

Outline of Study to Determine the Isotopic Signatures of Nitrate in Ground Water of the Umatilla Basin

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Meeting Objectives

- Present Goals of Project
- Present Fundamentals of Isotope Tracing
- Discuss criteria for site selection
- Receive recommendations from the group

Phases of Project

- Scoping- Fall 2003
- Reconnaissance Sampling-Winter 2003/2004
- Intensive Sampling of a few sites- Spring 2004
- Write up and complete- Spring 2005

Goals of Project

- Apply isotope tracing techniques to groundwater nitrates in the LUB GWMA
- Demonstrate proof of concept for nitrogen tracing in groundwater
- Determine the uncertainty of the results
- Transfer technical protocols to EPA and the state of Oregon

Basic Principles Behind the Use of Nutrient Isotopes as Tracers of Sources and Sinks:

- 1) Many different **sources** of nutrients have distinctive isotope ratios.
- 2) Many different **processes** (e.g., denitrification, nitrification) change the isotope ratios of the reactants and products such that the existence and extent of that specific process can be identified by measurement of the isotope ratios of the product and/or residual reactant.

In other words, different sources of nitrate and organic matter often have distinctive isotope “fingerprints” that can provide a better understanding of the system than just using mass balance “black box models”.

A Multi-tracer Approach to Tracing Nutrient Sources and Sinks in Aquatic Systems:

Nitrate is not the only nutrient in rivers and these nutrients can be traced with more than 1 isotope pair

Tracers of NO_3 sources and sinks:

There are 2 stable nitrogen isotopes (^{15}N , ^{14}N).
ratios of $^{15}\text{N}/^{14}\text{N}$ reported as $\delta^{15}\text{N}$.

There are 3 stable oxygen isotopes (^{18}O , ^{17}O , ^{16}O).
ratios of $^{18}\text{O}/^{16}\text{O}$ reported as $\delta^{18}\text{O}$.
ratios of $^{17}\text{O}/^{16}\text{O}$ reported as $\delta^{17}\text{O}$.

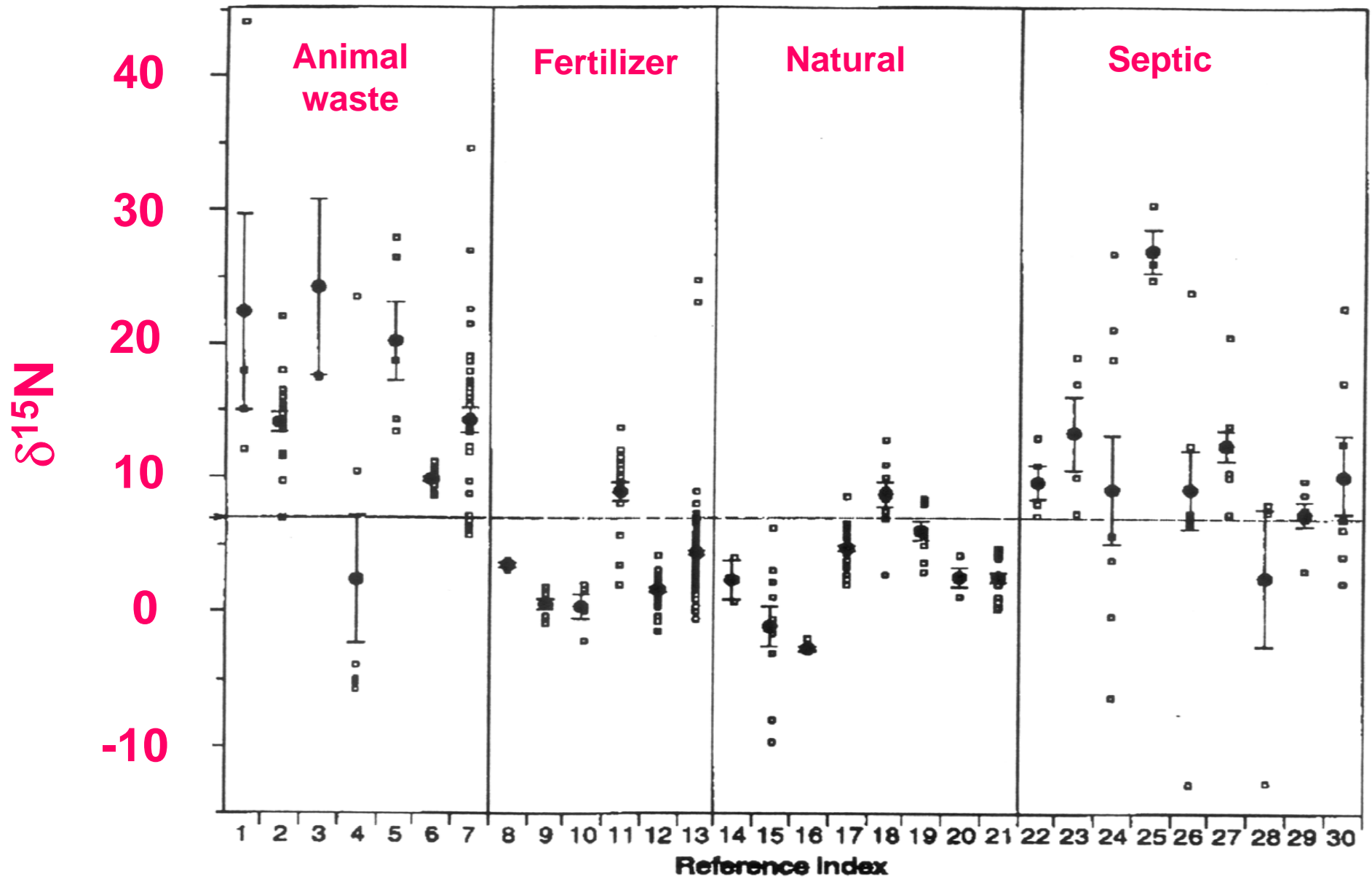
Tracers of NH_4 sources and sinks:

$\delta^{15}\text{N}$.

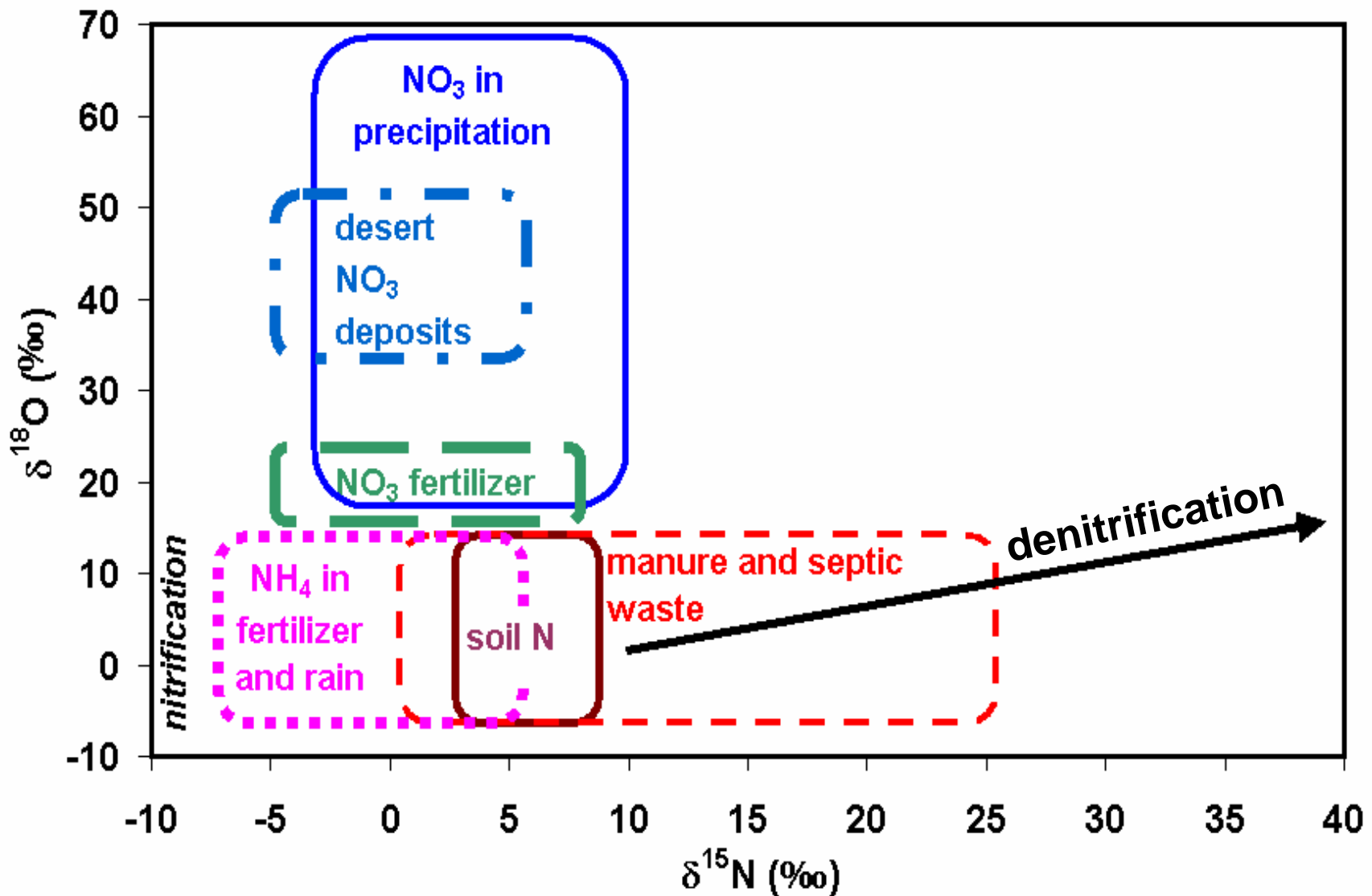
Tracers of POM and DOM sources and sinks:

$\delta^{15}\text{N}$, $\delta^{13}\text{C}$, $\delta^{34}\text{S}$, etc.

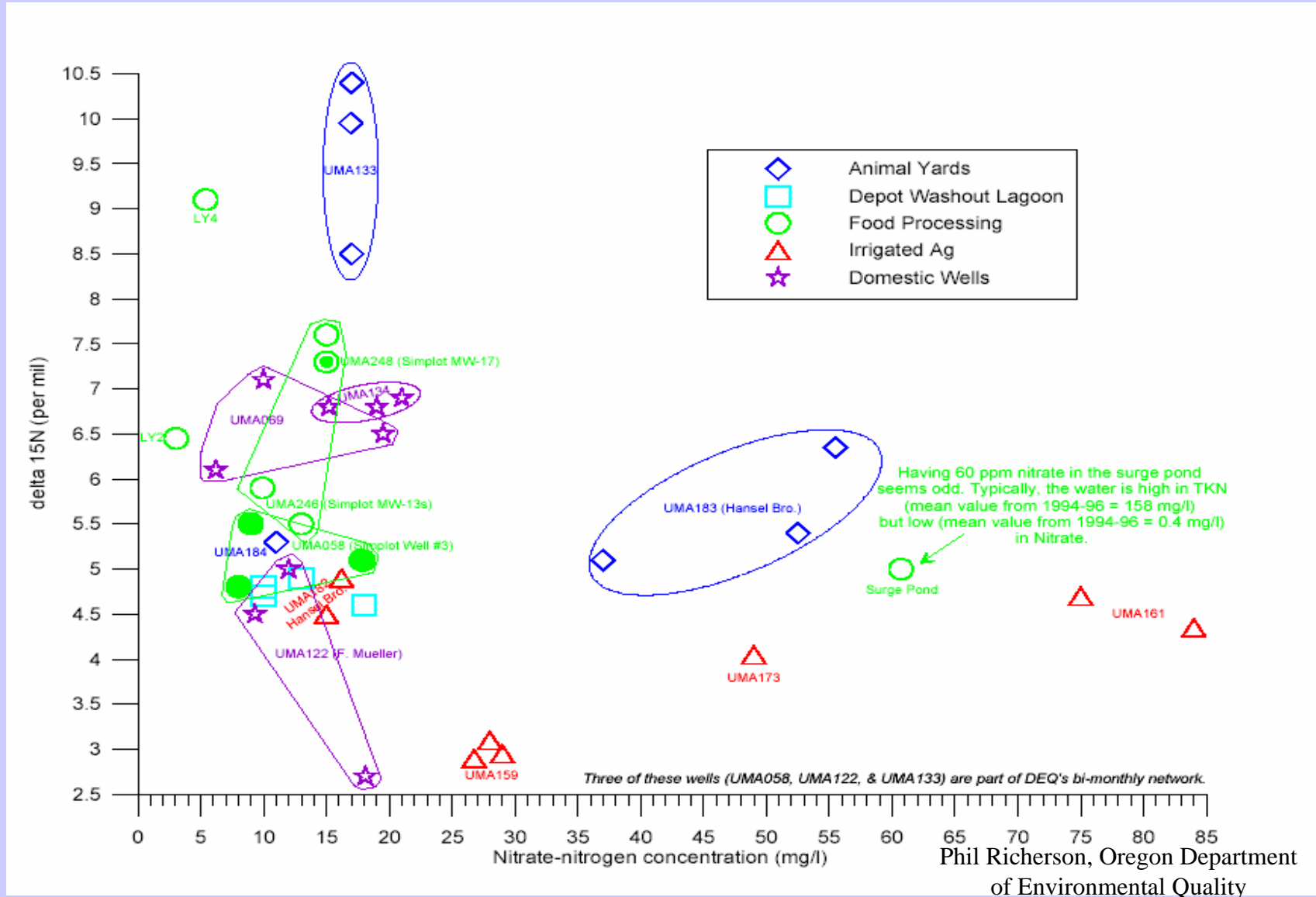
Ranges of Soil Water $\delta^{15}\text{N}$ Values for Different Land Uses



Ranges of $\delta^{15}\text{N}$ and $\delta^{18}\text{O}$ values of different sources of NO_3



Nitrogen Isotopes in the Umatilla GWMA



Proof of Concept

At a Minimum:

Given the identity and isotopic signature of a single constant primary source of nitrate:

Follow the isotopic signature of groundwater downgradient as it is diluted and possibly undergoes geochemical reactions

Possible Sources of Nitrate

- Irrigated Agriculture
- Land Application of food processing wastewater
- Concentrated Animal Feeding Operations (CAFOs)
- Umatilla Ordnance Depot
- Septic Systems in rural residential areas

Proof of Concept Continued

Add Temporal Complexity:

Given the isotopic signature of a single primary source of nitrate with changing source inputs:

Correlate the isotopic signature of downgradient nitrate with time by age dating groundwater

Proof of Concept Continued

Add Spatial Complexity:

Given the isotopic signature of multiple sources of nitrate with changing inputs:

Follow the isotopic signatures of two distinct plumes and follow their mixing

Criteria for Site Selection

- Identifiable Source(s) with distinguishable isotopic signal
- Known history of input timing
- Temporal and Spatial Complexity
- Availability of wells along flow path or accessible to water table by Geoprobe drilling
- Cooperation of landowners

Northeast Corner of Depot

- Spatial complexity
- Limited access to depot
- Two sources (depot landfill and food processing water)
- Large depth to water table

South of Depot

- Source complexity: Irrigated agriculture mixing with depot sources-may have similar isotopic signature
- Temporal complexity: Irrigated Agriculture after CAFO
- Access to aquifer limited to present wells.

Terrace

- Multiple sources- food processing waste and irrigated agriculture
- Spatial complexity- CAFOs downstream
- Large depth to groundwater
- Cooperation of owners unknown

New Irrigated Agriculture

- Single identifiable source
- Known history
- Determine groundwater velocity
- Large depth to water table

Echo Meadows

- Irrigated Agriculture and CAFO interdispersed
- Accessible by Geoprobe drilling