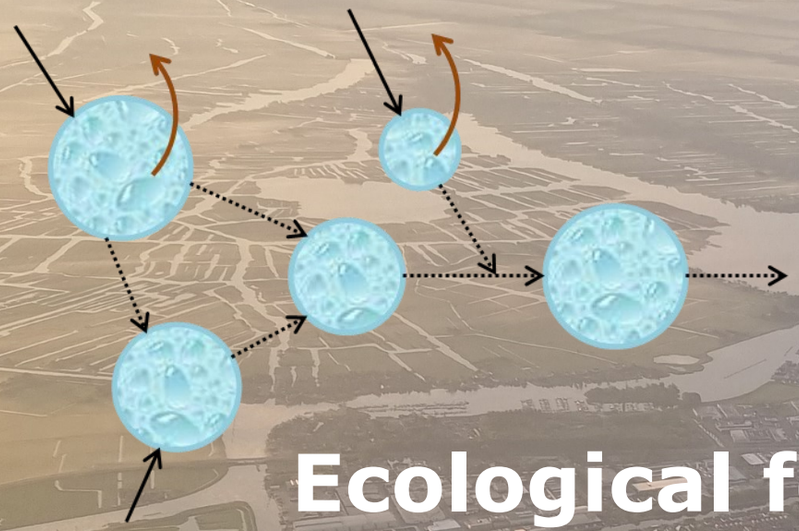


Ecological feedbacks in lakes and their importance for water quality

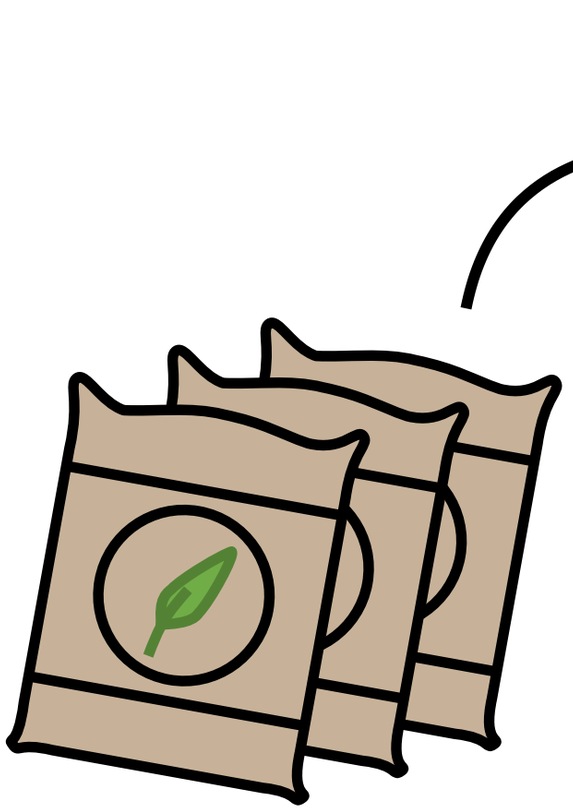
Dianneke van Wijk | 8 October 2024

WAGENINGEN
UNIVERSITY & RESEARCH

NIOO
NETHERLANDS
INSTITUTE
OF ECOLOGY
(NIOO-KNAW)

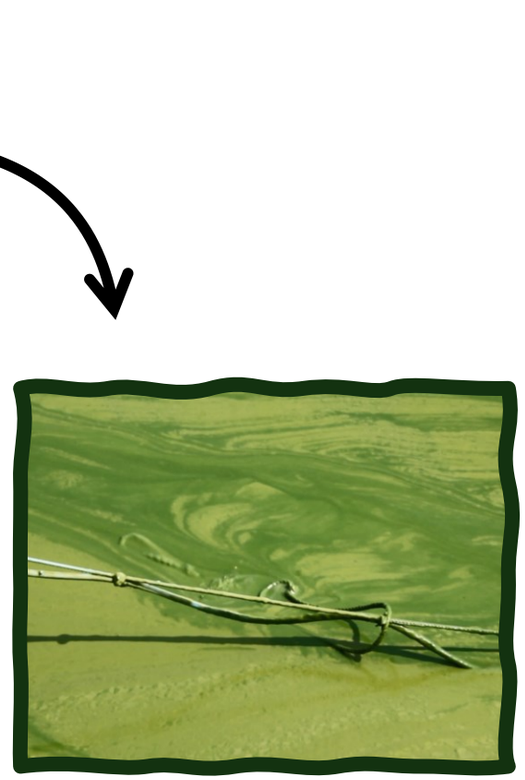
Picture by Annette B.G. Janssen

Nutrients: a dual problem…



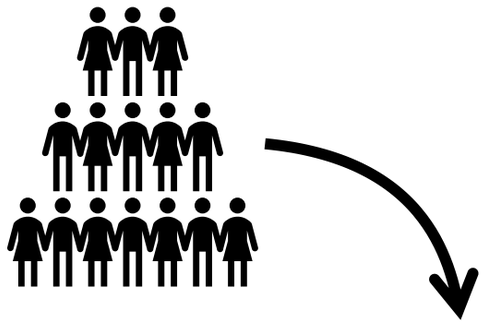
Resource scarcity

?



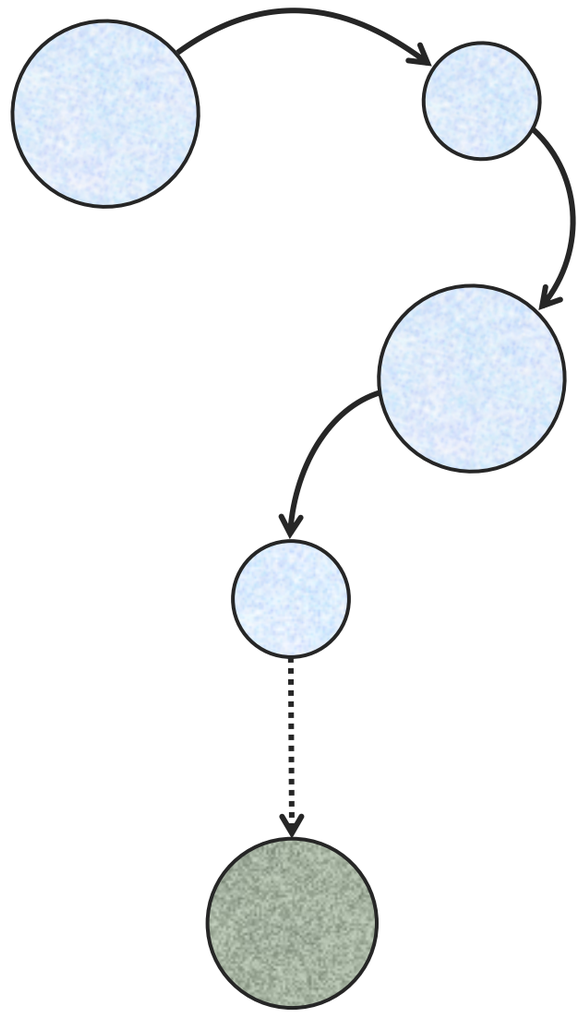
Water pollution

Nutrients: a dual problem…



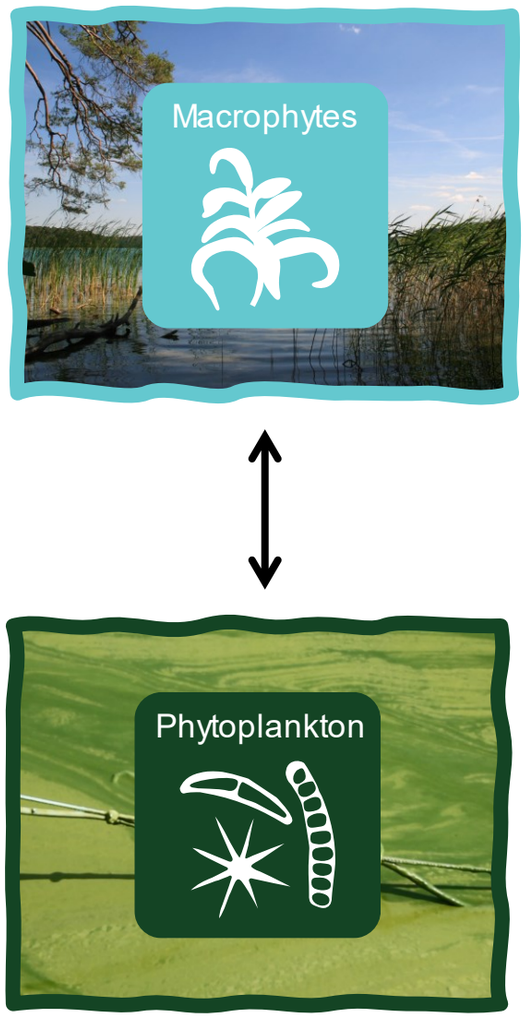
?

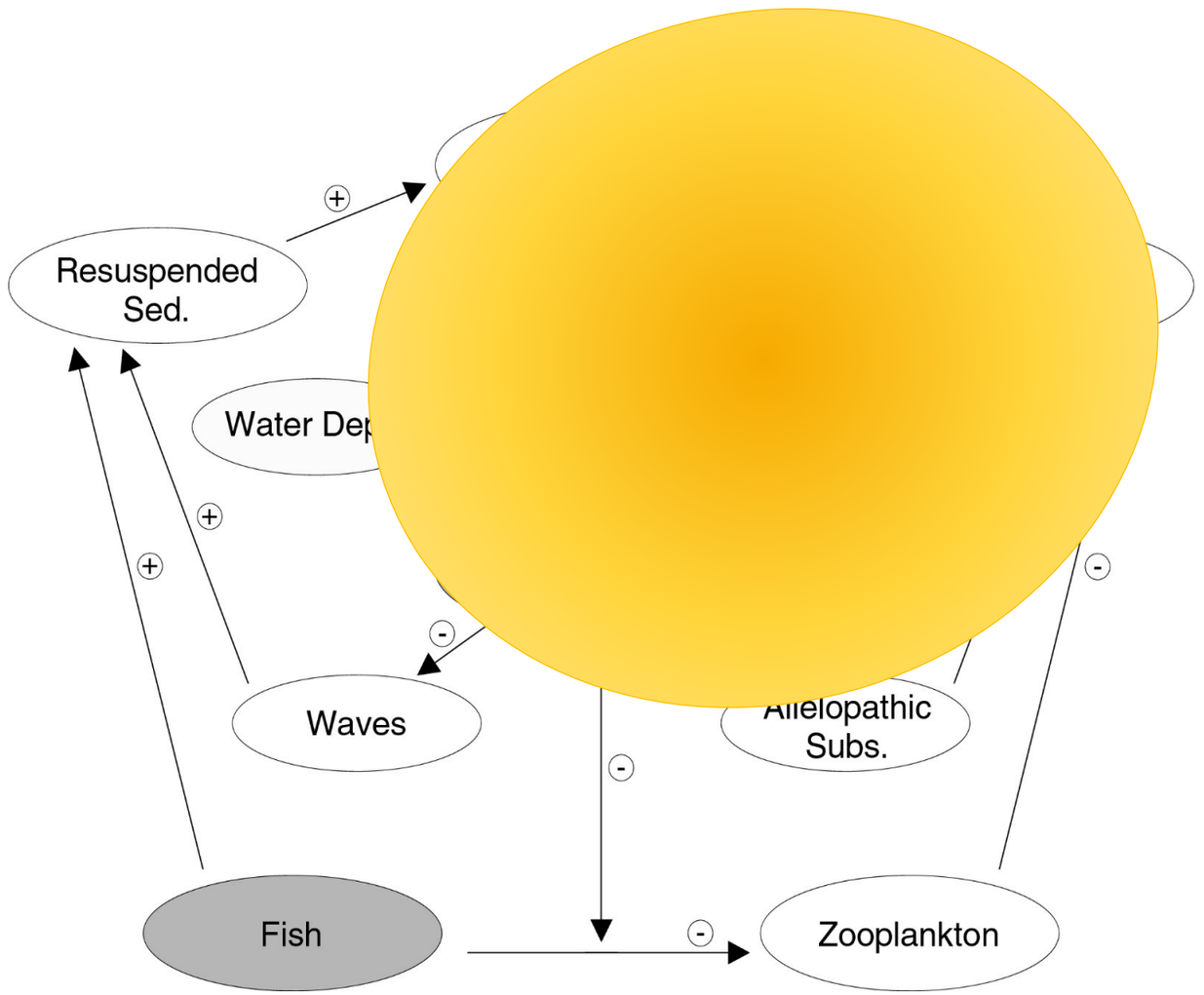
A solution…



Ecosystem state theory

& nutrient retention

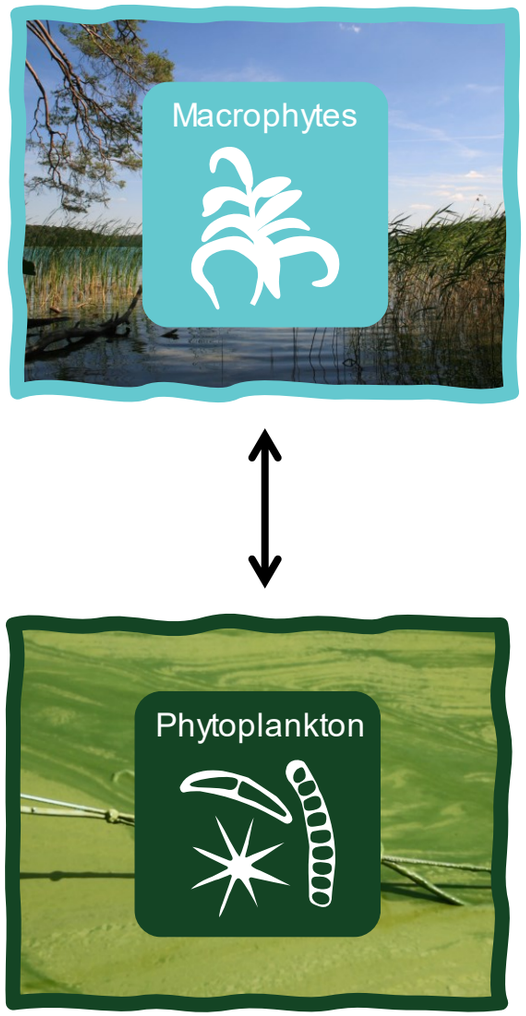


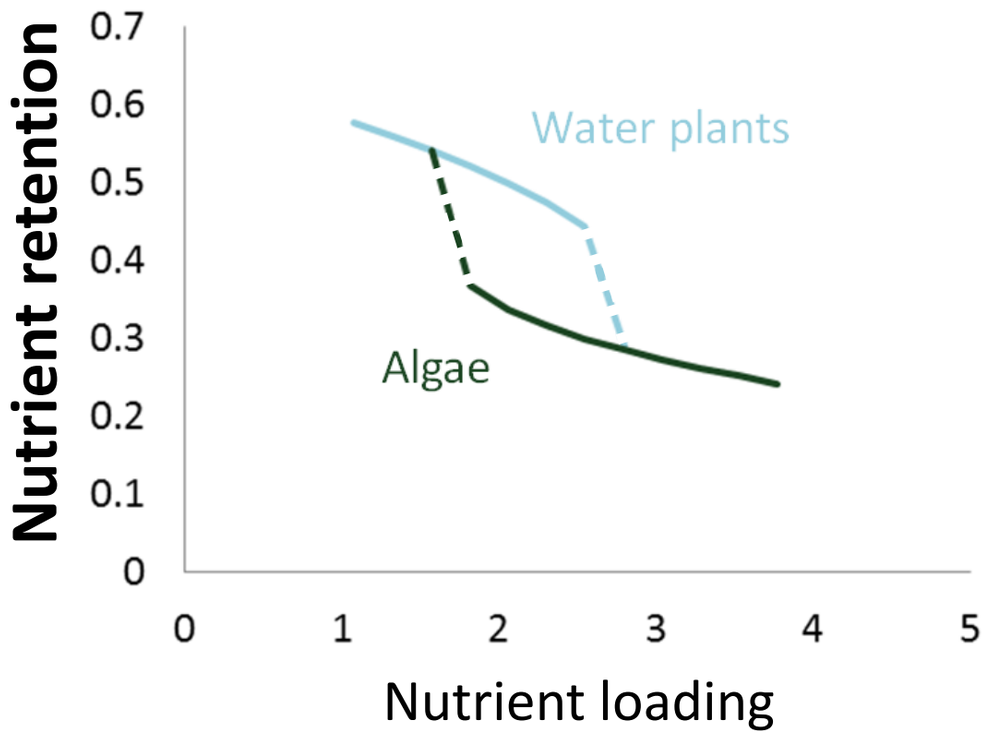


(Scheffer et al., 1993)

Ecosystem state theory

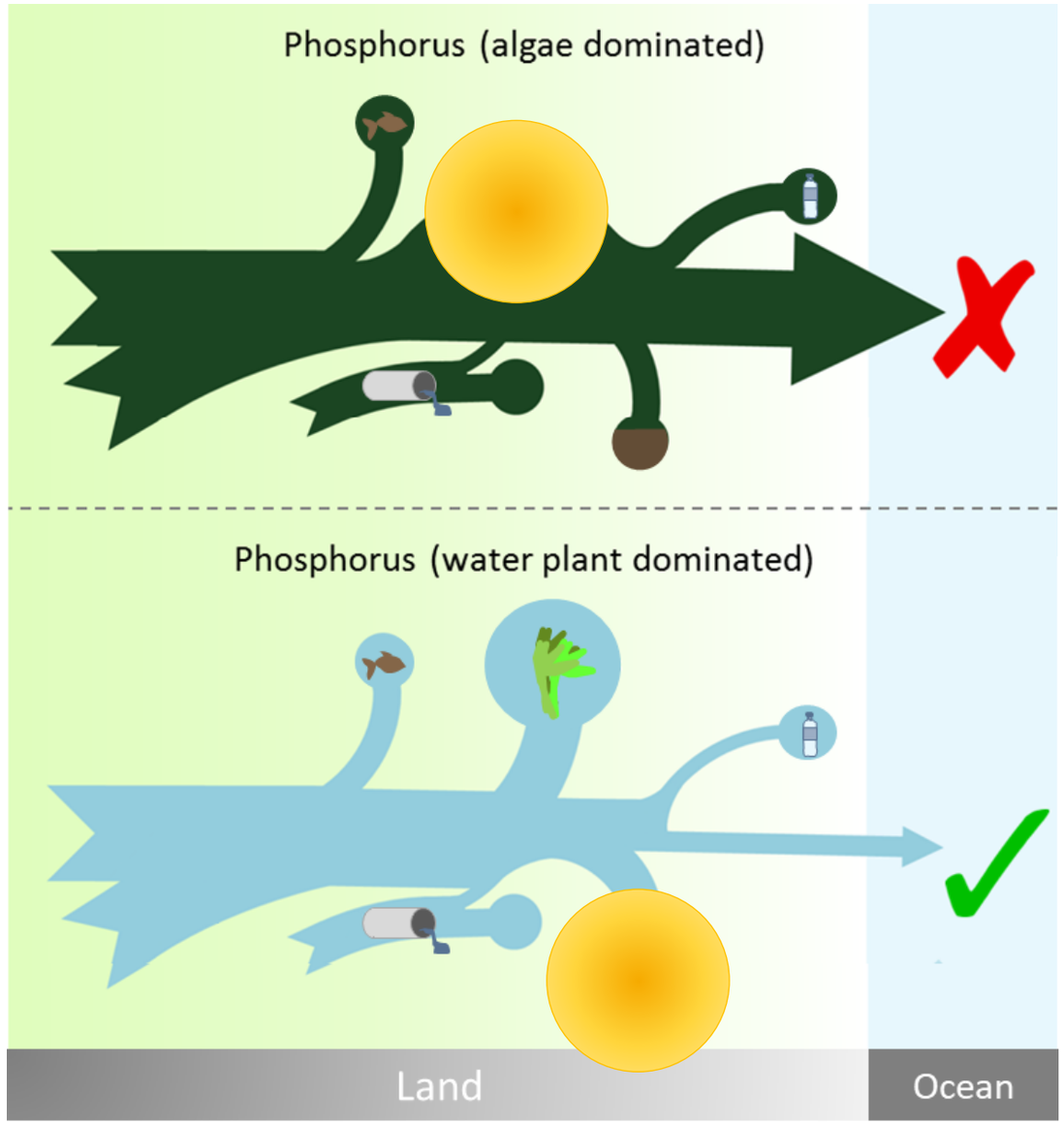
& nutrient retention





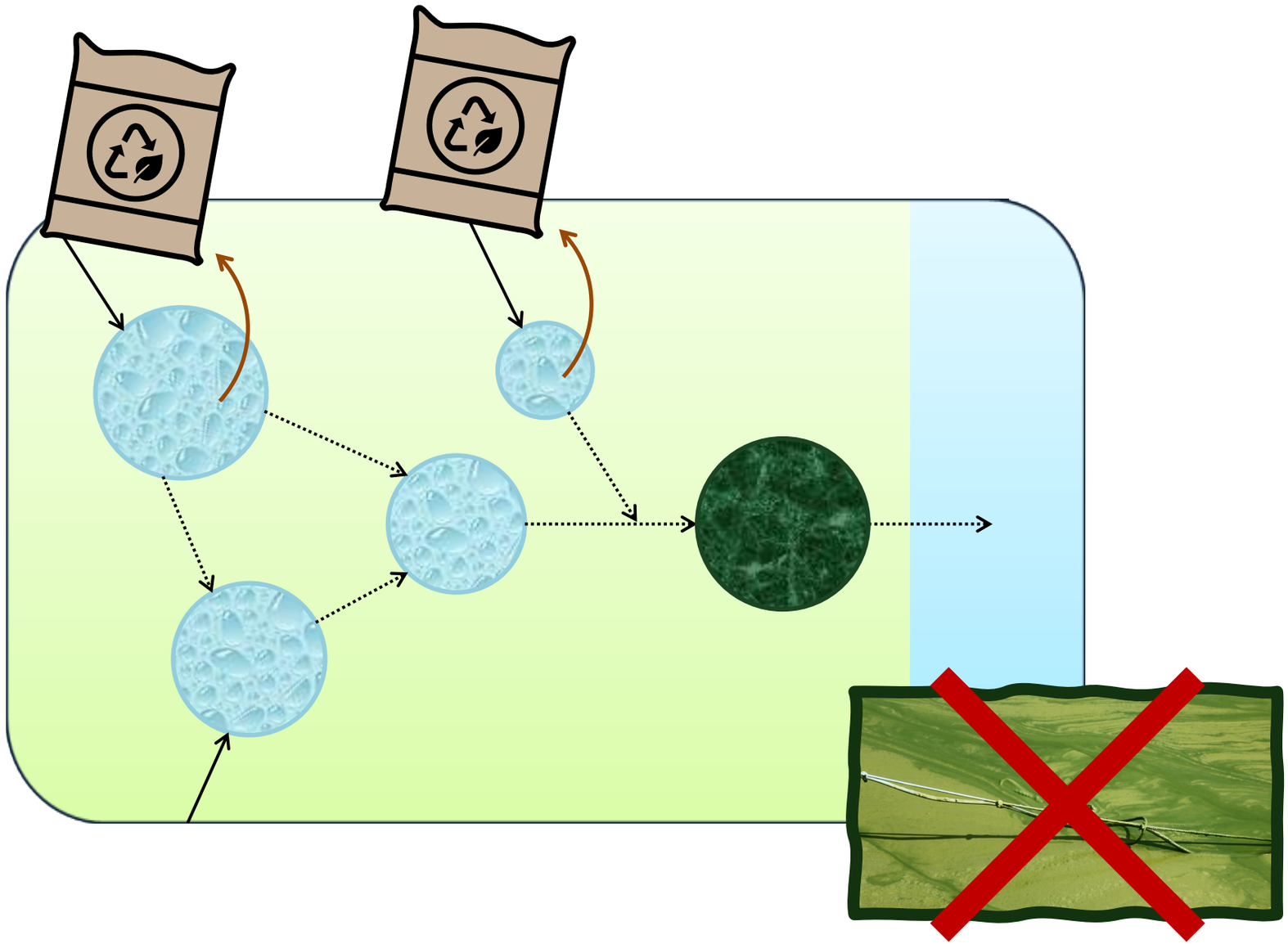
Ecosystem state

& nutrient flows



Smart Nutrient Retention Network

perspective



Can we model regime shift in (networks of) shallow lakes?

Theory

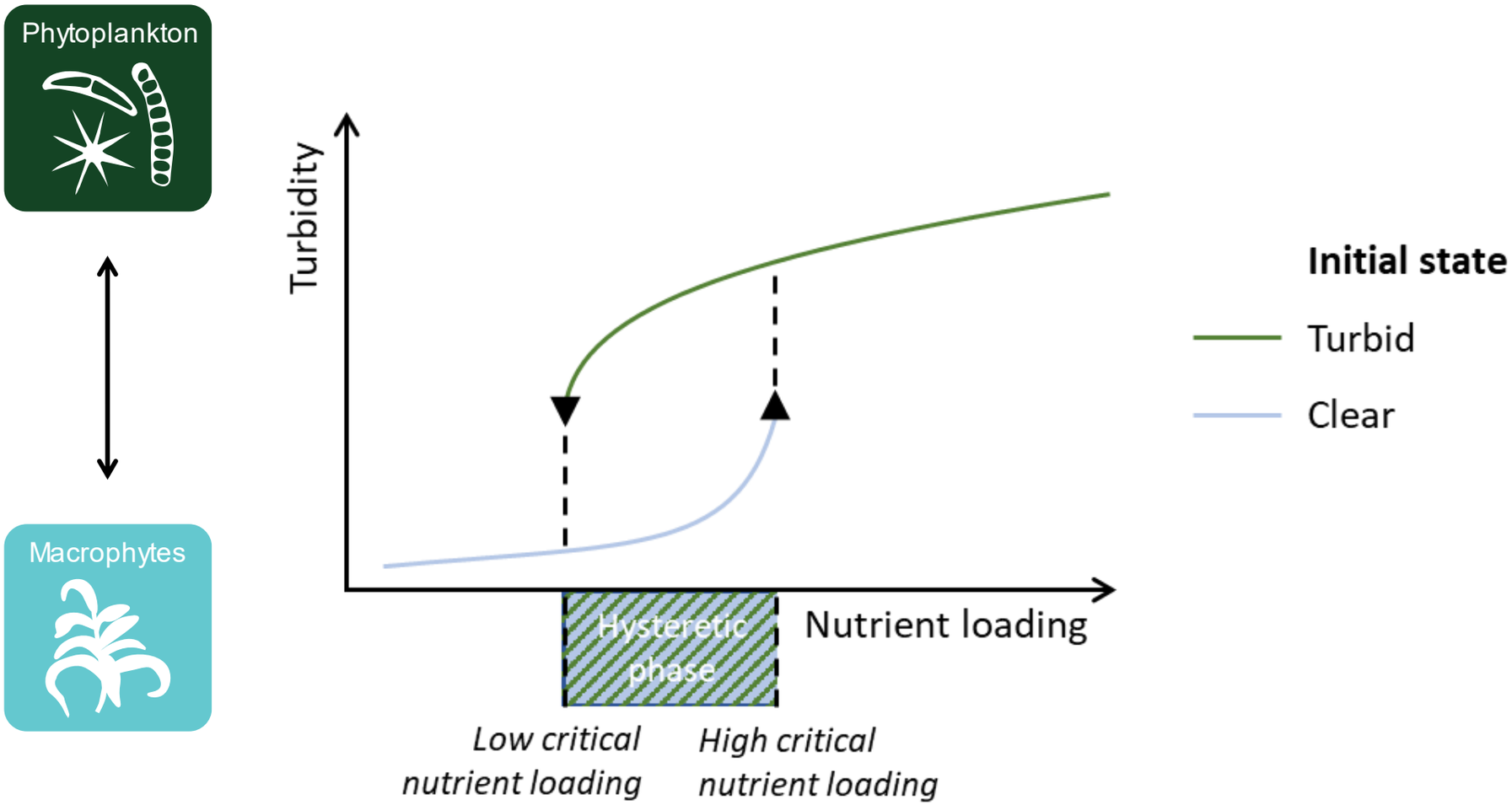
Critical turbidity
(Scheffer et al. 1990)

Nutrient and light competition
(Tilman 1982; Huisman and Weissing 1994; 1995)

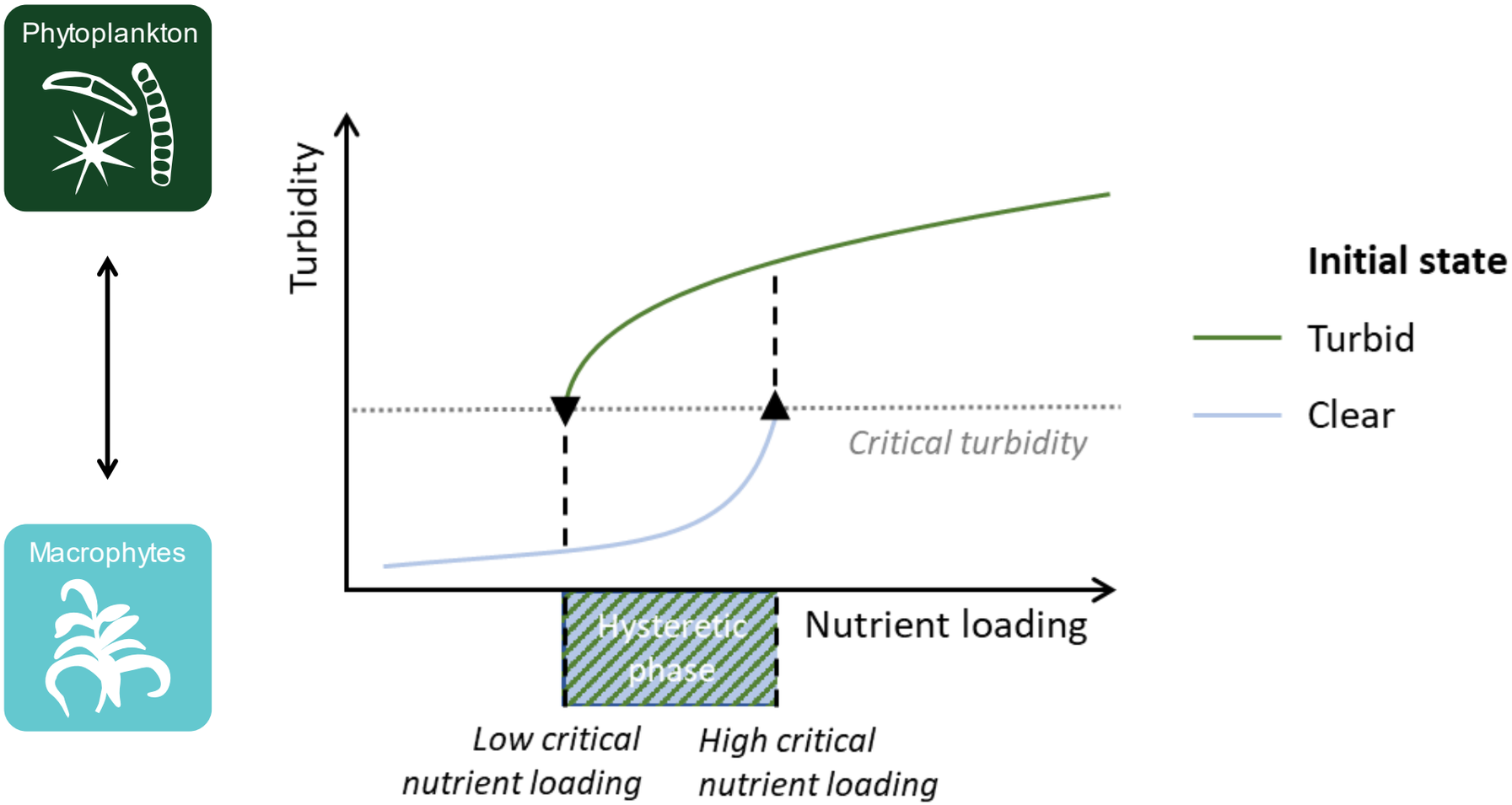
GPLake-M workshop:

Hands-on application for a real-world lake management case

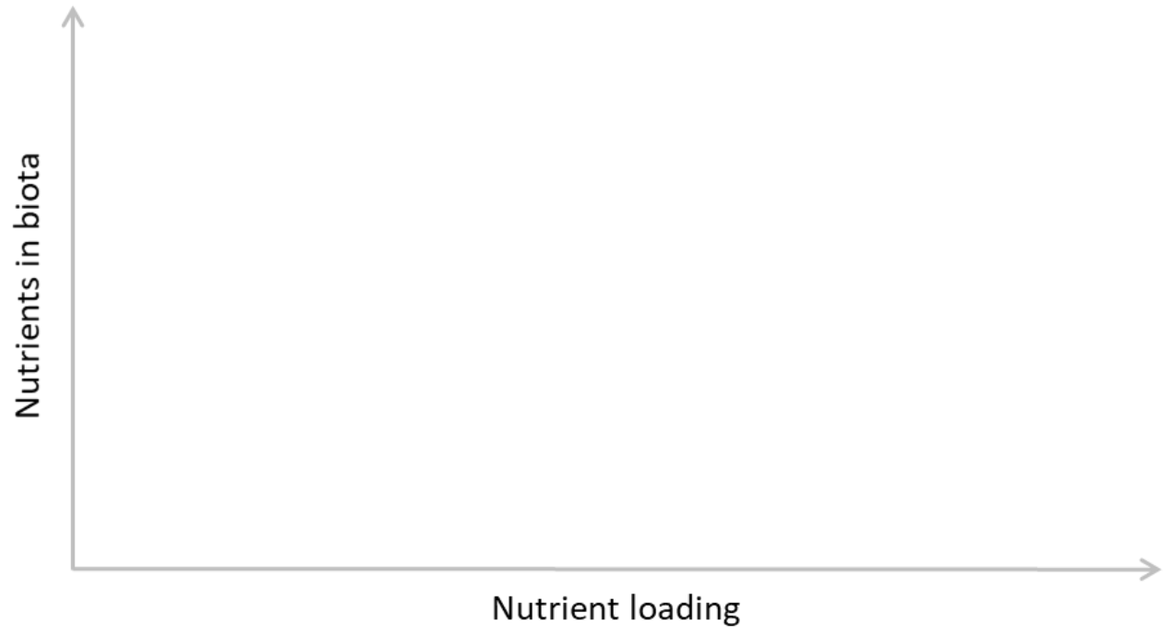
Regime shifts in shallow lakes ...



… explained by critical turbidity



GPLake-M: Eutrophication



Legend

- Macrophytes, initial clear
- Phytoplankton, initial clear

Initial state

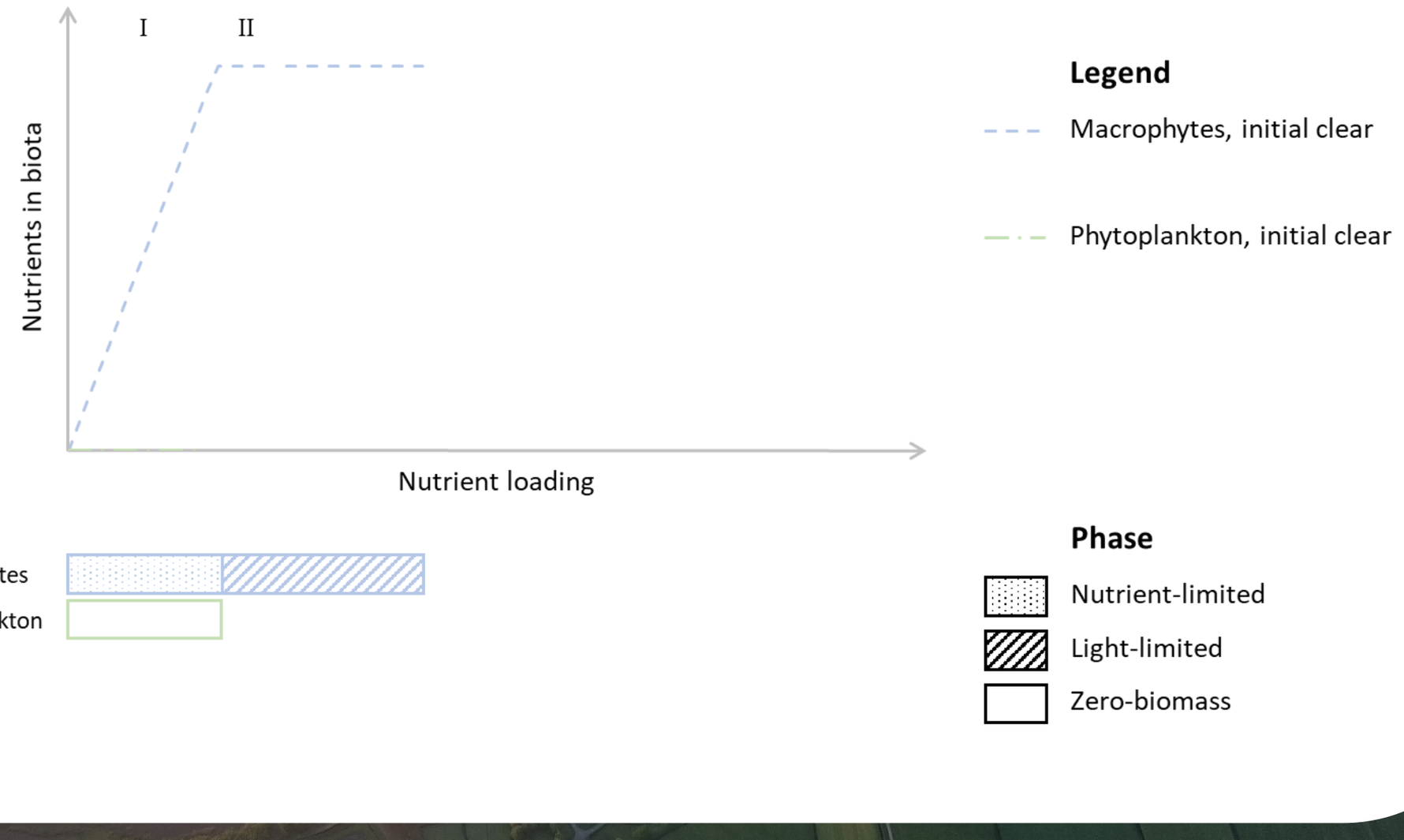
Clear	Macrophytes
	Phytoplankton

Phase

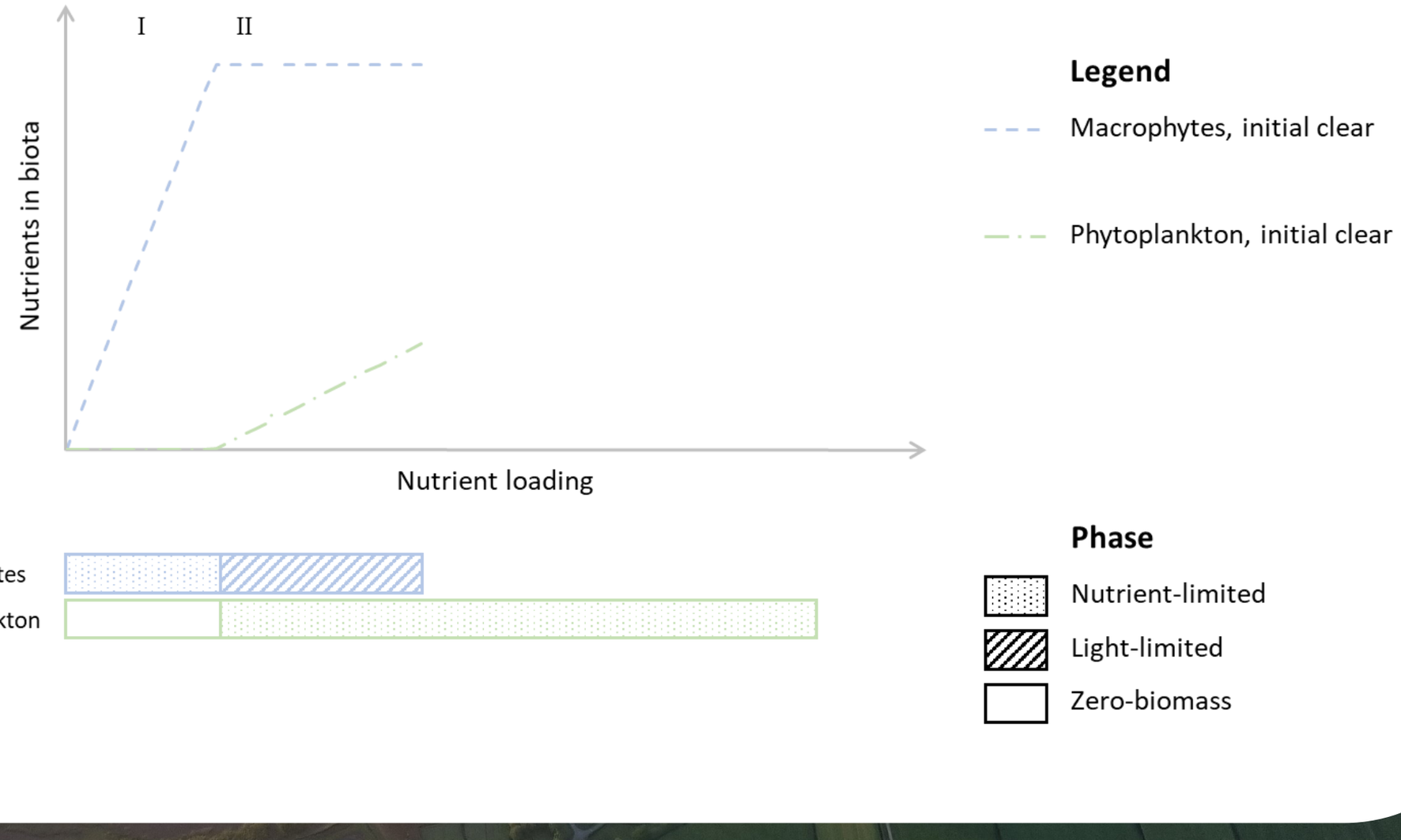
- Nutrient-limited
- Light-limited
- Zero-biomass

GPLake-M: Eutrophication

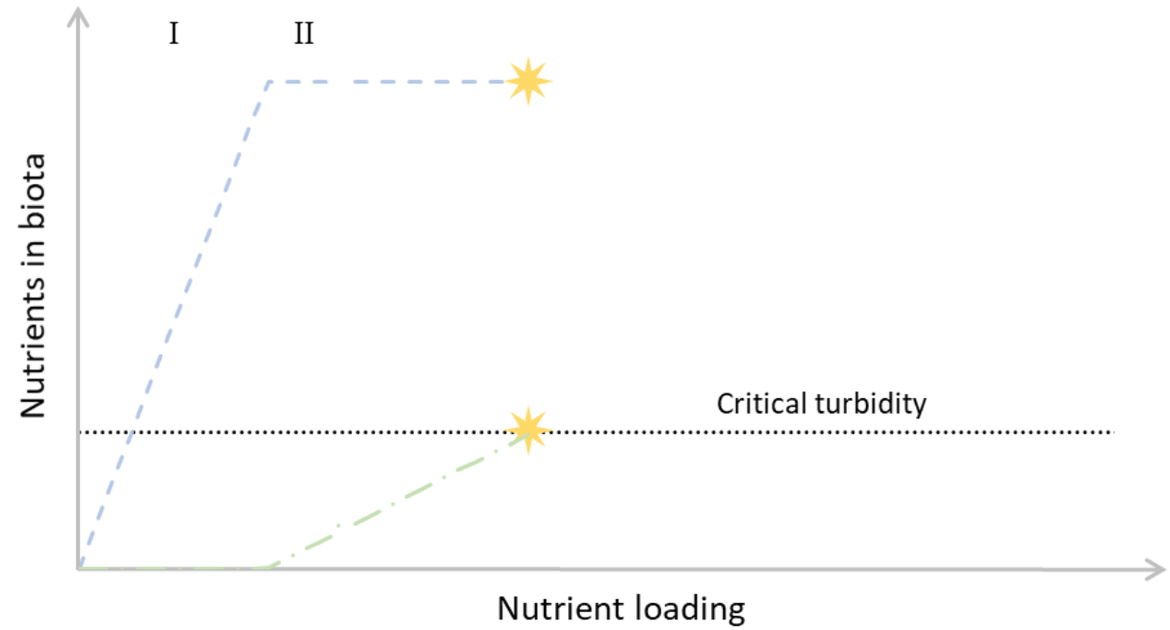
GPLake-M: Eutrophication



GPLake-M: Eutrophication



GPLake-M: Eutrophication



Legend

- Macrophytes, initial clear
- Phytoplankton, initial clear
- Regime shift

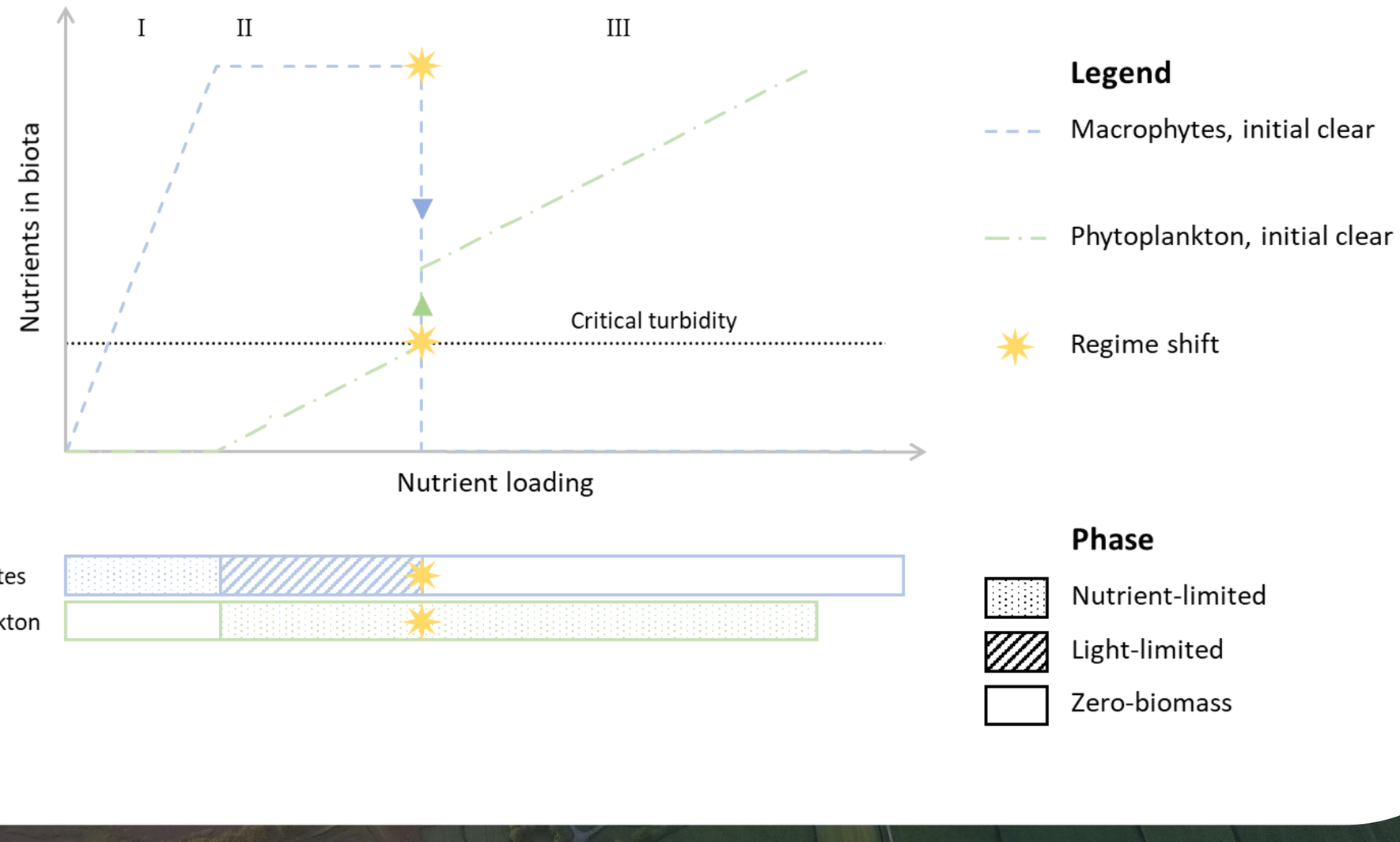
Initial state

Clear

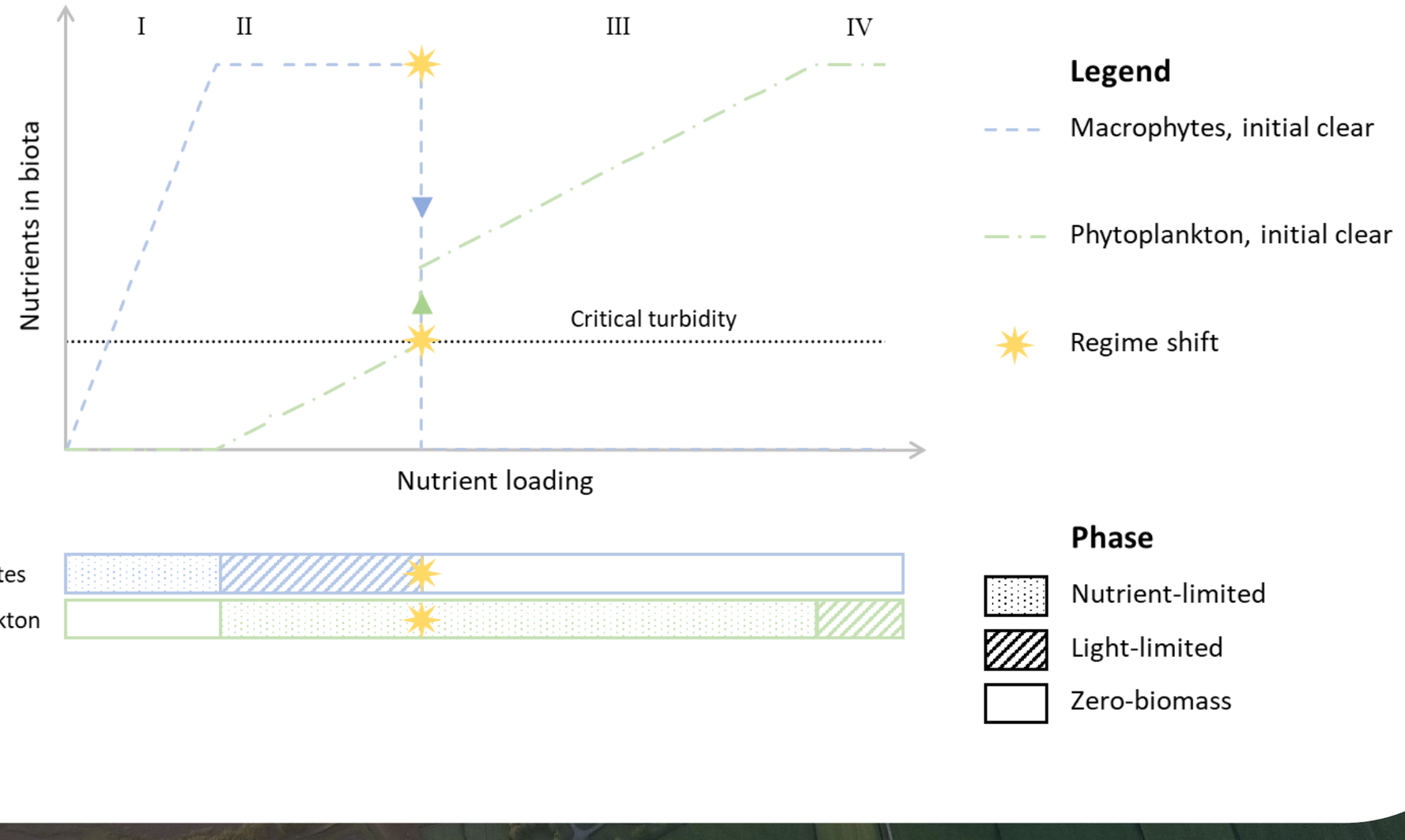
Phase

- Nutrient-limited
- Light-limited
- Zero-biomass

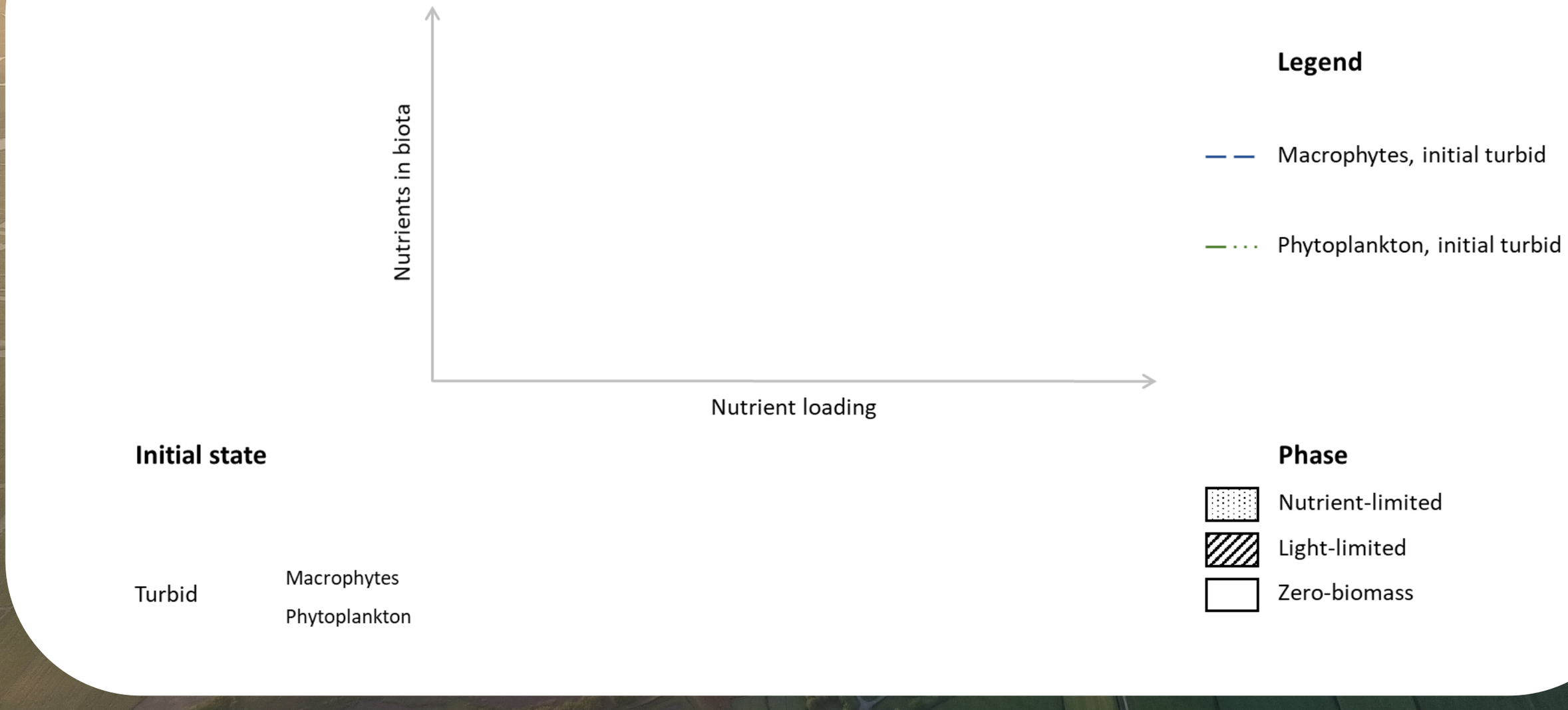
GPLake-M: Eutrophication



GPLake-M: Eutrophication



GPLake-M: Oligotrophication



GPLake-M: Oligotrophication

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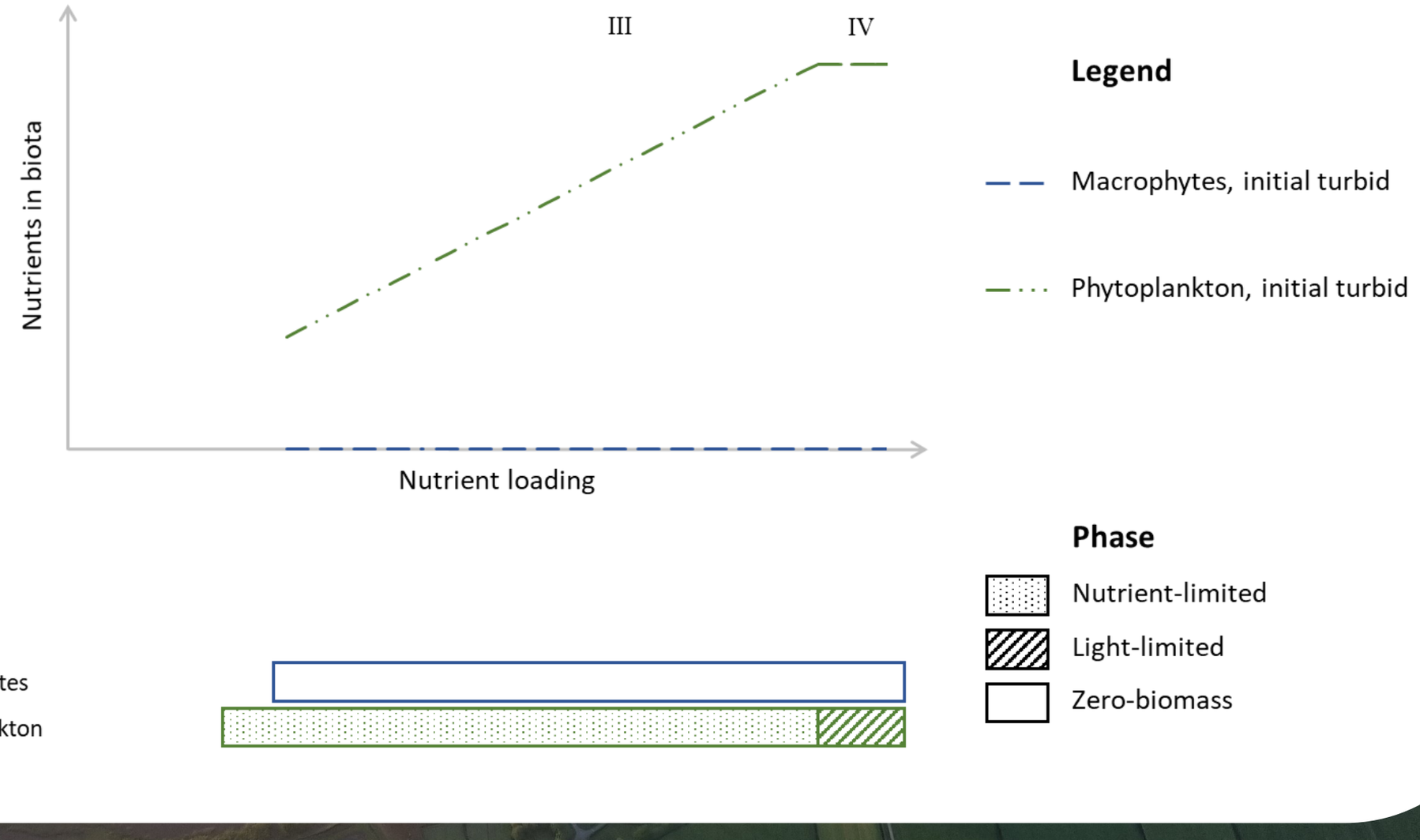
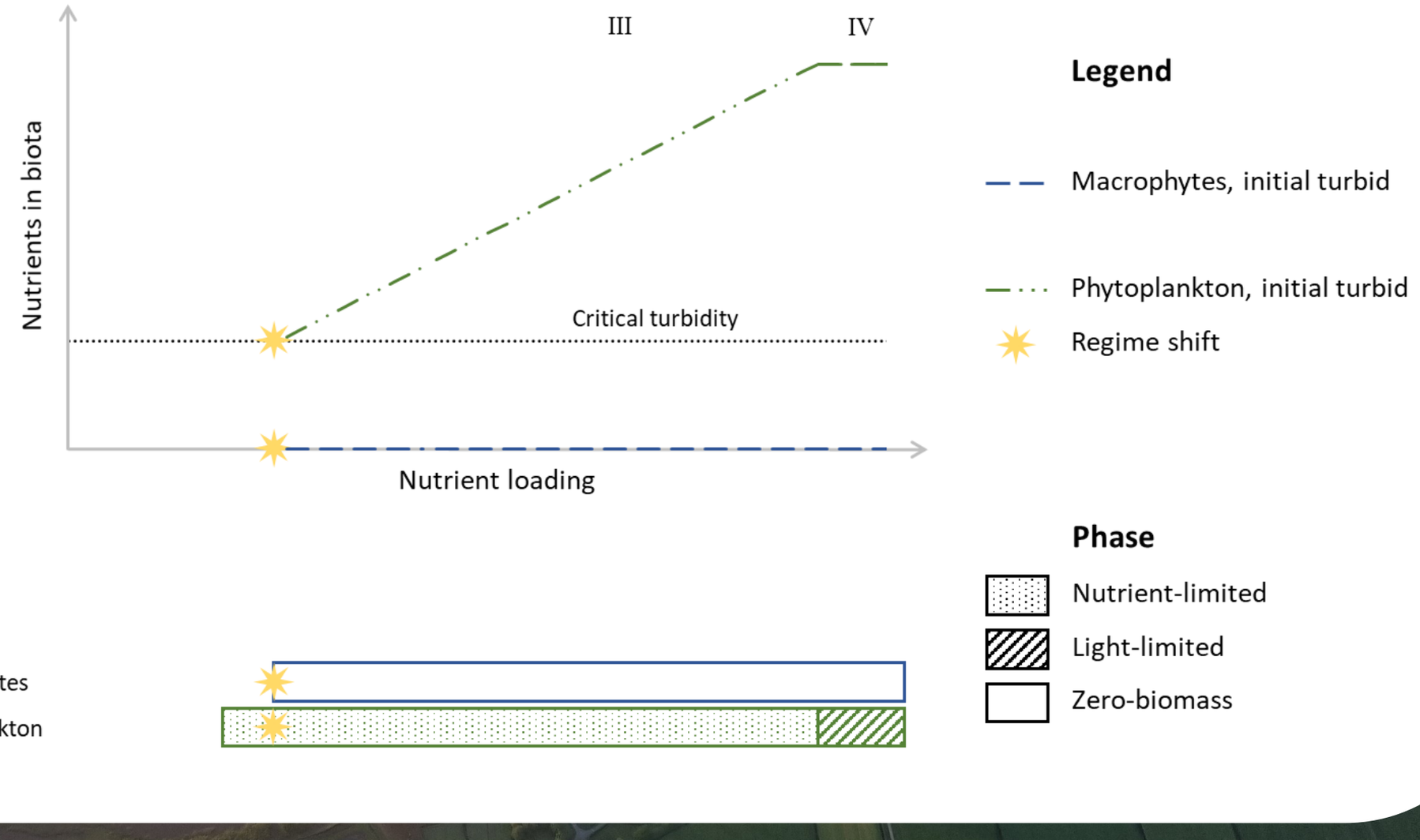
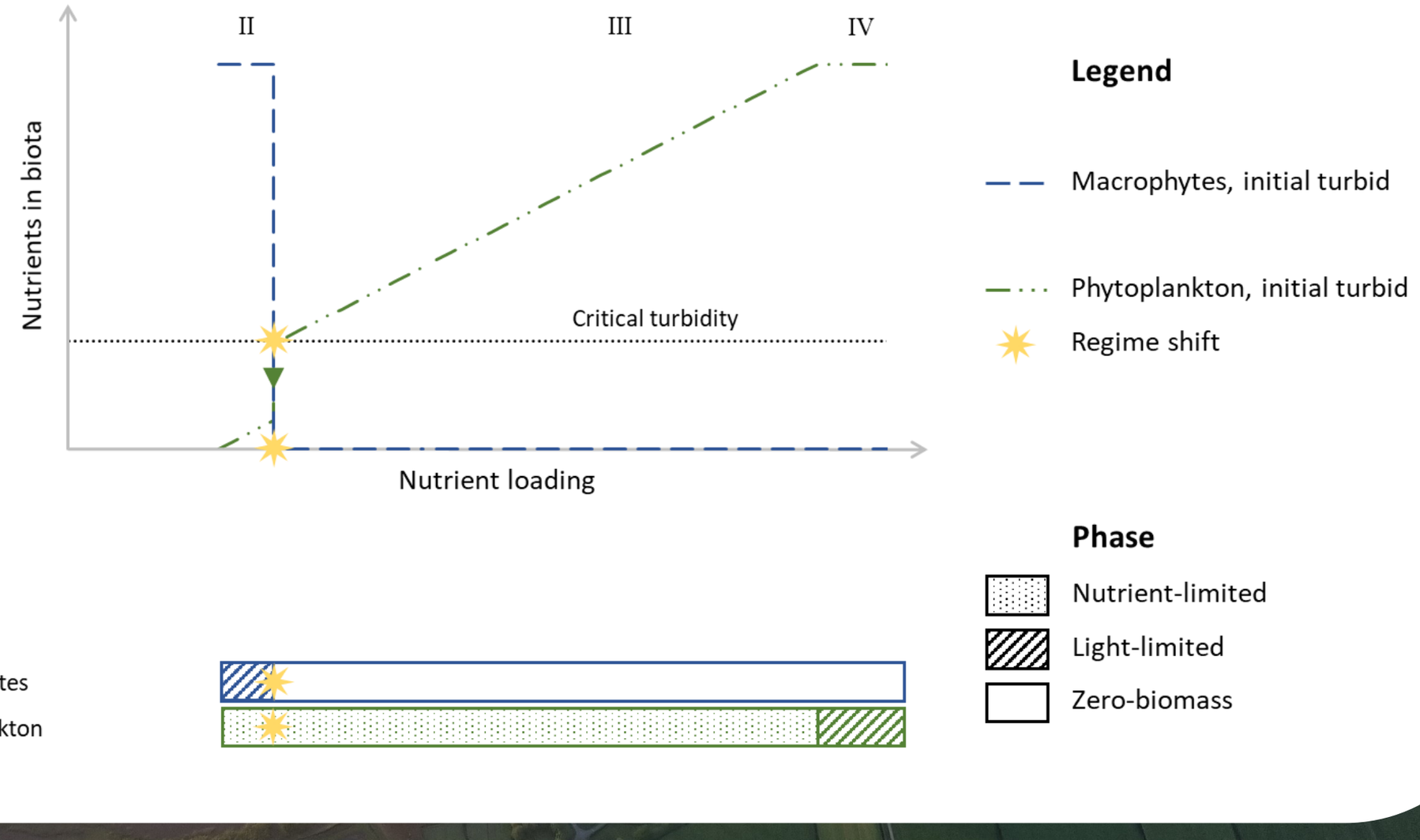


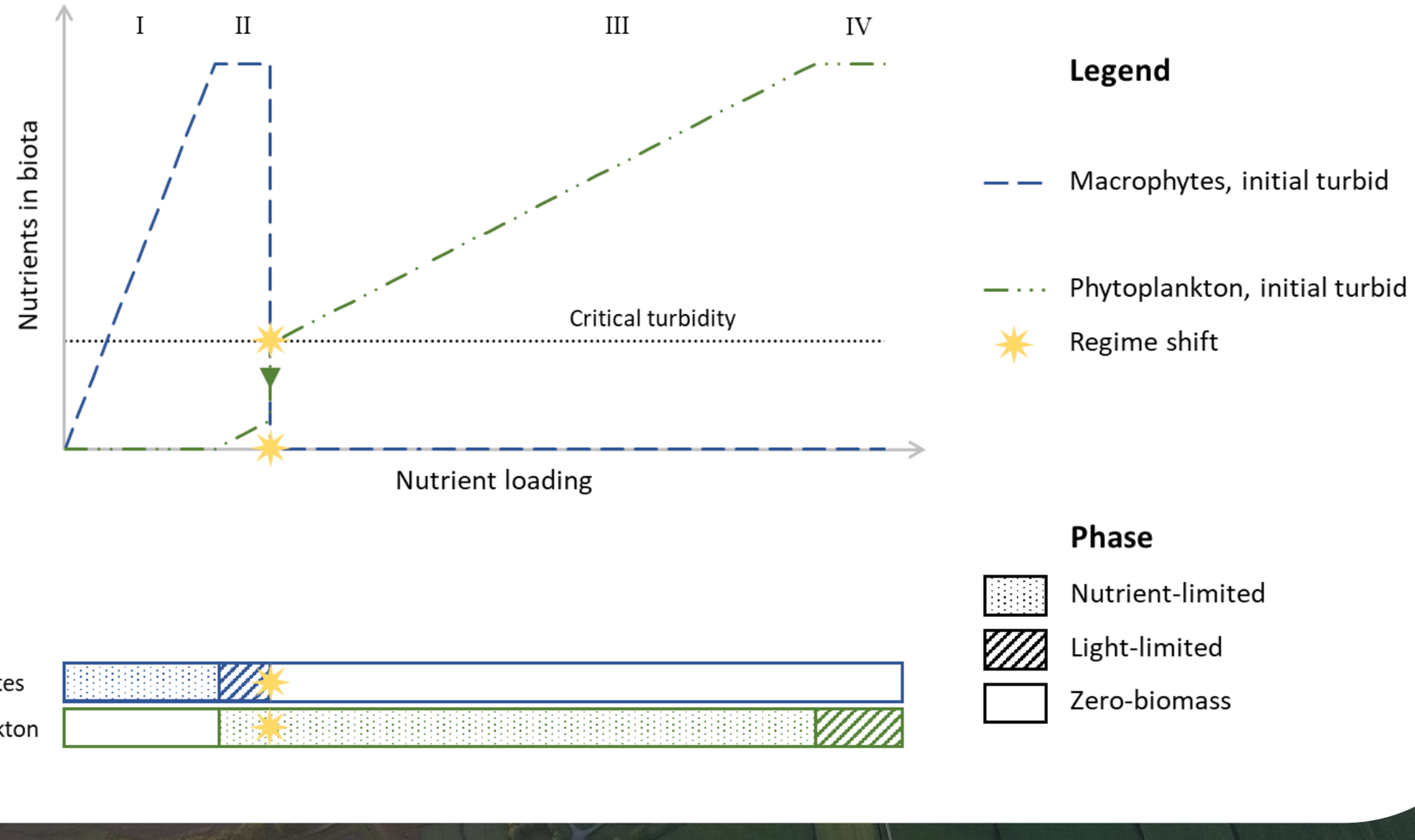
GPLake-M: Oligotrophication



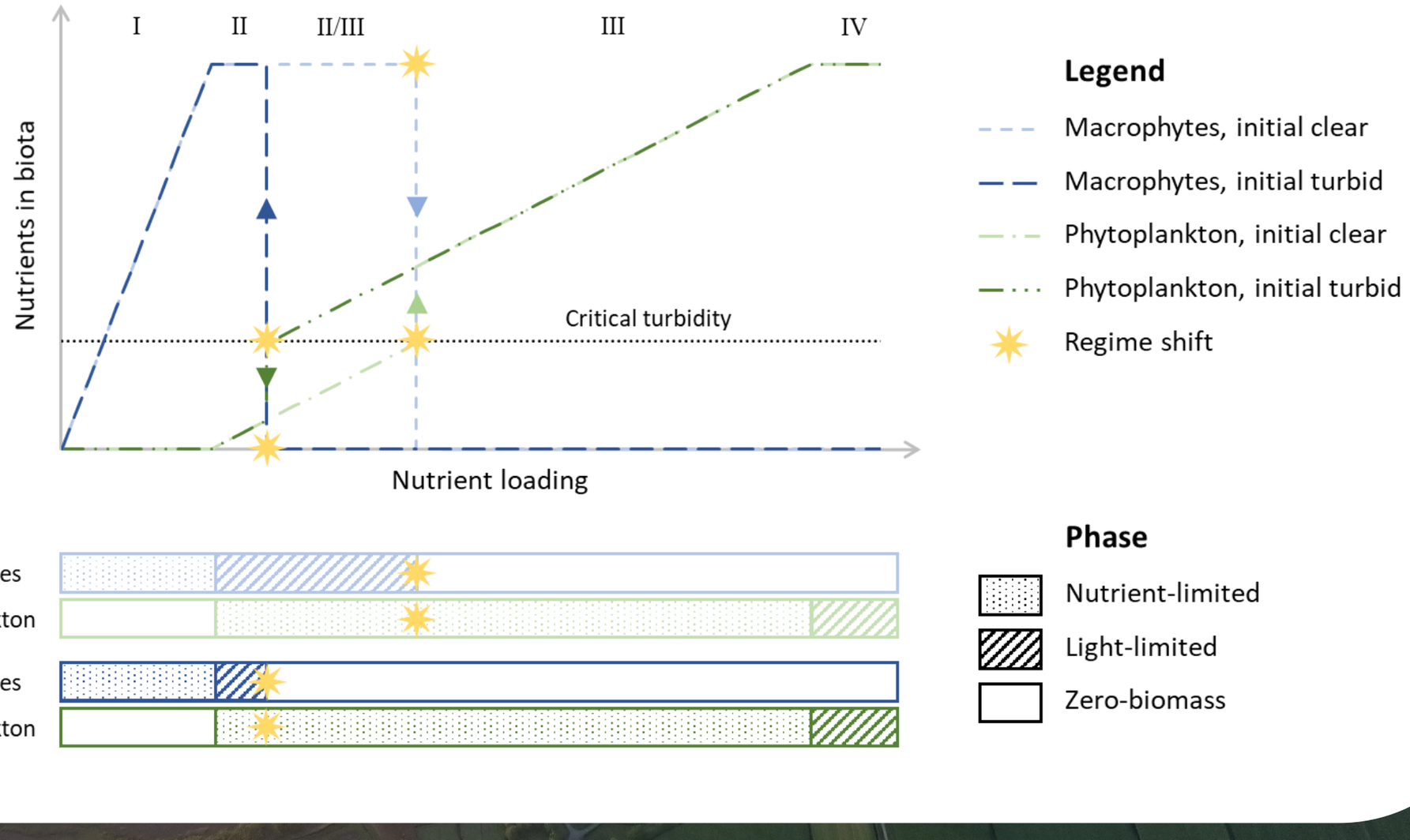
GPLake-M: Oligotrophication



GPLake-M: Oligotrophication

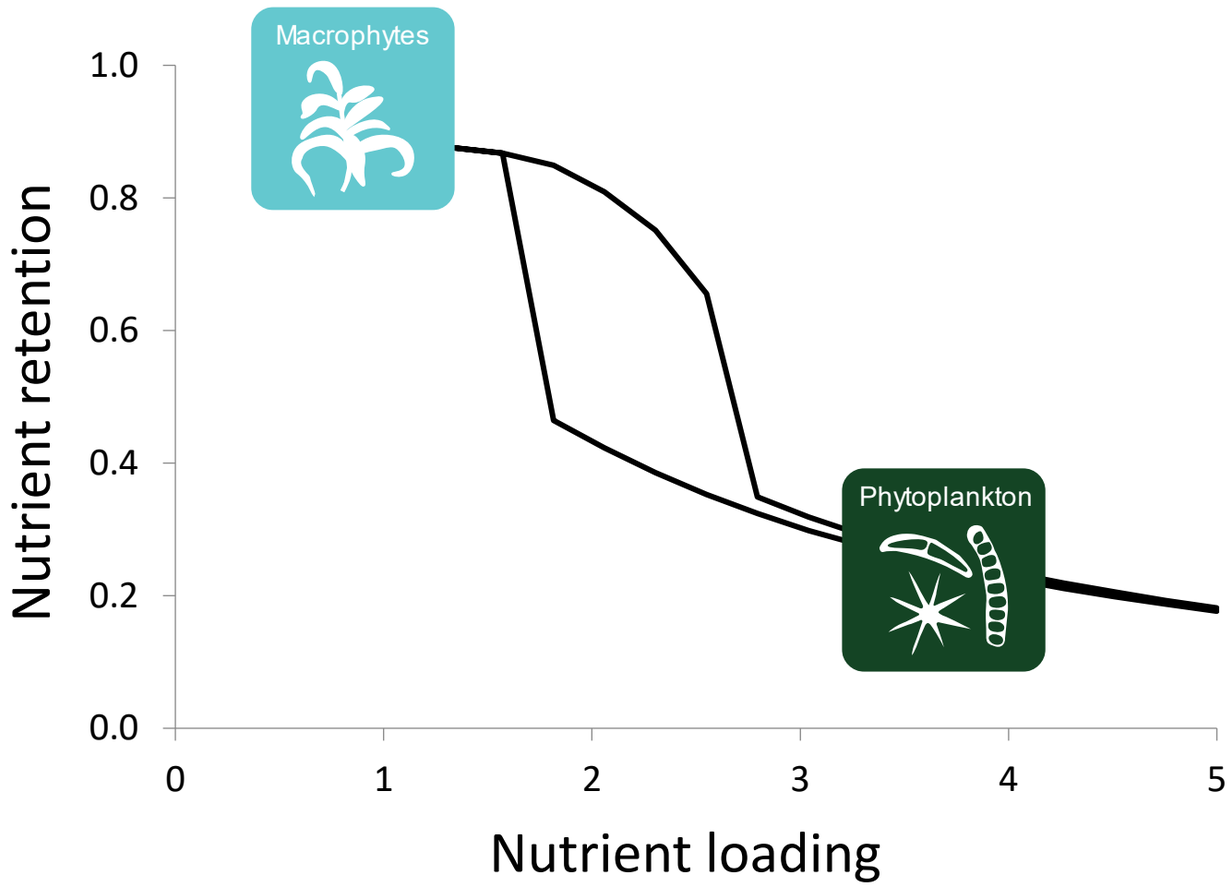


GPLake-M: Alternative states



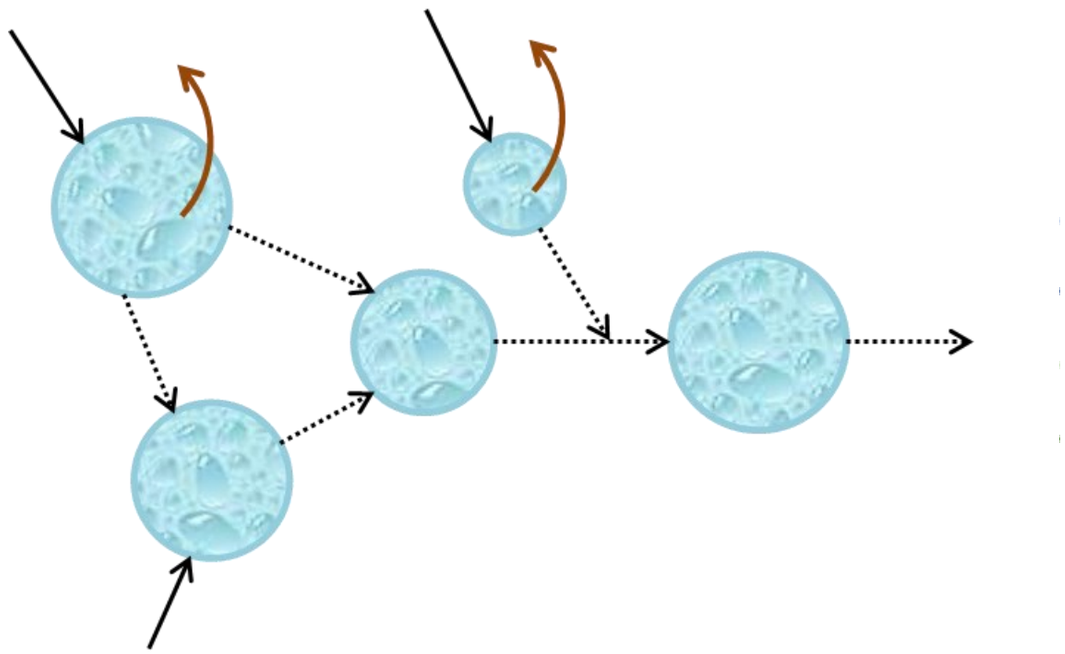
Towards a nutrient retention model

(GPLake-R)



Future perspective...

To model lake **ecosystem state** and **nutrient retention**...



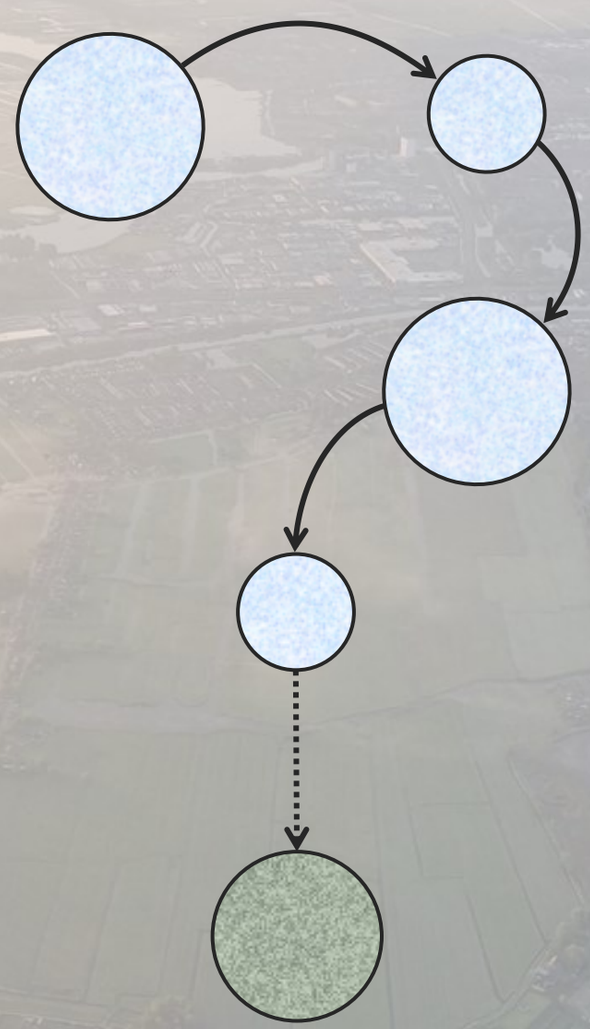
...in **networks** of lakes

Take home messages

Water quality and nutrient management may benefit from a **lake-network perspective**

Lake ecosystem state matters for nutrients &
Nutrients matter for lake ecosystem state

Lake ecological models may help to inform management



Literature

- **van Wijk, D., Teurlincx, S., Brederveld, R.J., *et al.*, 2021.** Smart Nutrient Retention Networks: a novel approach for nutrient conservation through water quality management. Inland Waters. 12(1):138-153.

- **van Wijk, D., Chang, M., Janssen, A.B.G., *et al.*, 2023.** Regime shifts in shallow lakes explained by critical turbidity. Water Research. 119950.

Ecological state

vs.

Waterbody type

Local interventions

Smart Nutrient Retention Networks

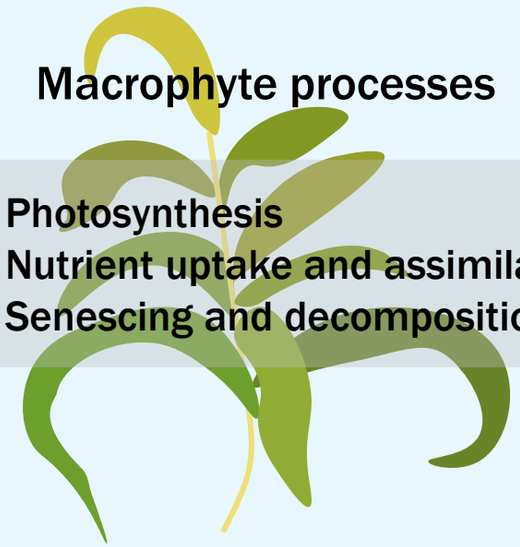
Catchment conditions

Goals

Chemical factors

- Nutrient concentration
- DO concentration
- Redox potential
- OC concentration
- pH

Macrophyte processes



- Photosynthesis
- Nutrient uptake and assimilation
- Senescing and decomposition

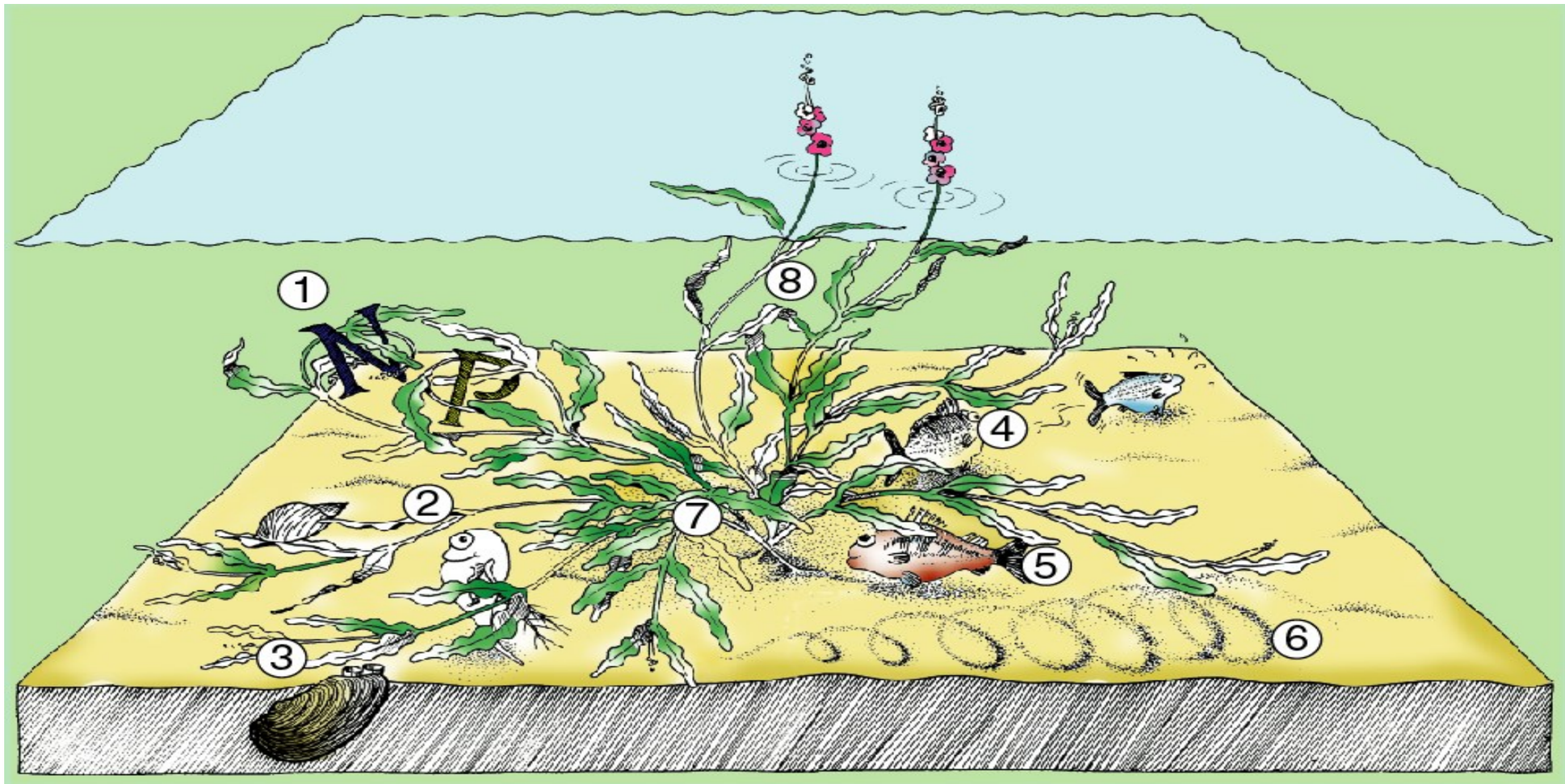
Physical factors

- Flow speed
- Water mixing
- Wave strength
- Sediment stability
- Epiphyte attachment area
- Refuge area
- Light climate
- Temperature

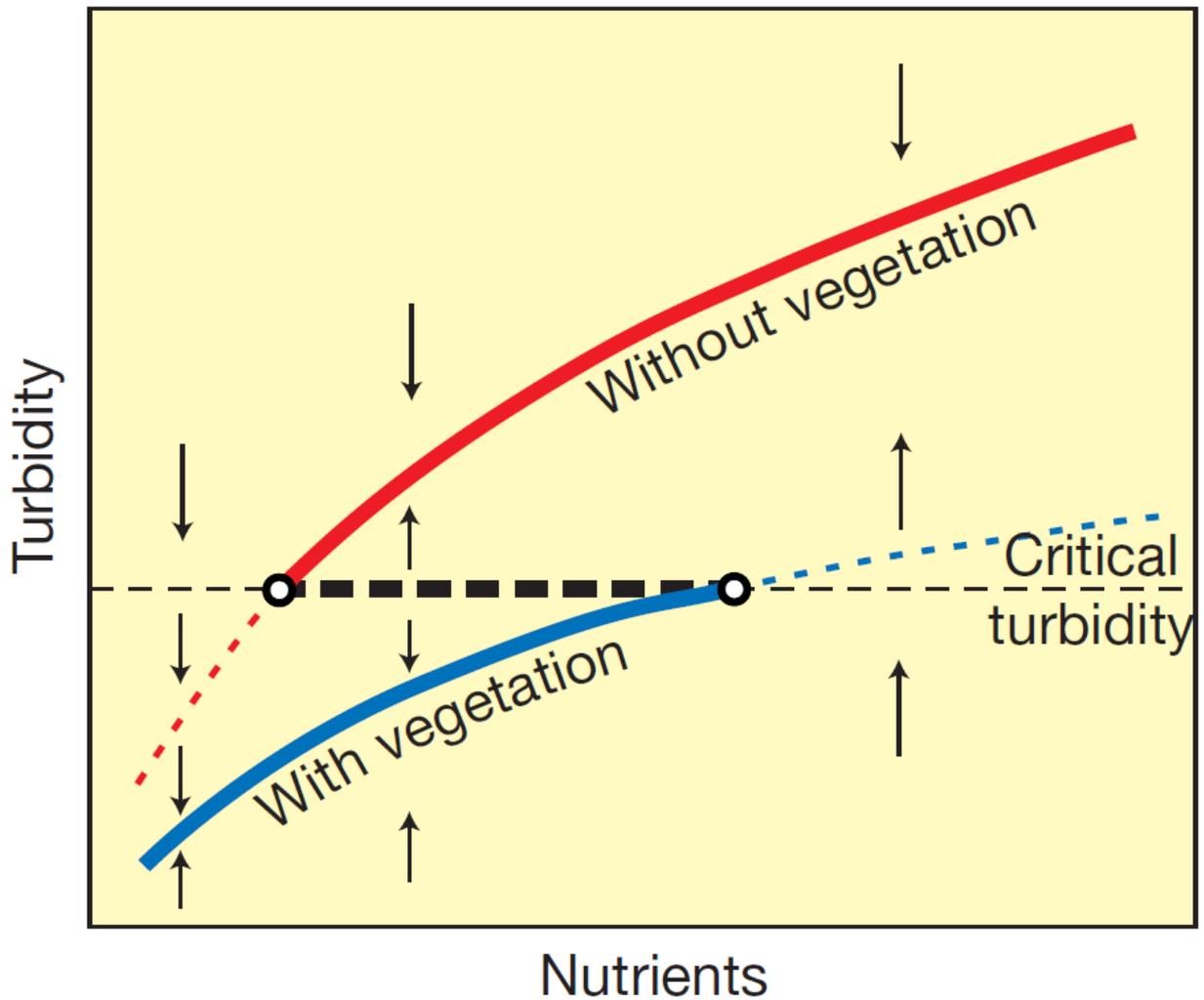
Natural nutrient retention processes

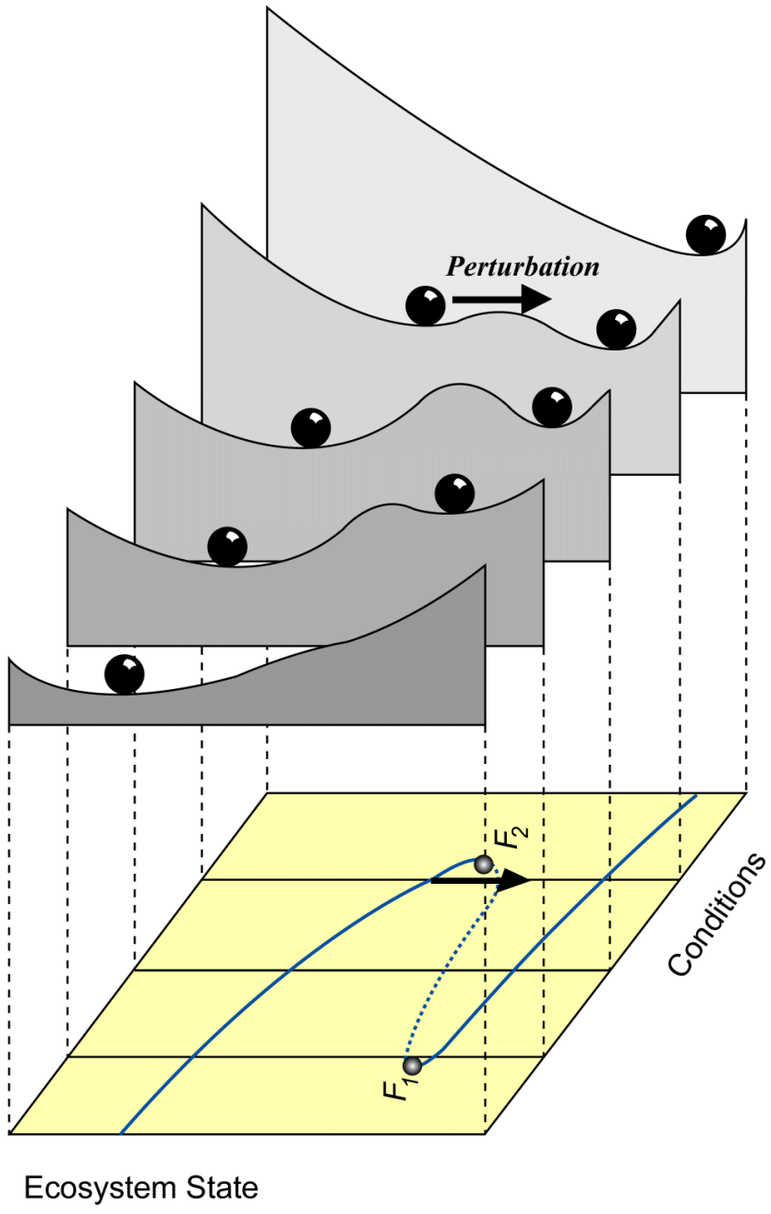
- (Coupled nitri-)denitrification
- P sorption to sediment
- Sedimentation
- Burial

(van Wijk et al., 2021)

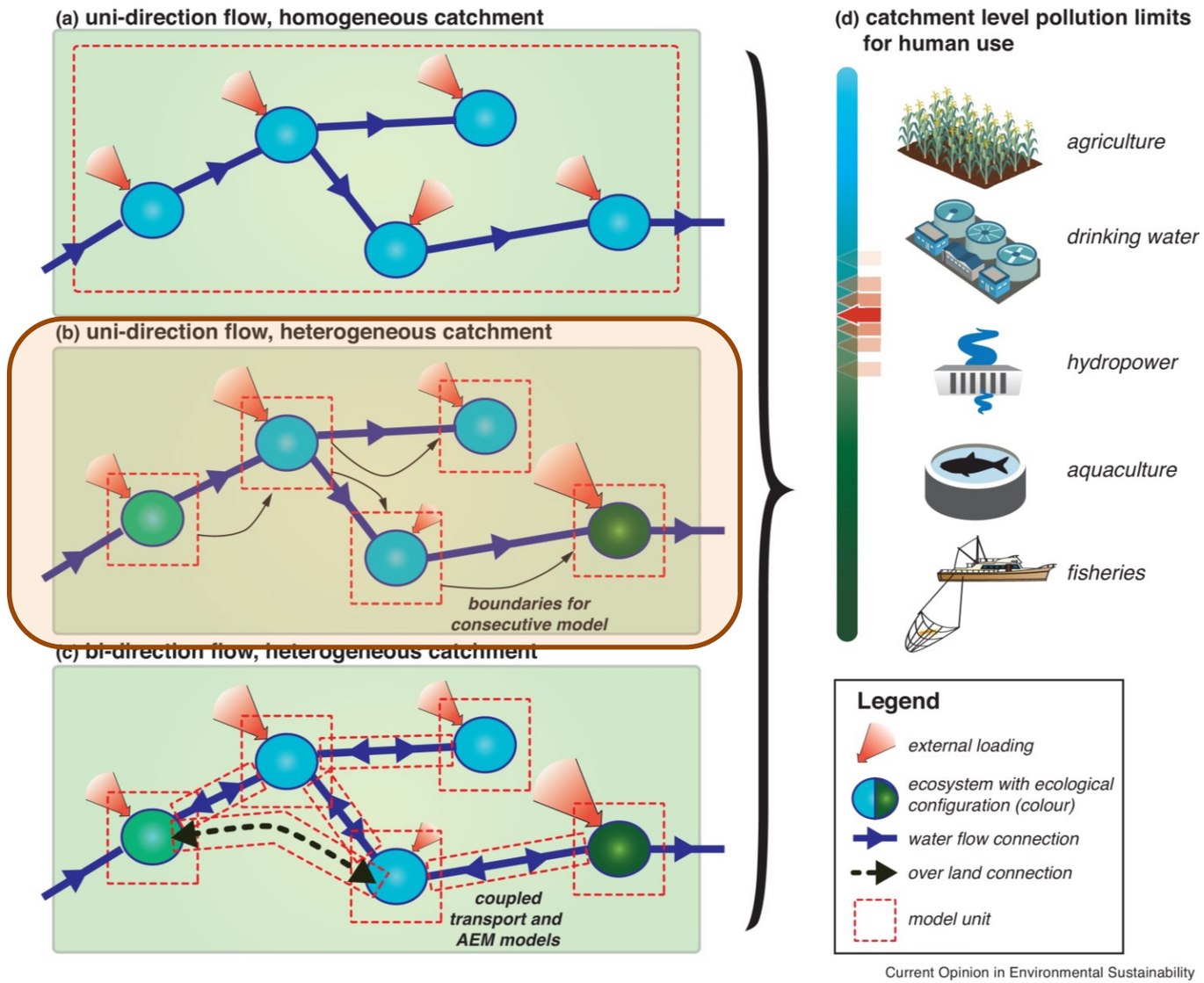


1. Remove nutrients for growth
2. Refuges for zooplankton
3. Improve conditions for macro filtrators
4. Favourize small perch over small roach
5. Refuges for small perch and small pikes
6. Stabilize sediment, reduce resuspension
7. Enchance denitrification
8. May have allelopathic effects

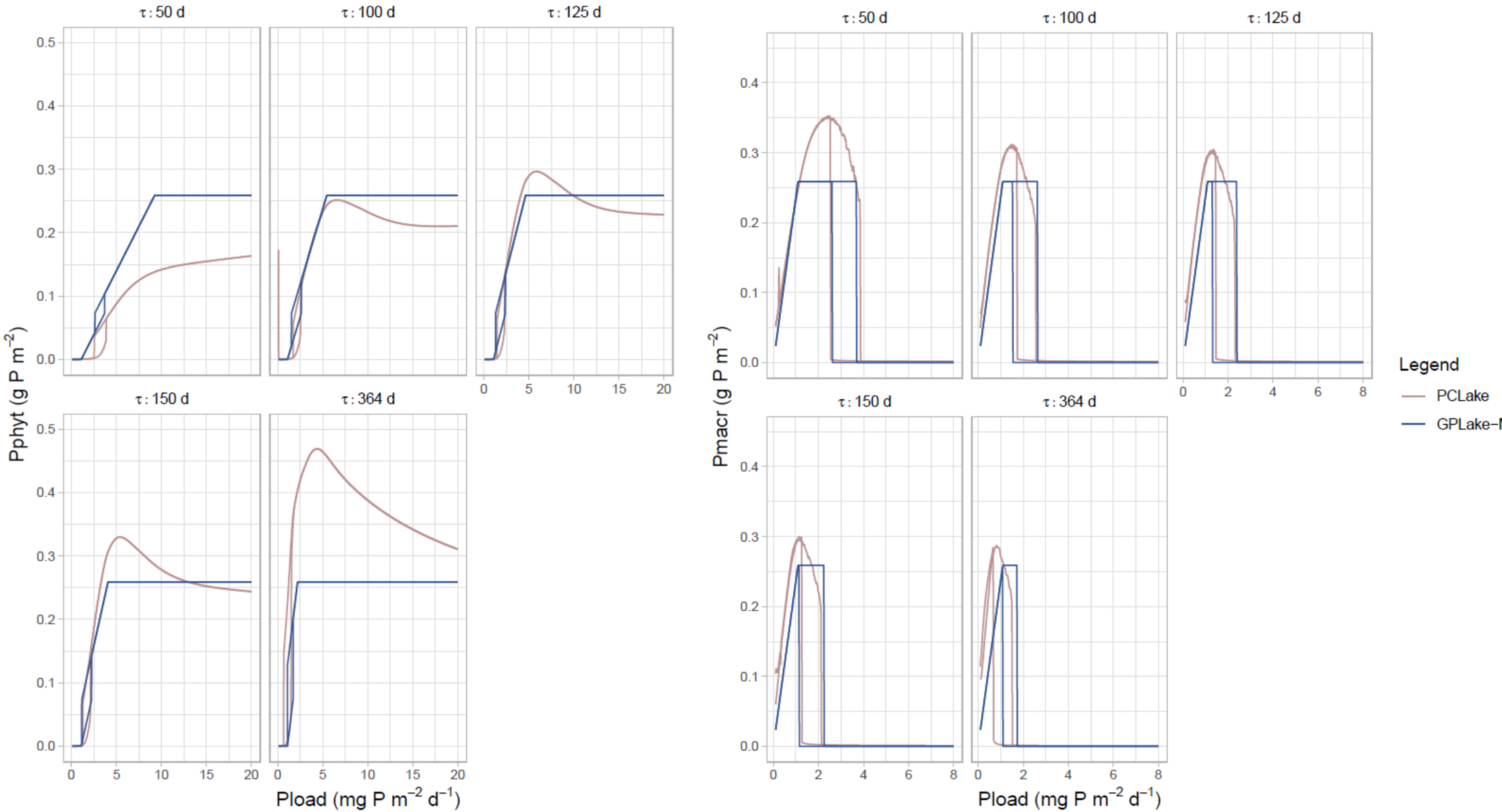

Turbidity
Without vegetation
Critical
turbidity
With vegetation
Nutrients

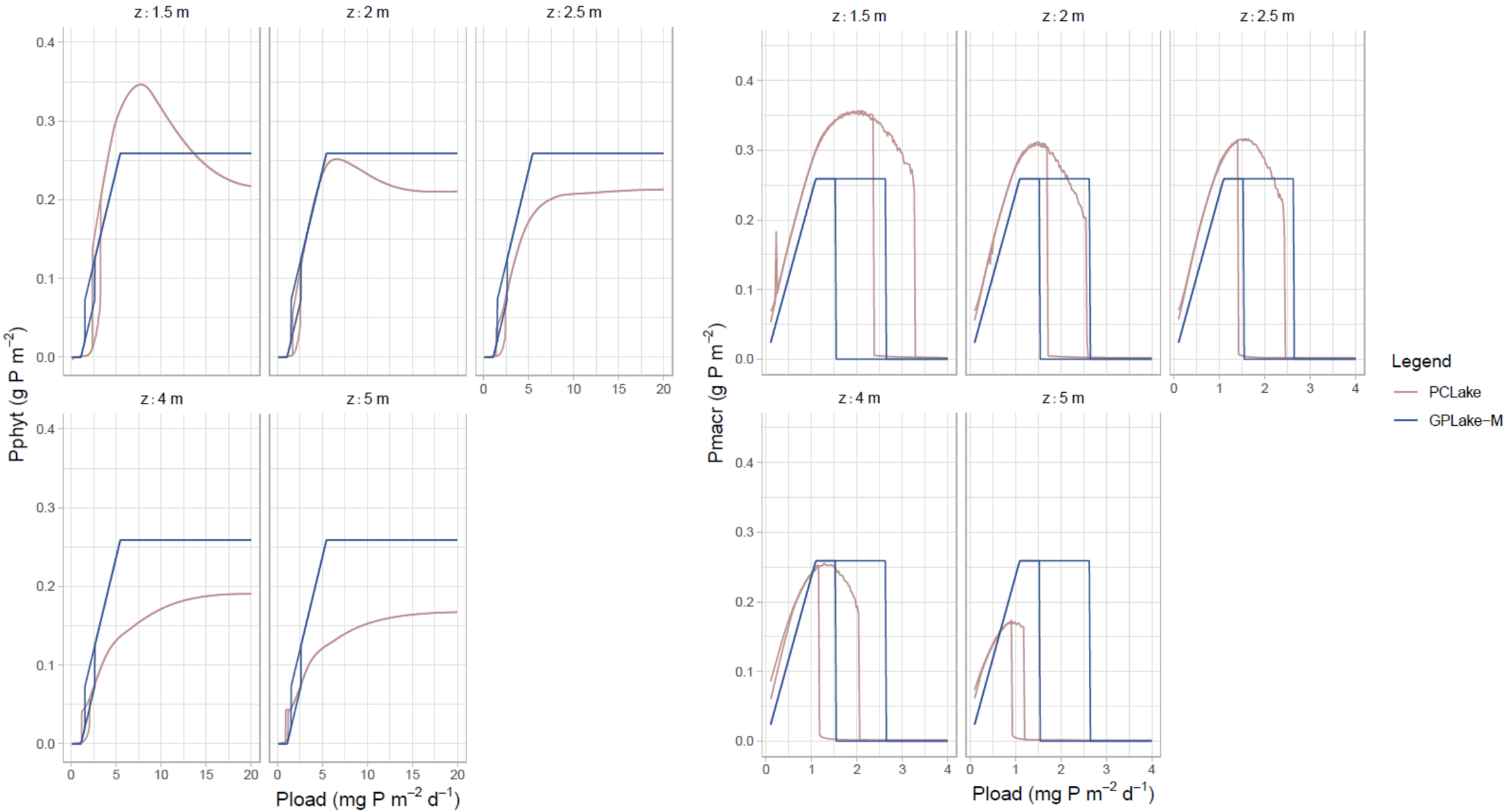

Perturbation
F_2
F_1
Conditions
Ecosystem State

The challenge - Modelling



(Teurlincx et al., 2019)


τ : 50 d
τ : 100 d
τ : 125 d
τ : 150 d
τ : 364 d
Pphyt (g P m^{-2})
Pmacr (g P m^{-2})
Pload (mg P m^{-2} d^{-1})
Legend
PCLake
GPLake−M


z : 1.5 m
z : 2 m
z : 2.5 m
z : 4 m
z : 5 m
Pphyt
Pmacr
(g P m^{-2})
Pload (mg P m^{-2} d^{-1})
Legend
PCLake
GPLake−M