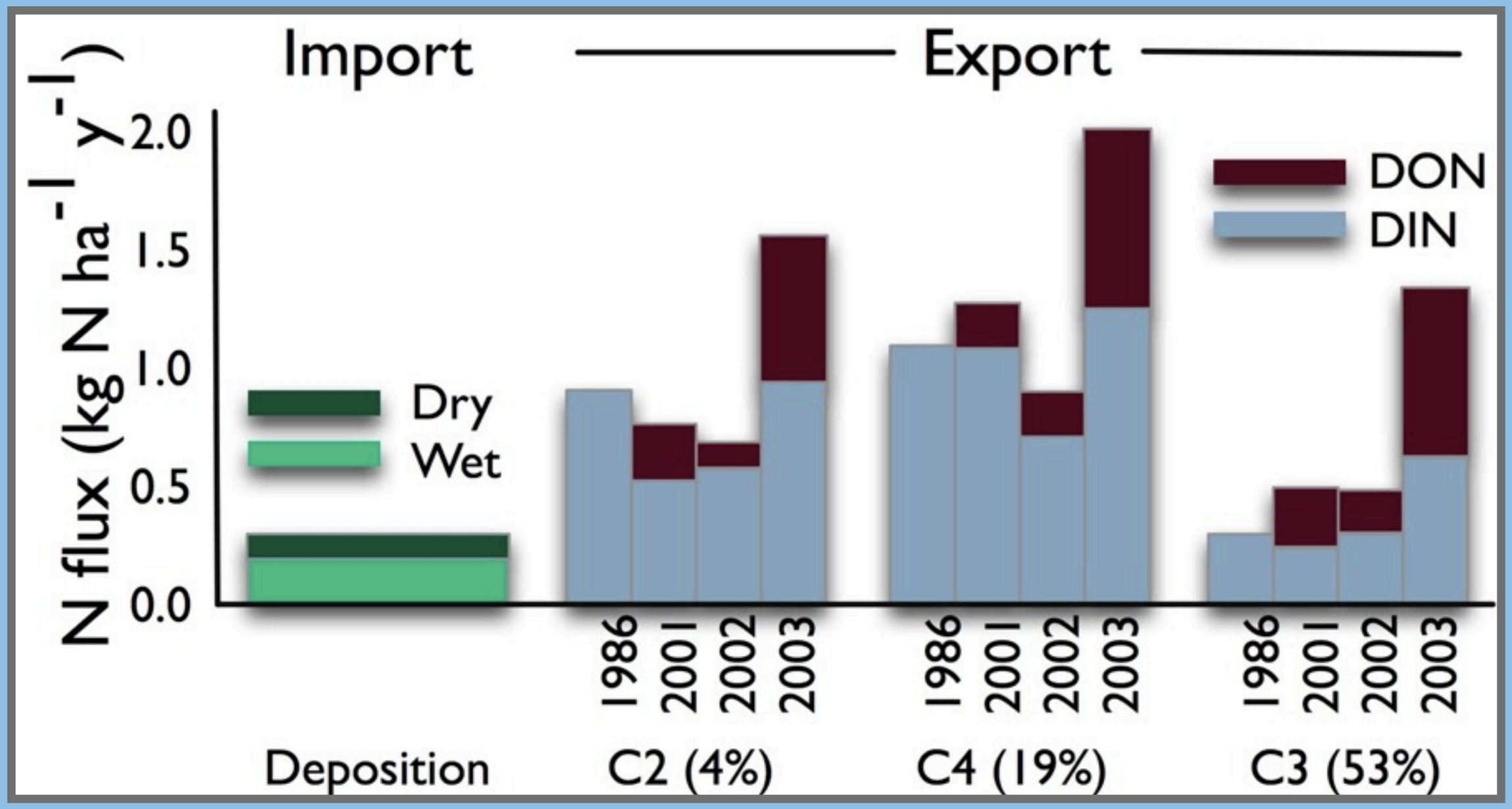
Permafrost thaw and a changing nitrogen cycle

Tamara K. Harms

Feb 15 2013

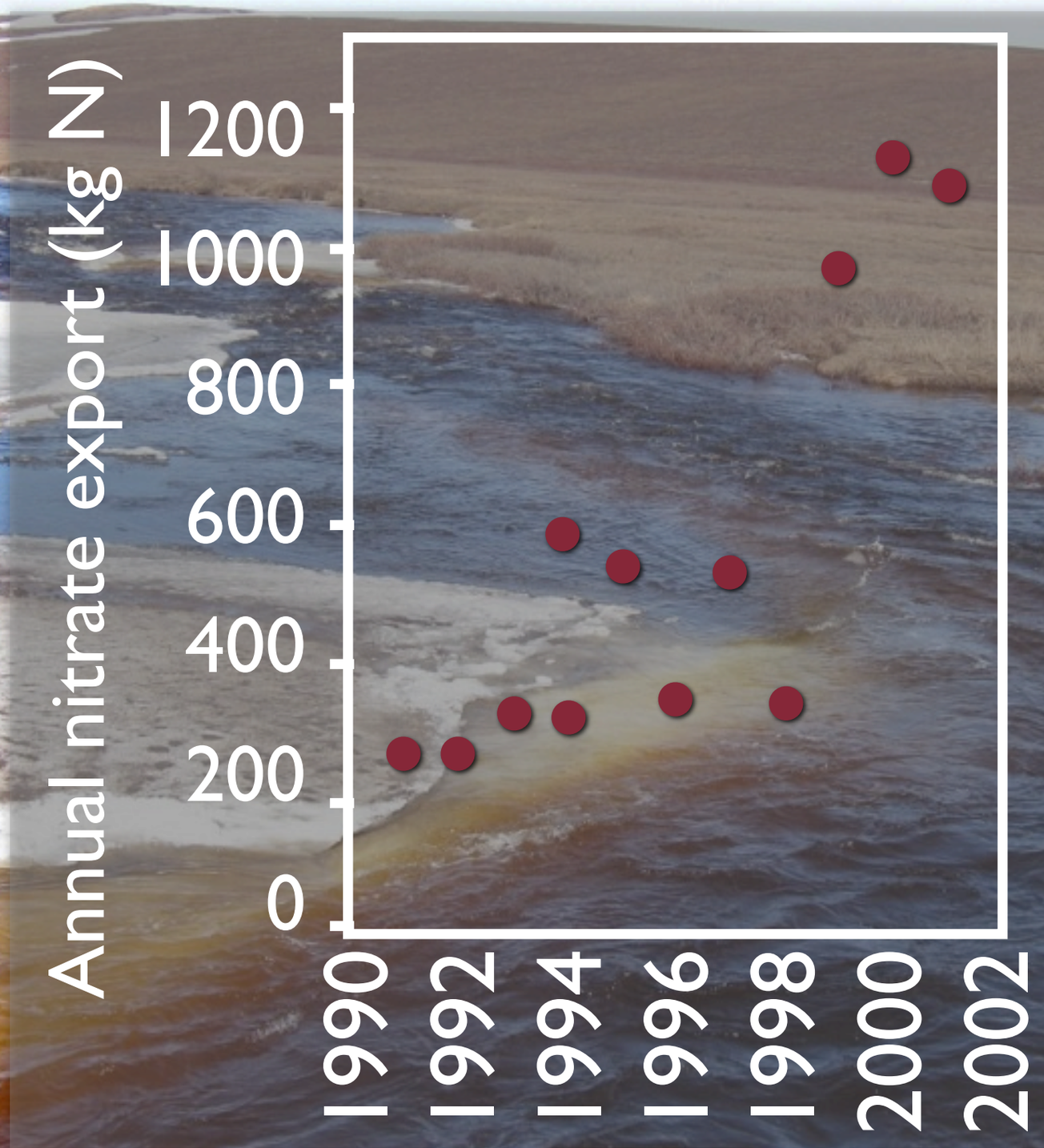
Acknowledgements: Ben Abbott, Andrew Balser, Jay Jones, Ann Olsson, Amanda Rinehart
National Science Foundation, Bonanza Creek LTER

N export from Alaskan catchments



Jones et al. 2005

Nitrate flux



McClelland et al. 2007

What causes export of N as nitrate?

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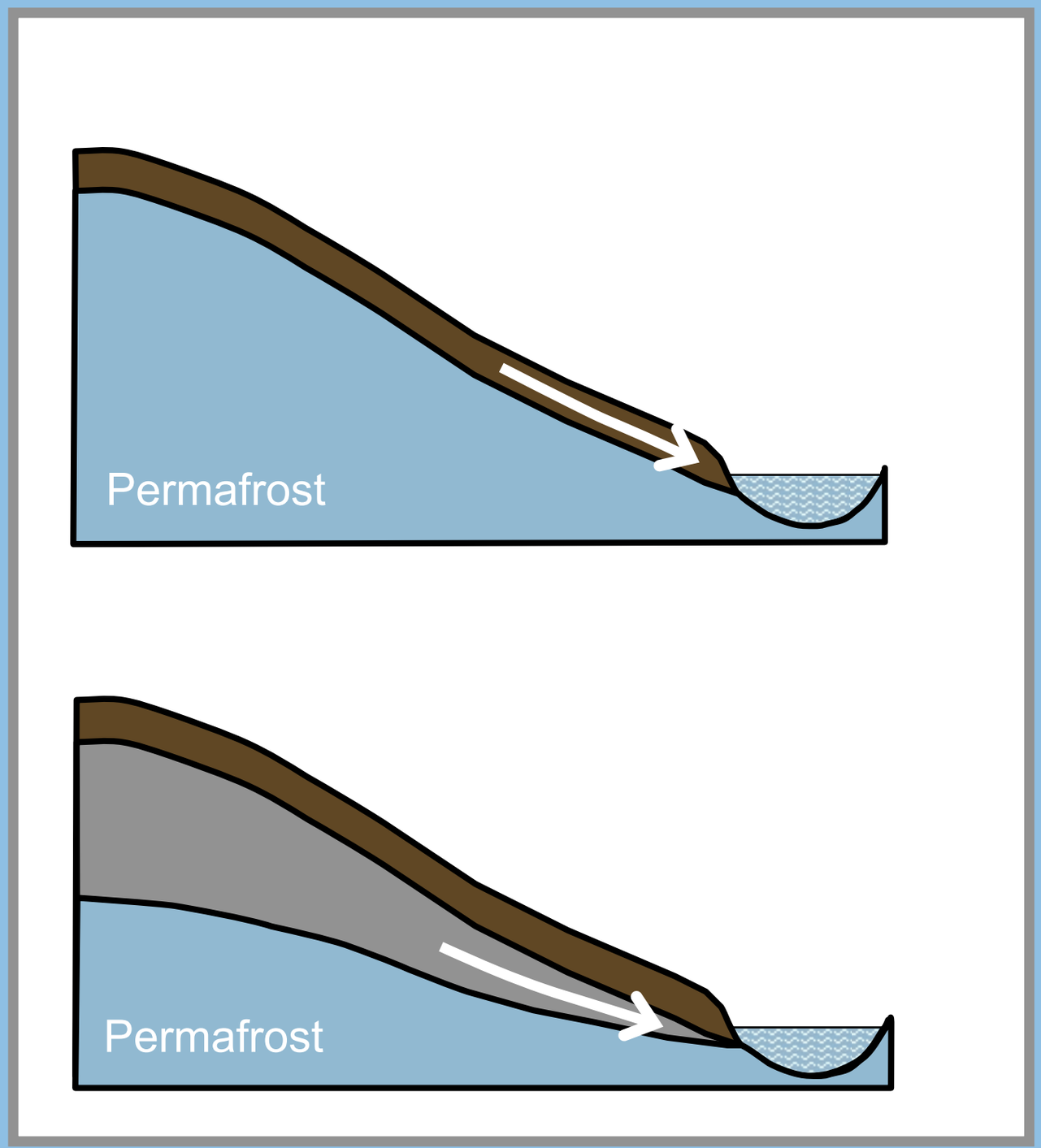
- Routing of flowpaths due to degrading permafrost

Active Layer



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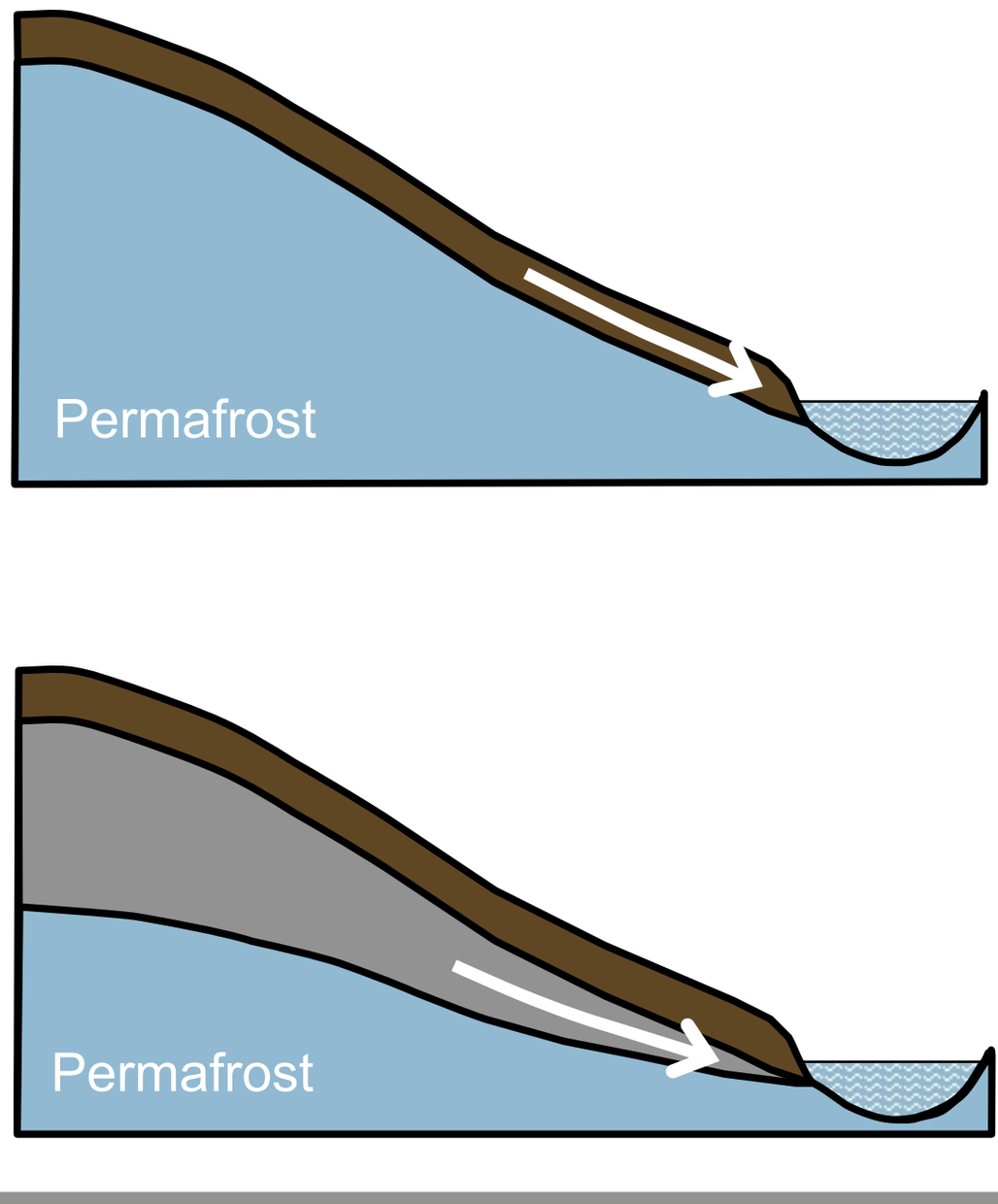

- Previously frozen organic matter

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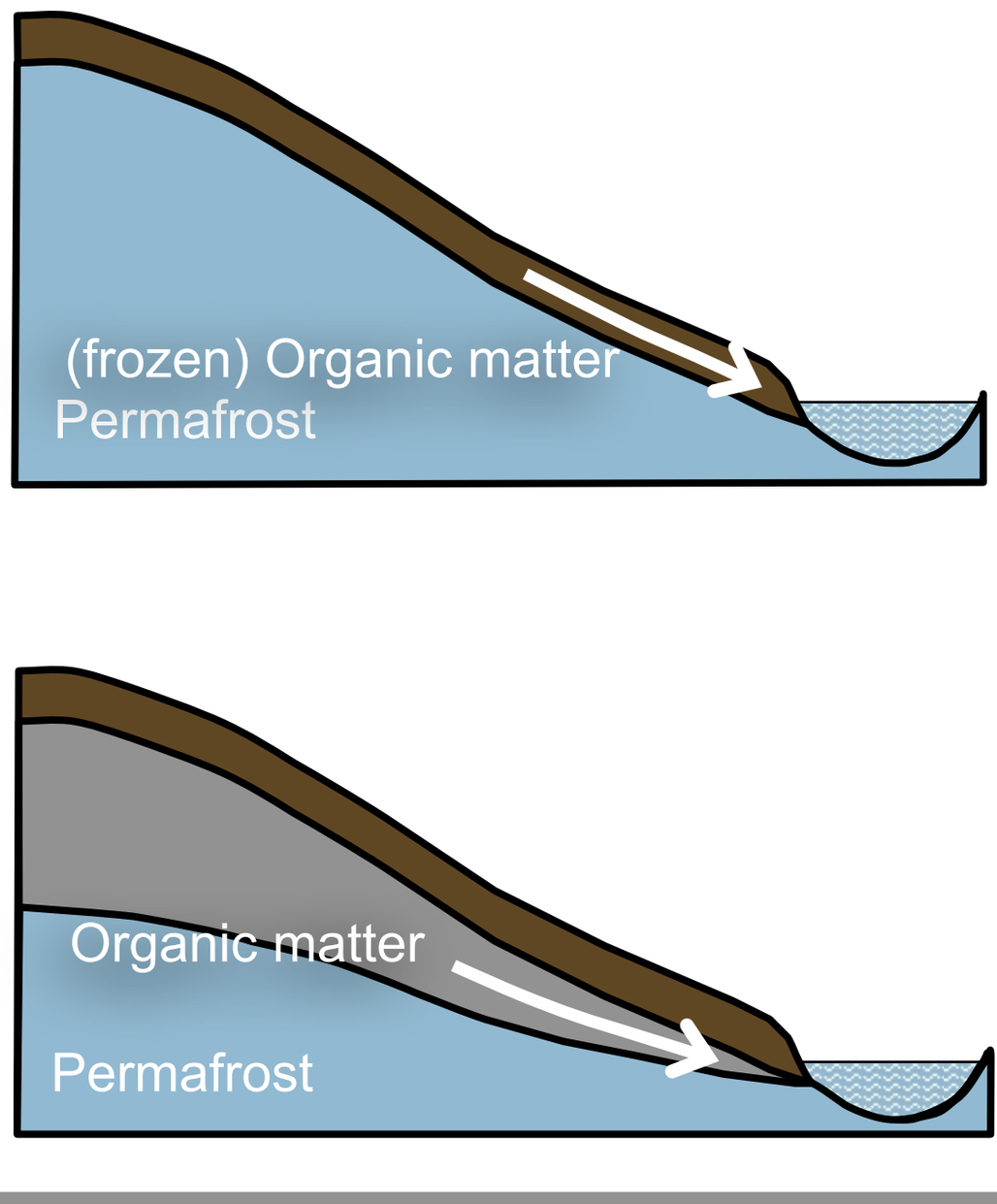

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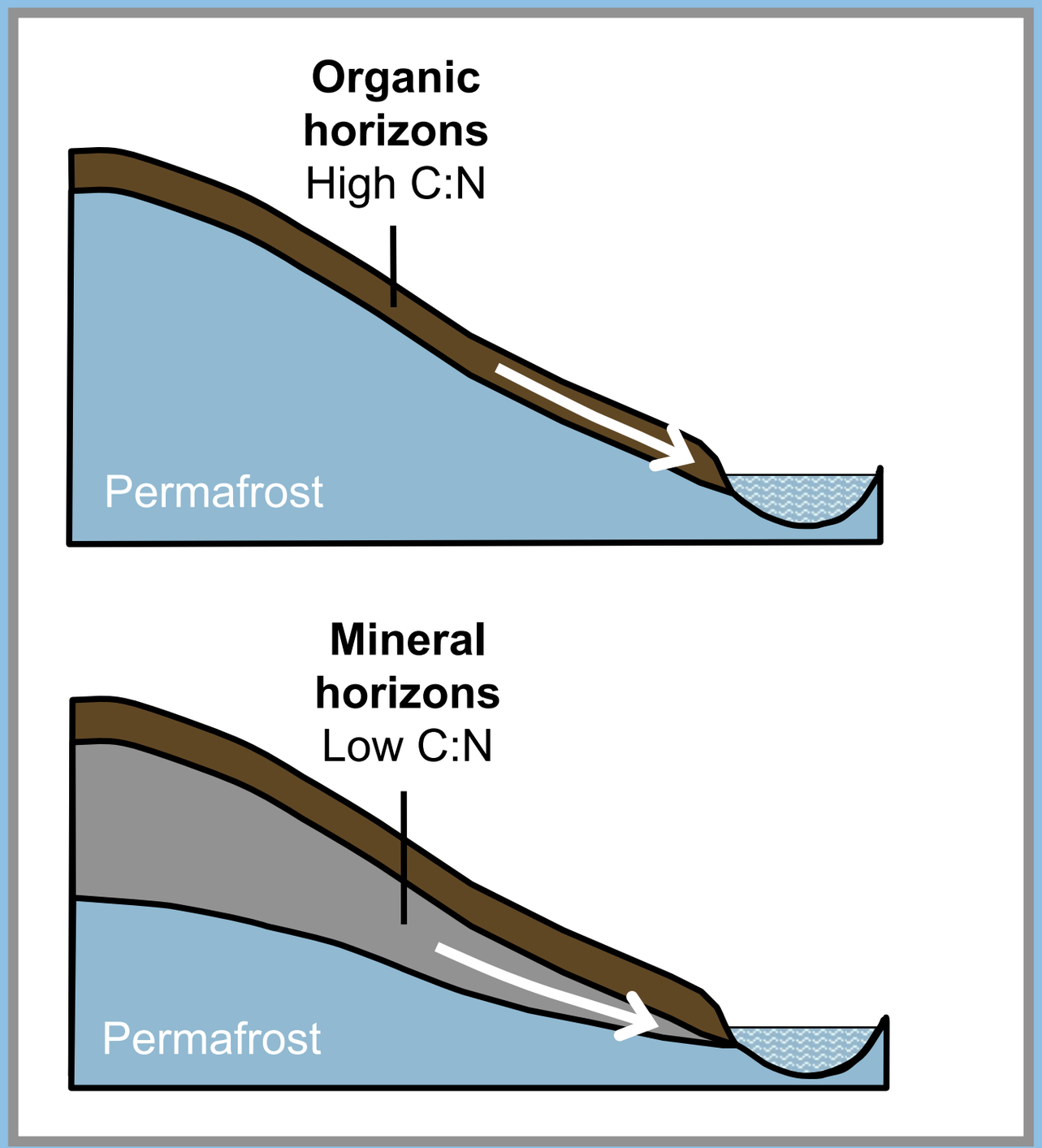

- Previously frozen organic matter
- Dominant biotic processes

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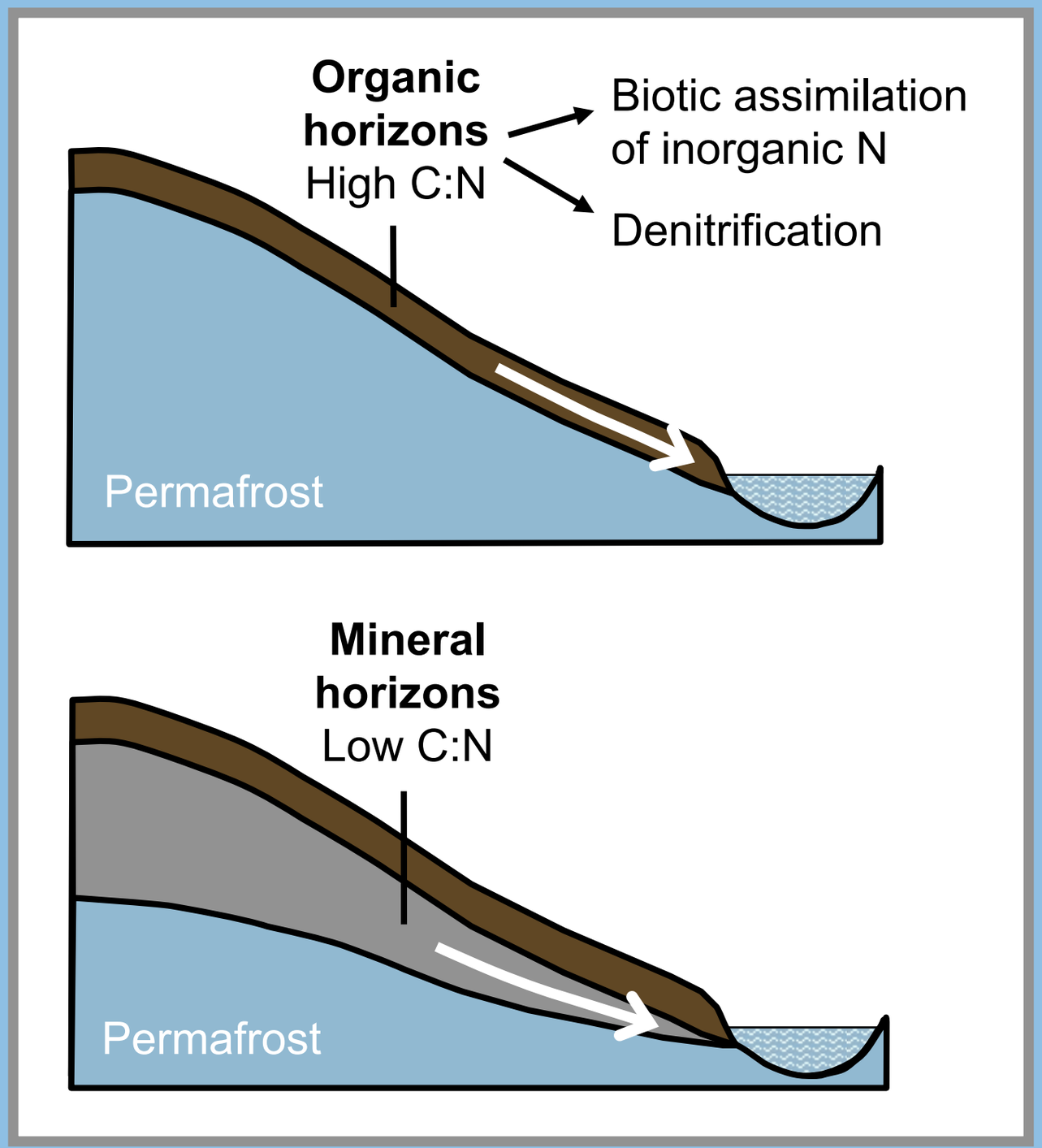

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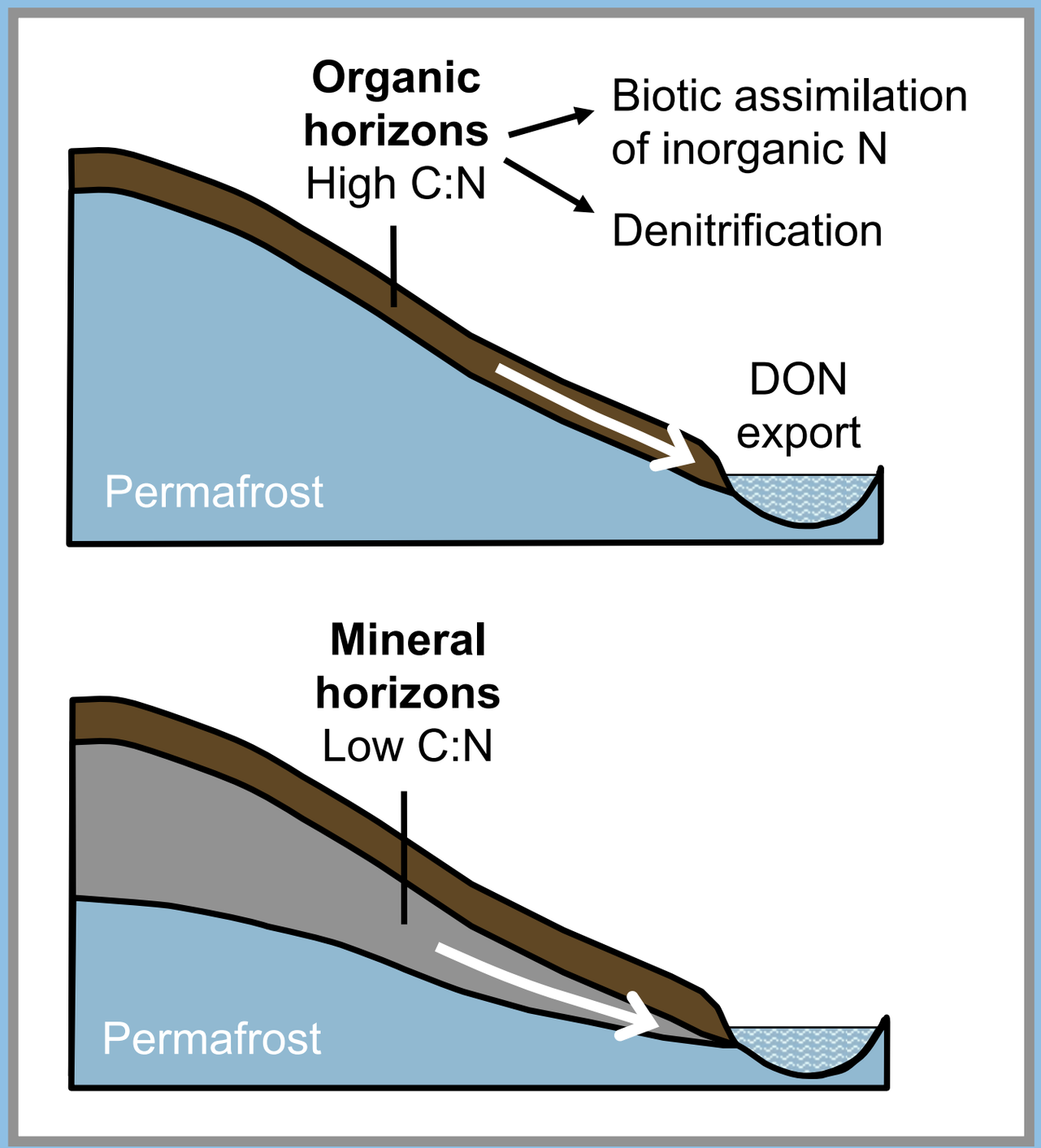

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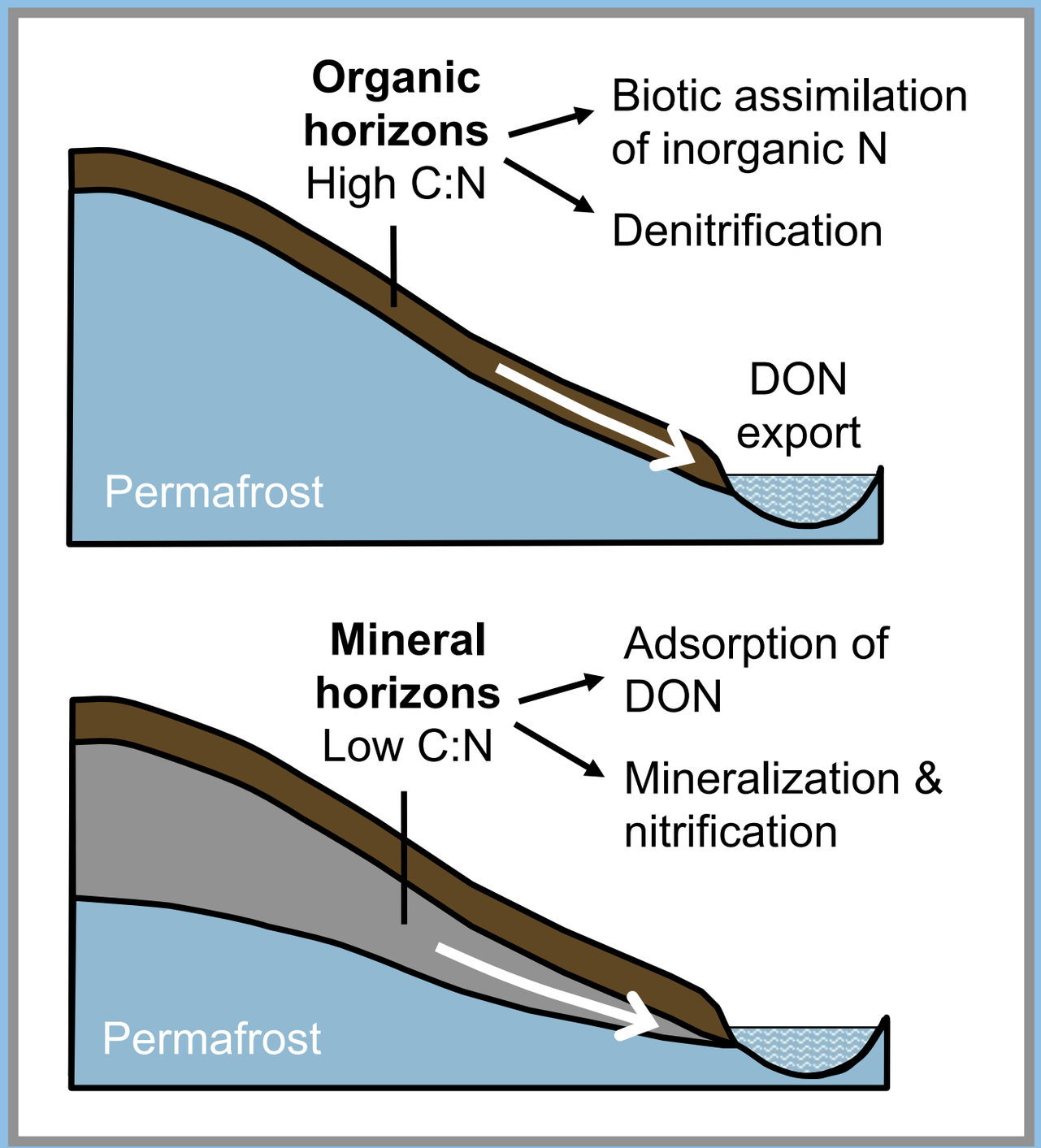

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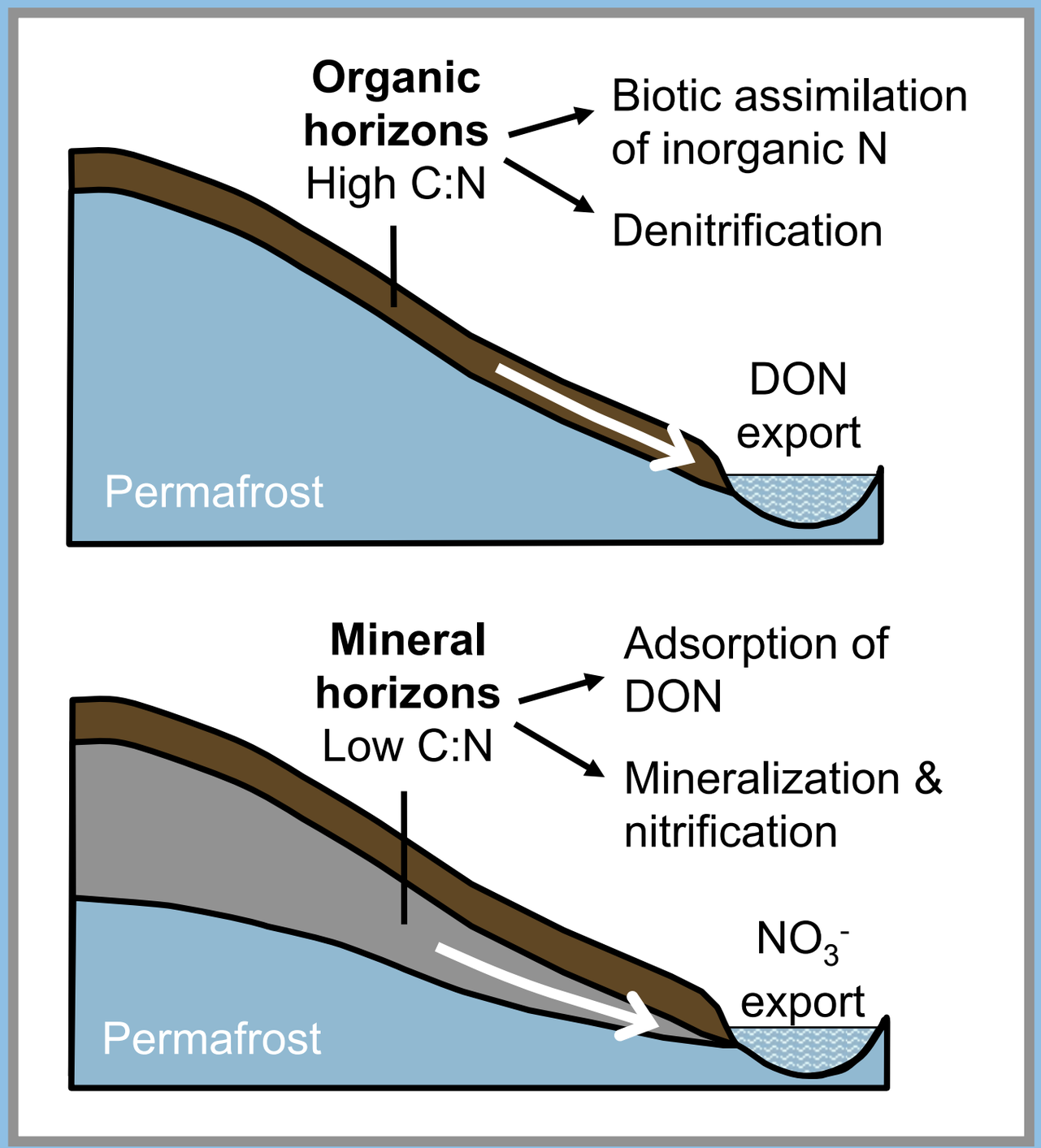

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Sources of nitrate

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- 24 streams along a latitude gradient

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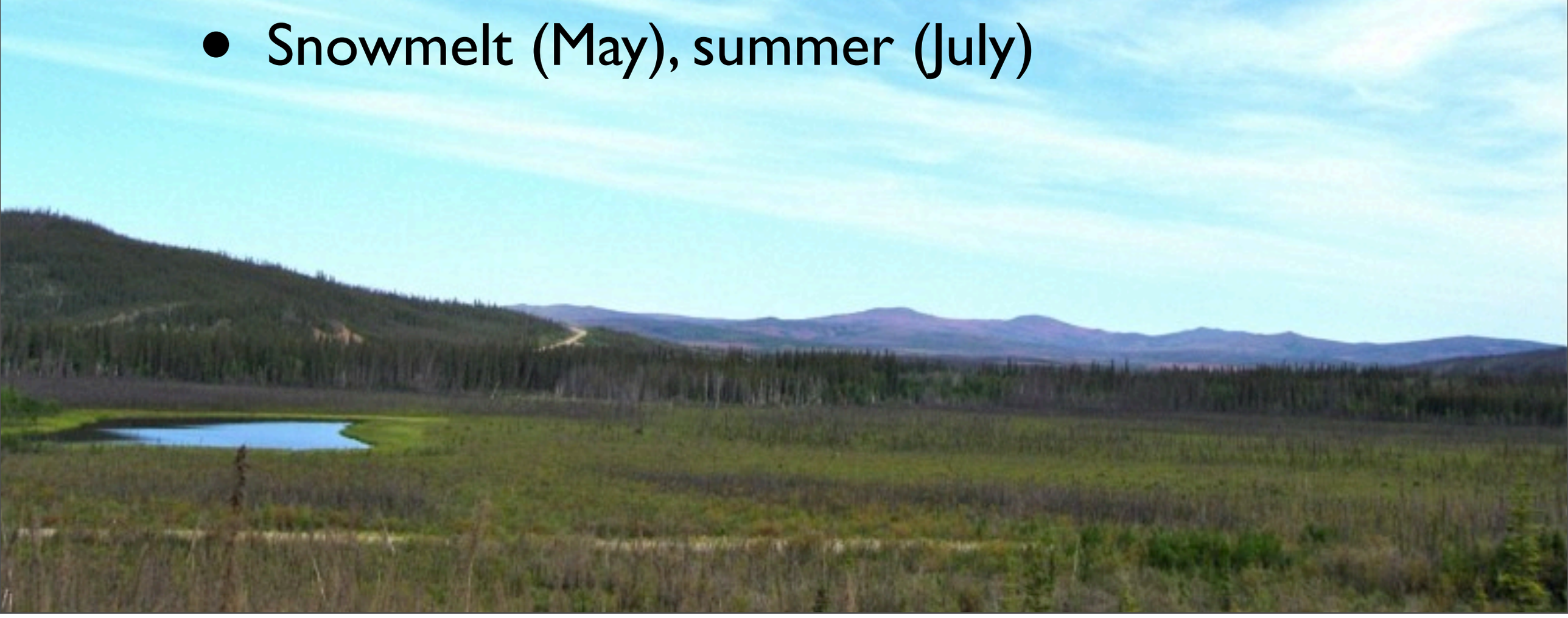

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- Discontinuous to continuous permafrost
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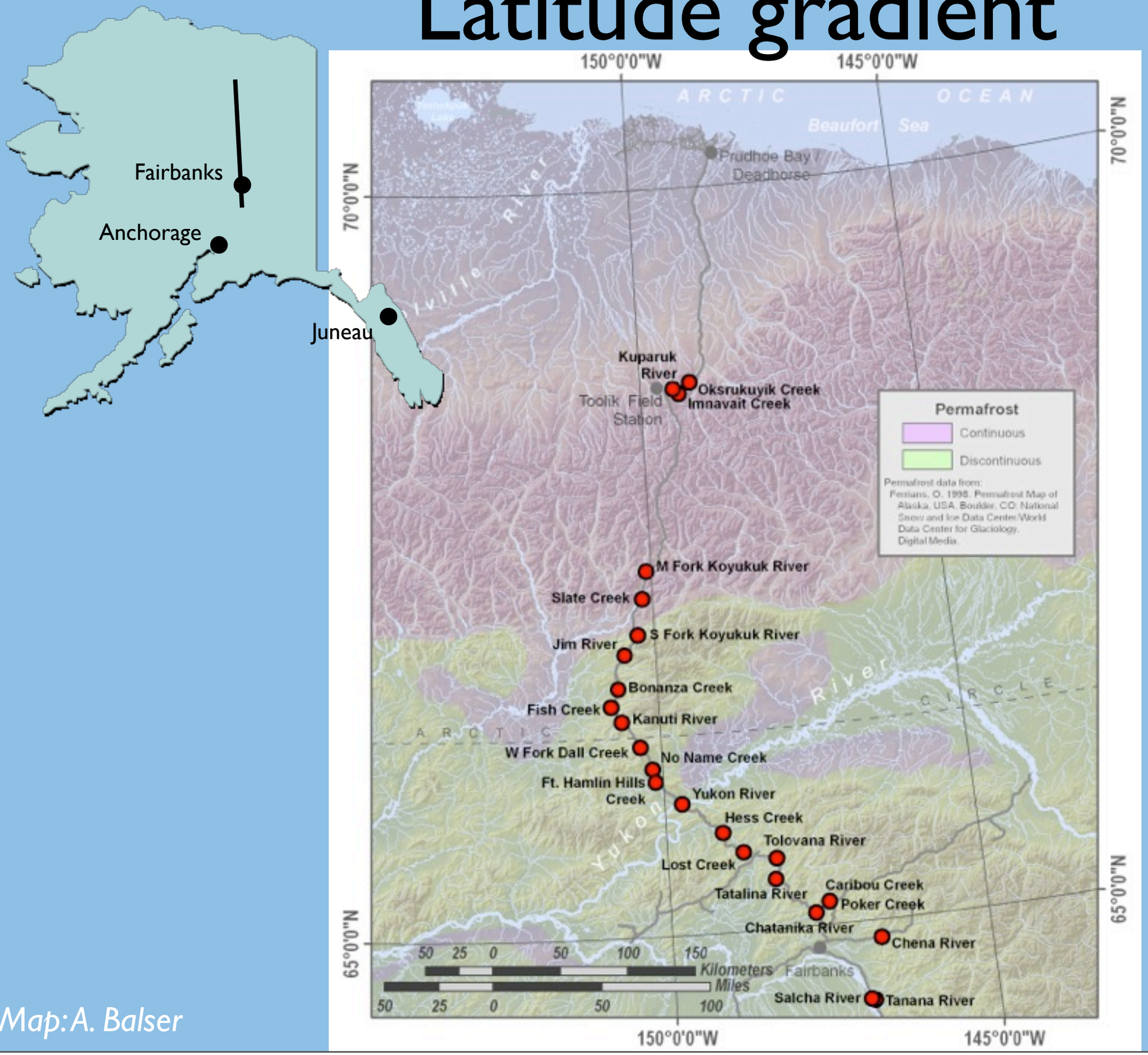
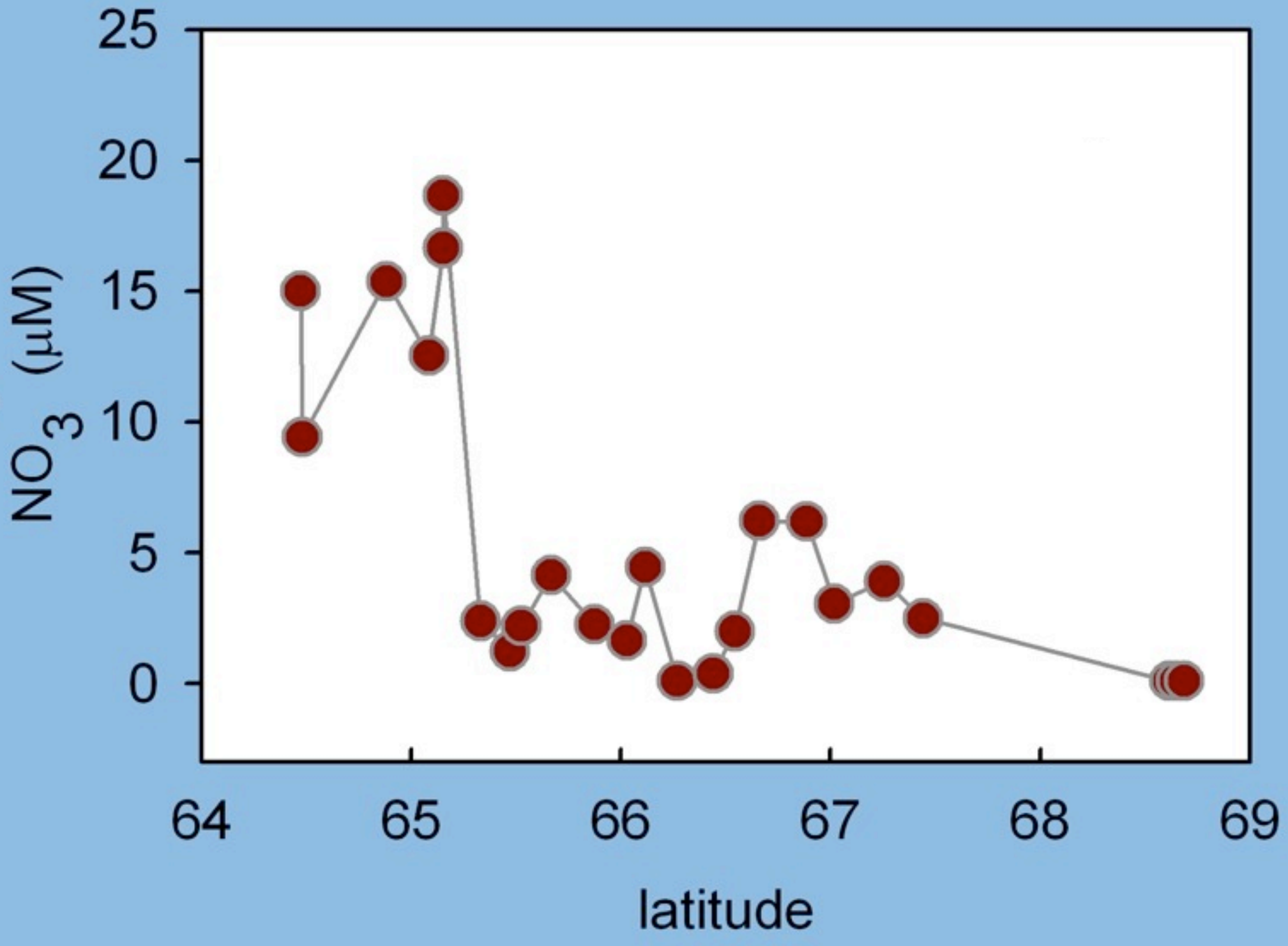
Latitude gradient



Map: A. Balser

Permafrost gradient



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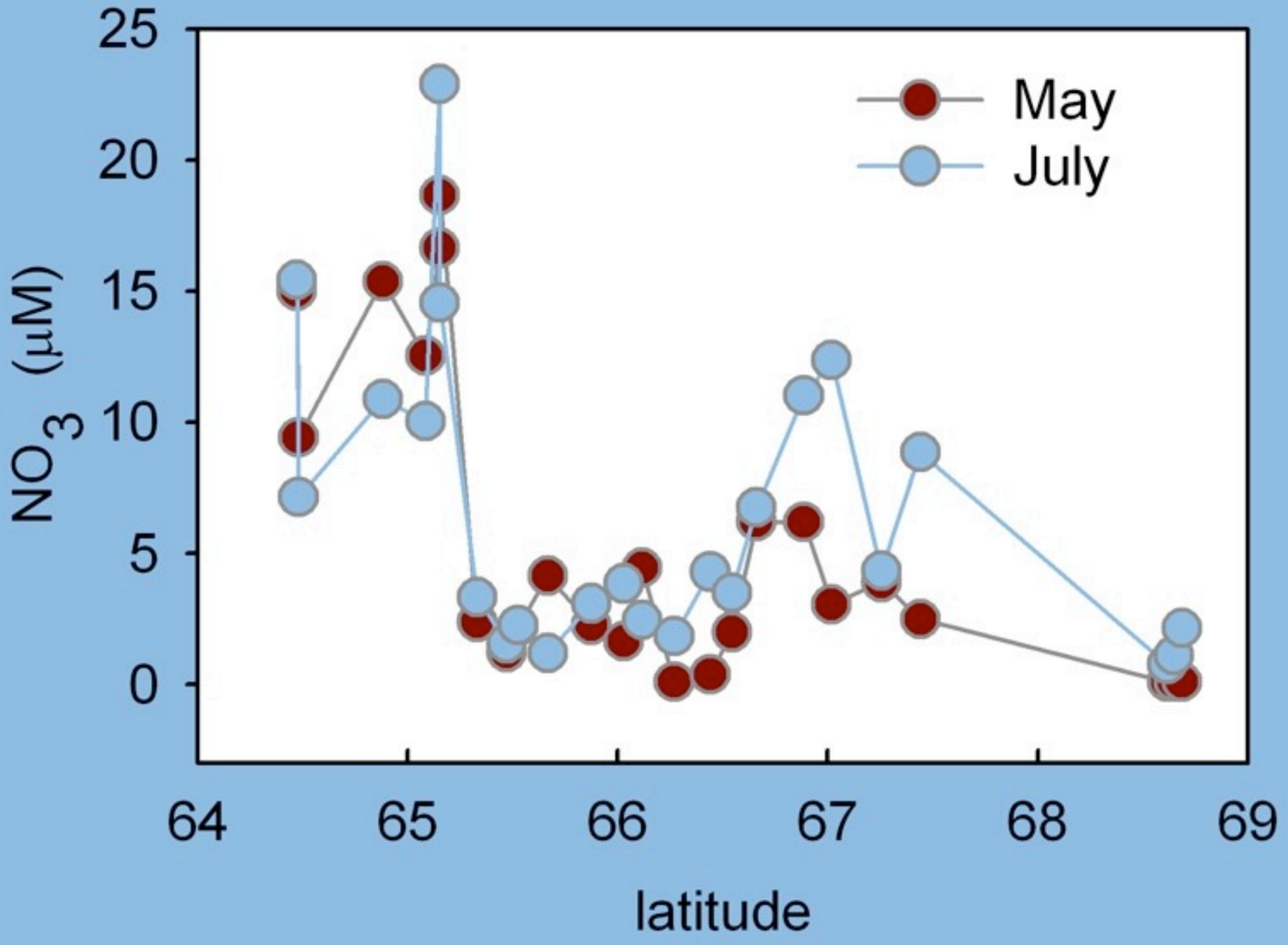

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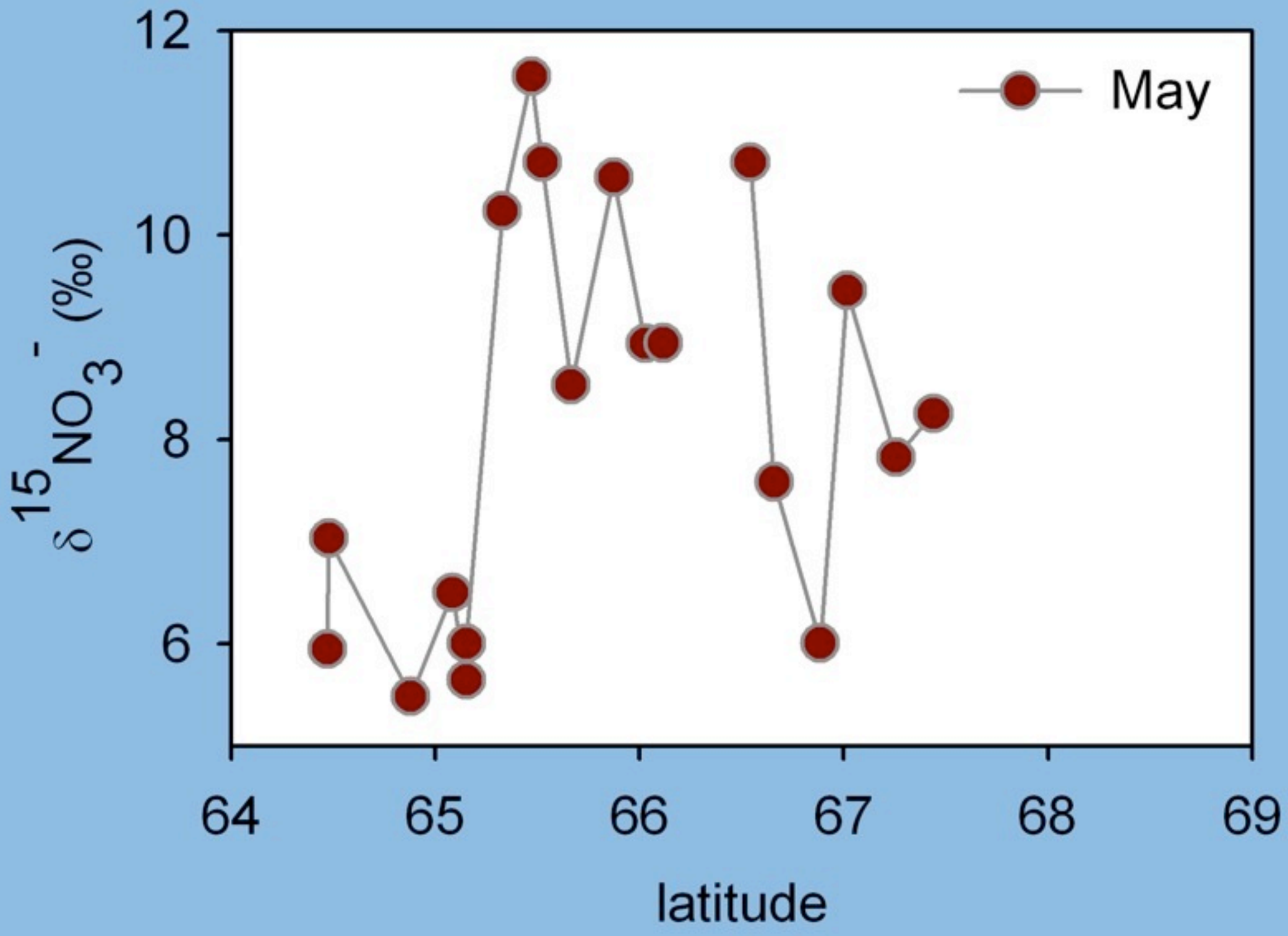

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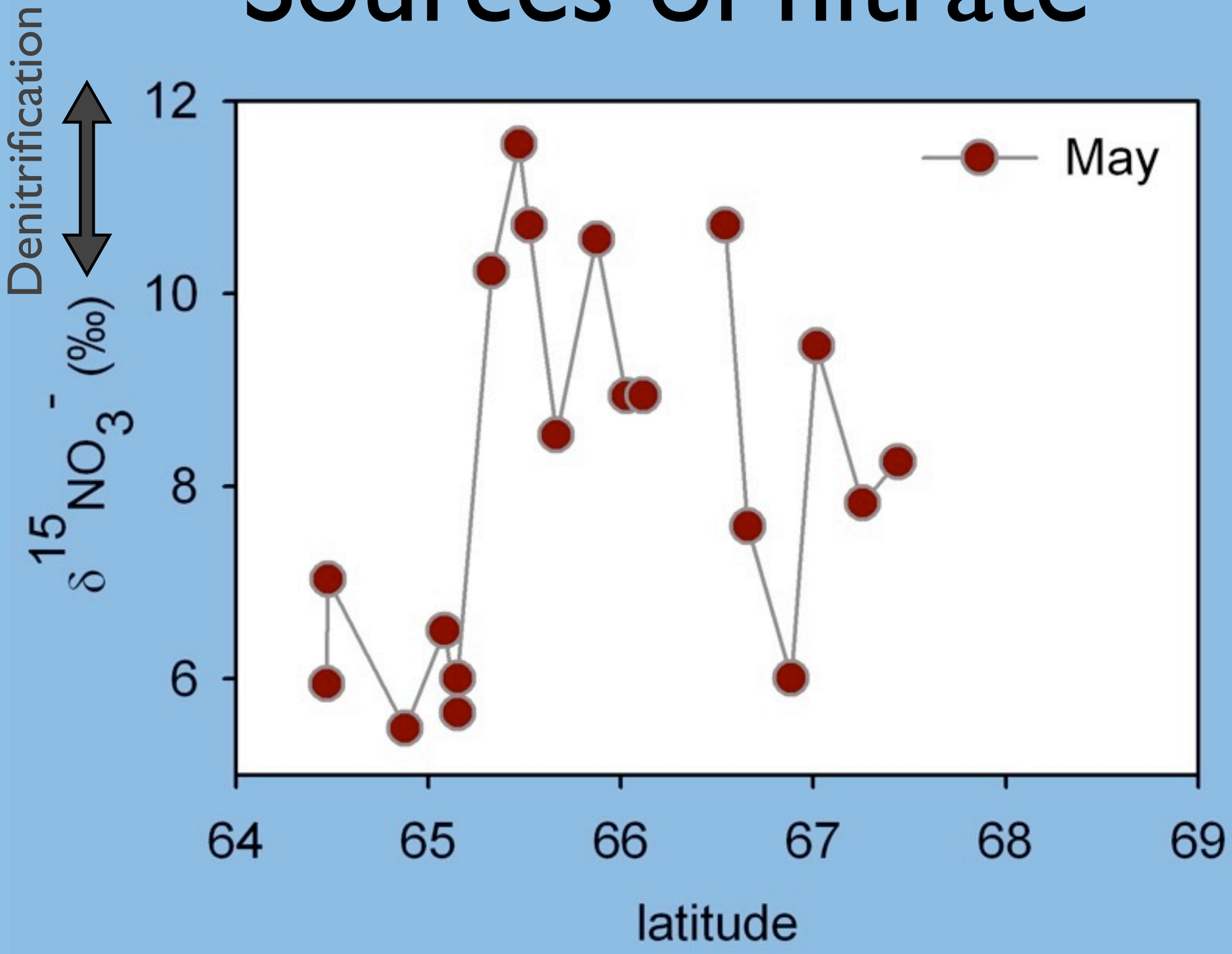

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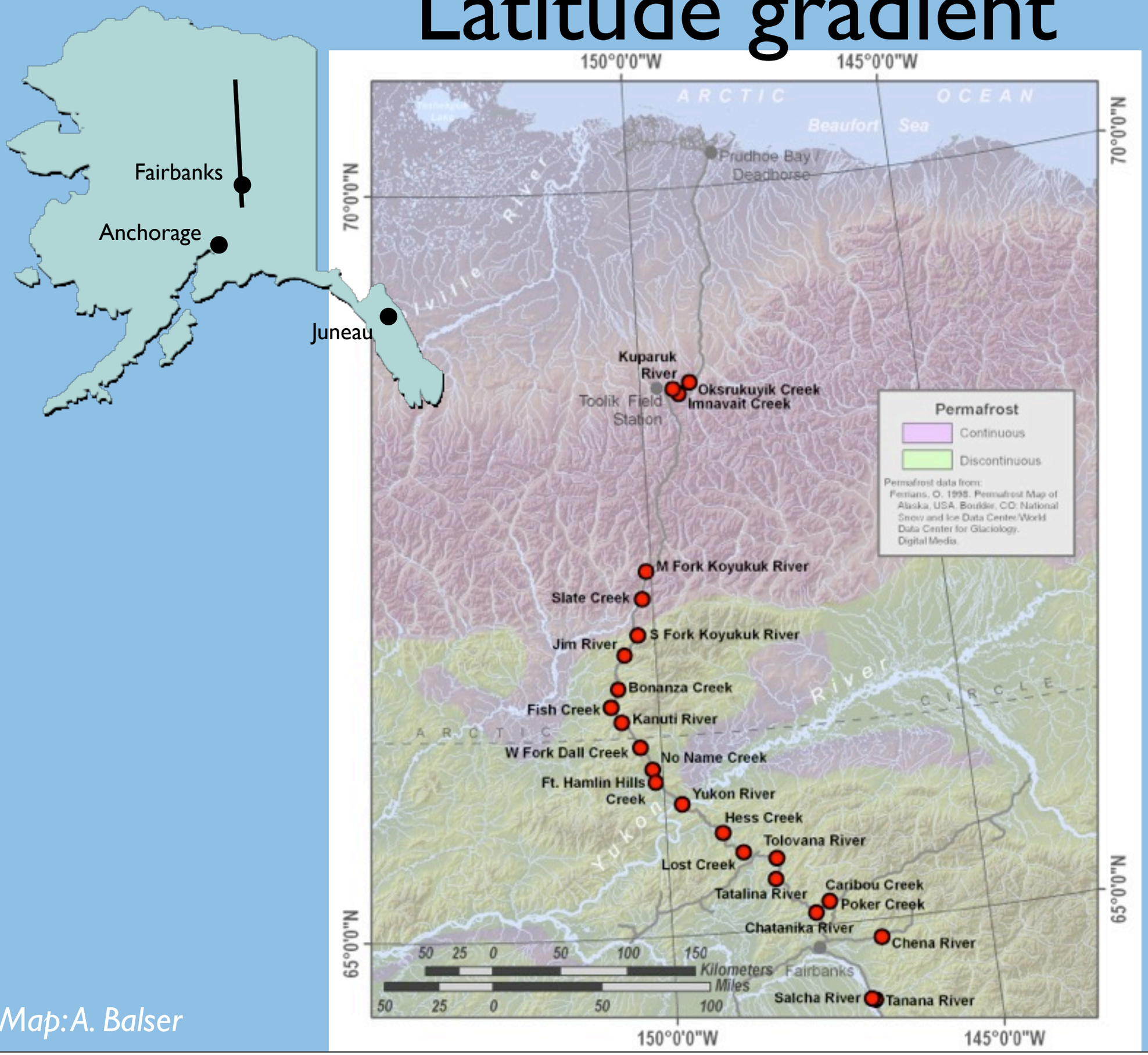

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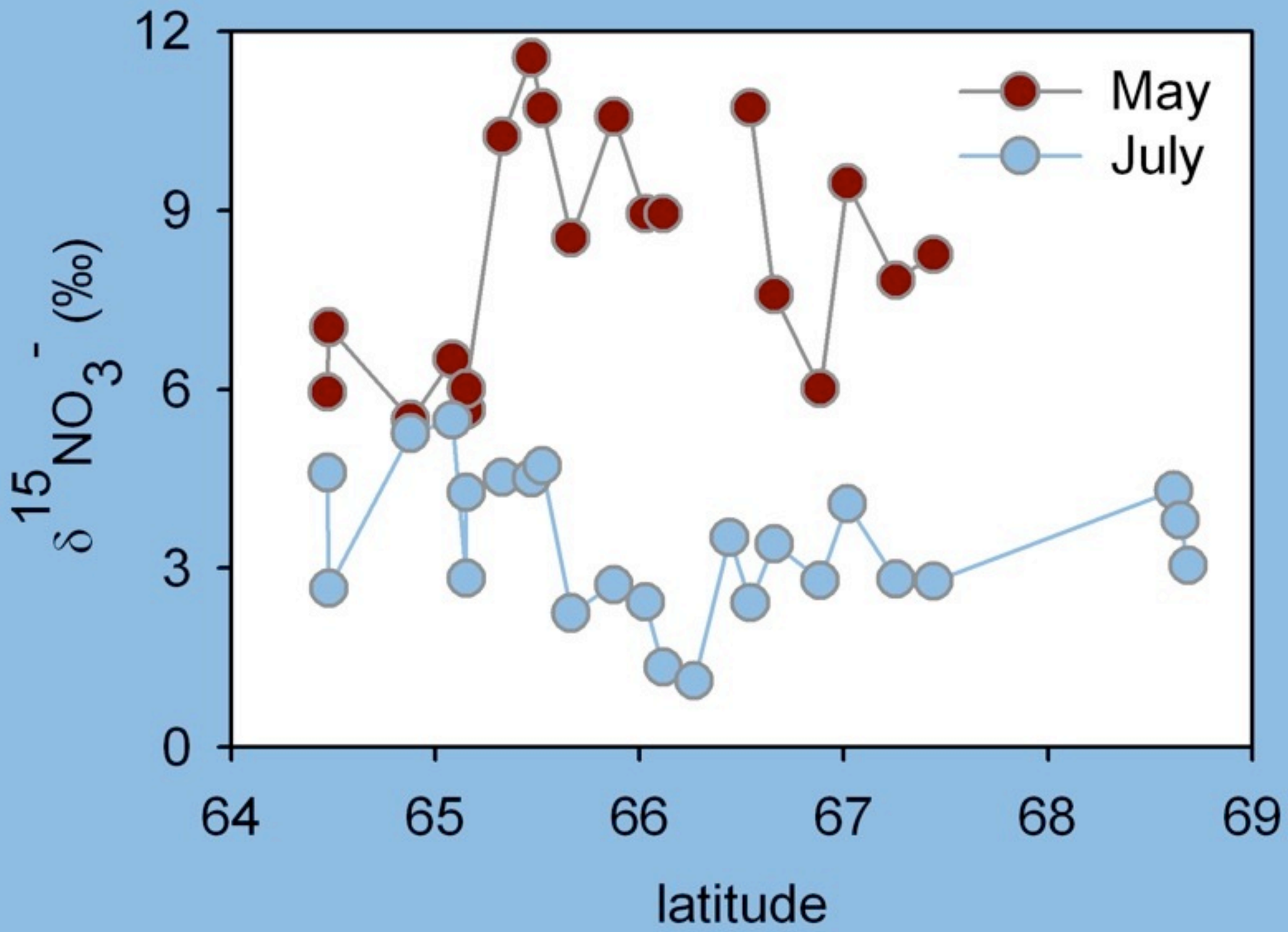

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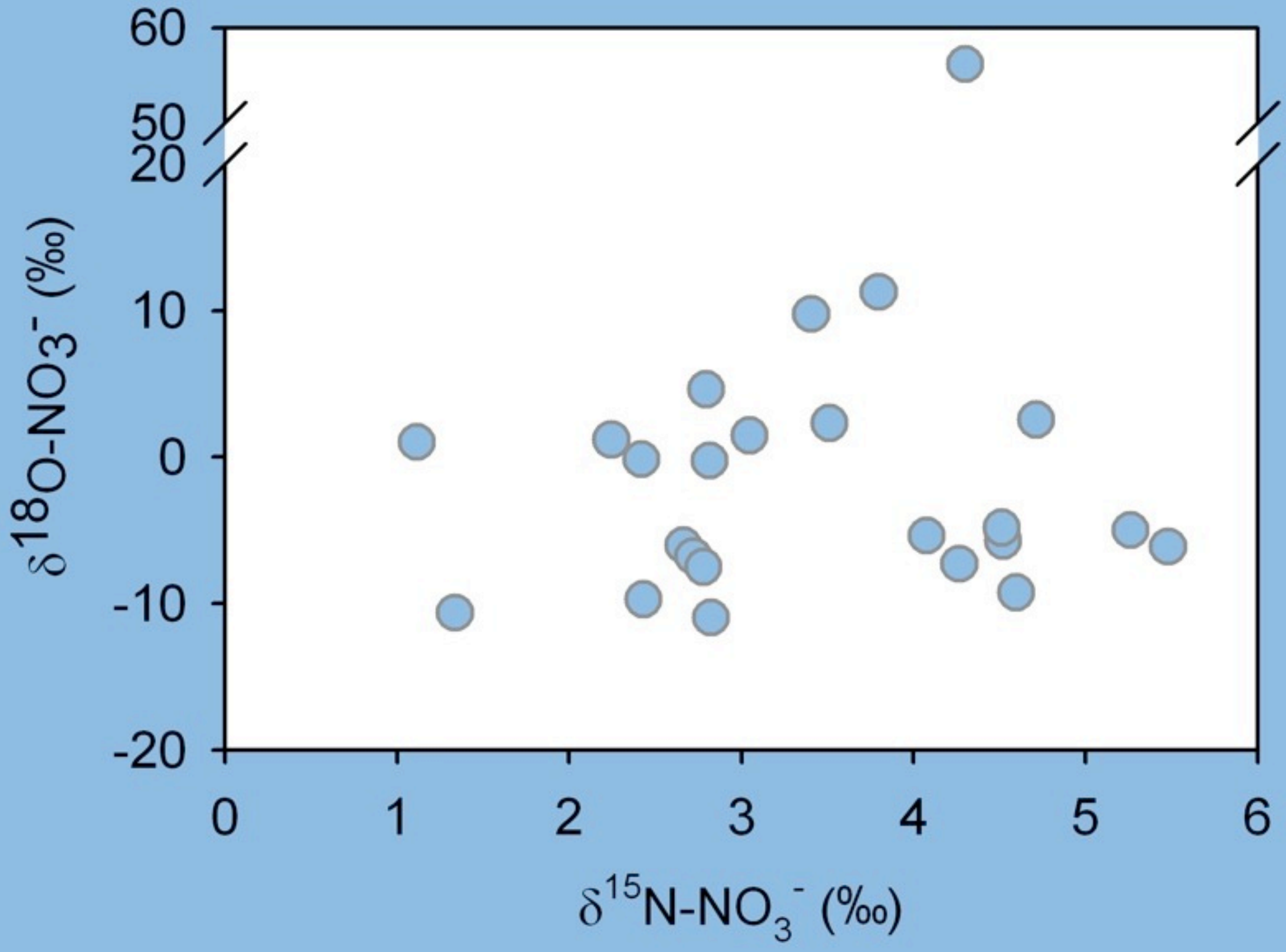

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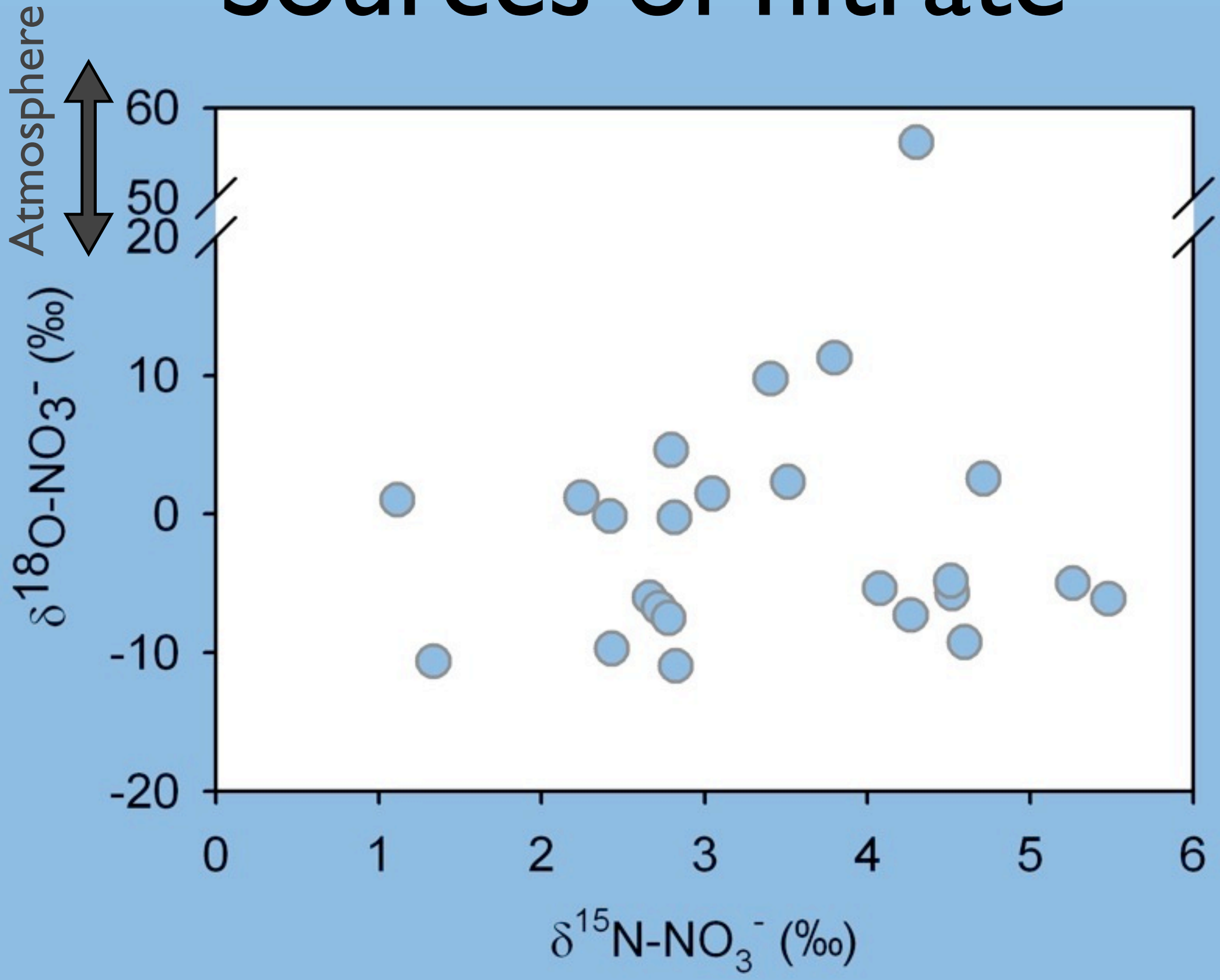

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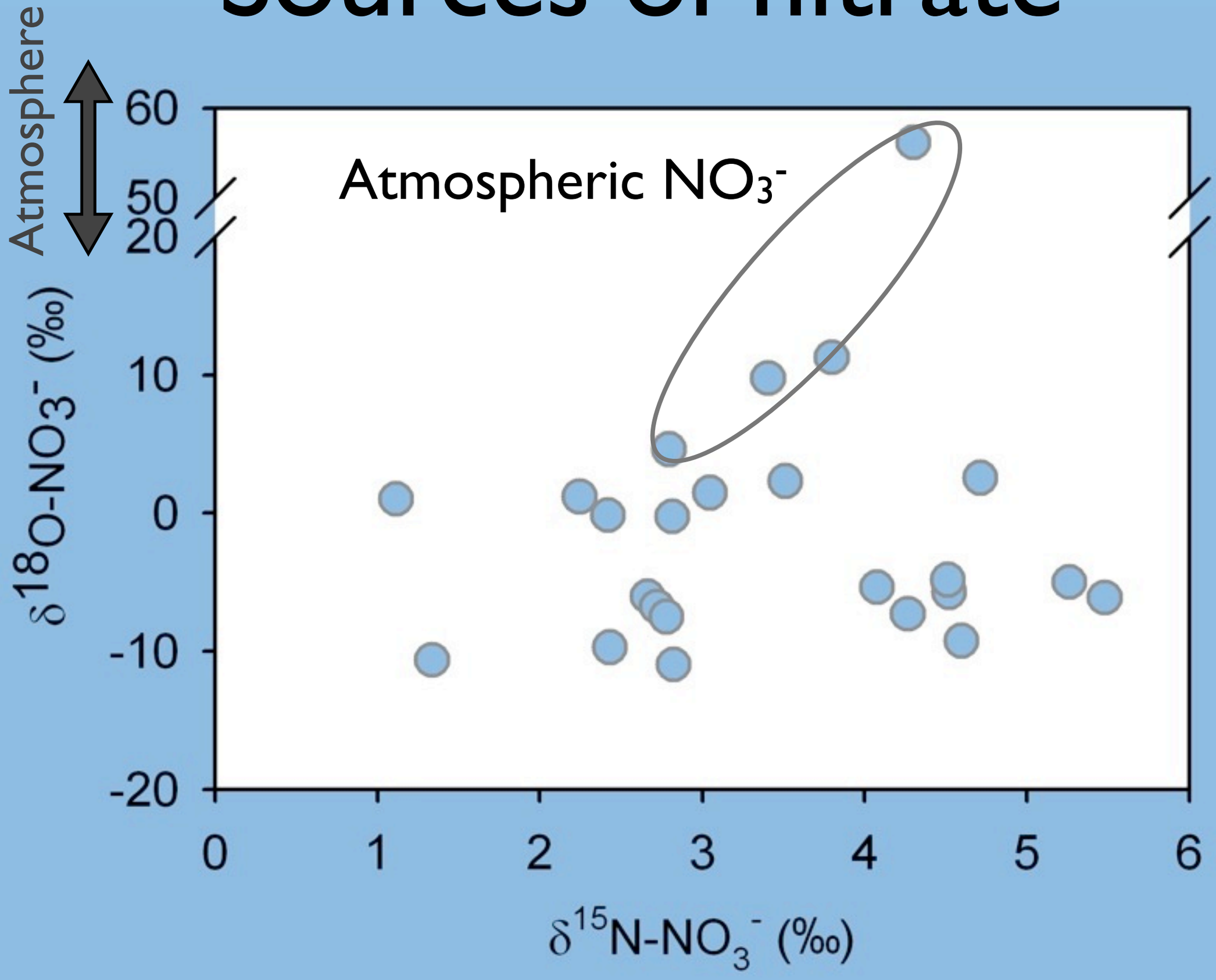

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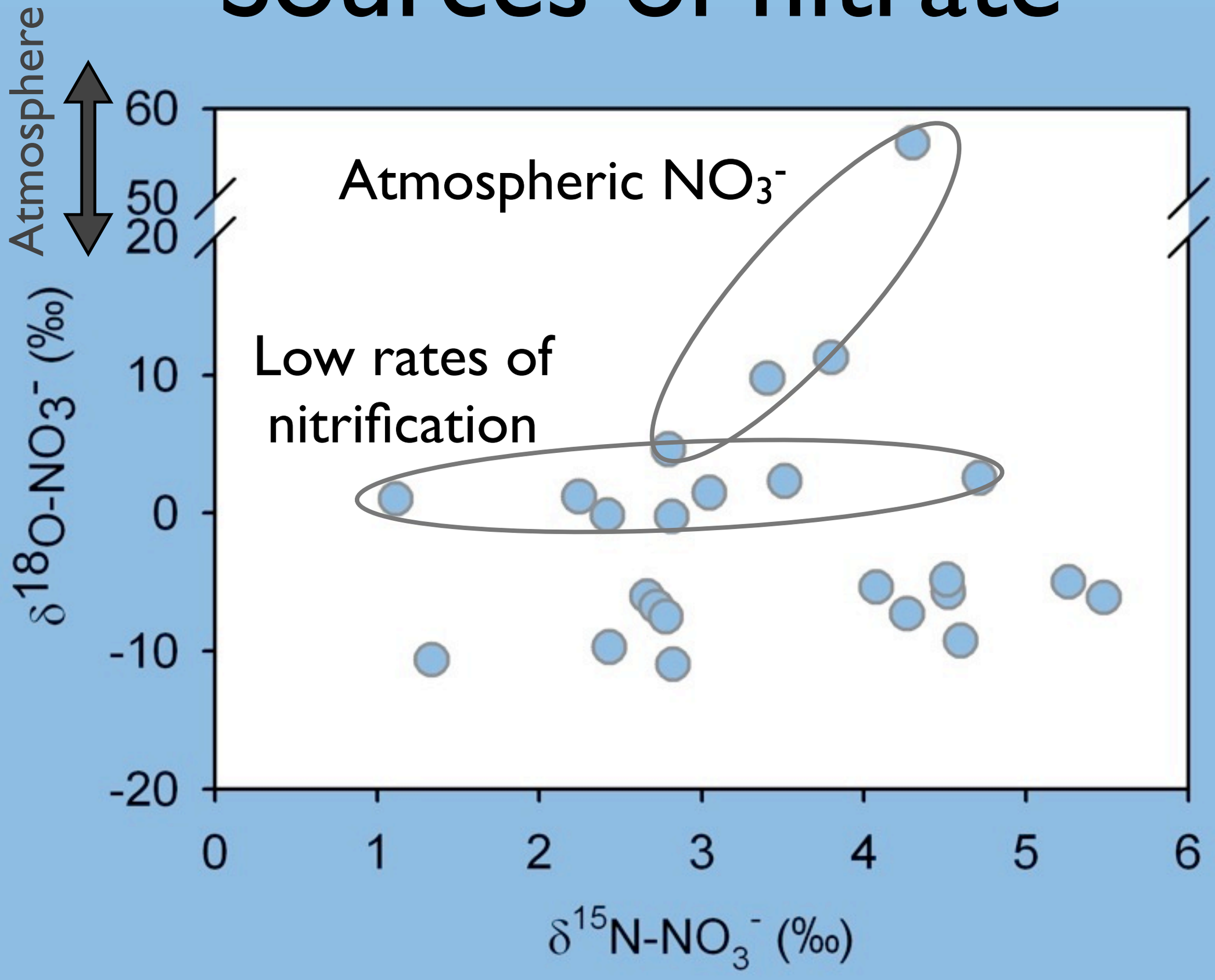

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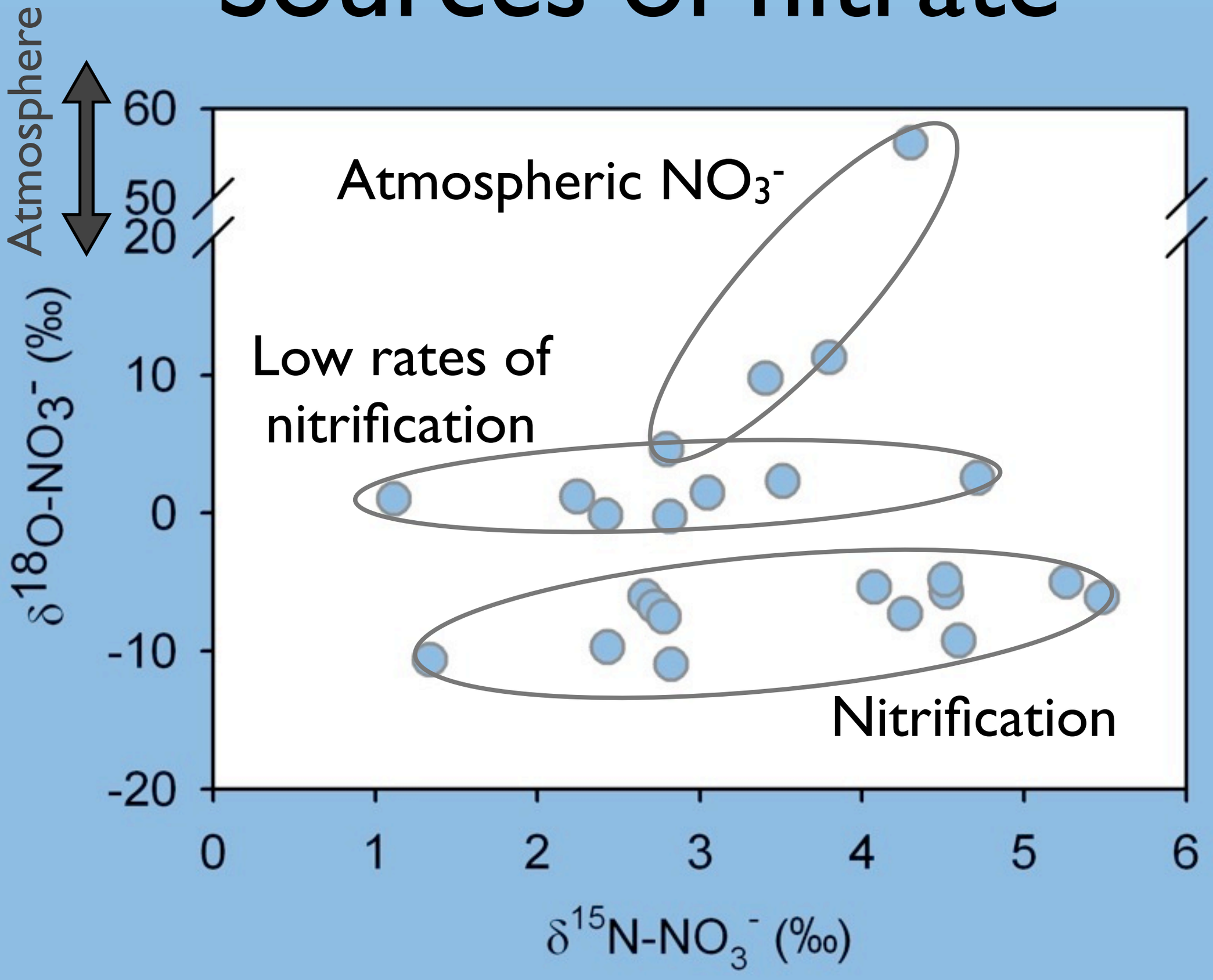

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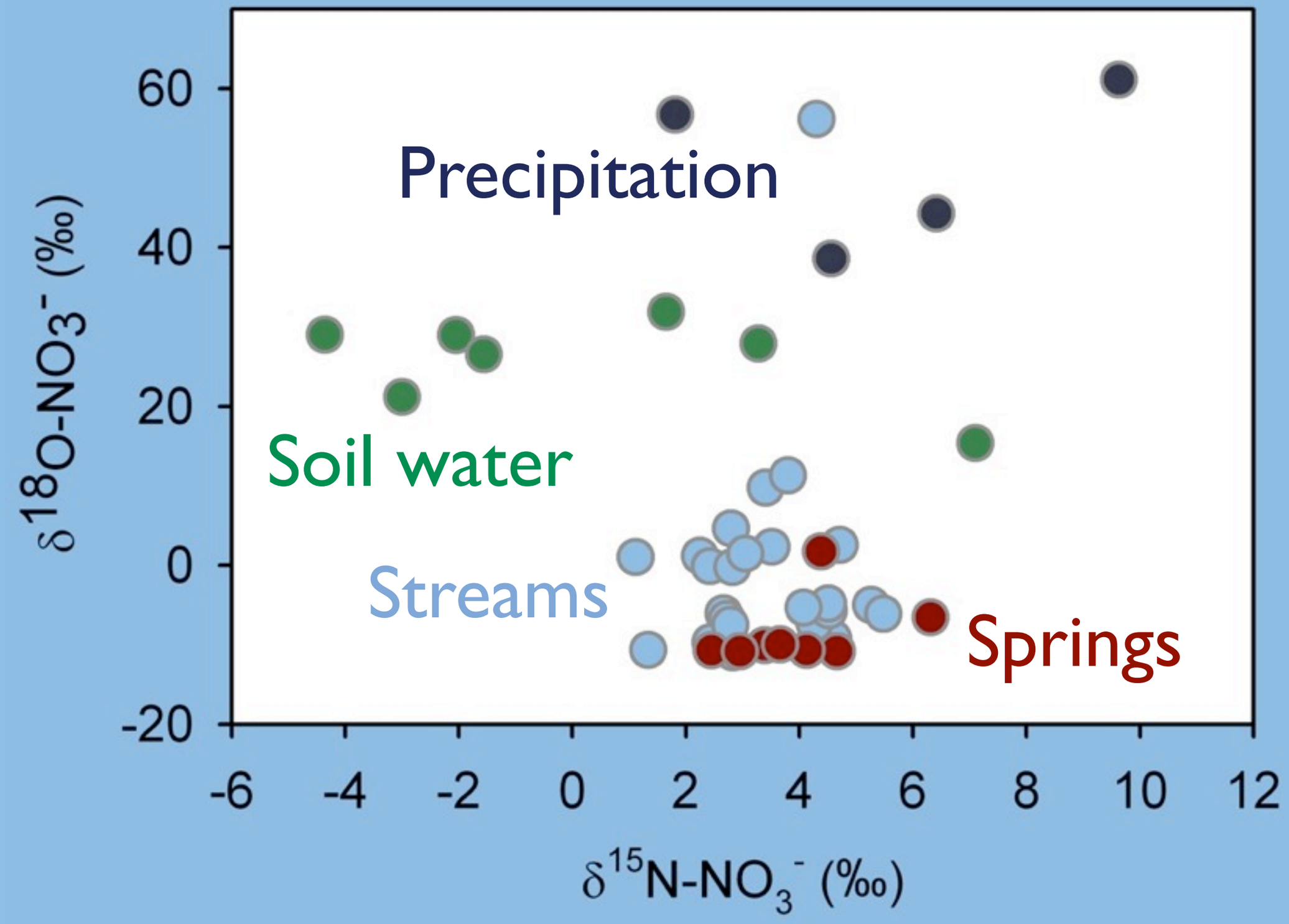

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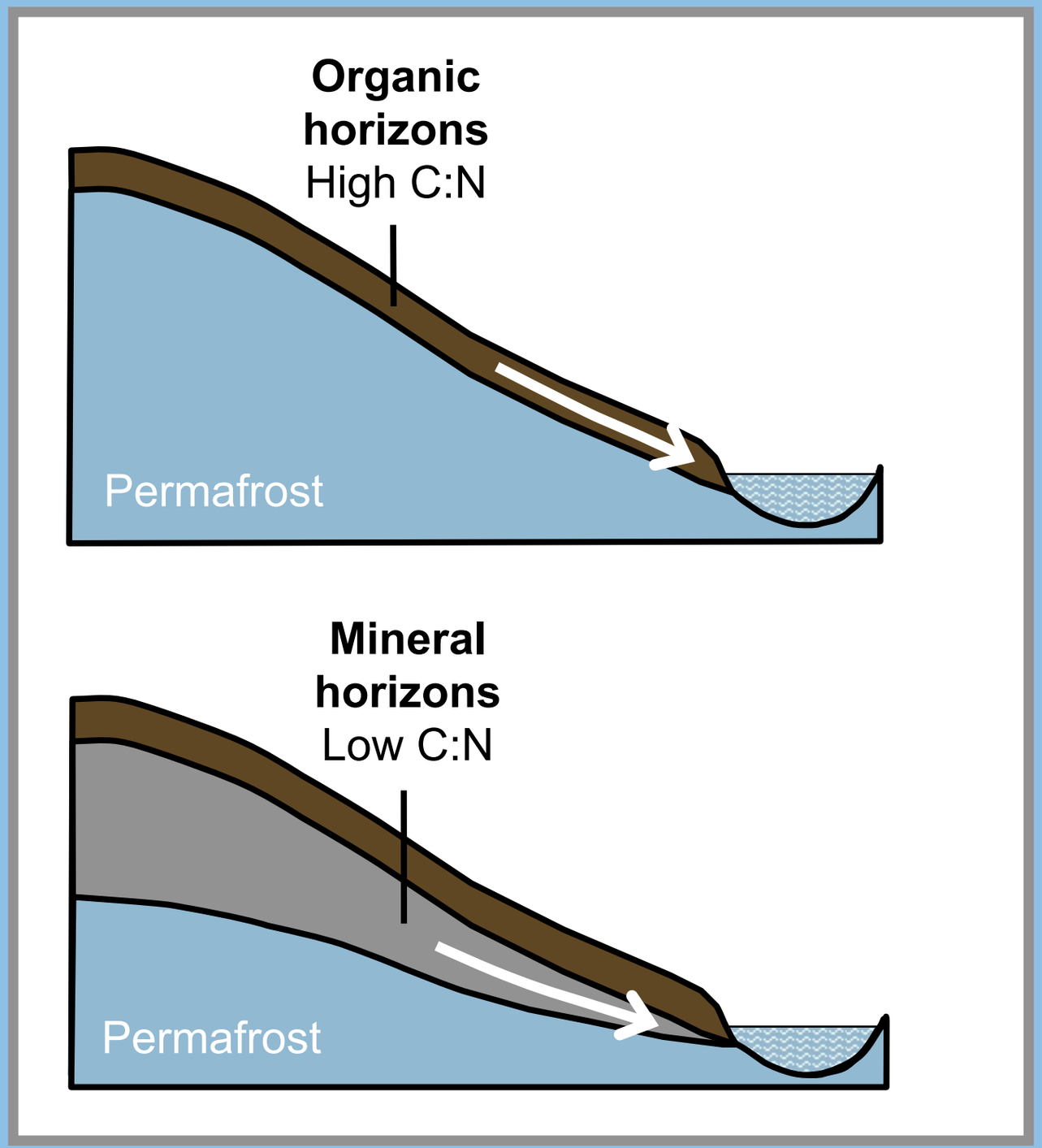

- Dominant biotic processes change with depth

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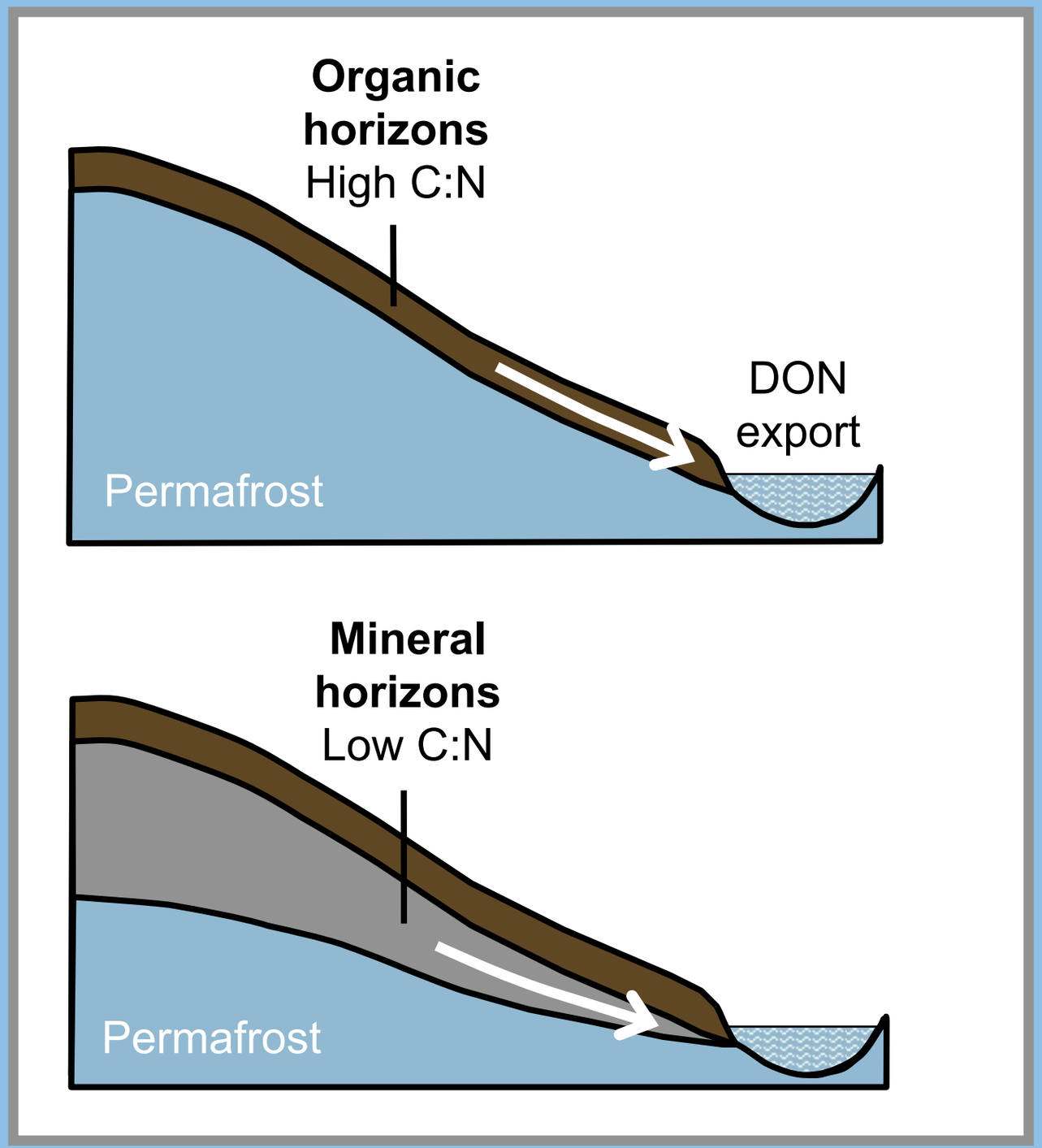

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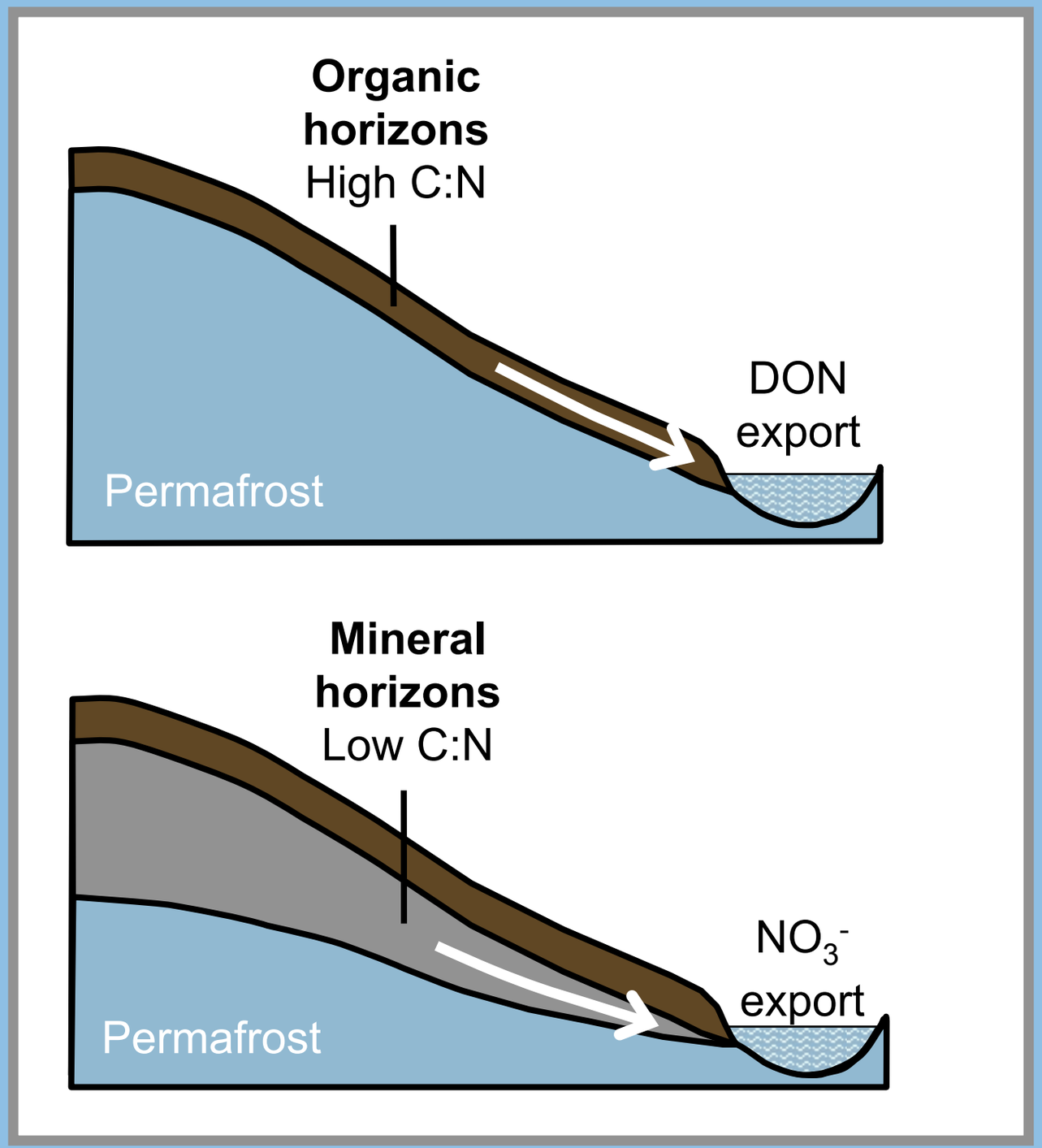

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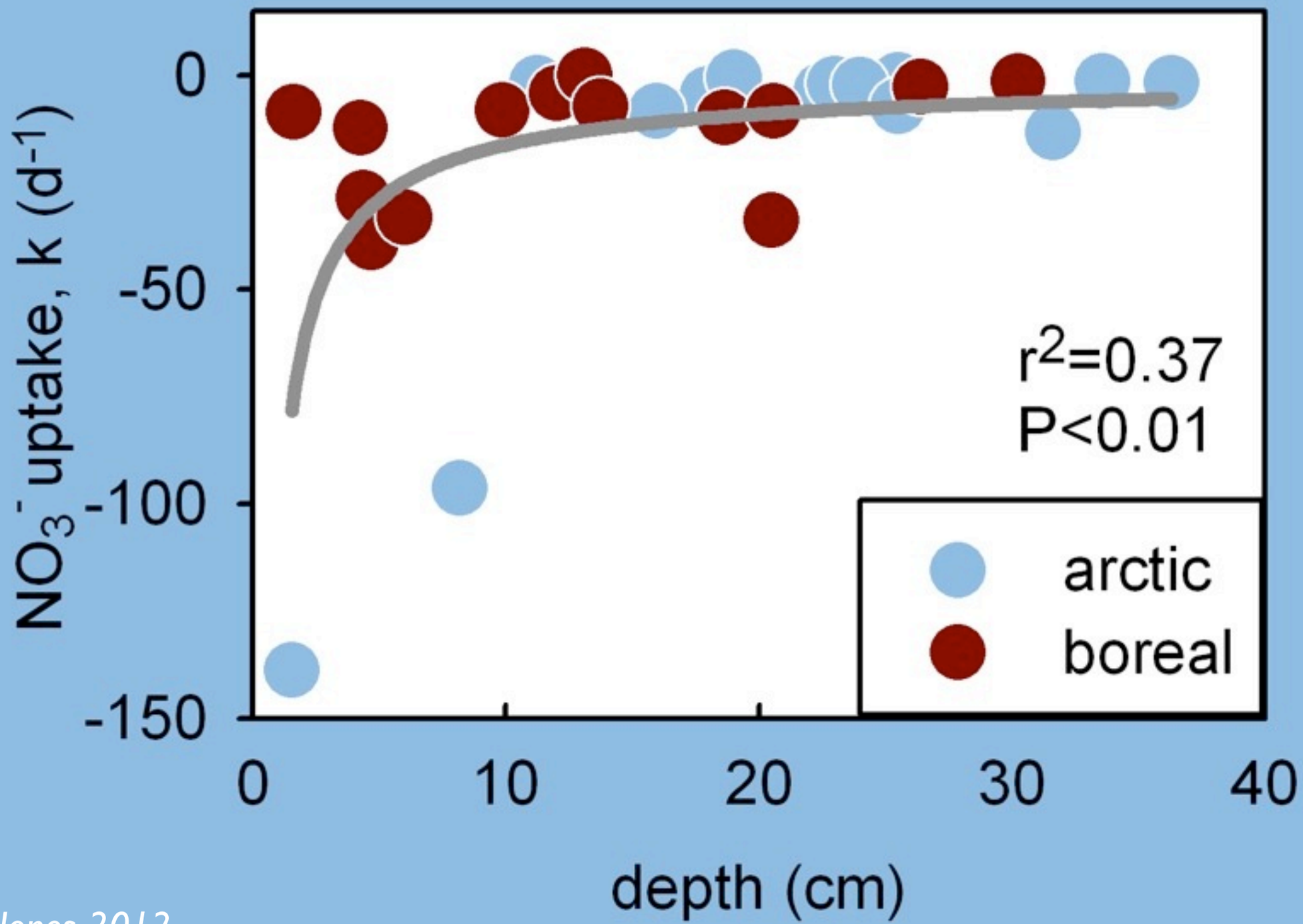
Depth of thaw

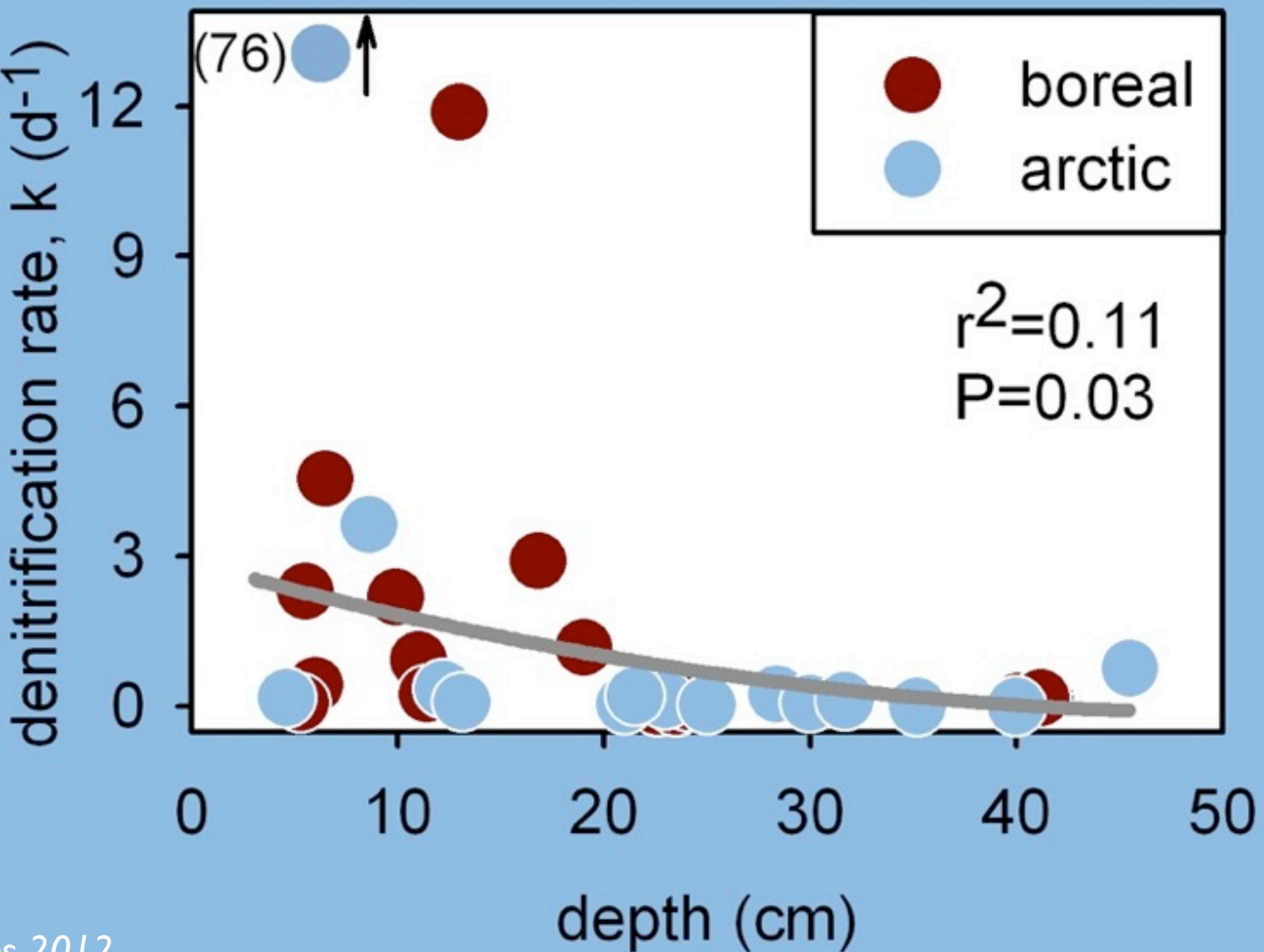
Net NO_3^- uptake: 0–4131 µg N m^{-2} d^{-1}



Harms & Jones 2012

Depth of thaw

Denitrification: 0–13 μg N m^{-2} d^{-1}



Harms & Jones 2012

Nitrate uptake in high-latitude N cycle

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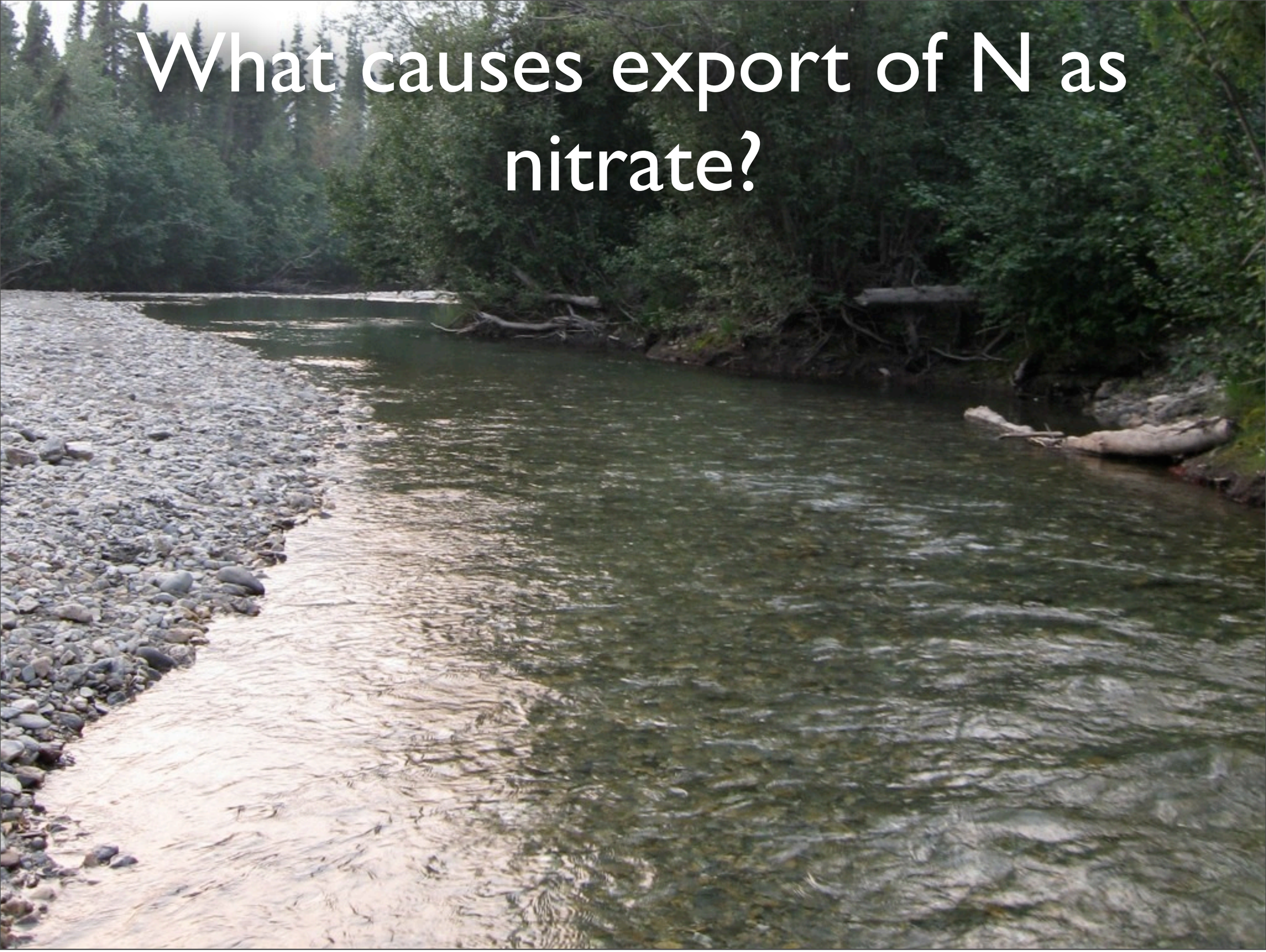
NO_3^- Uptake Velocity (mm d^{-1}):
Valley bottom = 10-20*Stream

What causes export of N as nitrate?



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- Retention of inorganic N occurs in shallow organic soils (thaw <20 cm)
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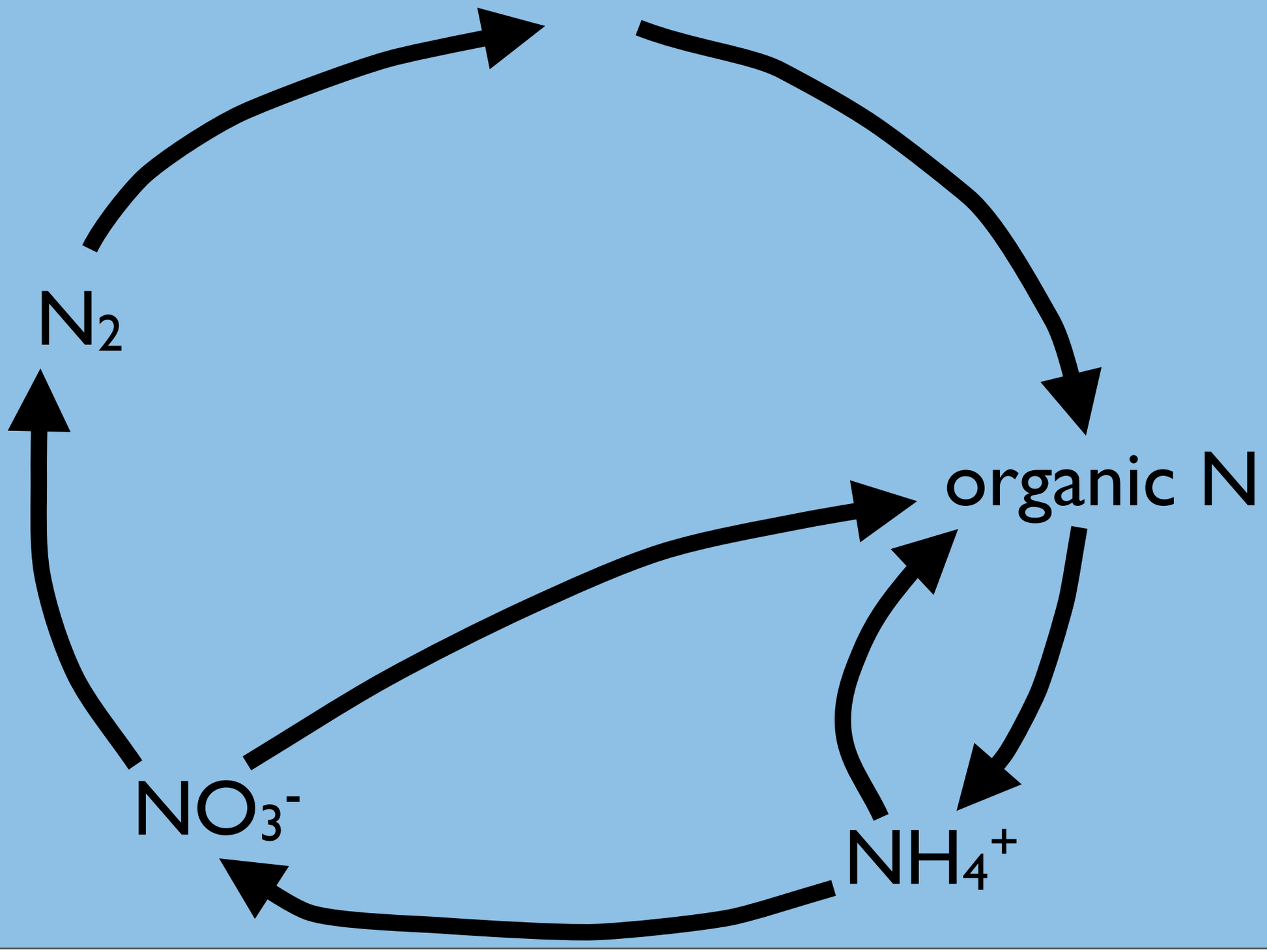
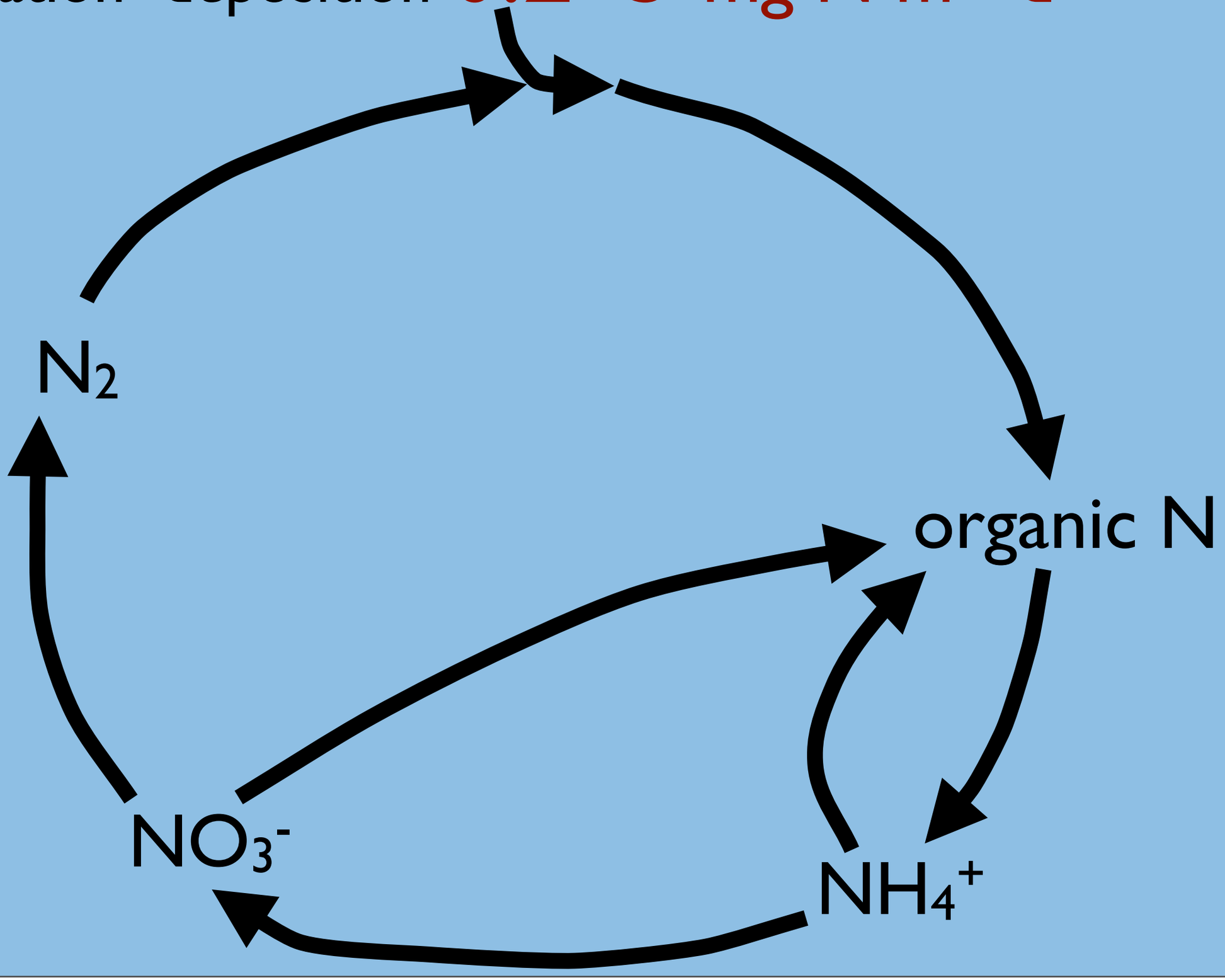
- Declining retention of inorganic N with increased thaw depth
- Need for increased understanding of N cycling processes at depth
- Relationships among terrestrial N cycling and hydrologic flowpaths determine N export response to permafrost thaw

High-latitude N cycle



High-latitude N cycle

Fixation+deposition 0.2–5 mg N m^{-2} d^{-1}



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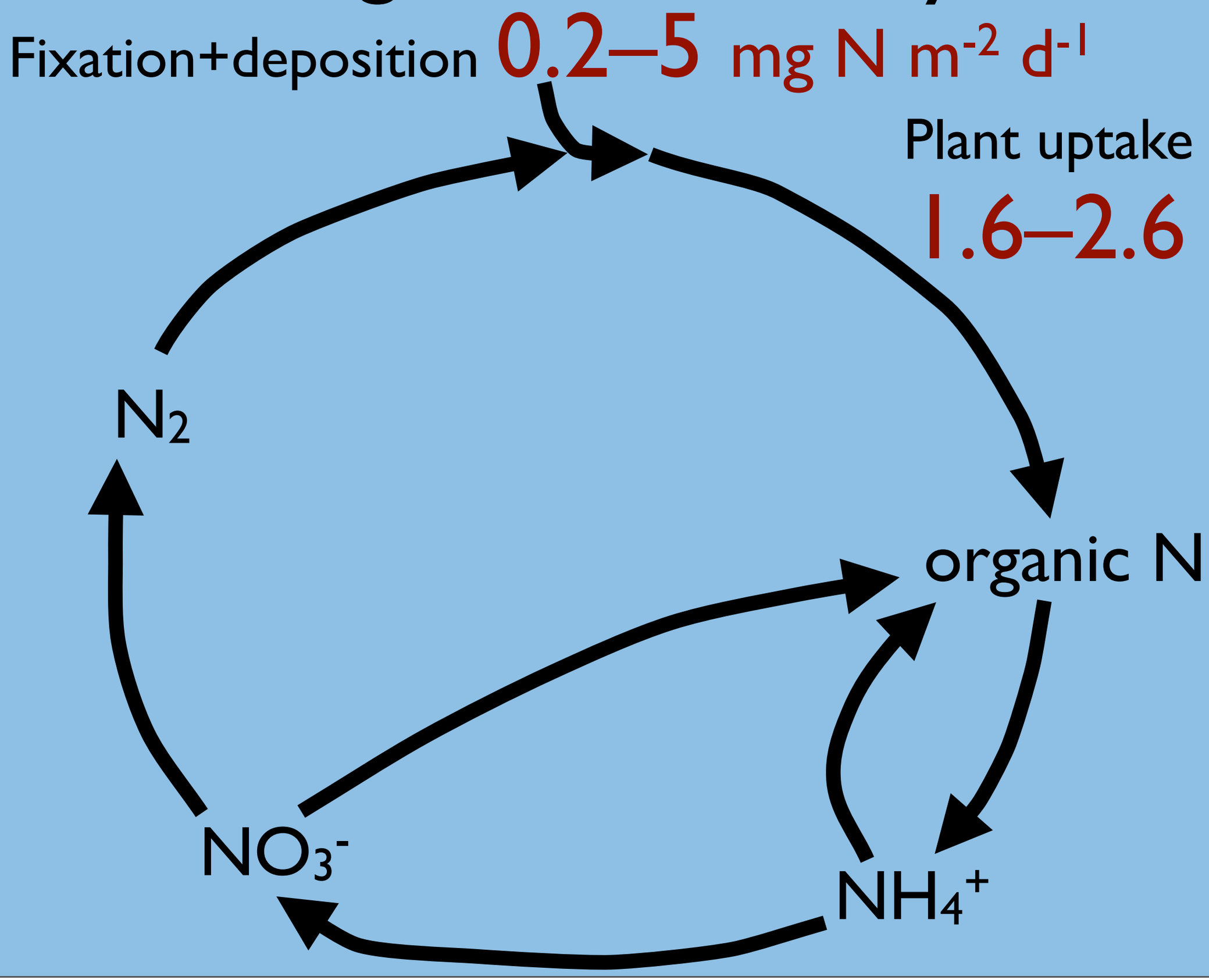

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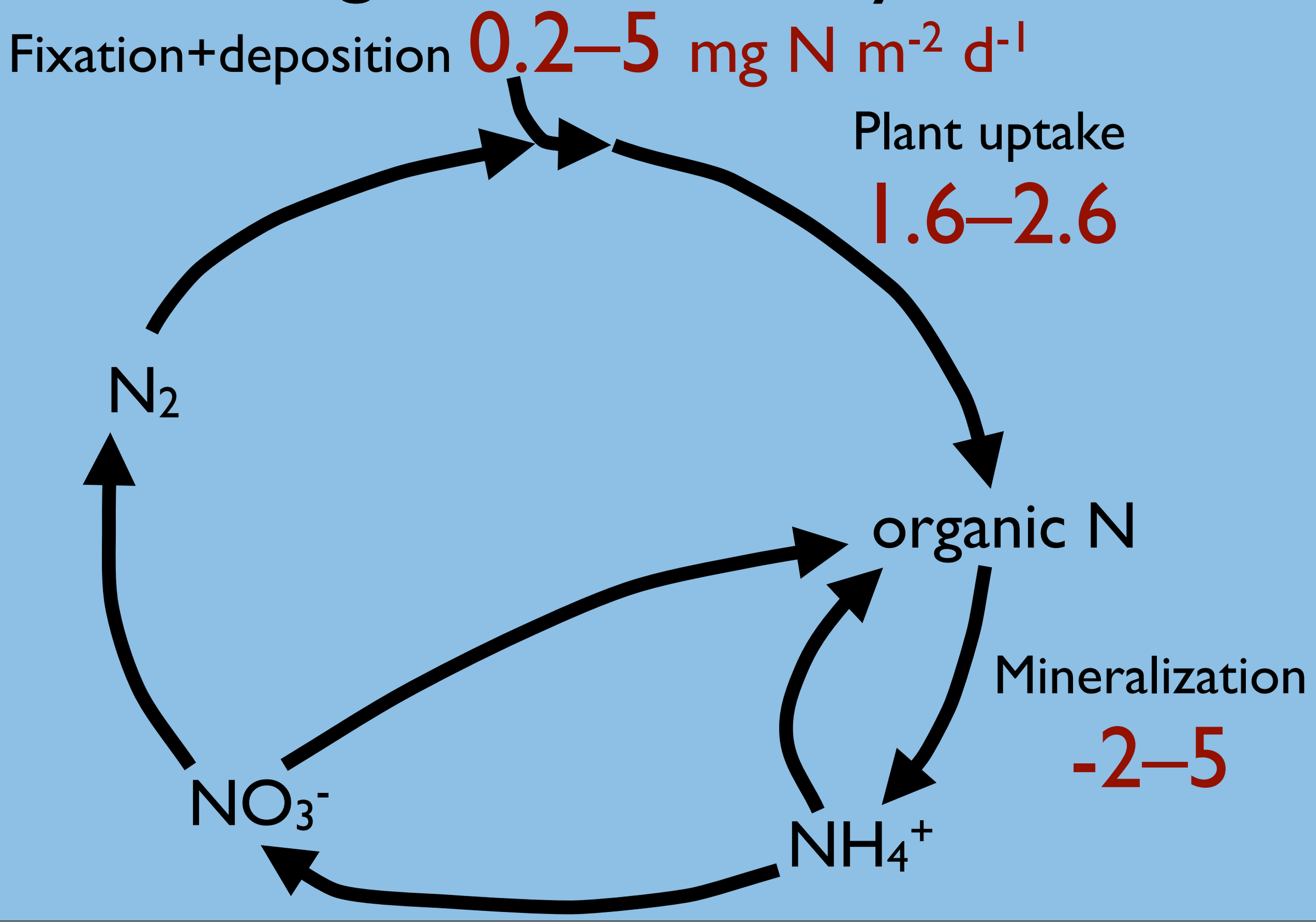

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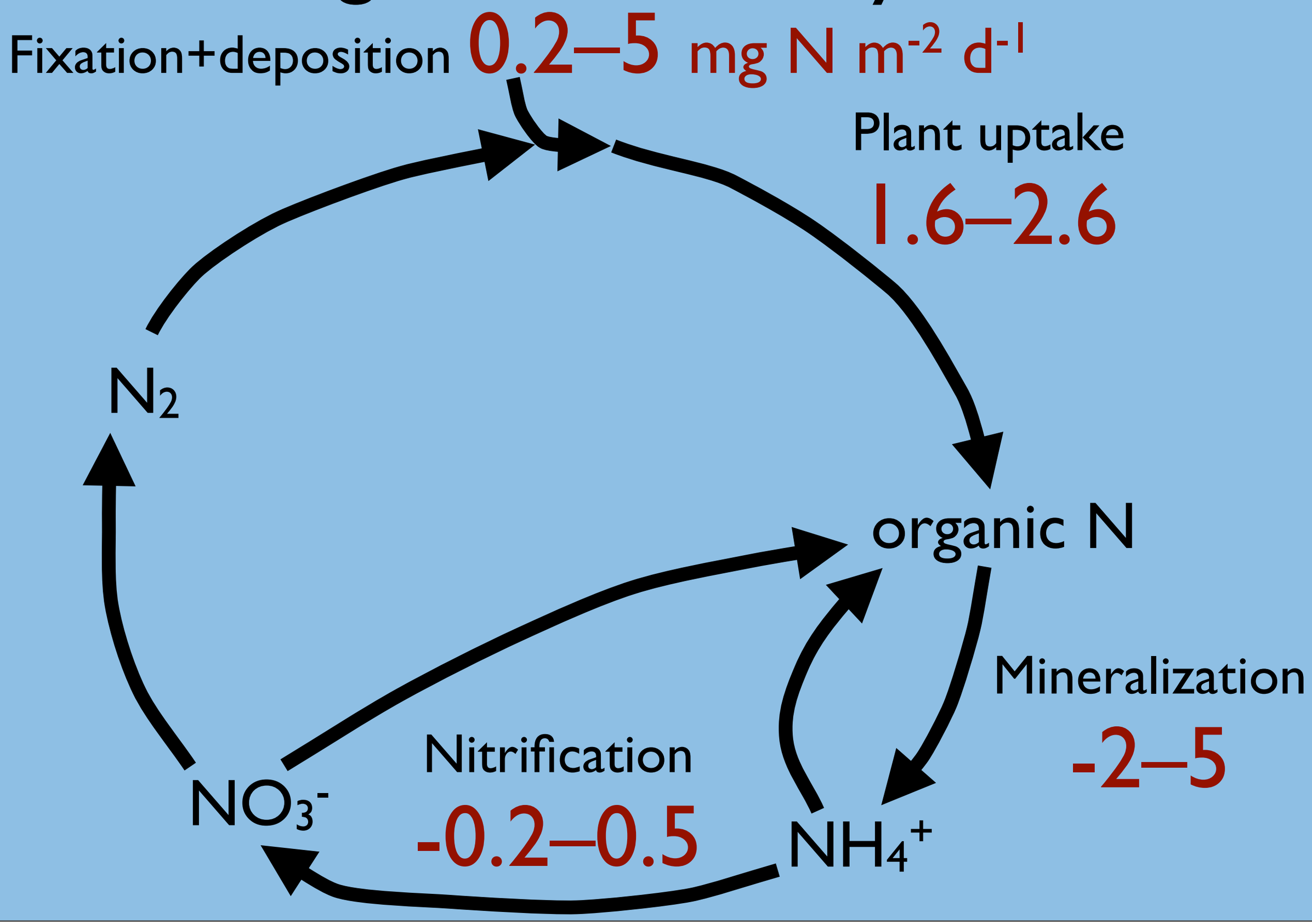

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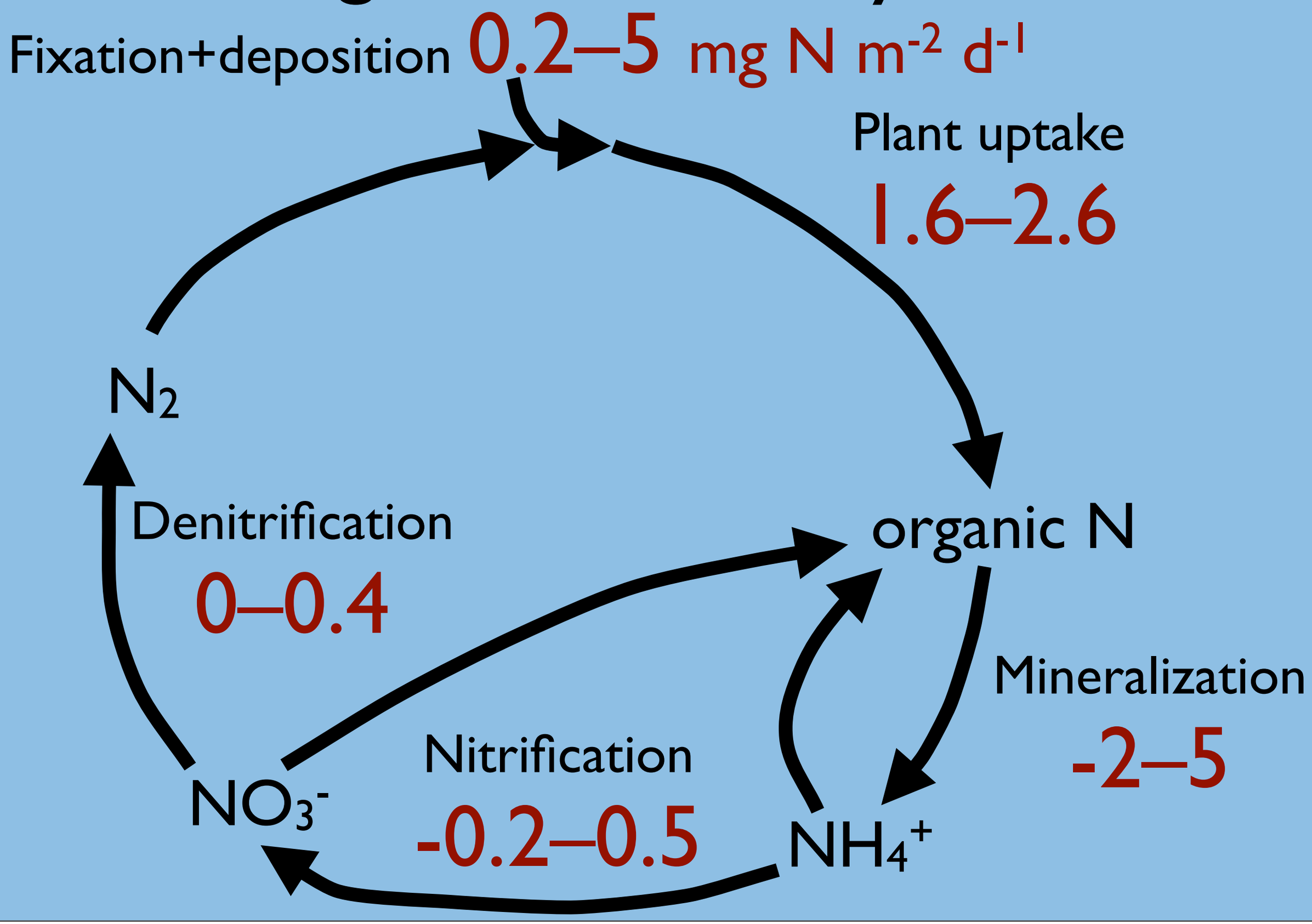

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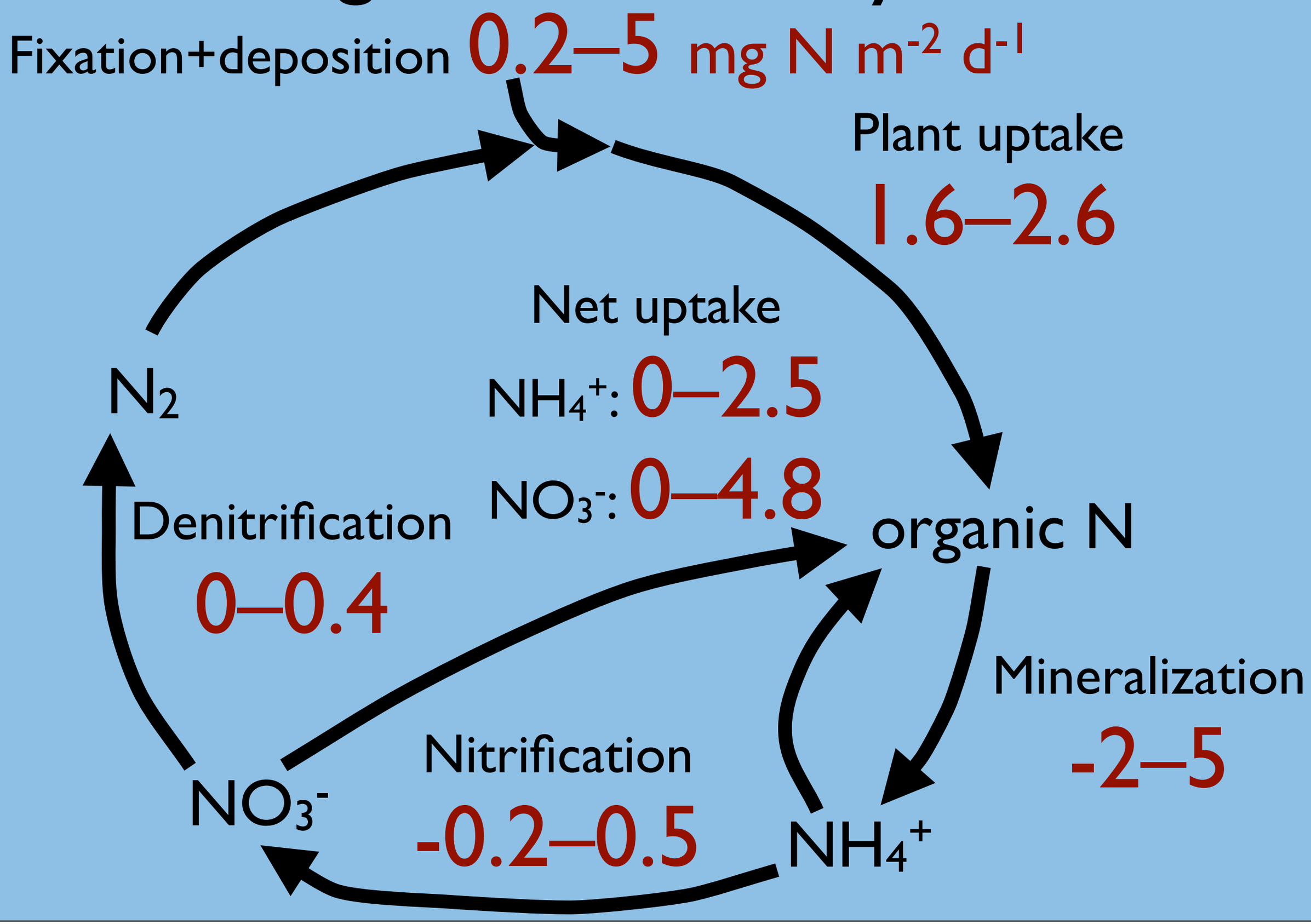

Thursday, February 14, 13

Reaction vs. transport

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Damköhler number=|k|*τ

Reaction time : Water residence time

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Reaction time : Water residence time

	Snowmelt	
	Arctic	Boreal
NH_4^+ uptake	2.4	3.3
NO_3^- uptake	1.3	0.7
denitrification	1.3	0

Reaction vs. transport

Damköhler number=|k|*τ

Reaction time : Water residence time

	Snowmelt		Autumn	
	Arctic	Boreal	Arctic	Boreal
NH_4^+ uptake	2.4	3.3	0.9	2.3
NO_3^- uptake	1.3	0.7	0.4	0.2
denitrification	1.3	0	0.4	0