GPLake-M workshop

Hands-on application of an ecological lake model

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Workshop outline

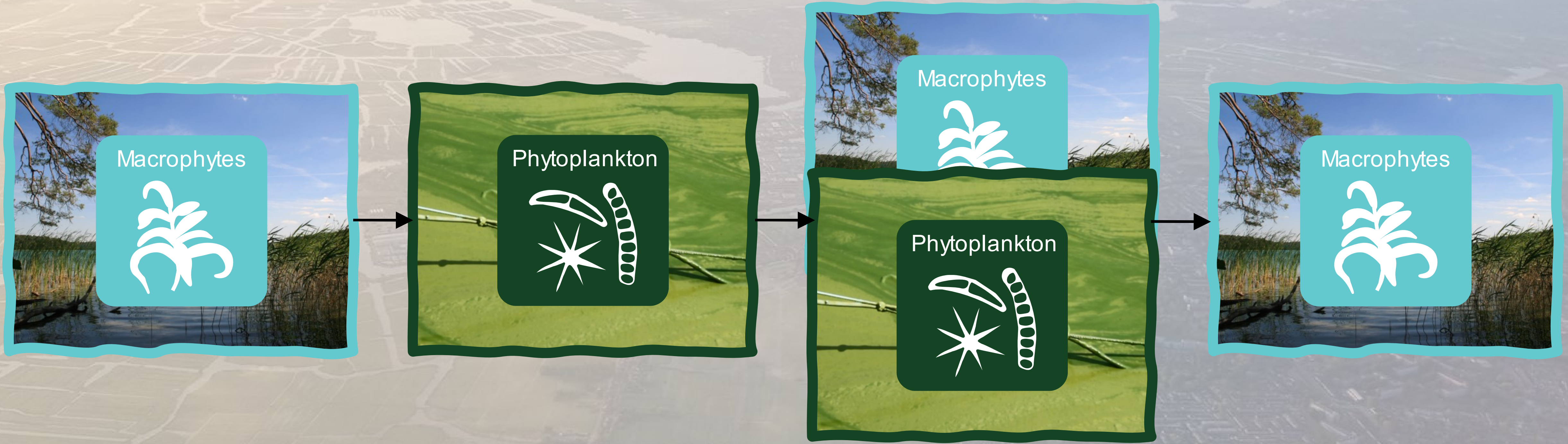
- Short intro Lake Veluwe case & GPLake-M
- Interactive discussion
- Appyling GPLake-M
- Reflection

Example application of GPLake-M

- Disclaimer: *This example is based on a real lake management case (o.a. described in Ibelings et al. 2007), but also uses fictive data. The aim is to show how the GPLake-M model can be applied.*

History of Lake Veluwe (Ibelings et al. 2007)

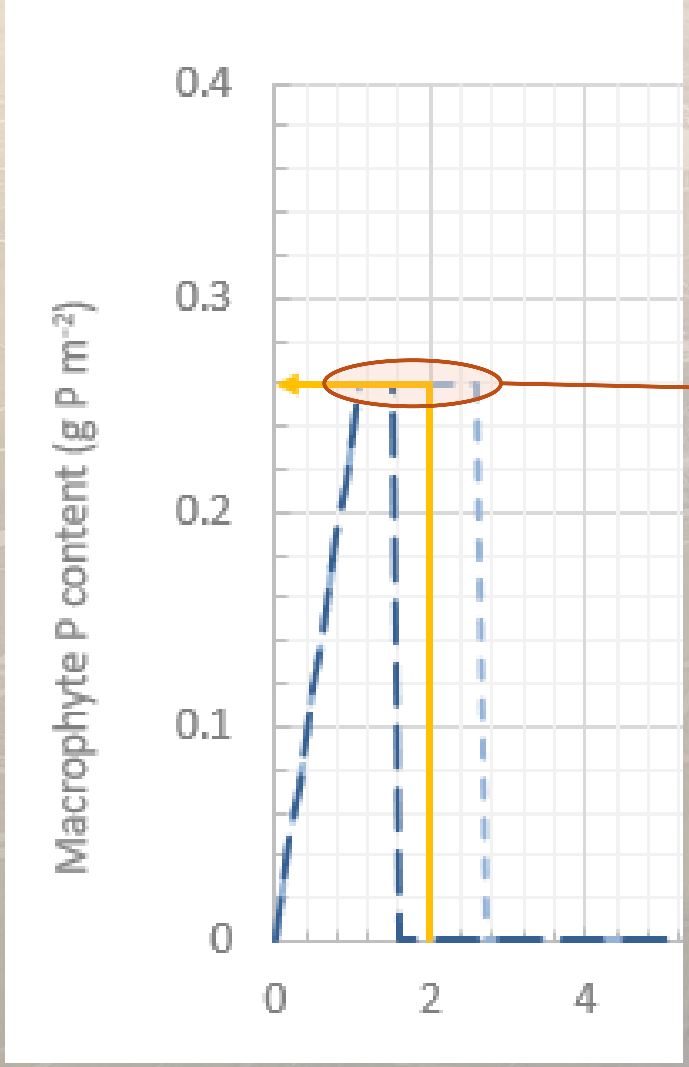
Phase 1 | Phase 2 | Phase 3 | Phase 4



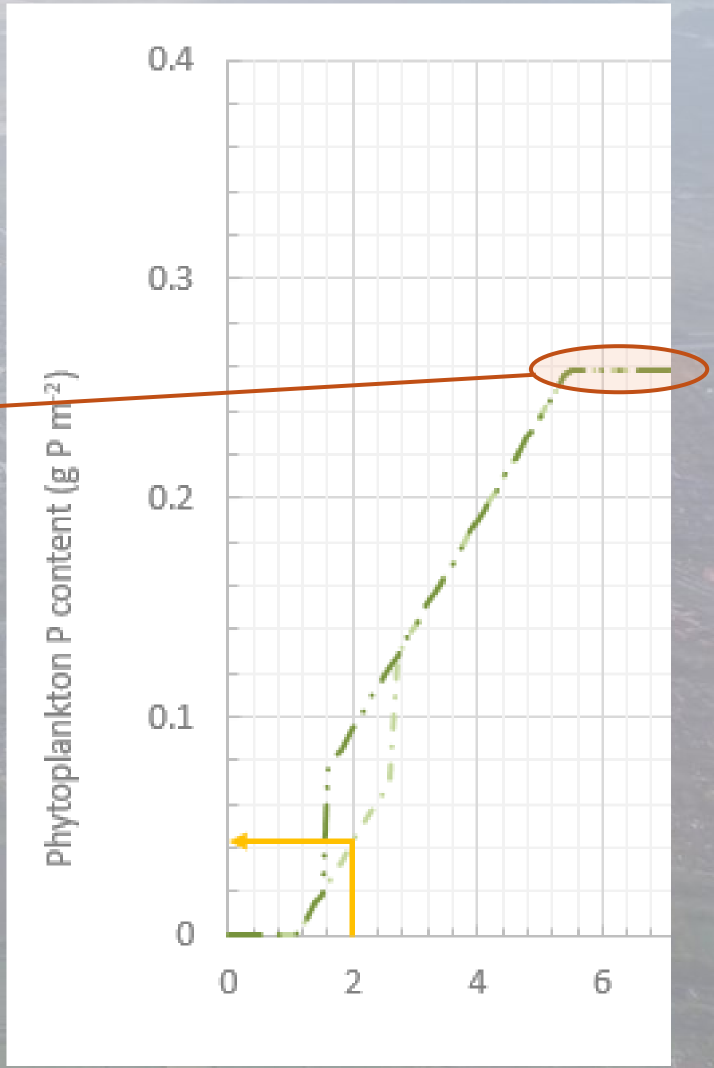
1957-1970 | 1971-1985 | 1986-1995 | 1996-present

Can we model this with GPLake-M?

Clear and turbid states in GPLake-M (van Wijk et al. 2023)



	Name	Value
INPUT	**Lake Characteristics**	
	Initial state	**clear**
	Current P loading [mg P m-2 d-1]	**2.0**
	Hydraulic residence time [d]	**100**
	Depth [m]	**2.0**
CONSTANTS	**GPLake-M parameters**	
	Critical turbidity [g P m-2]	0.073
	Plateau [g P m-2]	0.259
	Macrophyte Slope [d]	237
	Time scaling parameter s [d]	81
OUTPUT	**GPLake-M calculated parameters**	
	Phytoplankton Slope [d]	47.4
	Switch point I <- -> II [g P m-2 d-1]	0.0000
	Switch point II -> III [g P m-2 d-1]	0.0026
	Switch point II <- III [g P m-2 d-1]	0.0015
	Switch point III <- -> IV [g P m-2 d-1]	0.0055
	GPLake Water Quality Assessment at current P loading	
	Macrophyte P content [g P m-2]	**0.259**
	Phytoplankton P content [g P m-2]	**0.043**
	Current equilibrium set	**II**



Interactive discussion

- Kahoot!

What kind of management options do you know?

How to implement these management options in the model?

History of Lake Veluwe (Ibelings et al. 2007)

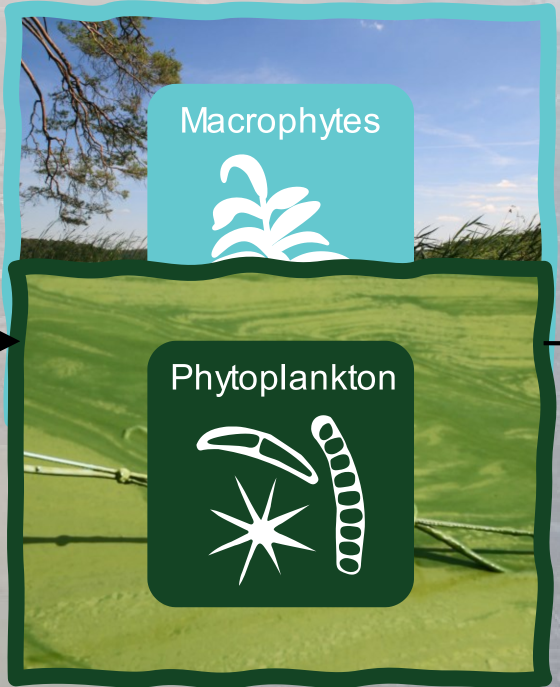
Phase 1

1957-1970

Phase 2

1971-1985

Phase 3



1986-1995

Phase 4

1996-present

Can we model this with GPLake-M?

Phase 1: 1957-1970: Initial clear state

- Check the ‘default settings’ of GPLake-M for an ‘average Dutch lake’
- Fill in the Lake characteristics of Lake Veluwe:
  - Initial state: Clear
  - Mean depth 1.5 m (Ibelings et al. 2007)
  - Assume:
    - Hydraulic residence time: 90 days
    - P loading: 2 mg P m^{-2} d^{-1}

- Result: Clear, macrophyte dominated

Phase 2a: 1971-1985: Increasing nutrient load

- P load increase to 3 g m^{-2} y^{-1} (Ibelings et al. 2007)

- Note unit conversion: 8.2 mg P m^{-2} d^{-1}

- Result: Turbid, phytoplankton blooms
- Background info: Mostly light attenuation by phytoplankton (Ibelings et al. 2007)

Phase 2b: 1979: Nutrient load reduction

- P load reduction from 3 to about 1 g m^{-2} y^{-1} (Ibelings et al. 2007)

- Note unit conversion: 2.7 mg P m^{-2} d^{-1}
- Note: Change initial state to turbid (result Phase 2a)

- Result: Less phytoplankton, but turbid
- Background info: Mostly non-algal light attenuation (Ibelings et al. 2007)

Phase 2c: 1979: Non-algal light attenuation

- How to implement background turbidity in the model?

- Decrease in critical turbidity
  - Assume: 10% decrease

- Result: Less phytoplankton, but turbid

Phase 2d: 1979-1985: Flushing

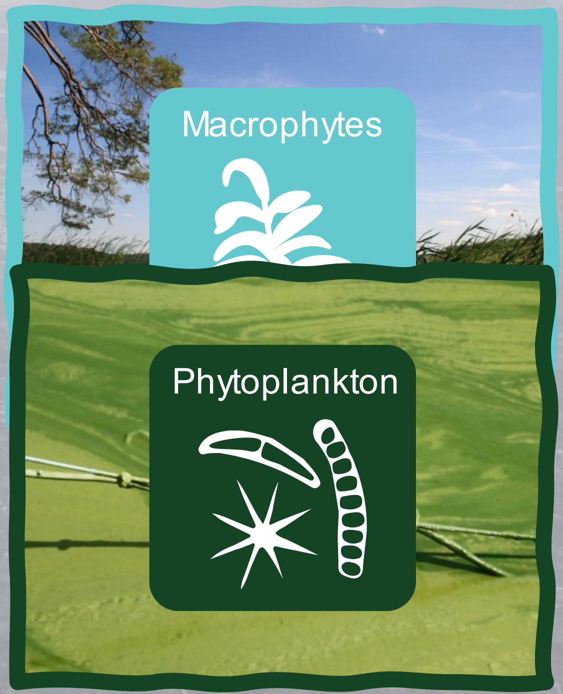
- How to implement Flushing?

- Reduce hydraulic residence time
  - Assume: 58 days (Janse et al. 2008)

- Result: Less phytoplankton, but turbid

Phase 3a: 1986-1995: Nutrient load reduction

- Reduce nutrient load to 2.3 mg P m^{-2} d^{-1}



- Result: Less phytoplankton, but turbid
- Background info: Shallow parts clear, deep parts turbid (Ibelings et al. 2007)

Phase 3b: 1994: Fish removal

- Removal of bioturbating fish (bream)
- Why?
  - Less sediment resuspension
- How to implement?
  - Set critical turbidity back to default
- Result: Clear, macrophyte dominated
- Background info: Rapid expansion of macrophytes to deeper parts of the lake and return of zebra mussles (Ibelings et al. 2007)

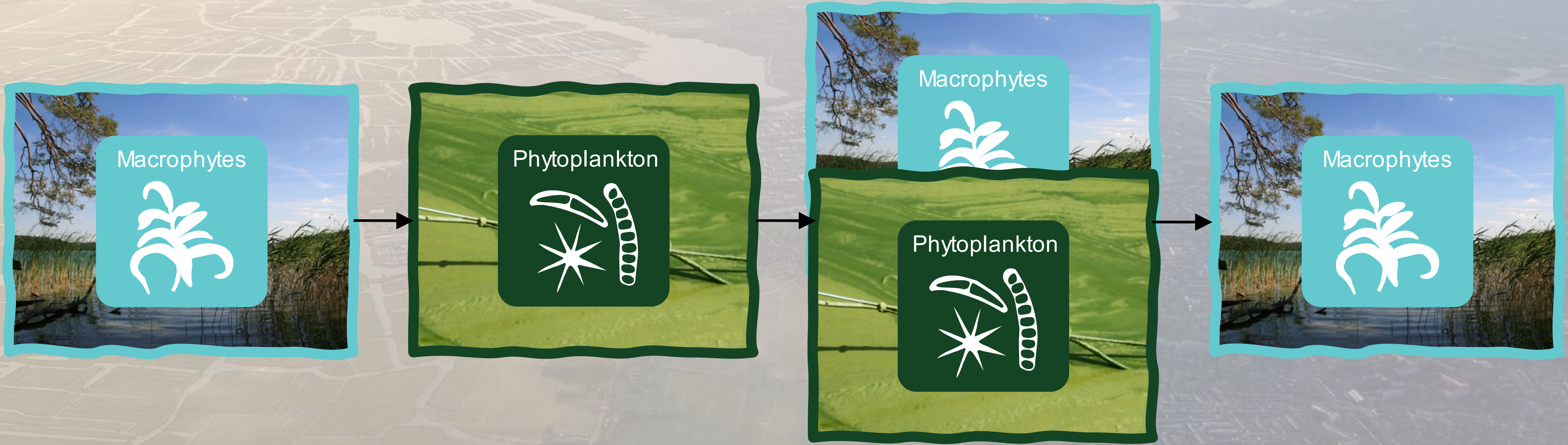
Phase 4: 1996-present

- How resilient is the lake to changes in nutrient loading?
  - Test by stepwise increasing nutrient loadings
  - Note: Change initial state to clear (result Phase 3d)

- Result: Final clear state
  - Up to P loading threshold for turbidification: 3.42 mg P m^{-2} d^{-1} (Janse et al. 2008)

History of Lake Veluwe (Ibelings et al. 2007)

Phase 1 | Phase 2 | Phase 3 | Phase 4



1957-1970 | 1971-1985 | 1986-1995 | 1996-present

Well done!

Reflection time…

References

- **Ibelings, B.W., Portielje, R., Lammens, E.H., *et al.*, 2007.** Resilience of alternative stable states during the recovery of shallow lakes from eutrophication: Lake Veluwe as a case study. Ecosystems, 10, 4-16.

- **Janse, J. H., Domis, L. N. D. S., Scheffer, M., *et al.*, 2008.** Critical phosphorus loading of different types of shallow lakes and the consequences for management estimated with the ecosystem model PCLake. Limnologica, 38(3-4), 203-219.

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