Managing nitrogen legacies to accelerate water quality improvement

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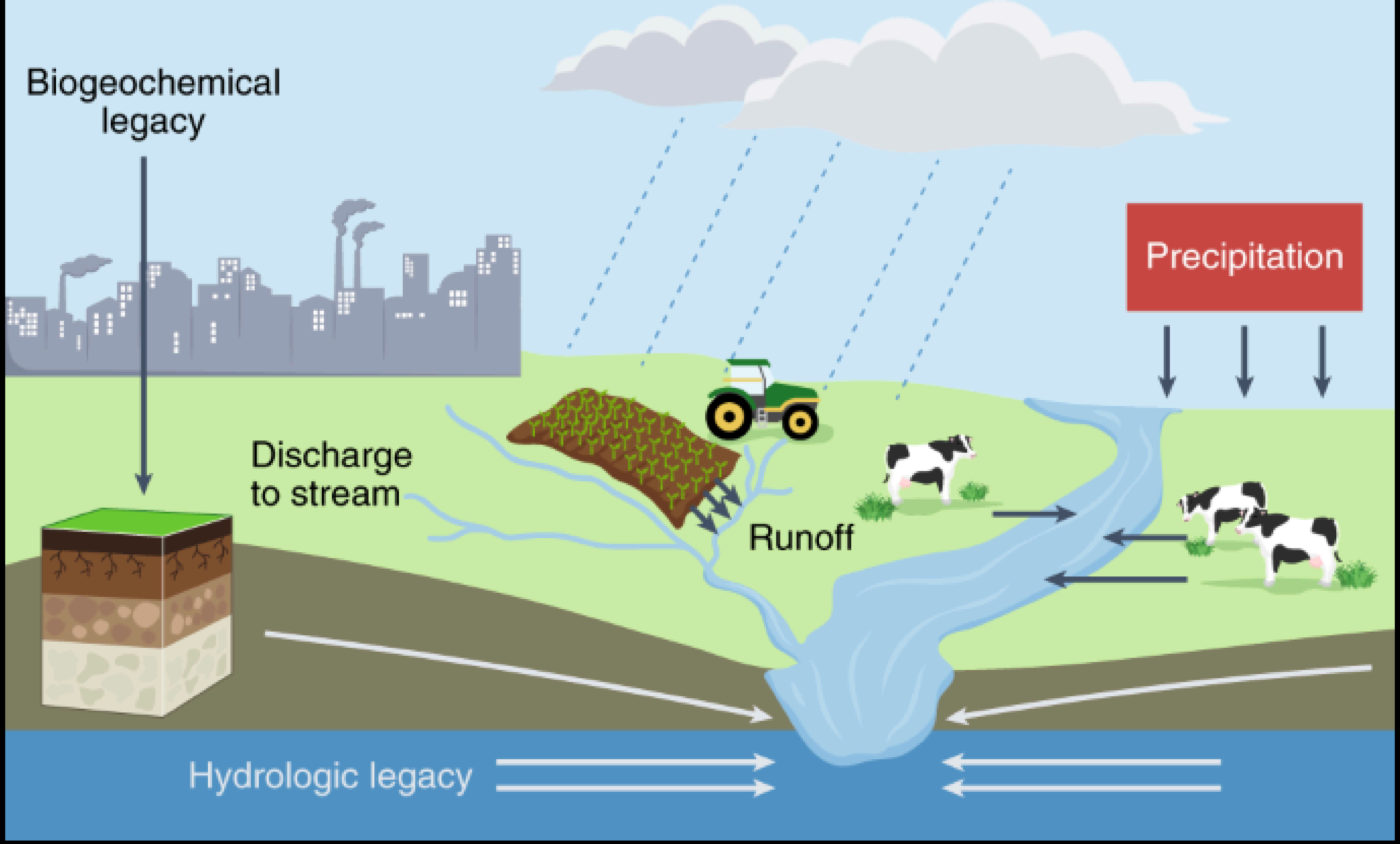
DROP Clarisse
VAES Daïna

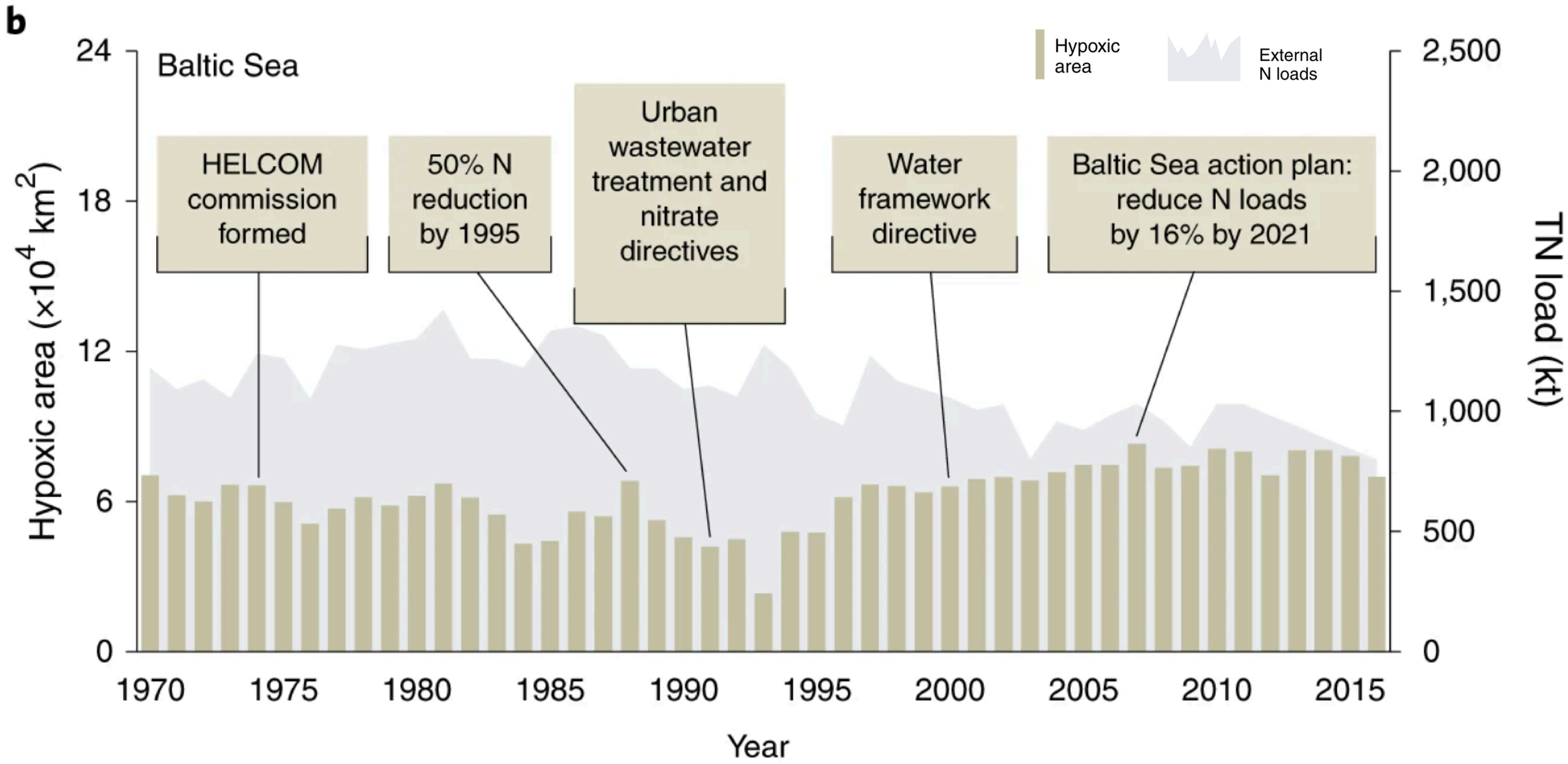
Nitrogen accumulation over decades

Legacy : Long term impact to the environment



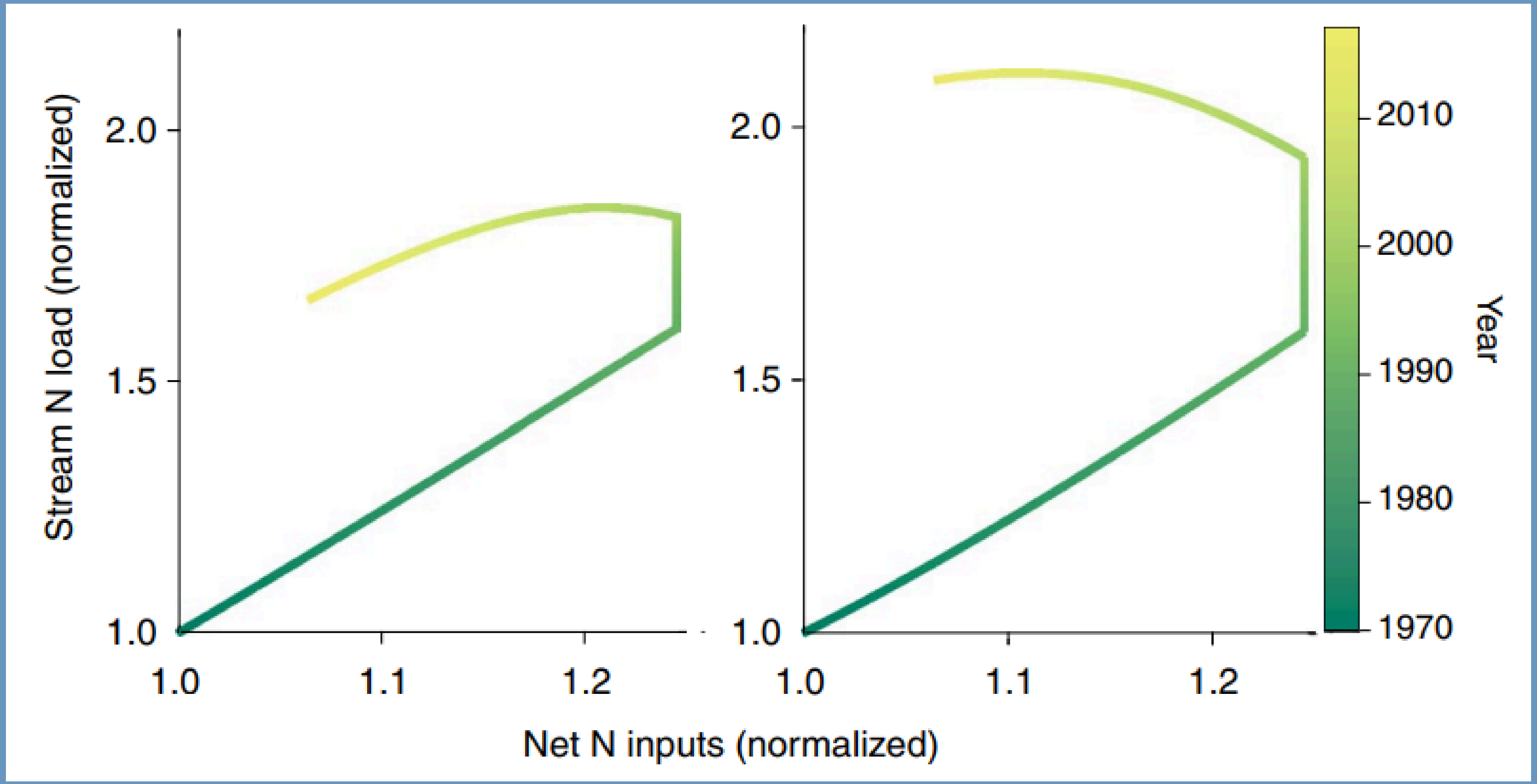
- Eutrophication
- Aquatic toxicity
- Drinking-water contamination

Lack of response to policy interventions



Relationships between watershed N inputs and stream N loads

Traditionnal view :



Mean groundwater travel time of 3 years

Mean groundwater travel time of 30 years

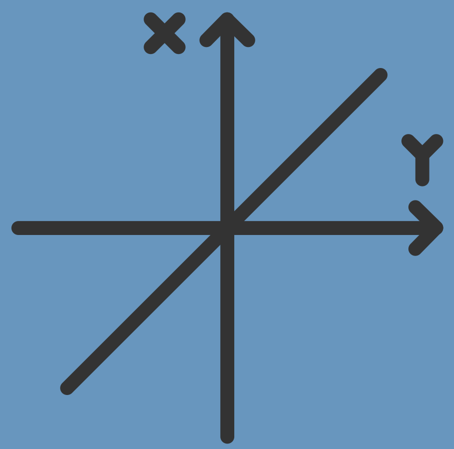
Lag times increase with the increase in groundwater travel times

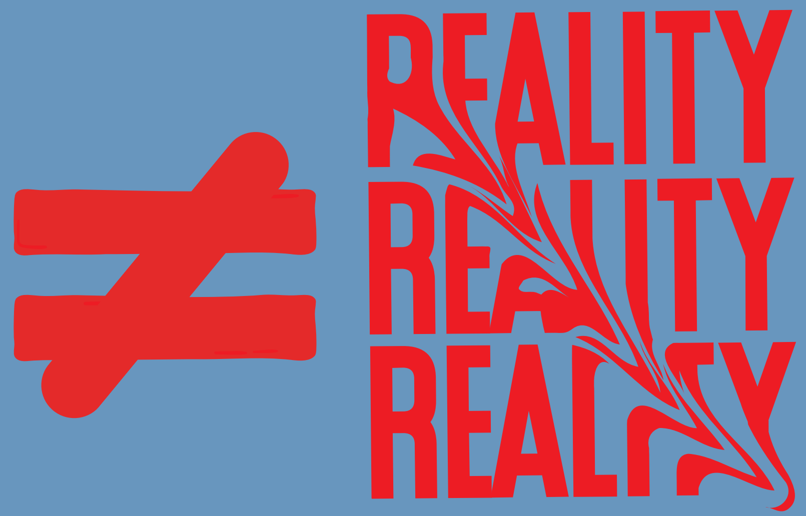
Assume linear relationship

Reducing N inputs

=

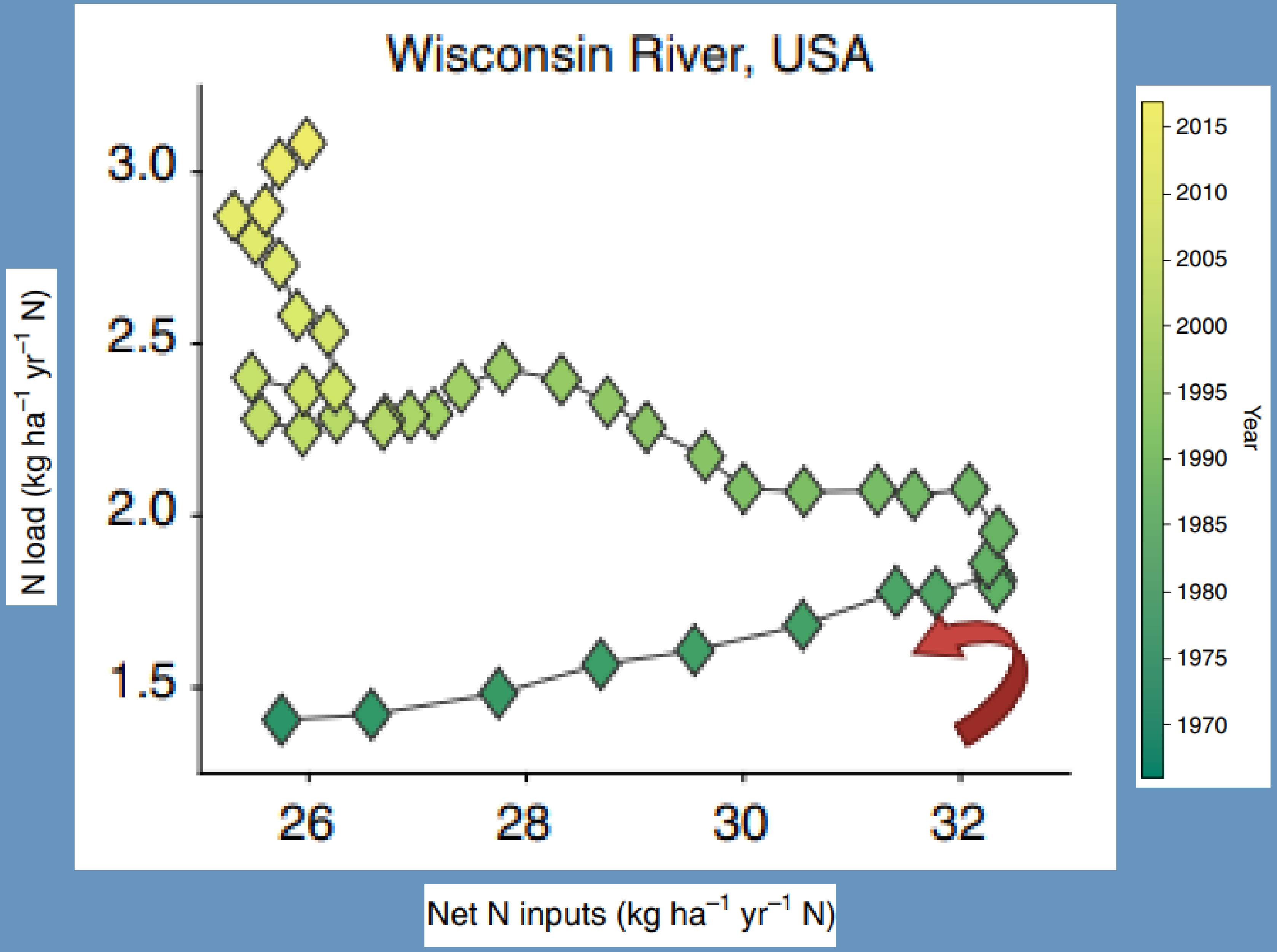
Proportional decrease in stream N load





Relationships between watershed N inputs and stream N loads

Observed Reality :



NONLINEAR RESPONSE

due to legacy nitrogen stored in soils, groundwater, and sediments.

Hysteresis Effect : "delayed response" or "memory effect" in a system.

Stream N loads depend on current and past inputs, causing delays in recovery.

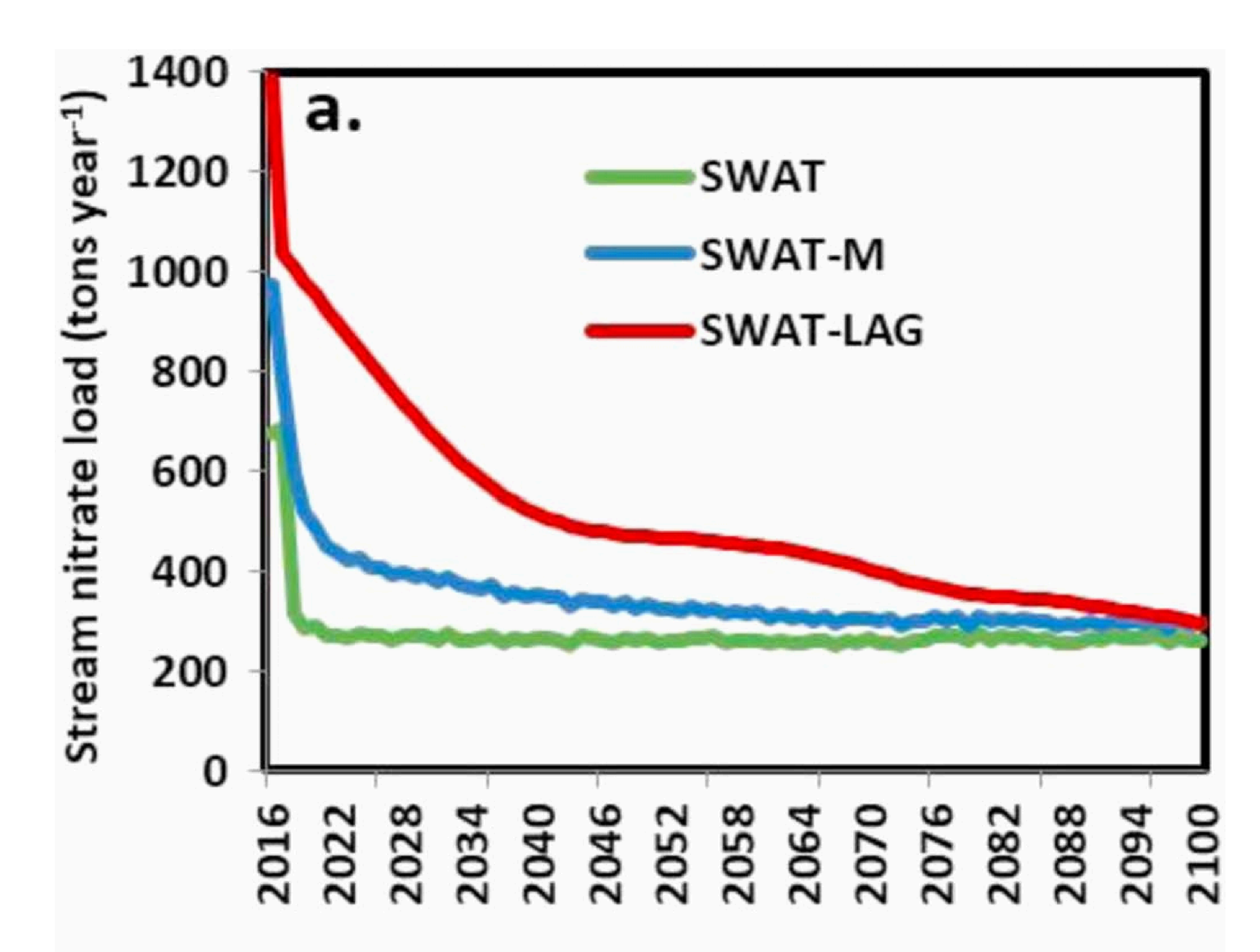
Predicting lag times

Models to predict transportation + nutrient fate: SPARROW, GlobalNEWS, SWAT

They ignore historical inputs and thus accumulation and depletion

SWAT-LAG considers the nutrient buildup in groundwater reservoirs

SWAT = Soil Water Assessment Tool



PROPOSED SOLUTIONS

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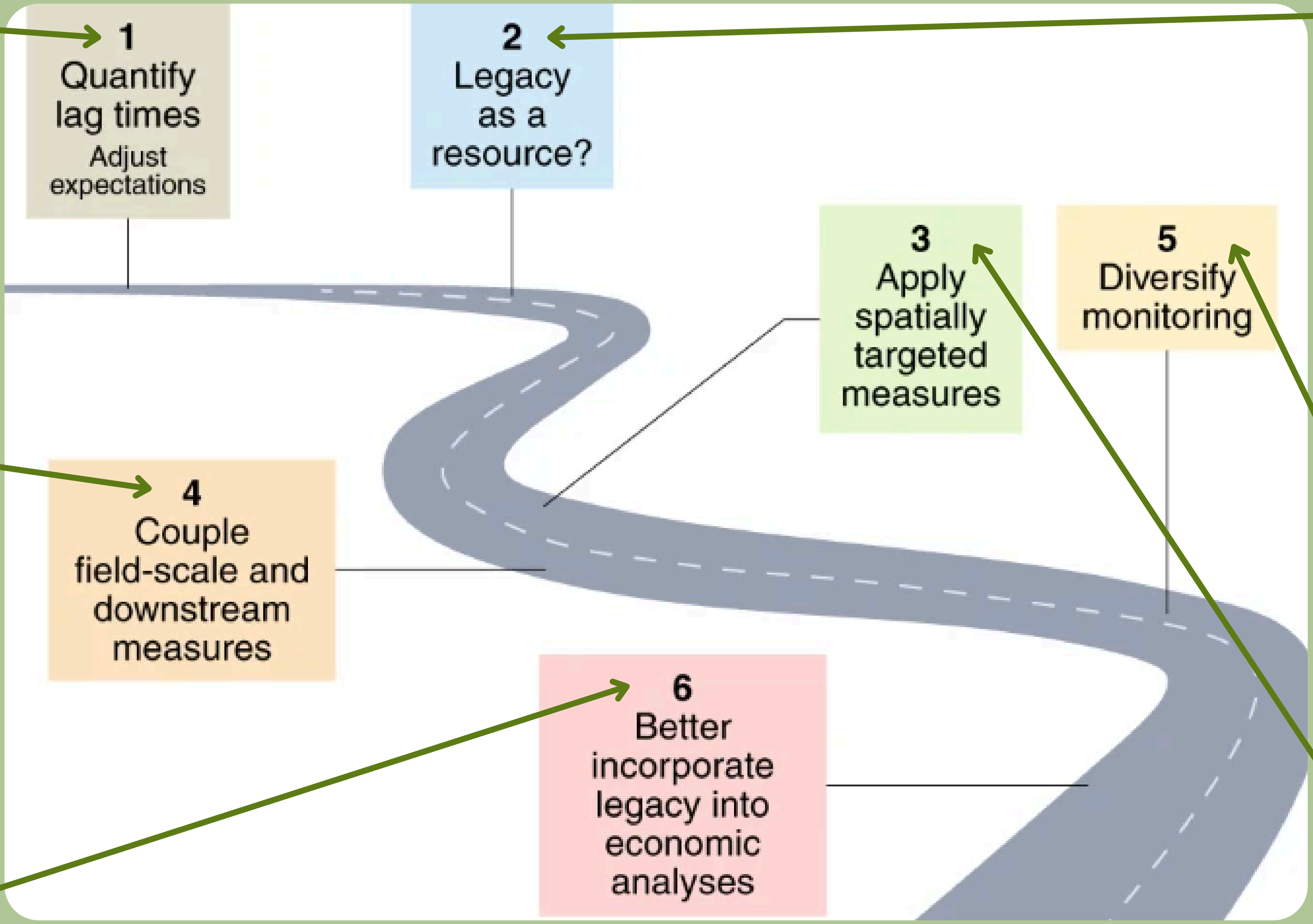
1
Use field data and models to estimate recovery timelines.

2
Optimize fertilizer use to draw down stored nitrogen.

4
Integrate soil-based practices (e.g., crop rotation) with downstream interventions (e.g., wetlands).

5
Measure nitrogen in soils, groundwater, and gases to capture progress.



6
Incorporate long-term benefits of addressing nitrogen legacies into cost-benefit analyses.

3
Focus on areas with high legacy nitrogen for maximum impact.

Strategies to target nitrogen legacies and accelerate water quality improvements

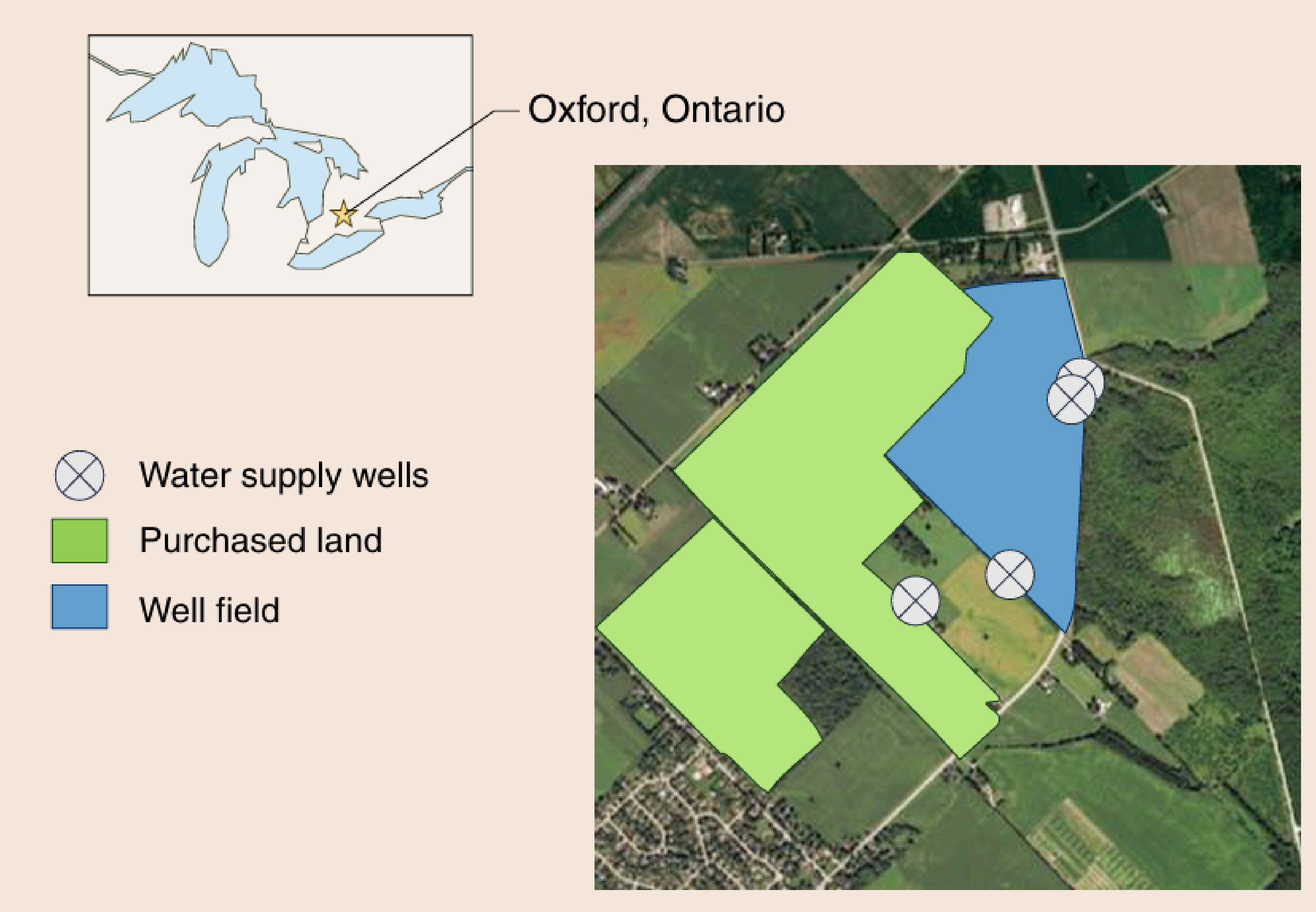
A success story

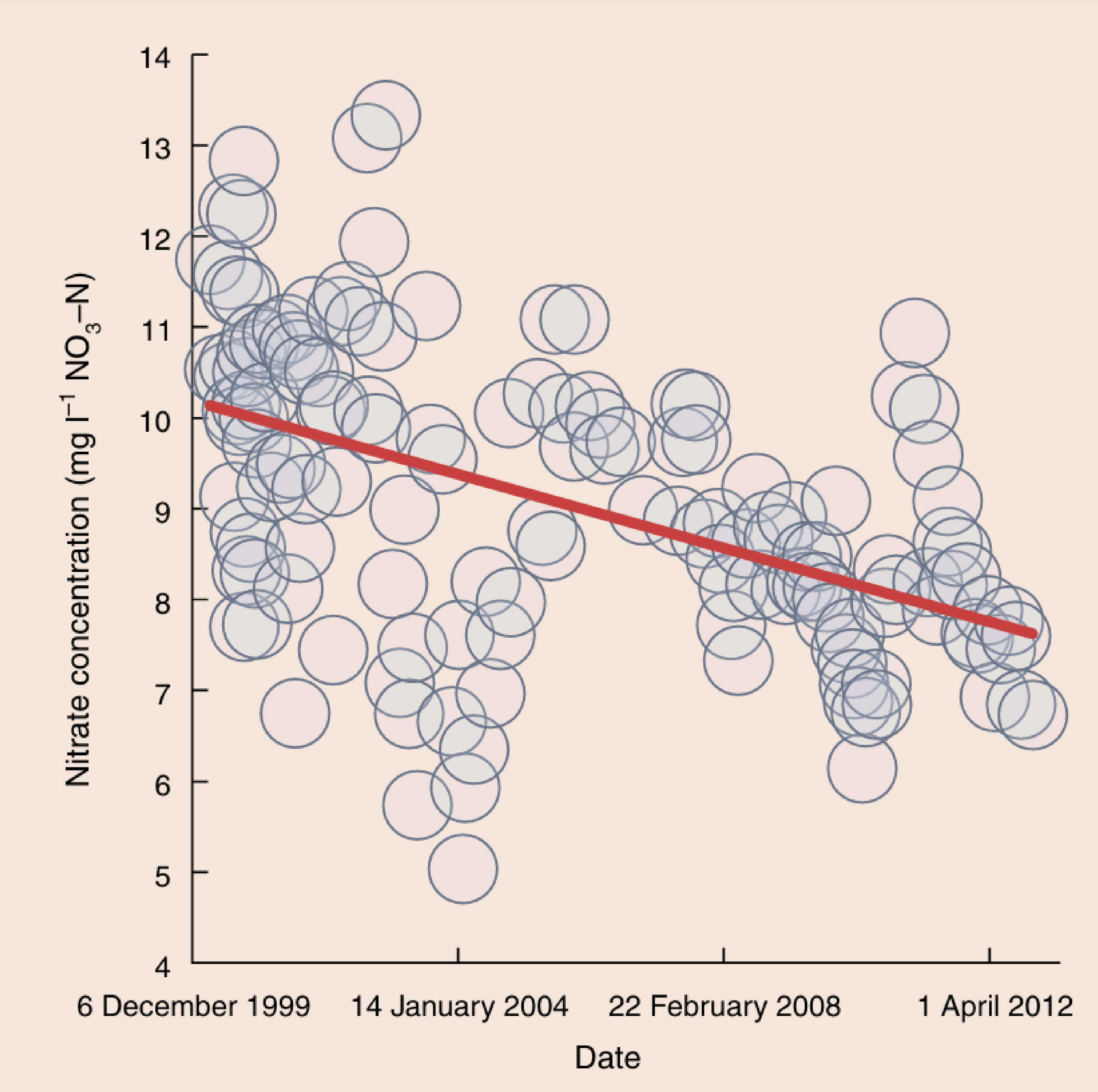
Tackle increasing nitrate concentrations (max 10 mg/L) in Ontario

Install treatment plant

Improve groundwater quality

Strict guidelines on cropping system and fertiliser use

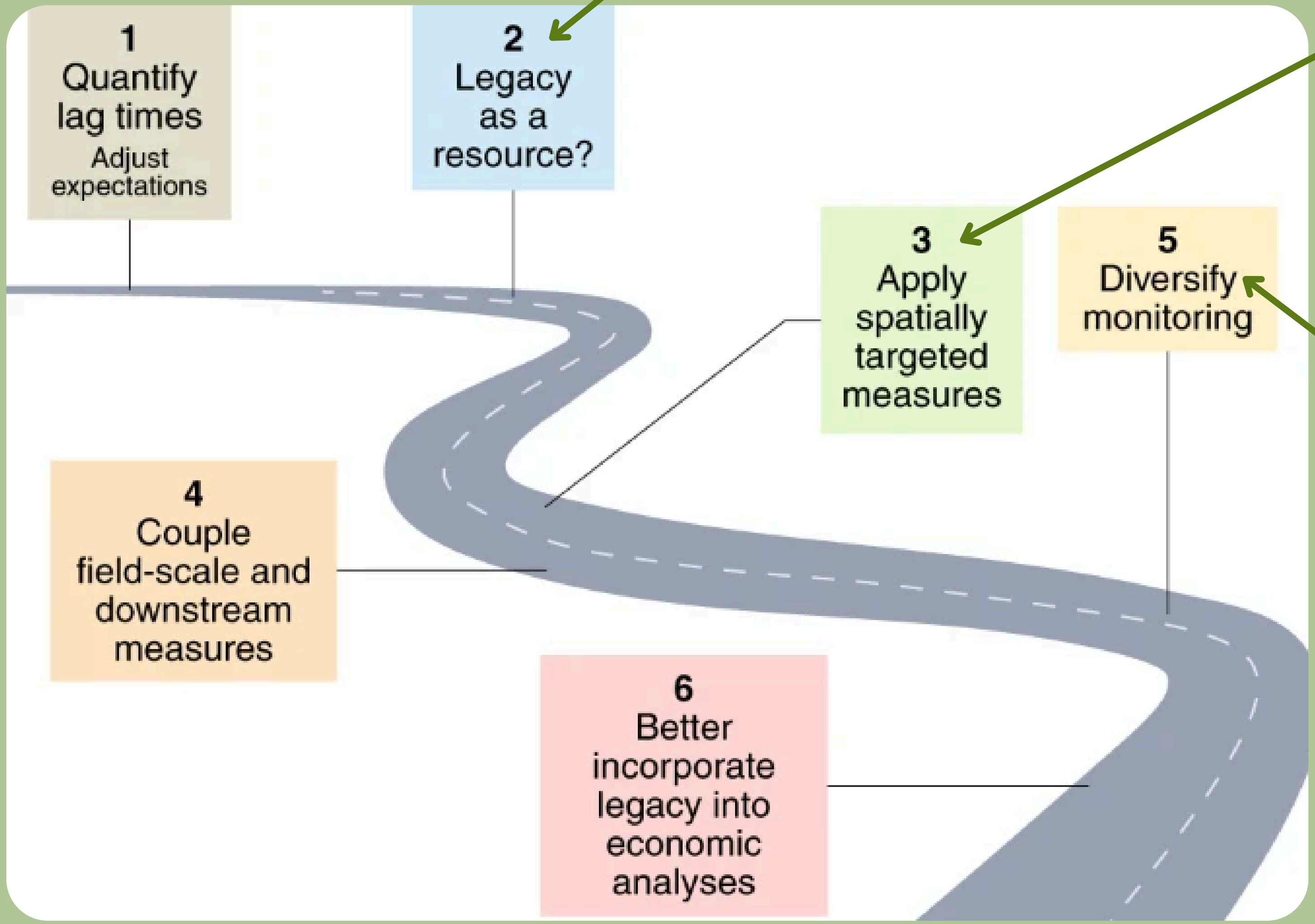




A success story

No decrease in crop yield with less fertilisers

Limit fertiliser utilisation



Take data from the shallow vadose zone

50% decrease in fertiliser N inputs

- 60% reduction in stored nitrate under root zone
- 50% reduction of porewater [nitrate]

IN 2 YEARS !

[Nitrate] in groundwater wells reduced of 30% in 10 YEARS

Discussion :

Nitrogen Legacies: Affects water quality for decades (hysteresis effect).

Challenges: Nonlinear relationship between nitrogen inputs and stream loads.

Strategies: Improve fertilizer use, combine solutions, measure legacies.

Takeaways: Long recovery time, more research needed.

Conclusion: Roadmap to address nitrogen pollution and improve water quality.

QUESTIONS ?