Landscape and BMP Nitrogen Processes –
BMPs and Landscape properties and their effects on nitrogen speciation in loads delivered to streams.

Focus on how plant-soil processes in forests and ag fields affect N species that move through soils toward streams.

Conceptual framework, then forests, then ag practices.

Jason Kaye **Penn State**

Conceptual framework:
Started with the following gut instinct and searched literature.

- Small amounts of DON and very small amounts of NH_4^+ move through soils to streams and they don't vary much across landscapes or BMPs.

- Variation in soil to stream transport is from NO_3^- variation

- This is in fact the punchline, but with some important exceptions

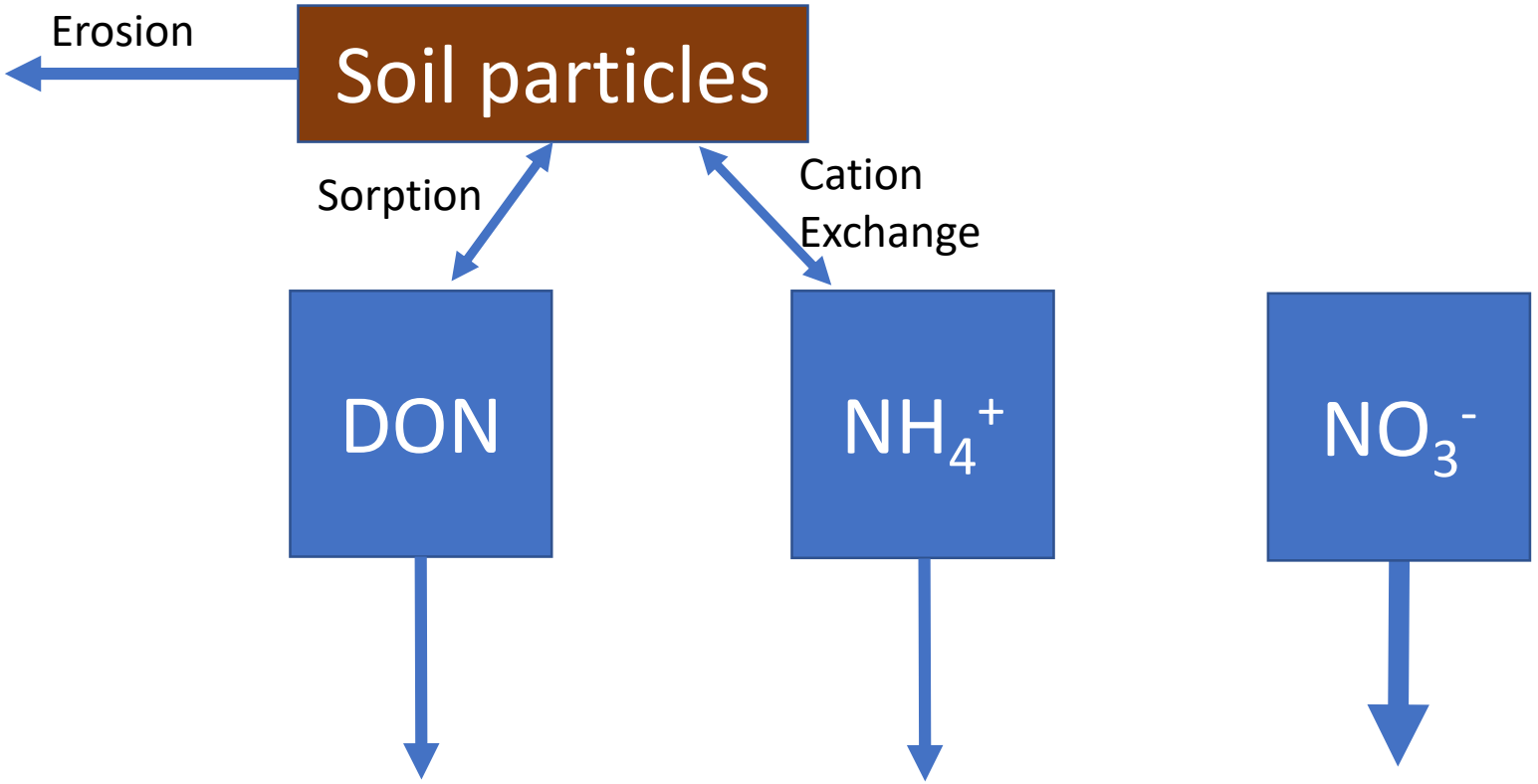
I focus on three N species, but DON may need refinement to specify urea or molecular wt

DON

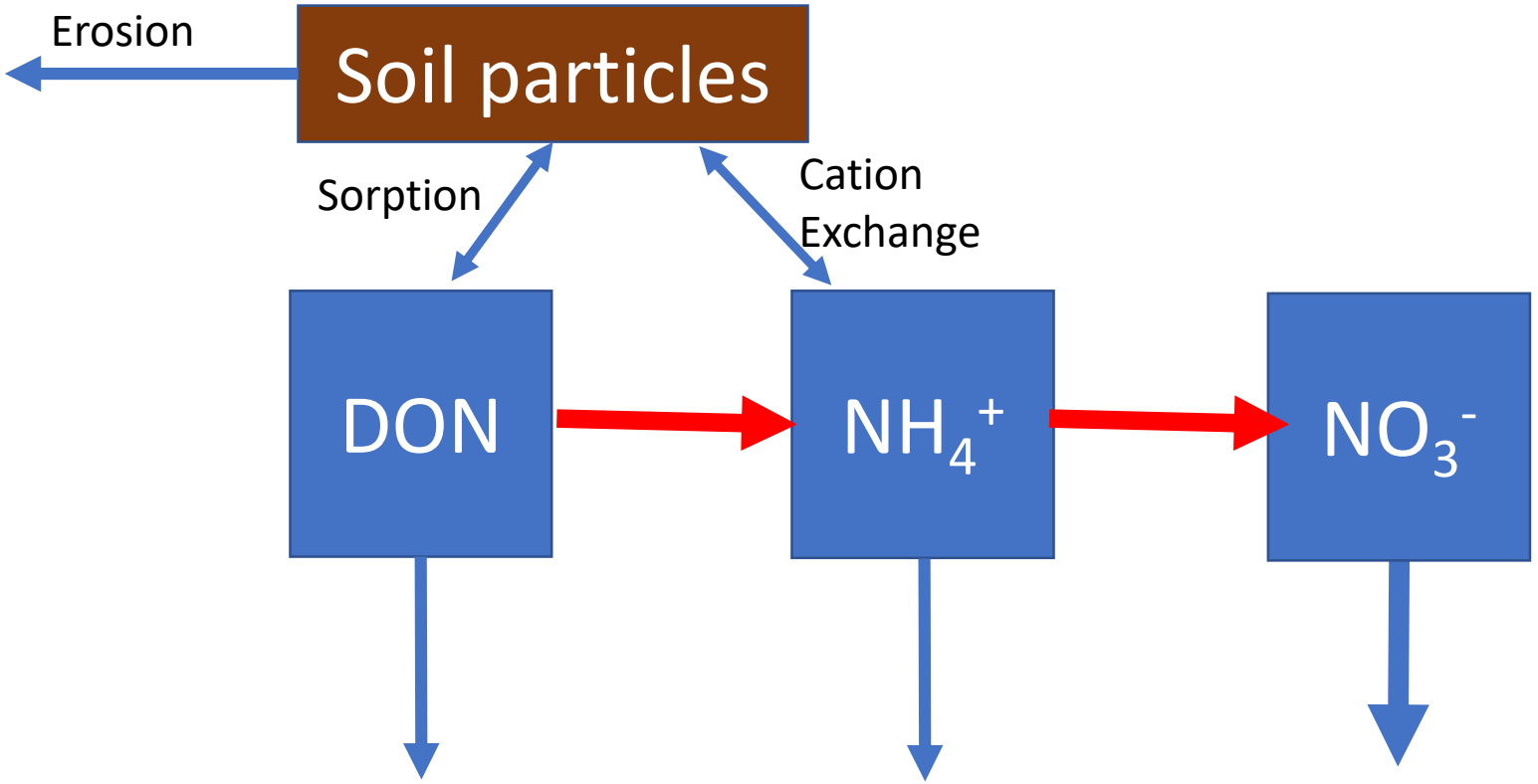
NH_4^+

NO_3^-

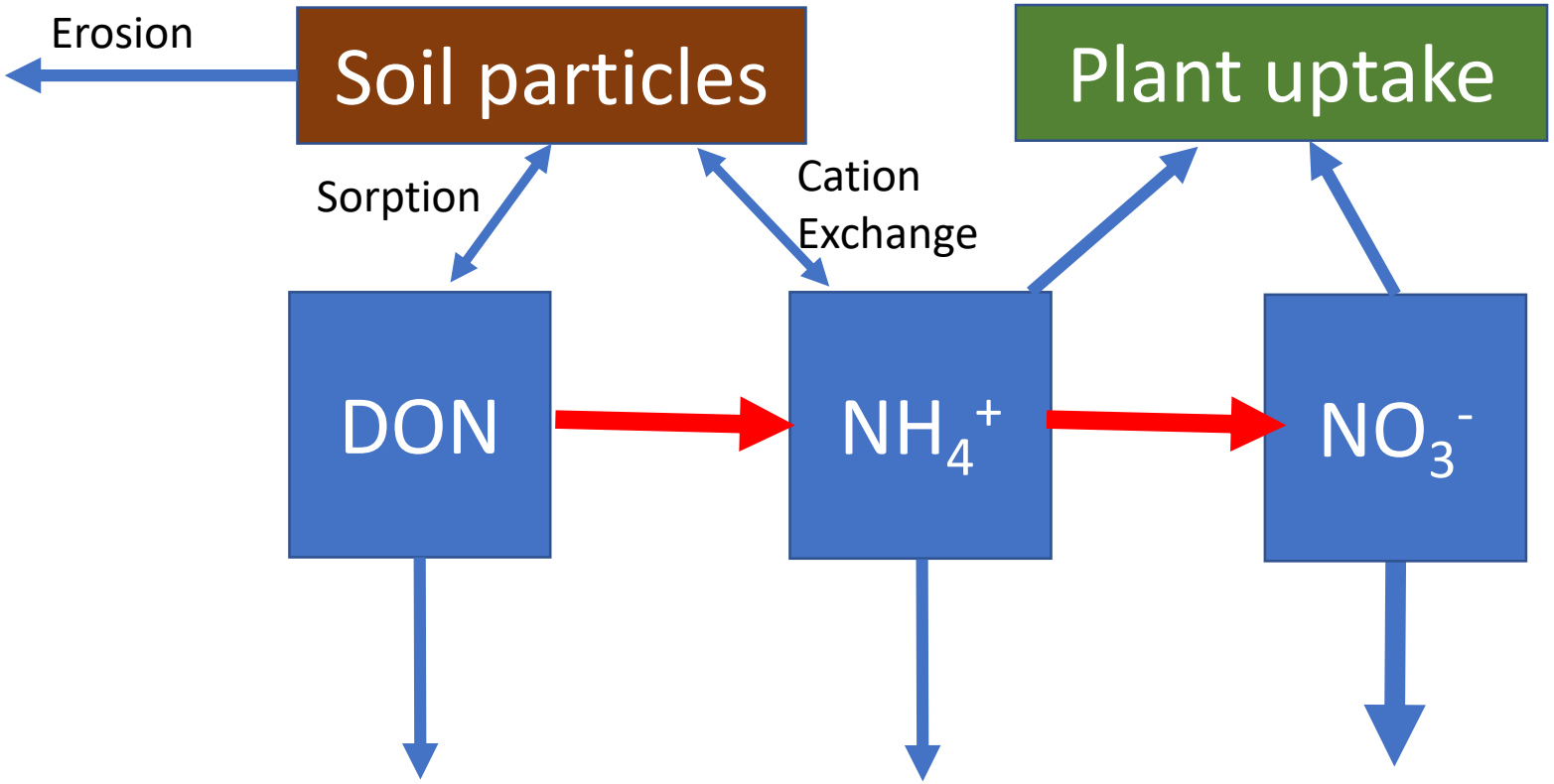
DON and ammonium have low leaching rates because they sorb to soil particles



At N rich sites microbial transformations increase the proportion of soil N as nitrate



In high-N sites, only high plant demand decreases leaching



These five headwater forest catchments in PA illustrate the key points: all low NH_4^+, medium DON & NO_3^- varies most

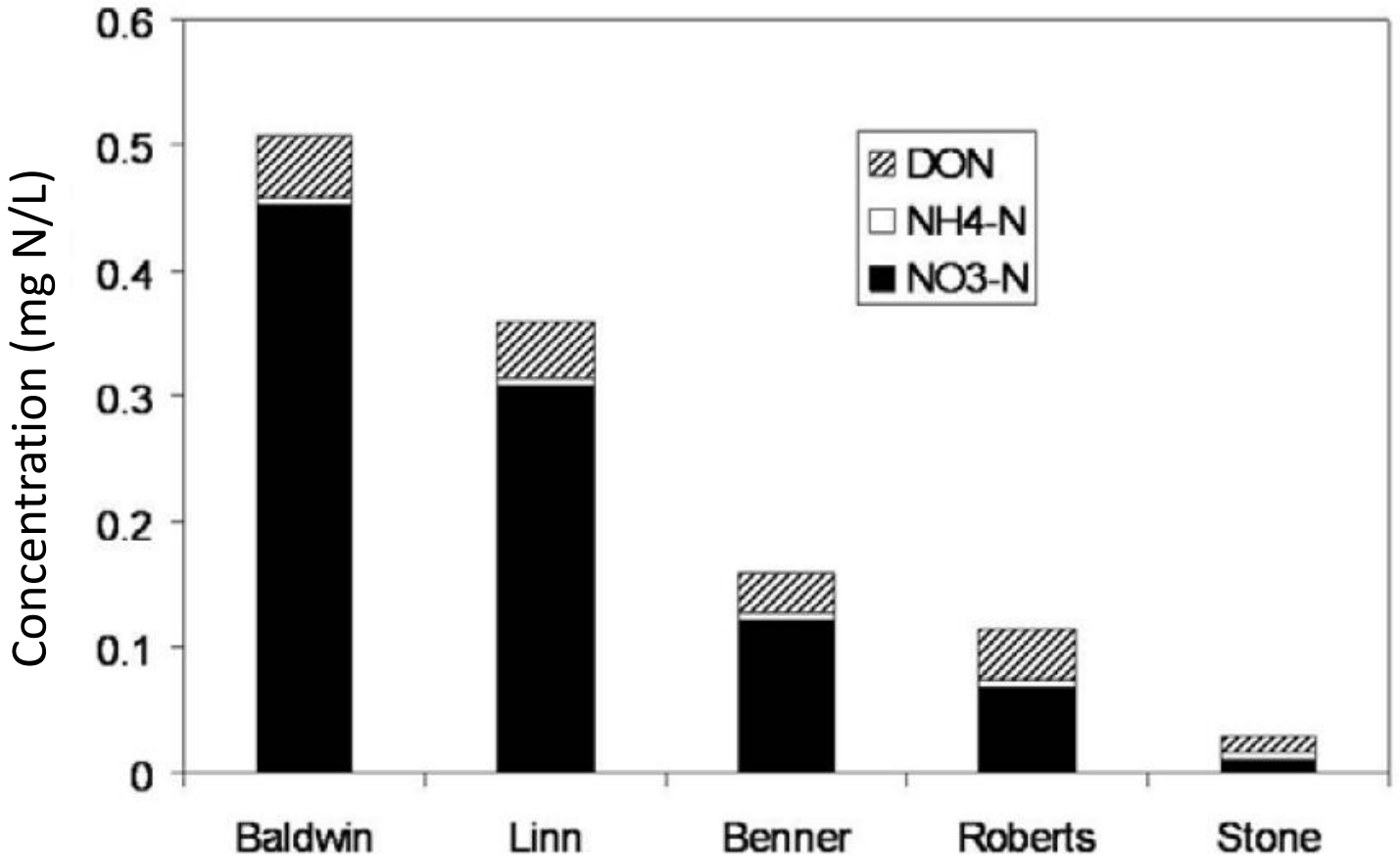


Fig. 2 Median concentrations of NO_3-N, NH_4-N and DON in each of the five streams in Pennsylvania from 1997–2003.

Dewalle et al. 2005

Soil pore water concentrations may be
1x (NO3)
10x (DON)
100x (NH4)
Greater than streams

What causes variation in NO_3^-

1. Denitrification
2. N deposition (decreasing w/ Clean Air Acts)
3. Long-term vegetation suppression, including gypsy moth outbreaks (but not most harvests)
4. Land use history
5. Seasonality: Low in fall for a week or two
6. Storms: Nitrate flushing when surface soils are hydrologically connected to streams

What causes exceptions to low DON and NH_4^+ rule in forests?

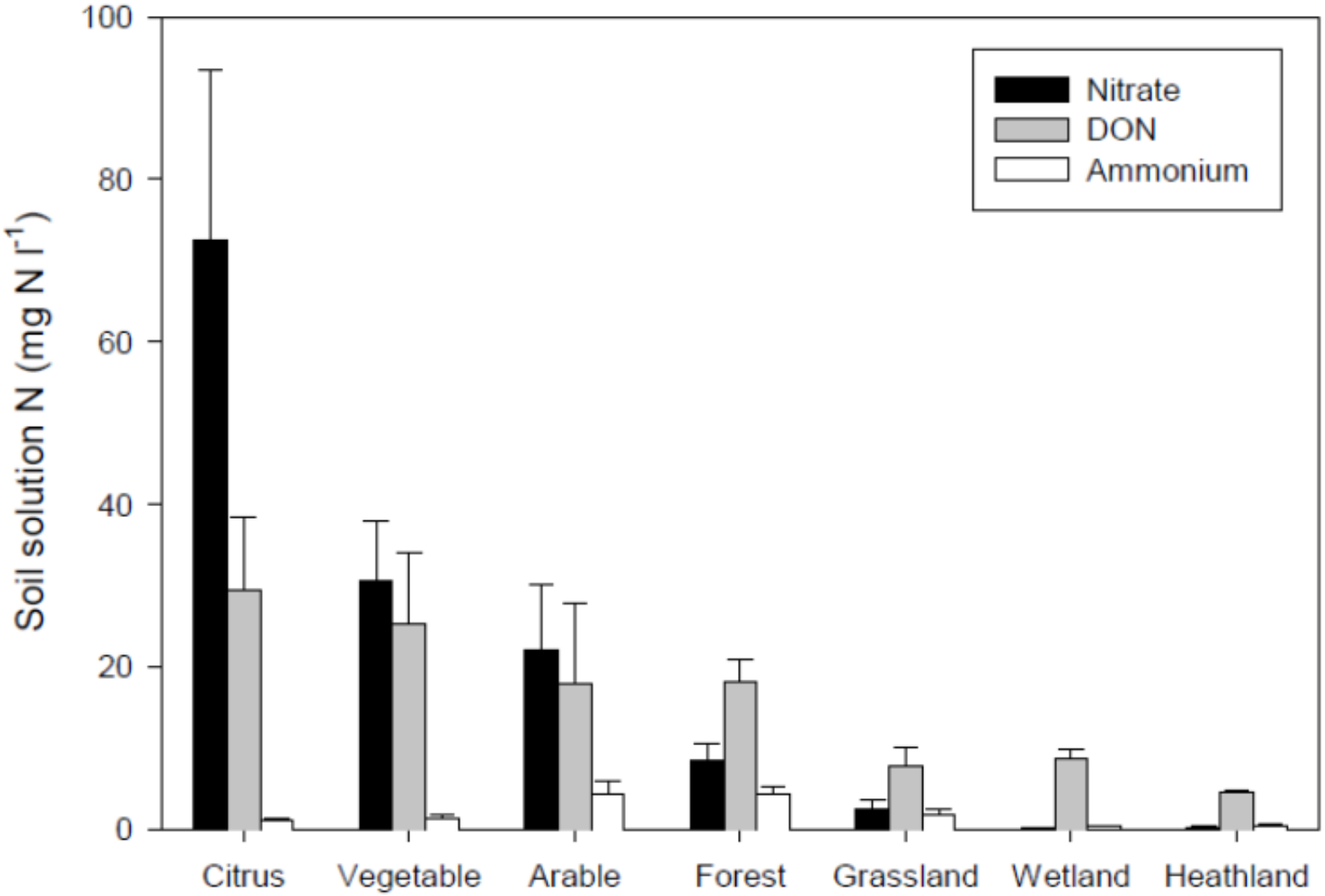
1. Sandy soils lose NH_4^+ and DON
2. Wetlands and peatlands have DON > NO_3^-.
3. Conifer forests often have DON > NO_3^-
4. Seasonality: pulse in DON in after litterfall can last ~ month
5. Storms: DON often has a flushing response
6. Particulate losses: Very few measurements.
   Can be high in urban areas

Returning to the premise before we transition to agricultural systems

- Small amounts of DON and very small amounts of NH_4^+ move through soils to streams and they don't vary much with management.

- Variation in soil to stream transport is from NO_3^- variation

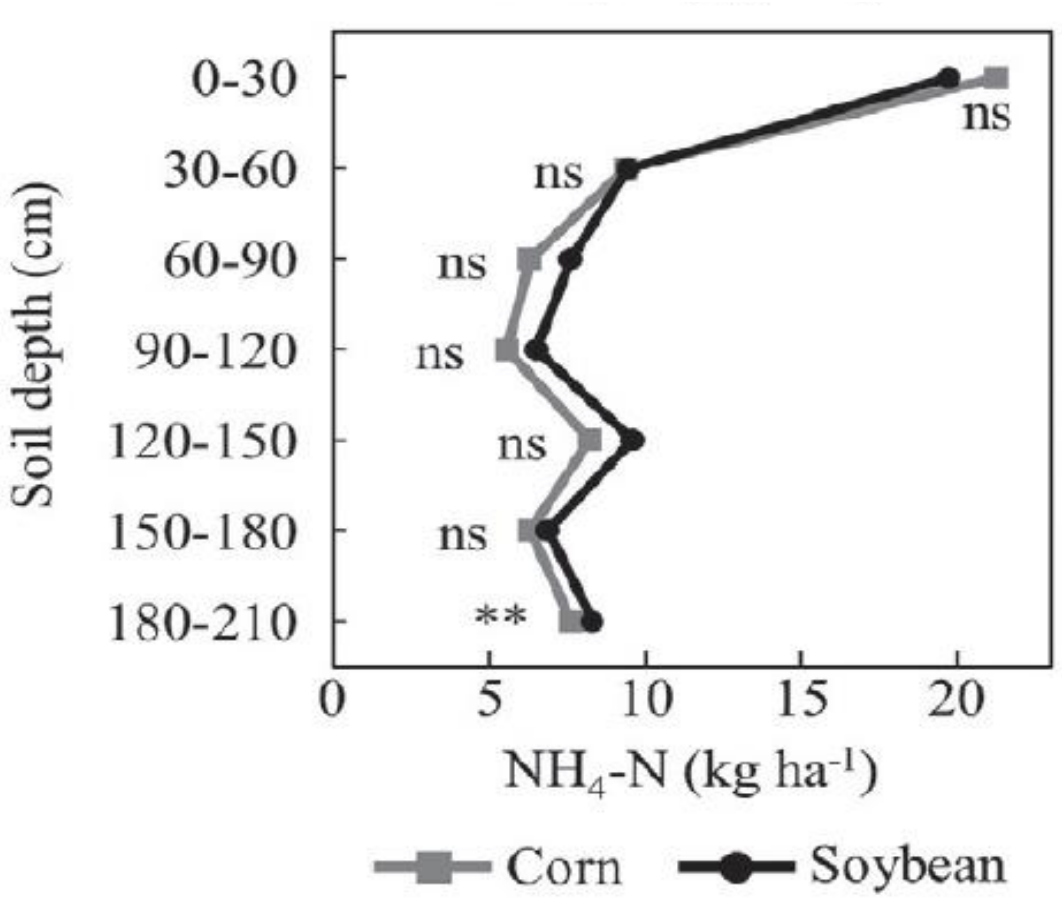
Surface soil solutions can have high DON & NO_3^-



Christou et al. 2005

Some Bay soils have significant NH_4^+ at depth

- 10-50 kgN/ha below 1 m
- Years of high inputs allow deeper accumulation (saturation concept)
- Does this NH_4^+ move to streams?



Hirsh and Weil 2018

DON concentrations also decrease with soil depth, but some leaching occurs

	Mean	Median
Deep leaching kg N/ha/yr	**13**	**4**
Percent of soluble N DON/(DON + NO_3^-)	**26**	**19**

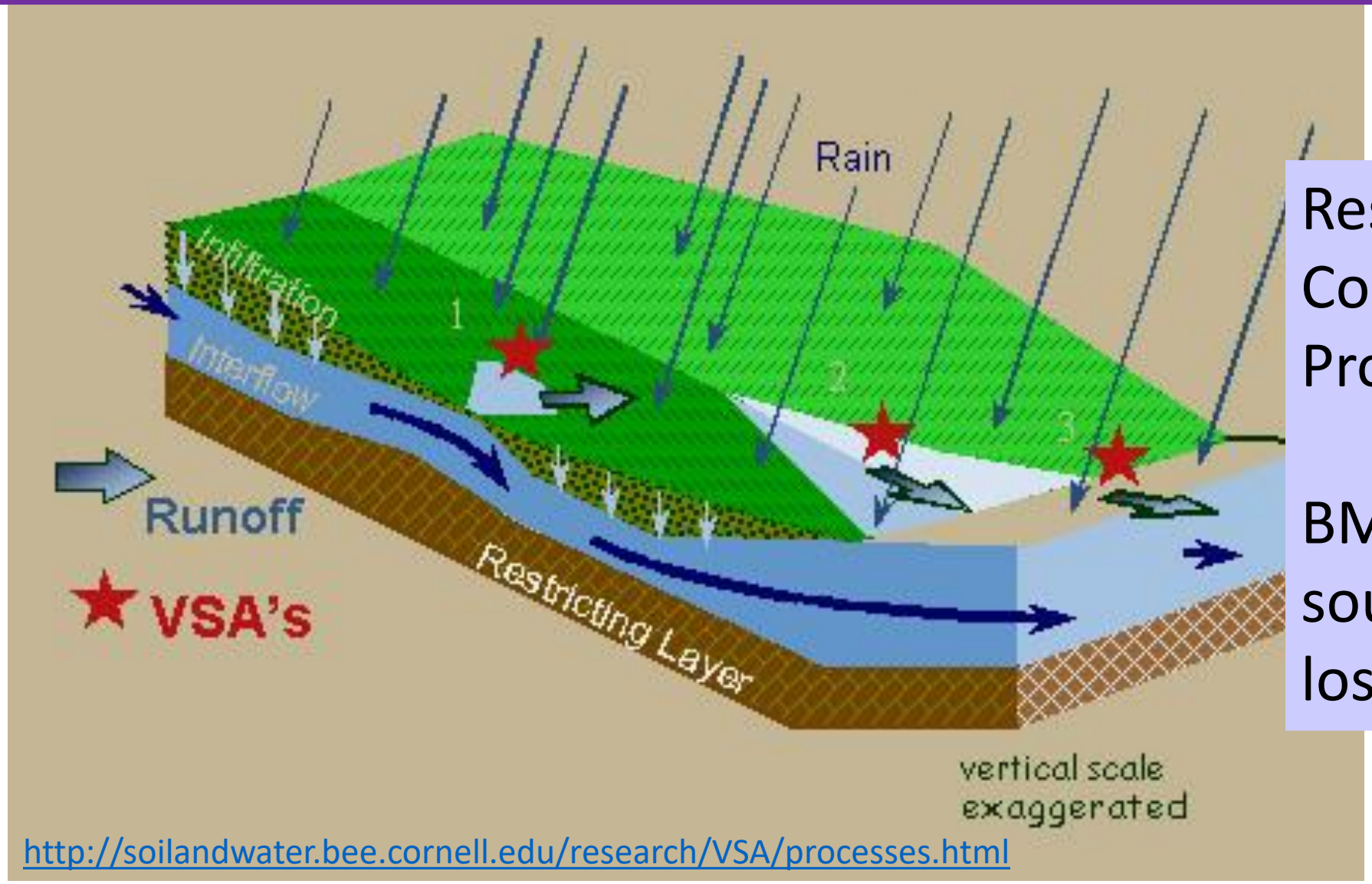
- Meta-analysis of DON leaching (VanKessel et al. 2009)

Leaching through ag profiles has low NH_4^+, medium DON, and highly variable NO_3^-

Exceptions where NH_4^+ and especially DON can be higher

- Macropores (no-till may increase DON loss)
- Sandy soils
- Long history of manure inputs
- Nitrate inhibitors could decrease nitrate fraction (need data)
- Urease inhibitors may increase DON fraction (need data)
- Storms: perhaps increased DON with increasing discharge

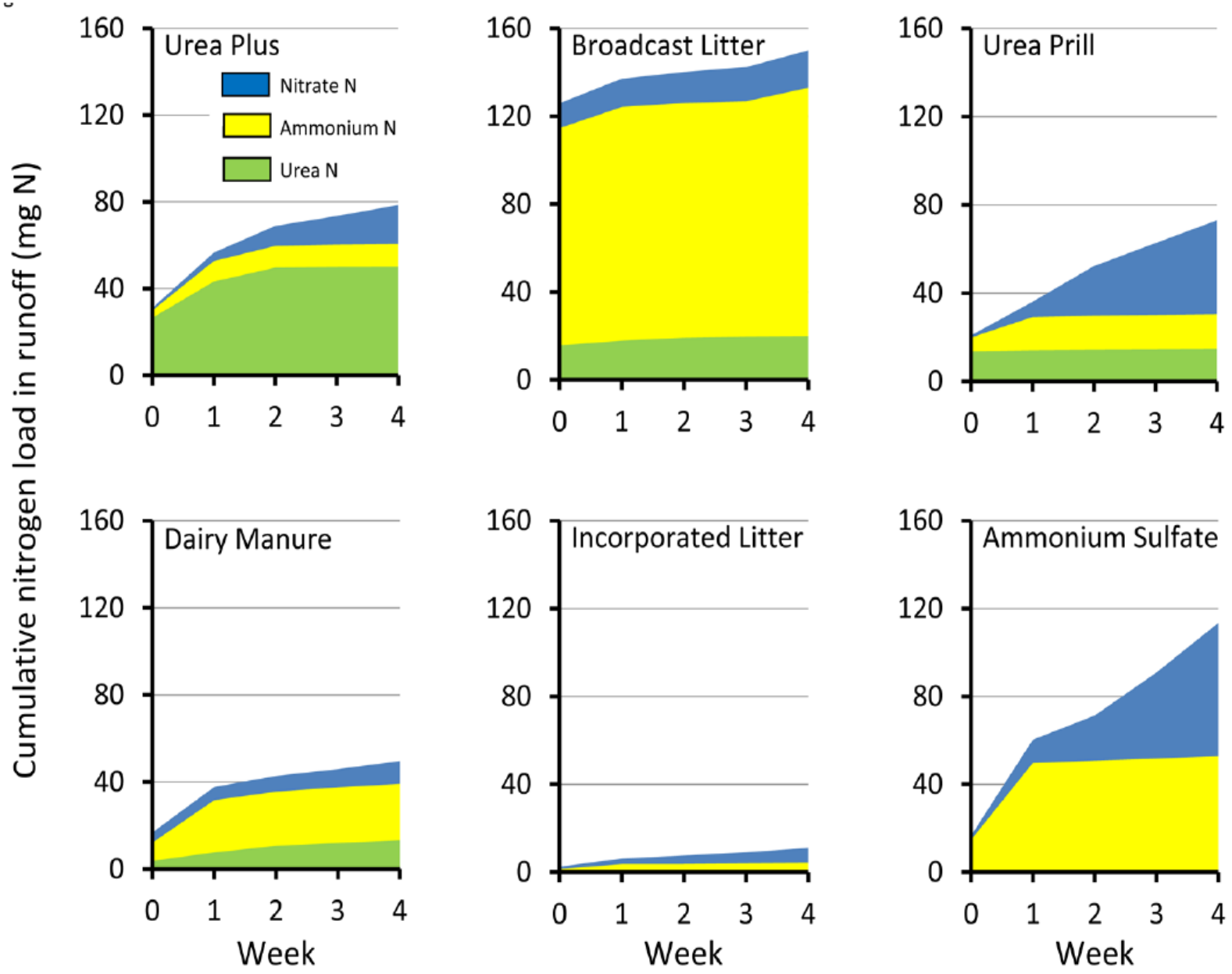
Surface runoff depends on landscape properties



http://soilandwater.bee.cornell.edu/research/VSA/processes.html

Restrictive layers
Convergent flowpaths
Proximity to stream

BMP: Cover in these source areas mitigates losses



Fresh inputs on source areas may lead to high DON or NH_4^+ runoff

Nitrate
Ammonium
Urea

Kibet et al. 2016 JEQ

Which BMPs and Landscape properties affect nitrogen speciation in loads delivered to streams?

Landscape properties:

1. soil texture
2. source areas
3. ecosystem type

BMPs:

1. no-till, cover cropping
2. manure incorporation
3. manure input history
4. inhibitors?

Unknowns

- What is DON?
- Does deep soil leaching = input to stream?
- Do soils become saturated with DON and NH_4^+?
- How important is particulate N as minerals, crop residue, or leaves?