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2022 Business & the Environment Conference & Expo
Session: Nitrates in Groundwater

OUTLINE

- Nitrogen Cycle
- Sources of Nitrate in Groundwater
- Stable Isotopes to Identify Sources of Nitrate
  - Example from the Cook Agronomy Farm

NITROGEN CYCLE

NOx Emissions

Anthropogenic Sources

Fertilizers

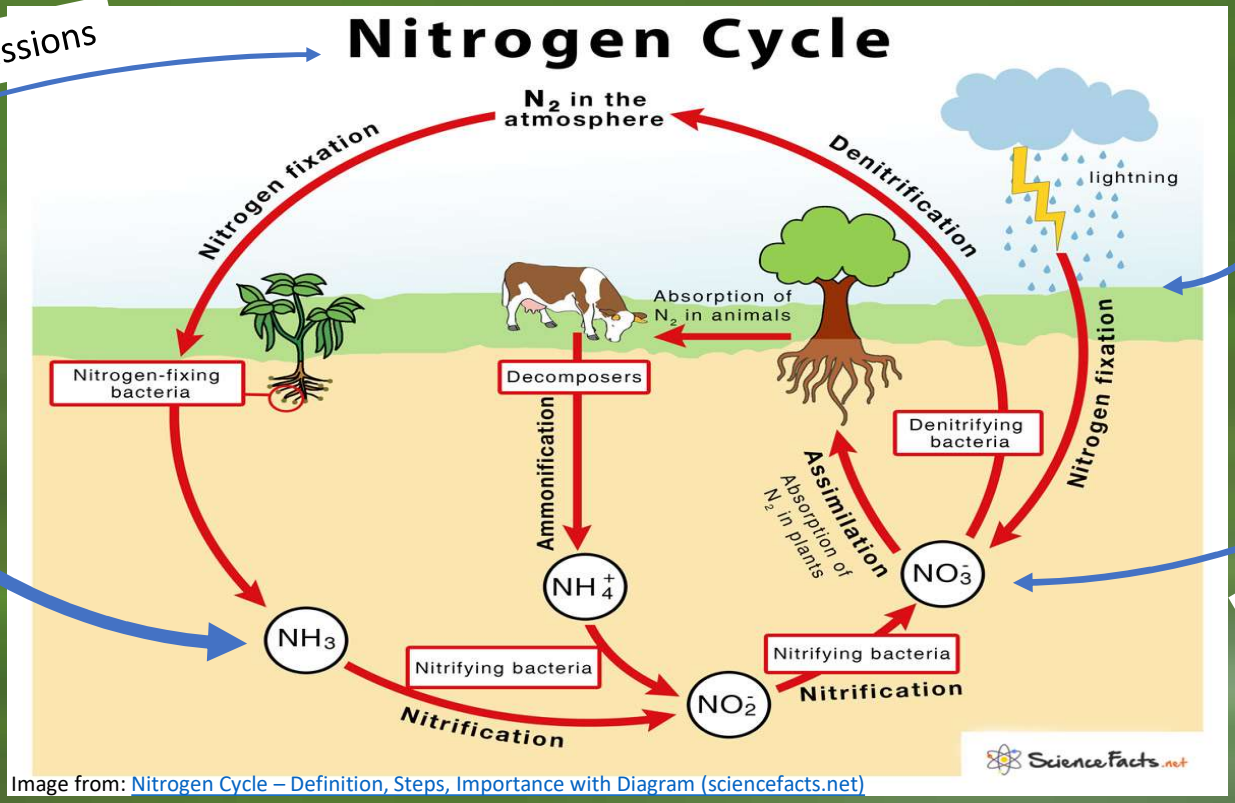

Image from: Nitrogen Cycle – Definition, Steps, Importance with Diagram (sciencefacts.net)

Solid Waste, manure, etc.

Anthropogenic Sources

Municipal & Septic Wastewater

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SOURCES OF NITRATE IN GROUNDWATER

Large scale

- Agriculture (fertilizer)
- Soil organic matter
- Biologic fixation
- Geologic sources
- Precipitation
- Air Deposition

Regional or site scale

- Industrial solid waste / wastewater
- Municipal solid waste / wastewater
- Septic systems
- Residential lawns and gardens

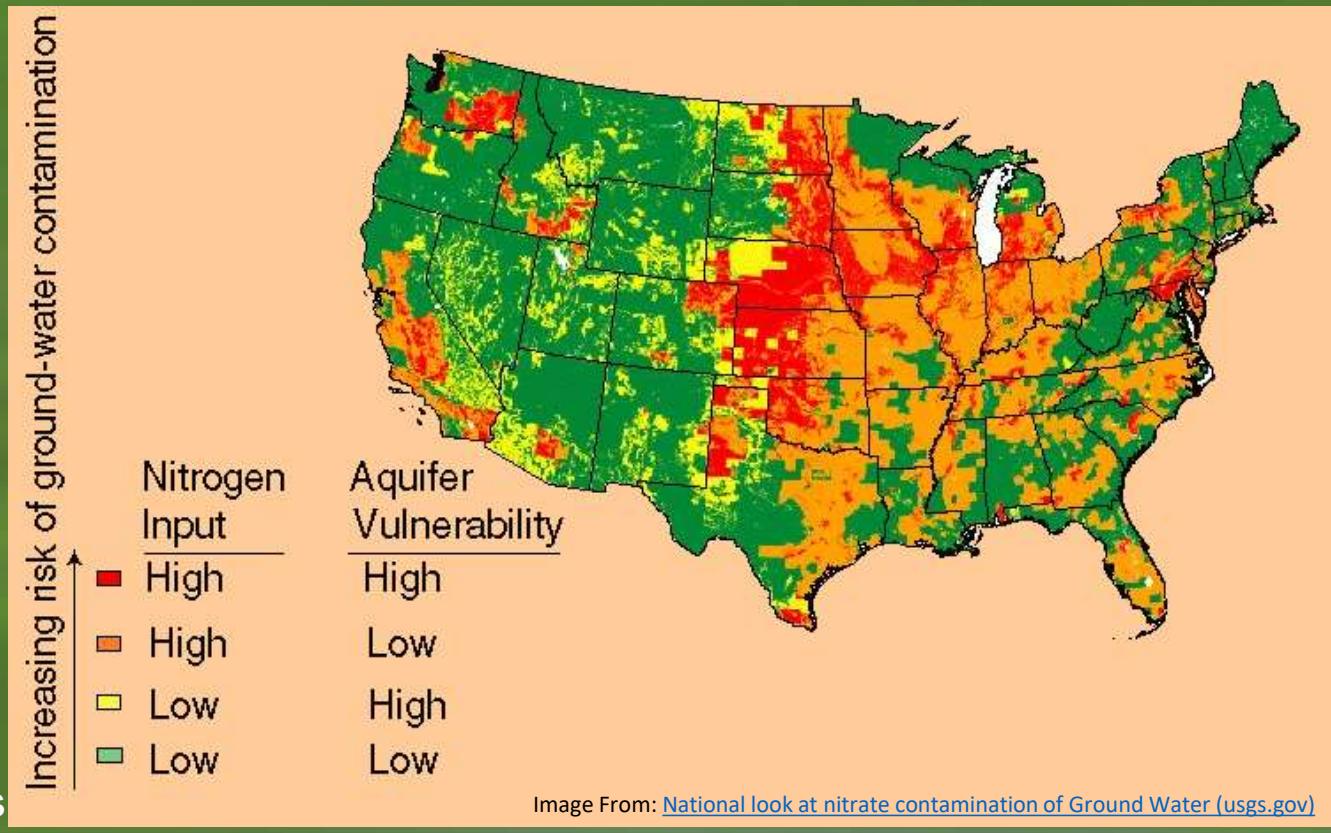

Image From: National look at nitrate contamination of Ground Water (usgs.gov)

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IDENTIFYING SOURCES OF NITRATE

Stable Isotopes

$$\delta^{15}\mathrm{N}_{\mathrm{nitrate}} = \left(\frac{\left[{}^{15}N{:}\,{}^{14}N\right]_{sample}}{\left[{}^{15}N{:}\,{}^{14}N\right]_{standard}} - 1 \right) \times 1000 \ \text{‰}$$

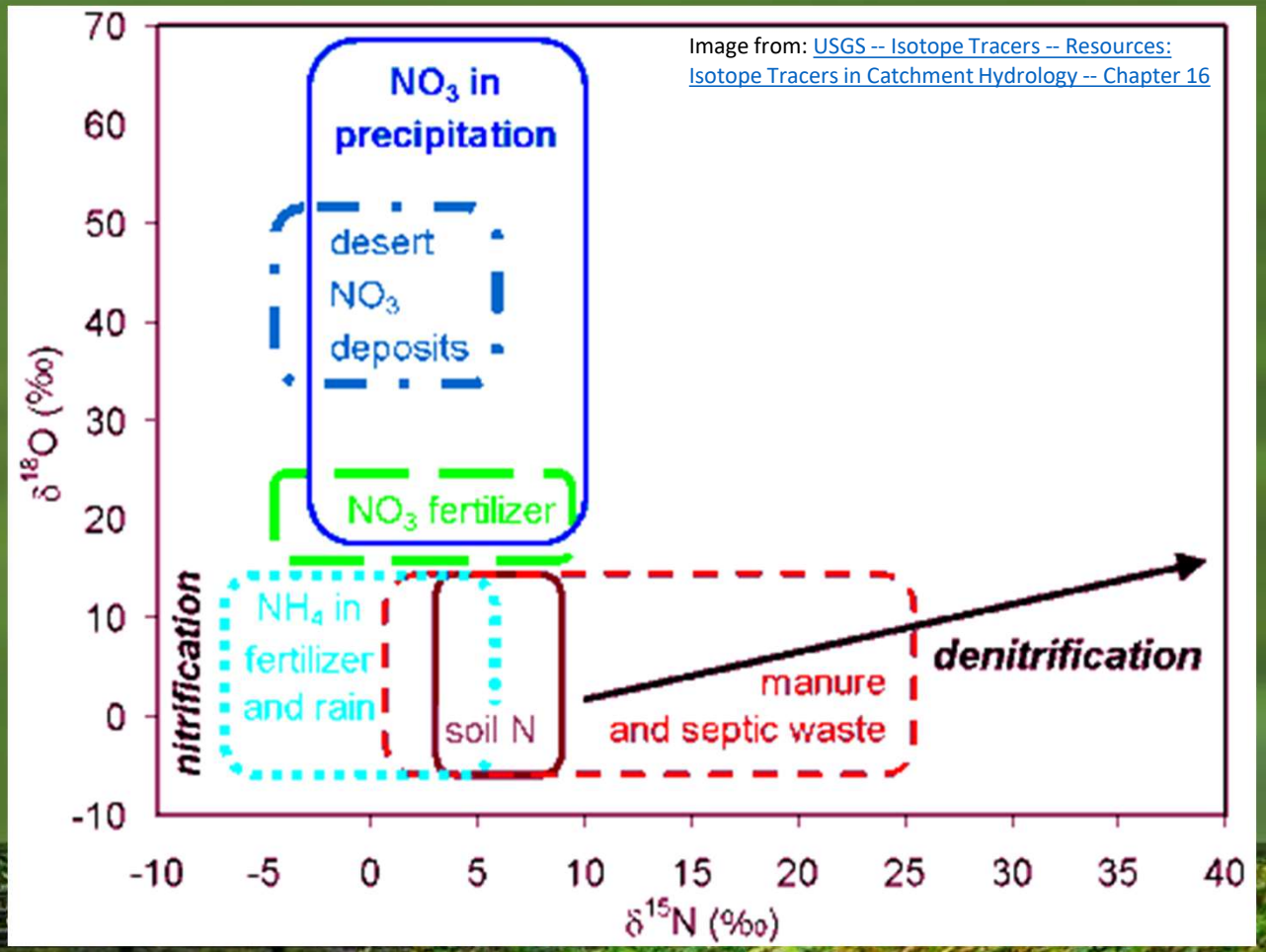
$$\delta^{18}\mathrm{O}_{\mathrm{nitrate}} = \left(\frac{\left[{}^{18}O{:}\,{}^{16}O\right]_{sample}}{\left[{}^{18}O{:}\,{}^{16}O\right]_{standard}} - 1 \right) \times 1000 \ \text{‰}$$

- Oxygen standard is VSMOW
- Nitrogen standard is atmospheric N_2
- Discrimination:
  - $\uparrow\delta^{18}$O or δ^{15}N = enrichment in ^{18}O or ^{15}N
  - $\downarrow\delta^{18}$O or δ^{15}N = depletion in ^{18}O or ^{15}N

IDENTIFYING SOURCES OF NITRATE

- Denitrification will enrich both ^{18}O and ^{15}N in the remaining nitrate pool
- Nitrification produces nitrate with similar ^{15}N range as the source and ^{18}O ranges based on local water and atmospheric ^{18}O ranges. Can be estimated as:

$$\delta^{18}O_{nitrate} = (2/3)\ \delta^{18}O_{water} + (1/3)\ \delta^{18}O_{atmospheric\ O2}$$



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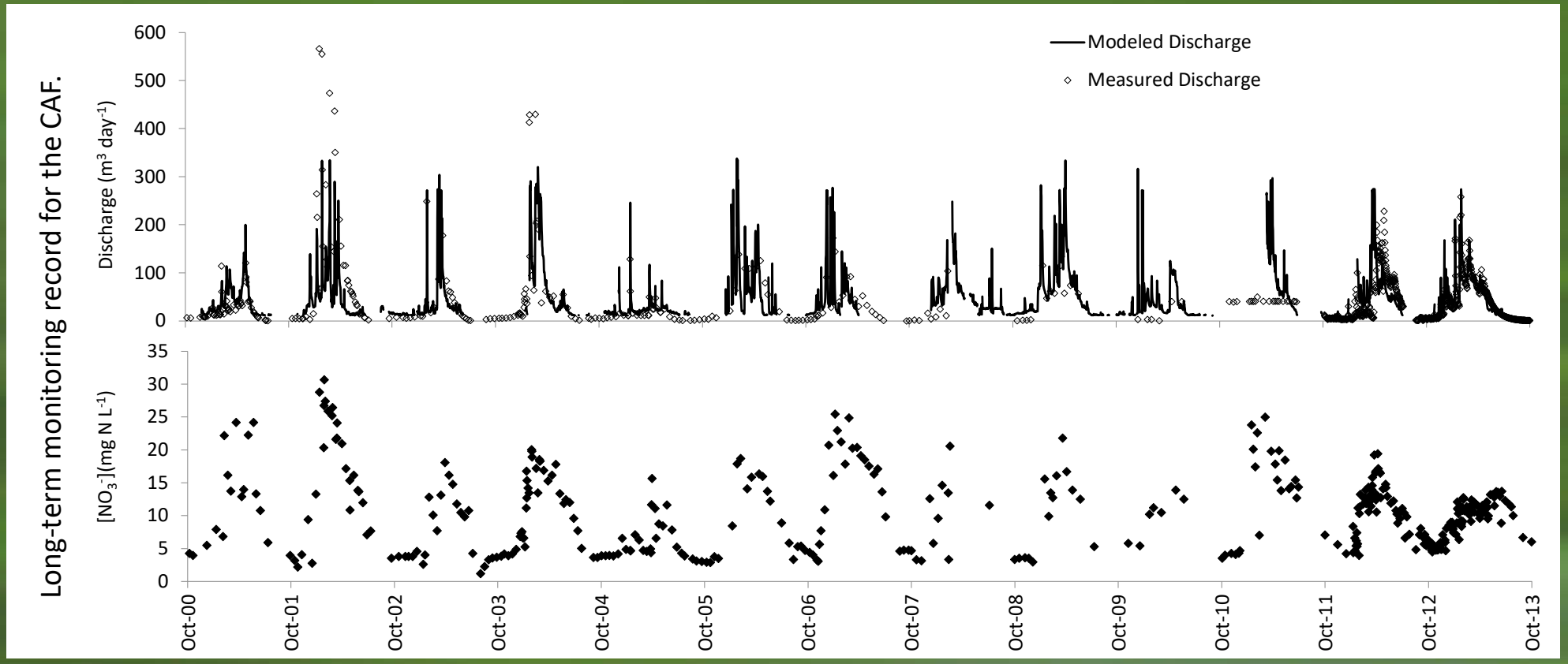
IDENTIFYING SOURCES OF NITRATE - EXAMPLE



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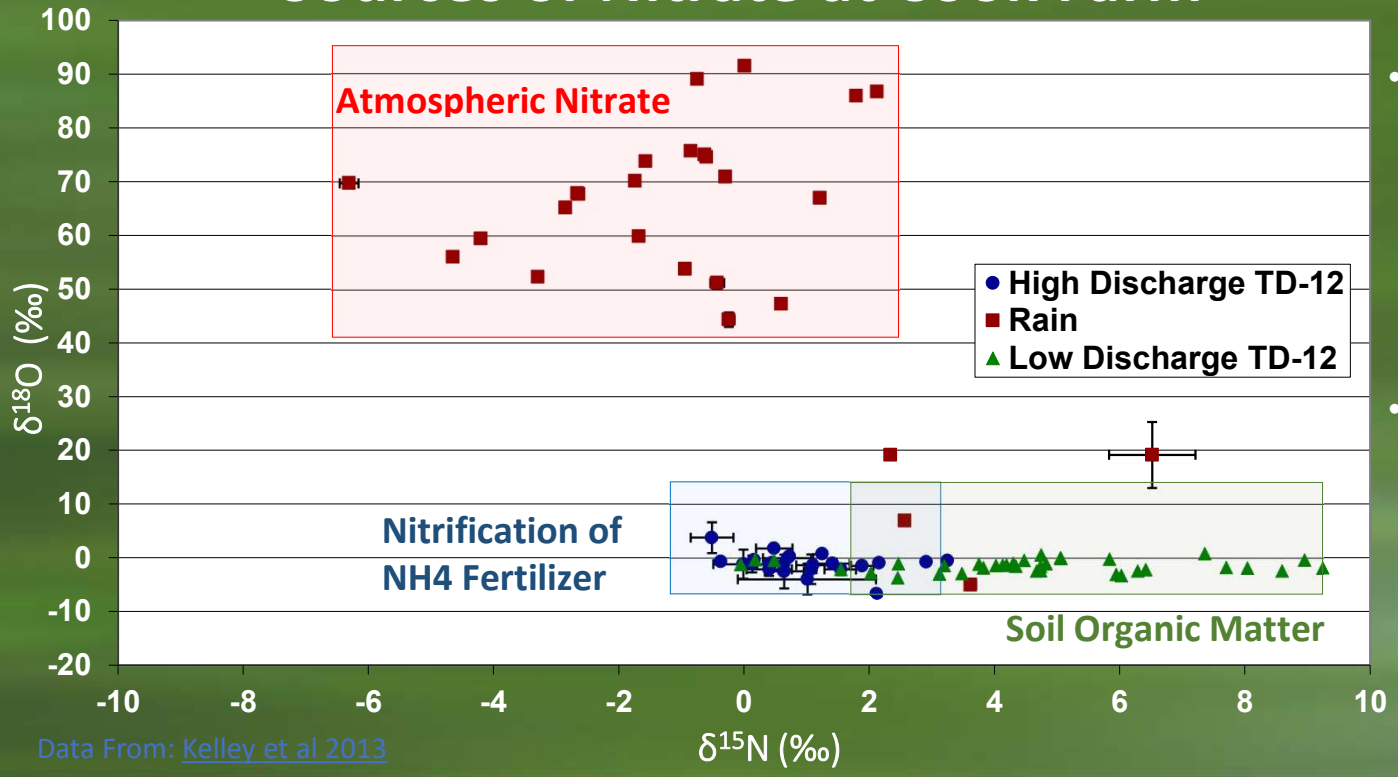
IDENTIFYING SOURCES OF NITRATE - EXAMPLE

Sources of Nitrate at Cook Farm



Data From: Kelley et al 2013

- We identified seasonal sources of nitrate in an artificial drain discharge:
  - High-discharge nitrate from synthetic fertilizer
  - Low-discharge nitrate from soil organic matter
- Nitrification was the dominant cycling process.

Expected $\delta^{18}O_{nitrate}$ = -1.9
Observed Mean $\delta^{18}O_{nitrate}$ = -1.3 ± 1.5‰

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CONTACT INFORMATION

Thank you

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Winter at the Cook Agronomy Farm

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