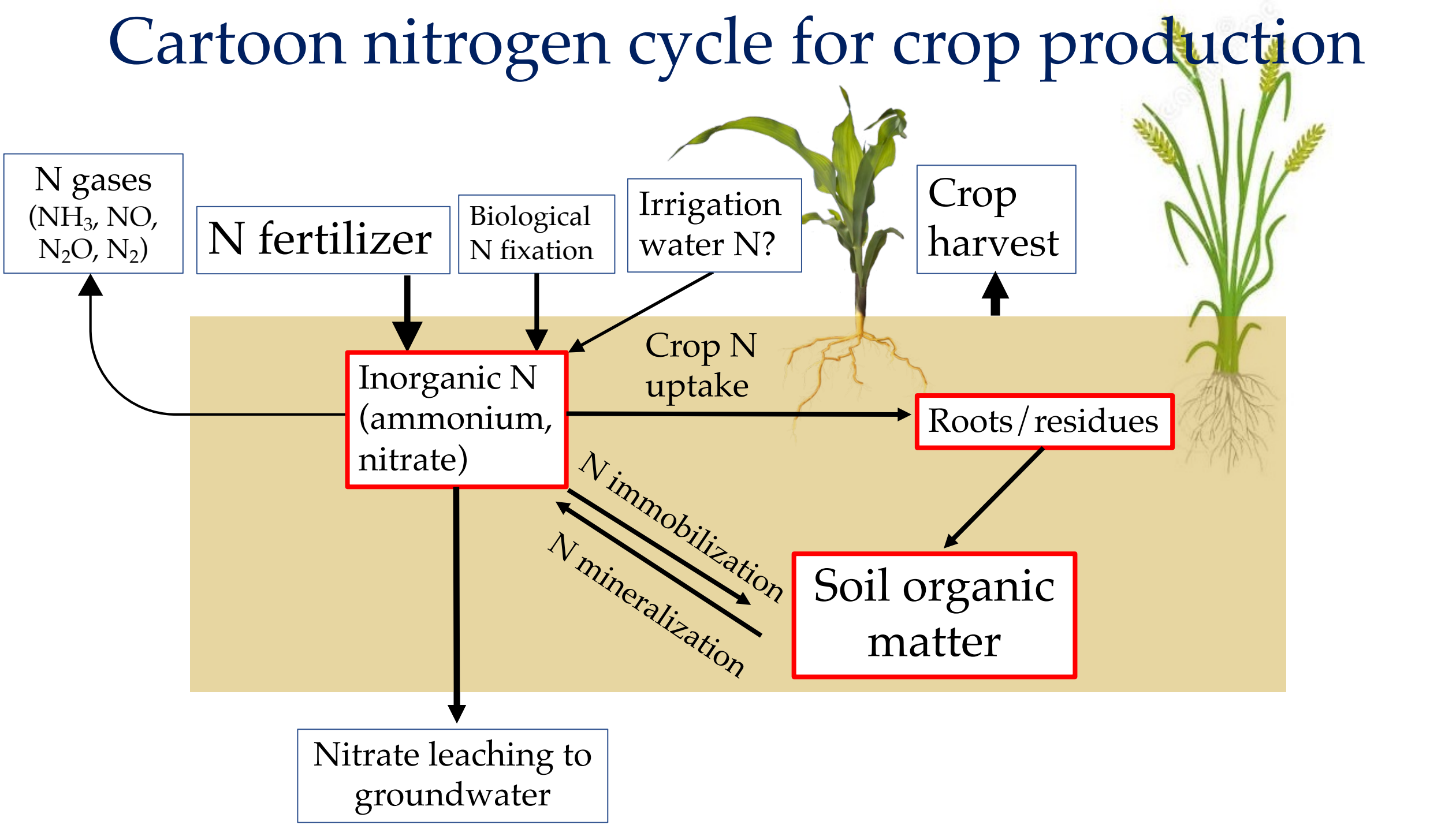

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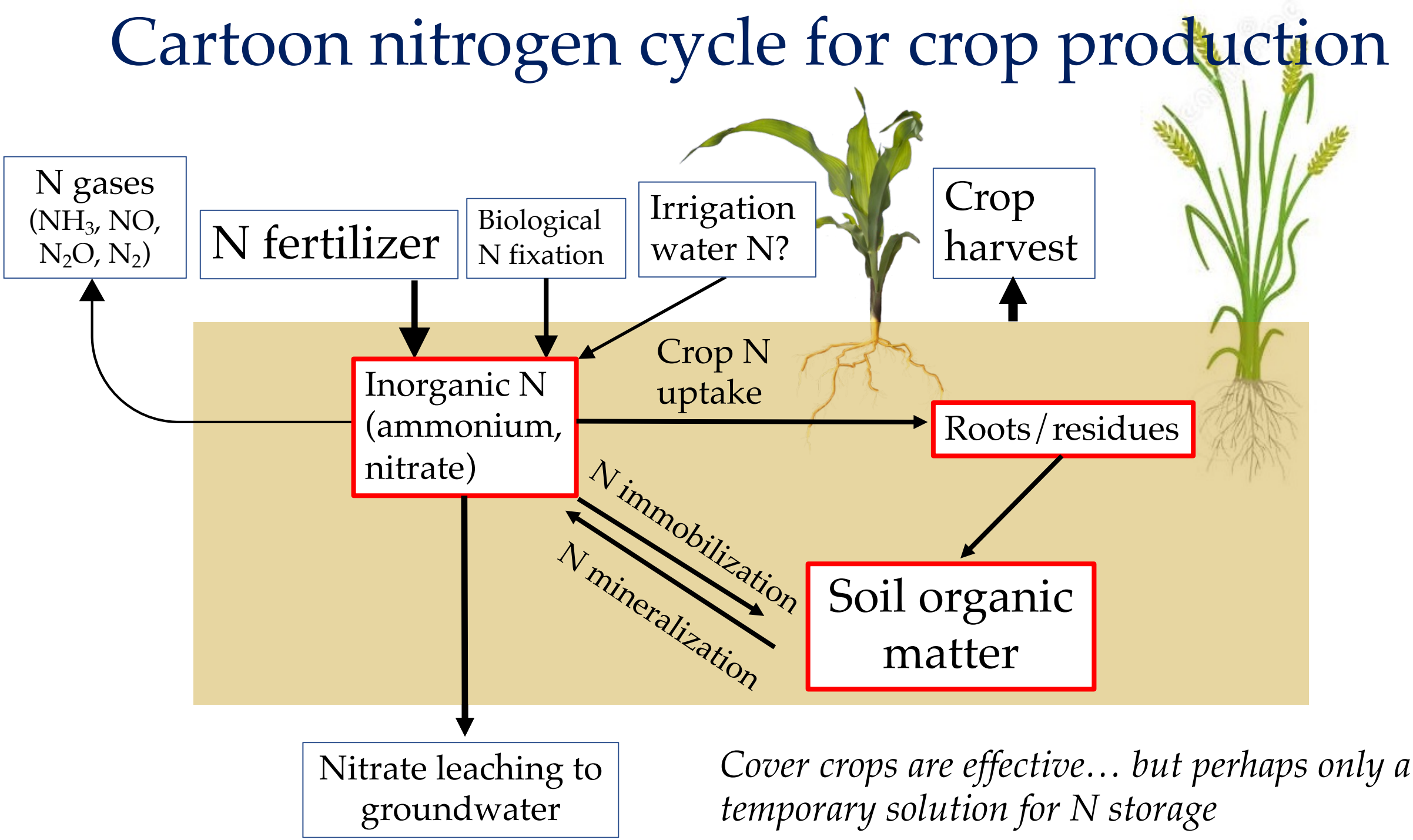
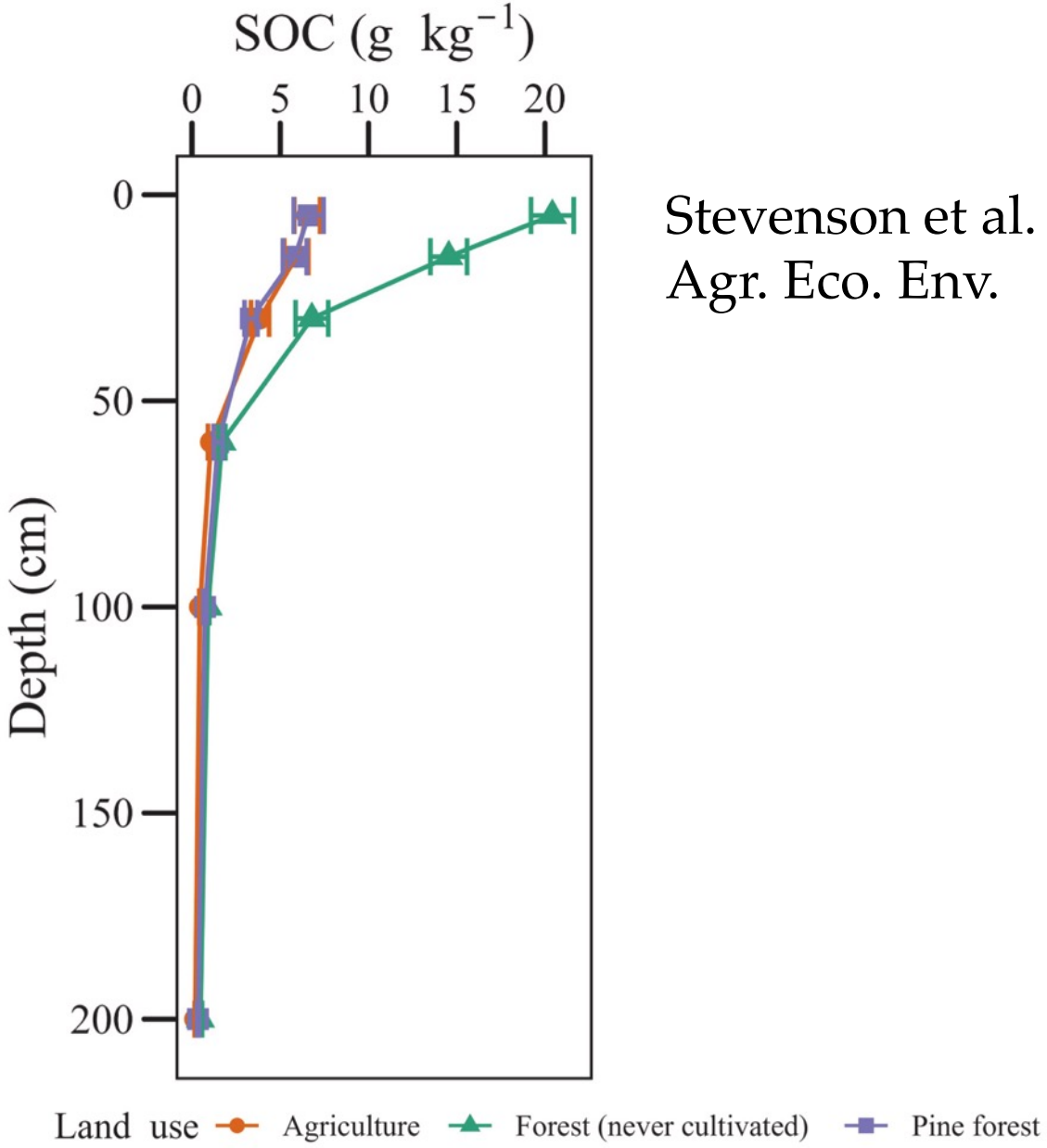


Cover crops are effective… but perhaps only a temporary solution for N storage


Oat roots
1% OM
< 0.5% OM

Is it realistic for cover crops / intercrops to increase organic matter in sandy soils?

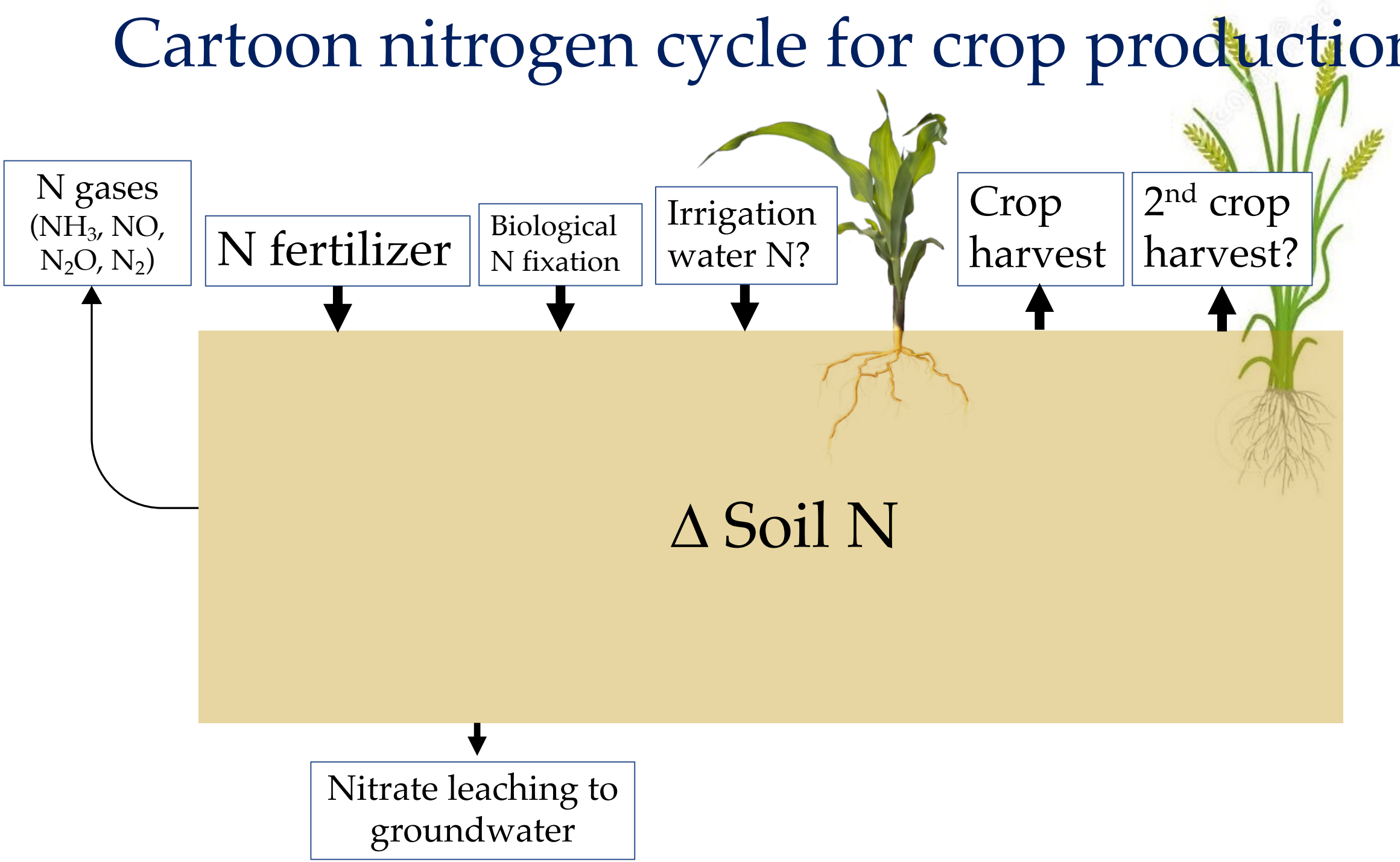


Stevenson et al. 2024, Agr. Eco. Env.

- What happens to the N that was stored in the cover crop biomass?

- What happens to the N that was stored in the cover crop biomass?
  - Stored in soil organic matter (unlikely in sandy soils)
  - Mineralized and leached (unfortunate)
  - Mineralization and uptake by the subsequent cash crop (ideal)
    - Only benefits *long-term* water quality if:
      - An N credit was taken (unlikely)
      - N fixation was partially suppressed (possible for a legume cash crop)
  - Alternative: harvest the cover crop (as a cash crop?)…

Cartoon nitrogen cycle for crop production



Winter camelina: a promising opportunity to haul off excess N from your rotation

- Seeds can produce an edible oil or biodiesel
- High protein content, typical N removal of ~30 lb N/acre
- Growing interest in the Upper Midwest
- Can also be used as a non-harvested cover crop

https://cropsandsoils.extension.wisc.edu/winter-camelina/

Crop residue harvest: another unconventional opportunity to improve your N budget

Example with potato:

- Green or senesced vines contain substantial N (tens of lb/acre)
- Potato vines have low C:N ratio and high decomposition/N leaching potential
- Could we feasibly remove this N source, and also reduce pathogen pressure?
- Compost the material off-site
- Approach could be translated to other crops

Take-home points:

- We will likely need an “all of the above” approach to comprehensively address nitrate leaching
- Common sense and unorthodox management strategies may be needed
- Need to rigorously evaluate impacts of practice changes with measurements
- **steven.hall@wisc.edu**