NICHES

Nature's integration
in cities' hydrologies,
ecologies and societies

Assessing Ecological Resilience of urban catchments to combined sewage overflows: *The case of Rotterdam*

Dr. Sven Teurlincx (NIOO-KNAW)

Bringing forward NBS in major cities /
24-03-2025 / Online

Funded by
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MEET THE TEAM

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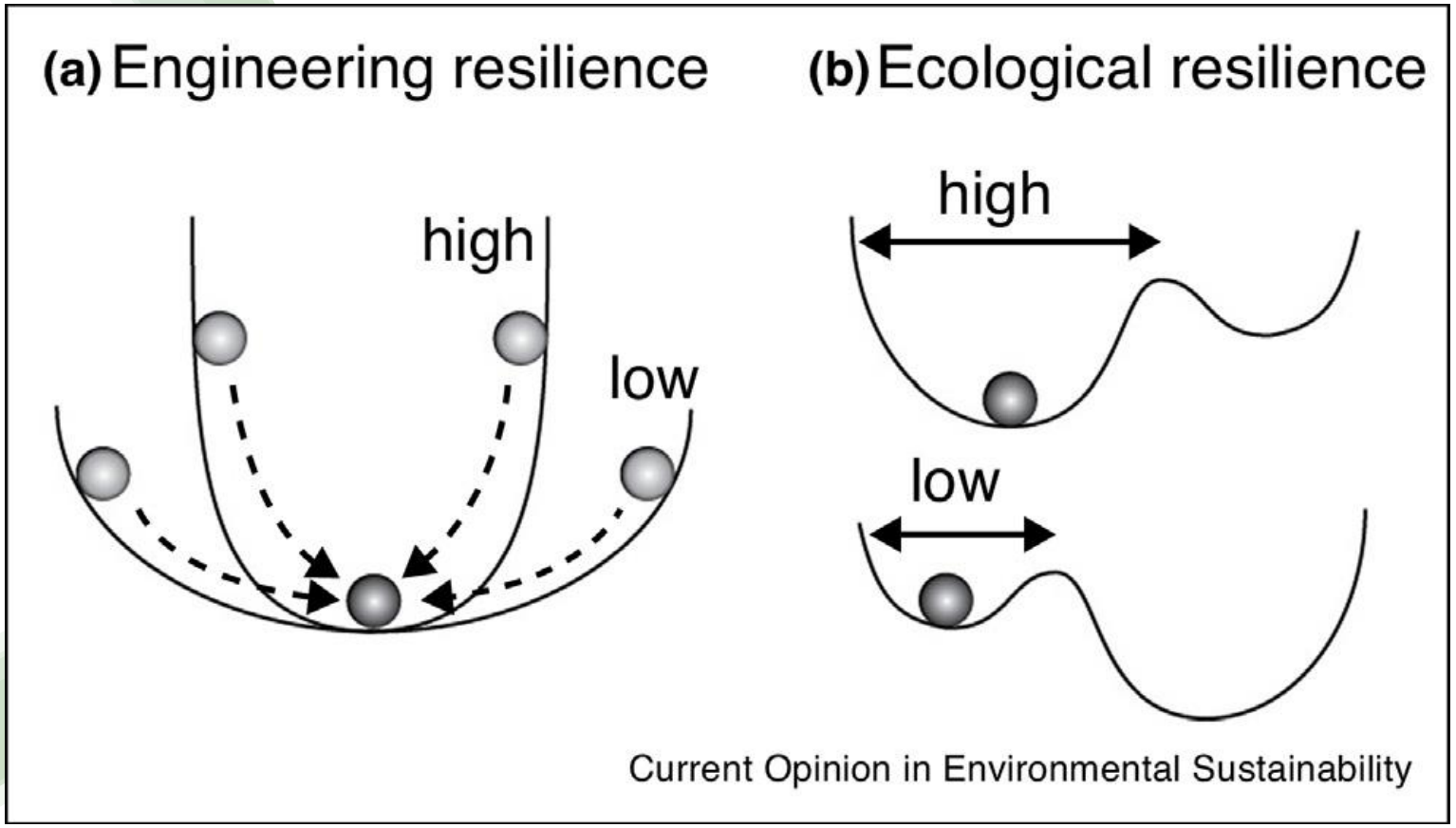
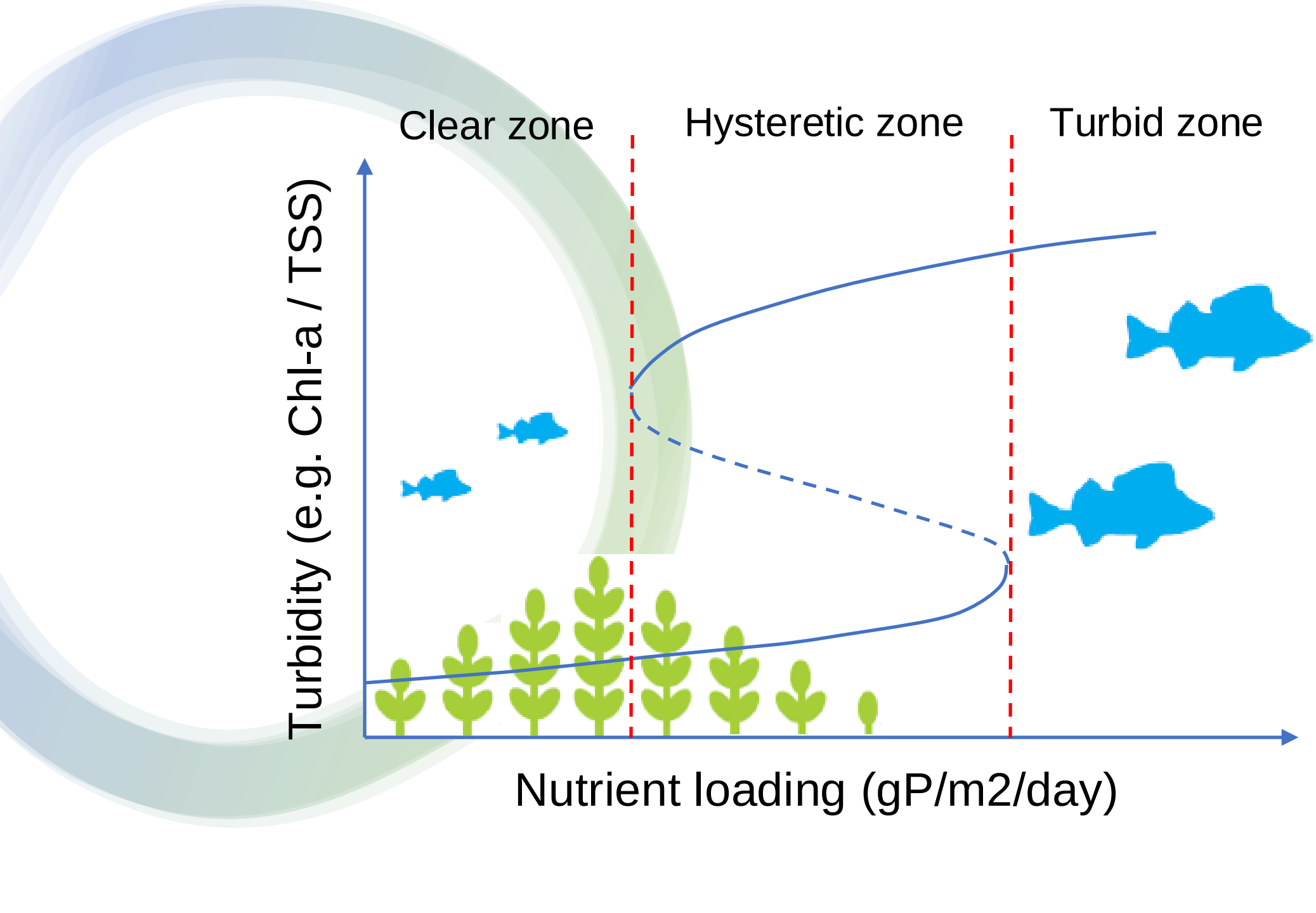
Setting the stage: Ecological vs technical resilience

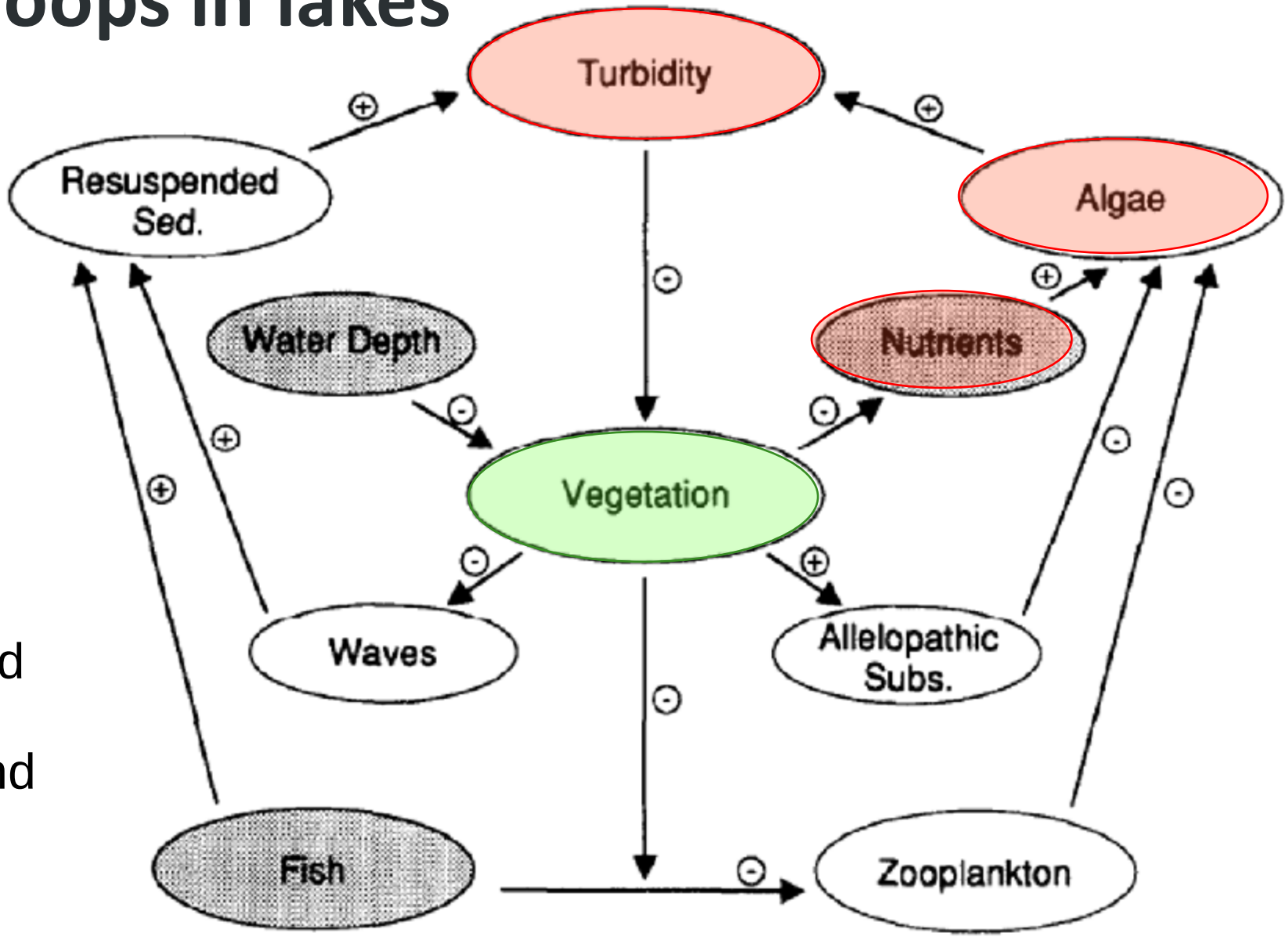
- Technical
  - Single state
- Ecological
  - Multi-state



Sterk, M., van de Leemput, I. A., & Peeters, E. T. (2017). How to conceptualize and operationalize resilience in socio-ecological systems?. *Current opinion in environmental sustainability*, *28*, 108-113.


Clear zone
Hysteretic zone
Turbid zone
Turbidity (e.g. Chl-a / TSS)
Nutrient loading (gP/m2/day)

Feedback loops in lakes

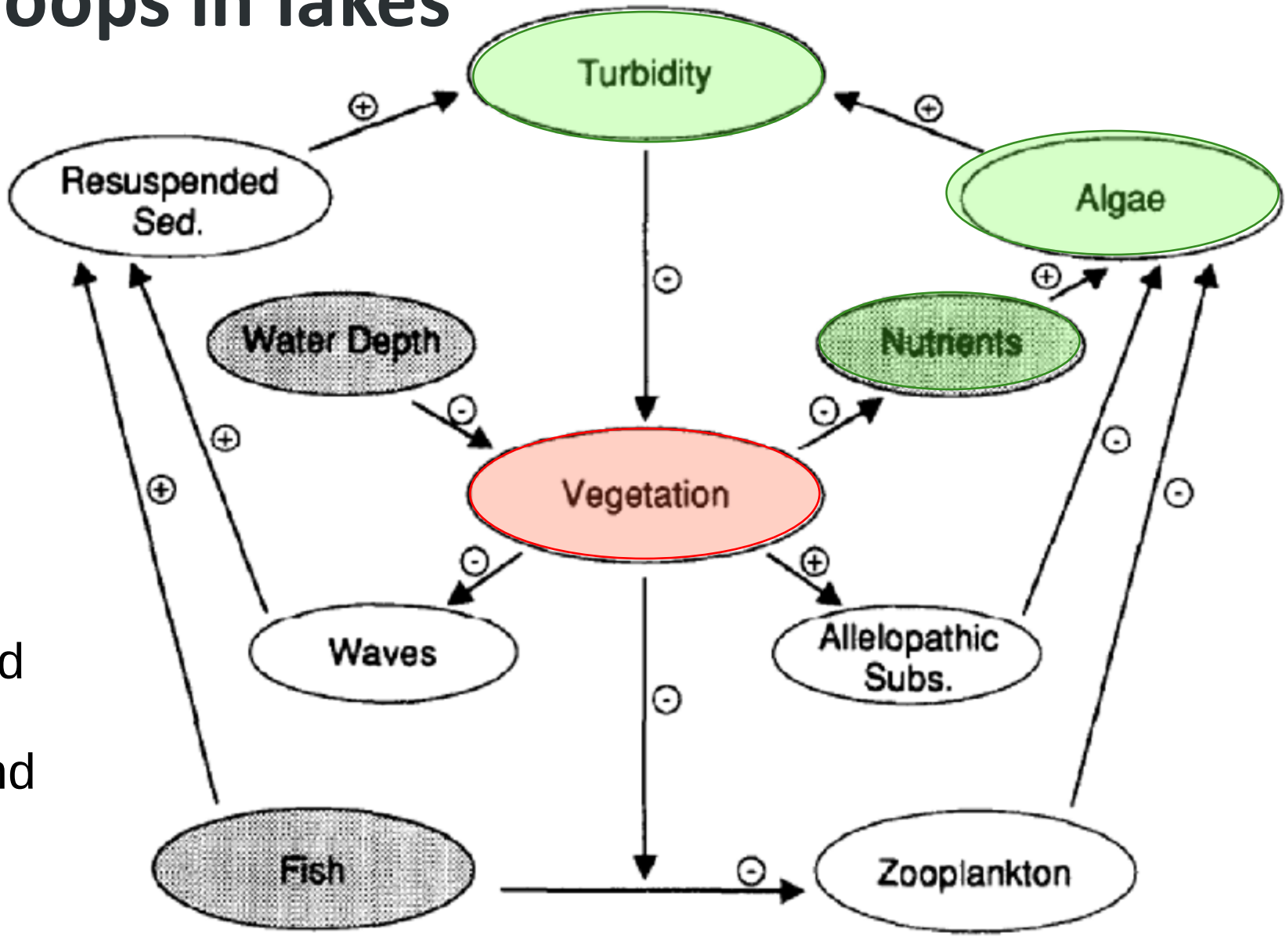


+ Similar trend

- Inverse trend

Scheffer, M., et al (1993). Alternative equilibria in shallow lakes. *Trends in Ecology & Evolution, 8*(8), 275-279.

Feedback loops in lakes



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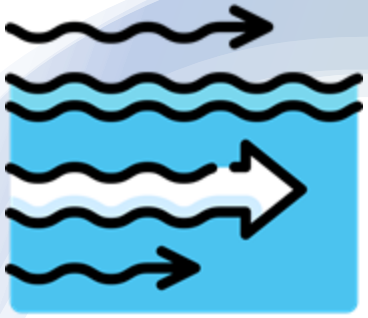

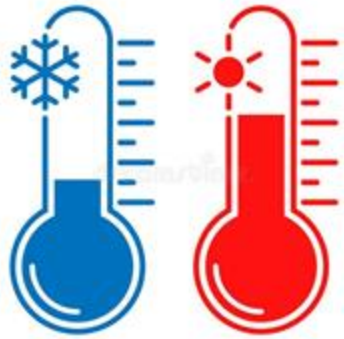

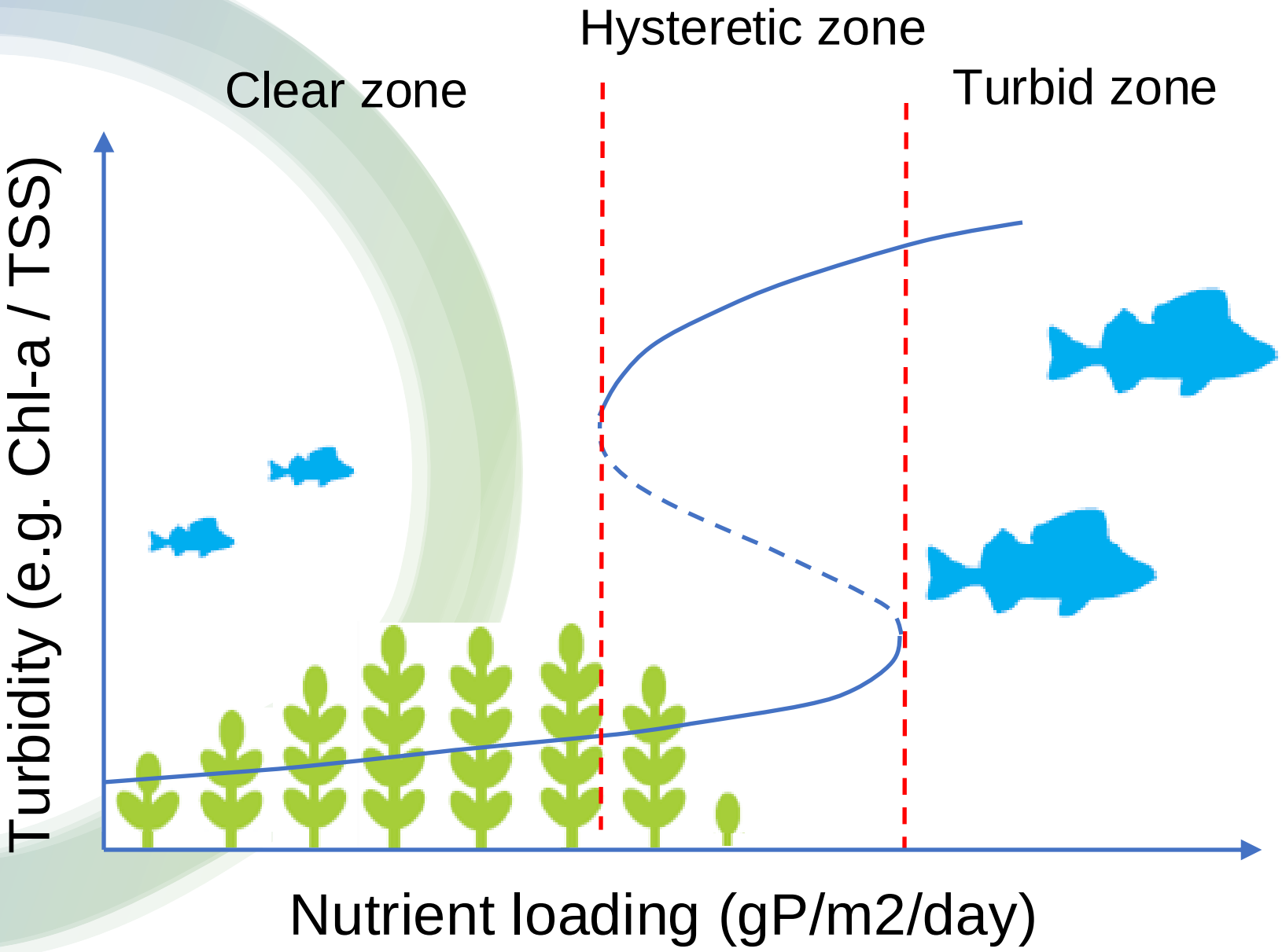
Clear zone
Hysteretic zone
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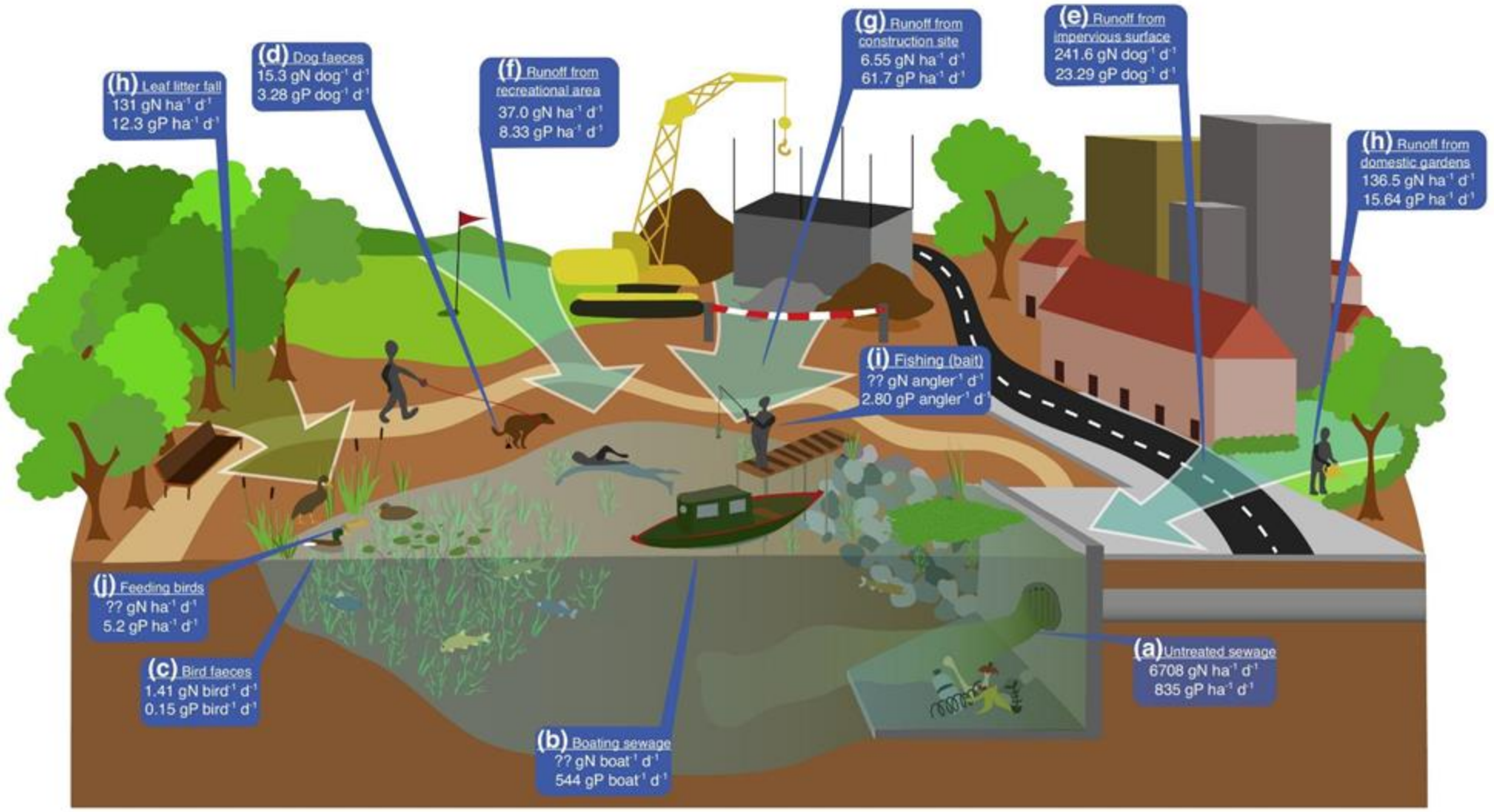
Turbidity (e.g. Chl-a / TSS)
Nutrient loading (gP/m2/day)

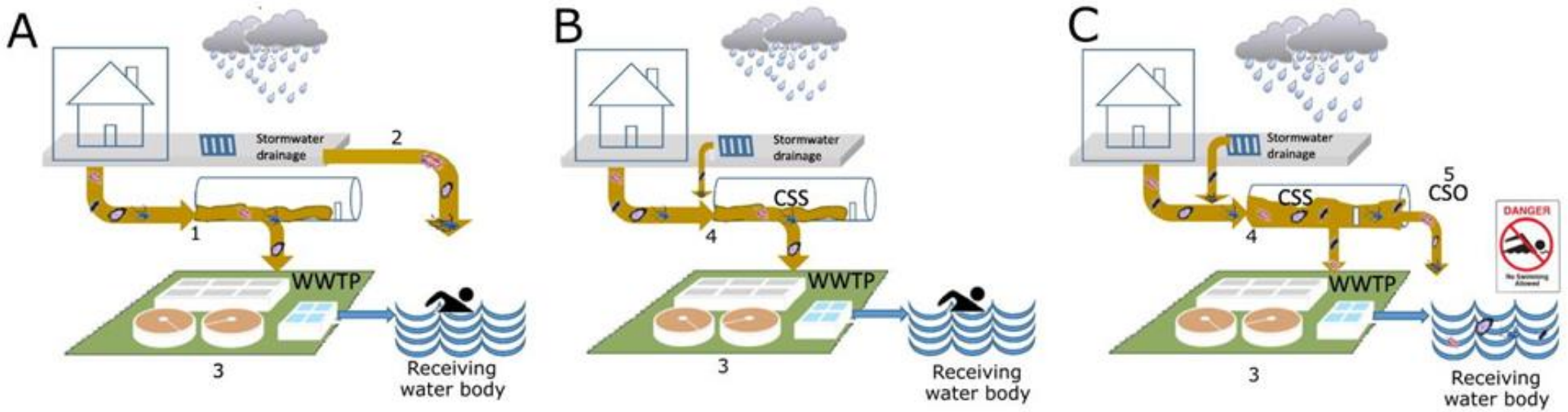
Nutrient sources in urban context



Teurlincx, S., Kuiper, J. J., Hoevenaar, E. C., Lurling, M., Brederveld, R. J., Veraart, A. J., ... & de Senerpont Domis, L. N. (2019). Towards restoring urban waters: understanding the main pressures. *Current Opinion in Environmental Sustainability*, *36*, 49-58.

Combined sewer overflows (CSOs)

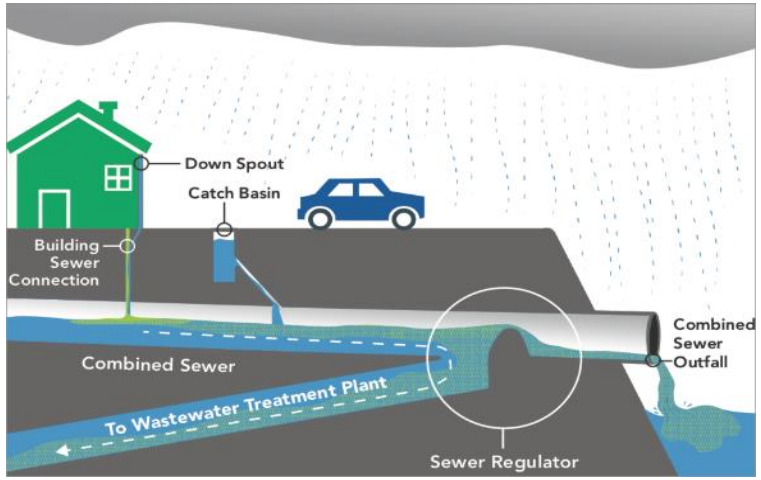
- Impacts on water quality for people
  - Ecosystem services
- Impacts on water quality for nature
  - Ecological water quality



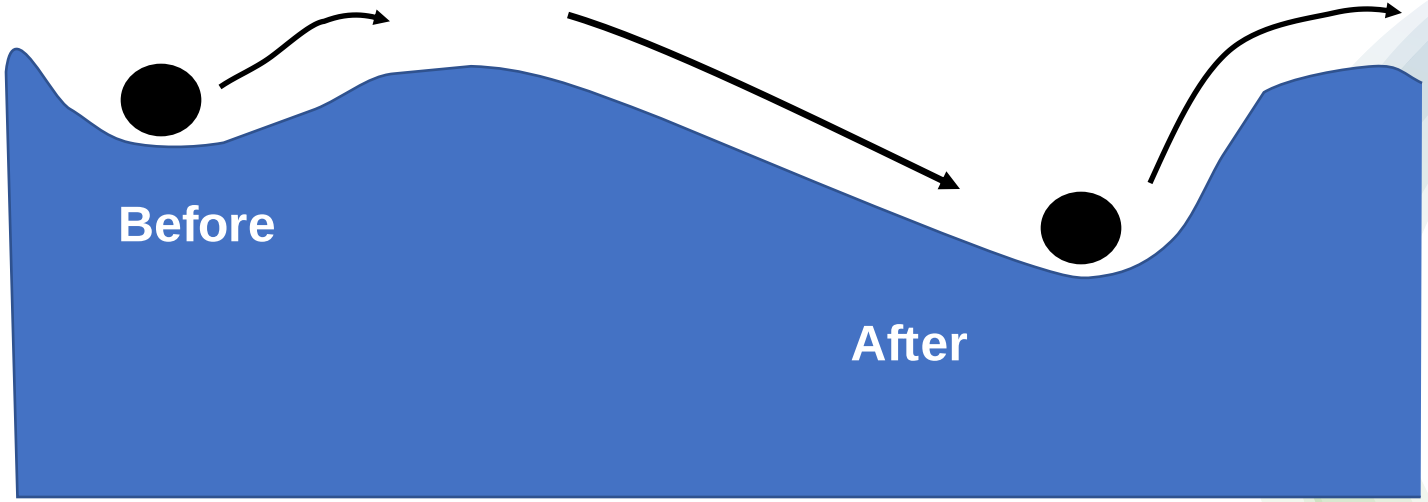
1- Wastewater sewer	2- Stormwater sewer	3- Wastewater treatmen plant (WWTP)
4- Combined sewer system (CSS)	5- Combined sewer overflow (CSO)	

Botturi, A., Ozbayram, E. G., Tondera, K., Gilbert, N. I., Rouault, P., Caradot, N., ... & Fatone, F. (2021). Combined sewer overflows: A critical review on best practice and innovative solutions to mitigate impacts on environment and human health. *Critical Reviews in Environmental Science and Technology*, *51*(15), 1585-1618.

Ecological resilience in the context of CSOs



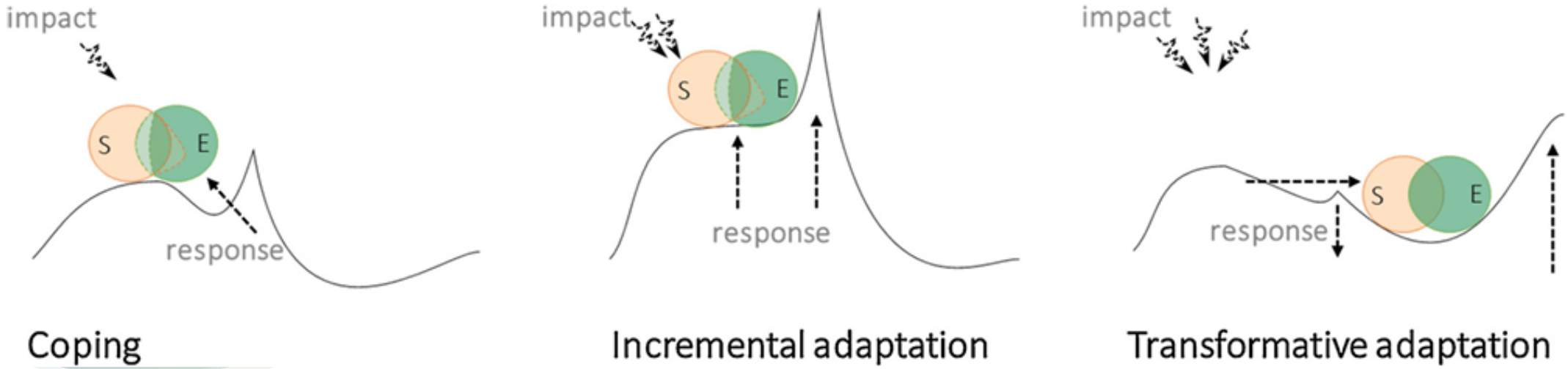
Effects of extreme precipitation



Adapted after Munthali, De Senerpont Domis & Marcé, *Environmental Research Letters, 2022*

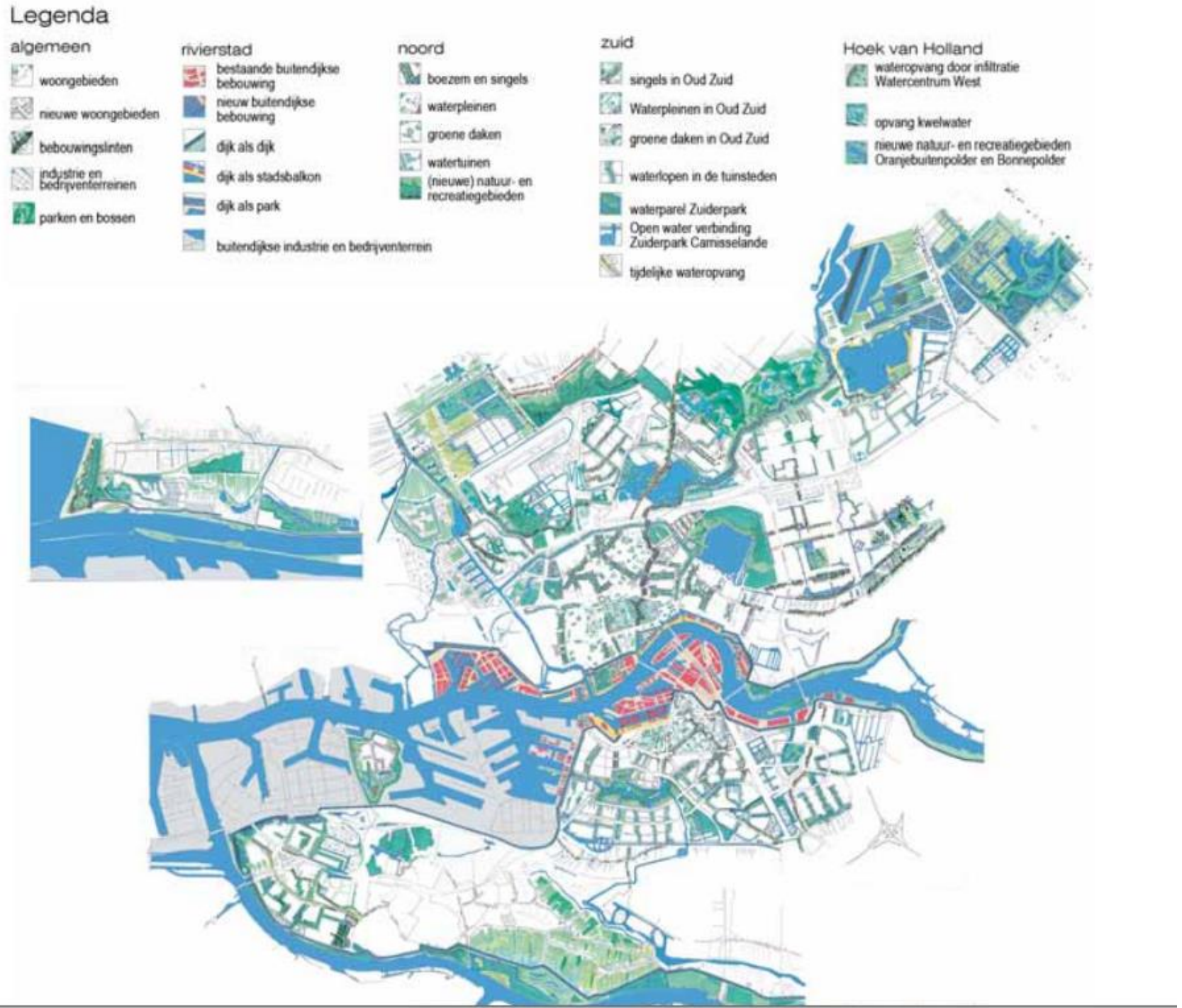
Adaptation strategies and resilience thinking

- *Coping*: continual effort to push back against collapse
- *Incremental*: Increase resilience of the system in current state
- *Transformative:* Shift to a more desireable and stable state



Fedele, G., Donatti, C. I., Harvey, C. A., Hannah, L., & Hole, D. G. (2019). Transformative adaptation to climate change for sustainable social-ecological systems. *Environmental Science & Policy*, *101*, 116-125.

Rotterdam case study



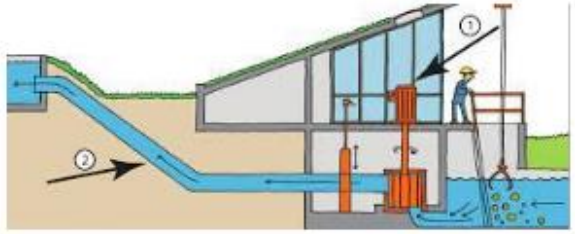
Rotterdam water system: CSOs

Gravity sewers
2.678 km

1711 km combined sewers
567 km rainwater sewers
183 km waste water sewers

Sewage pressure pipe
365 km

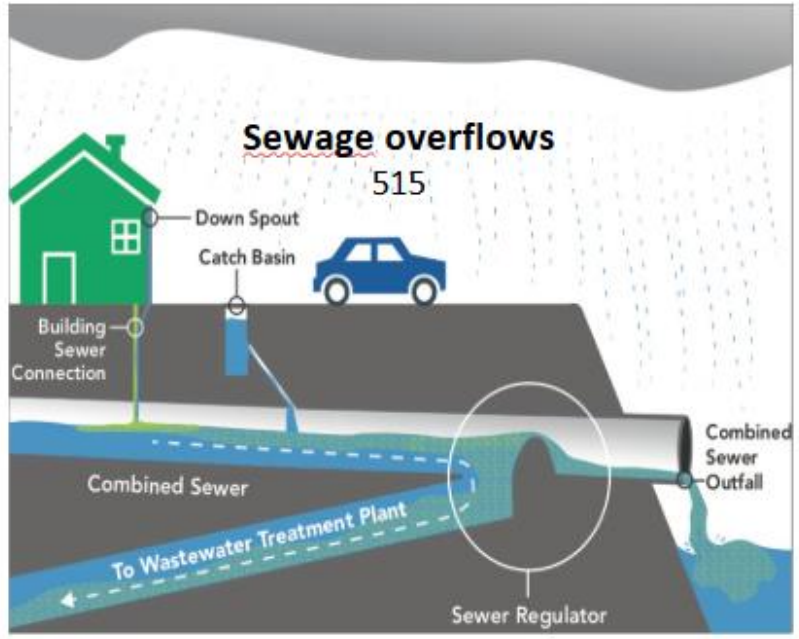
Pumping stations
964



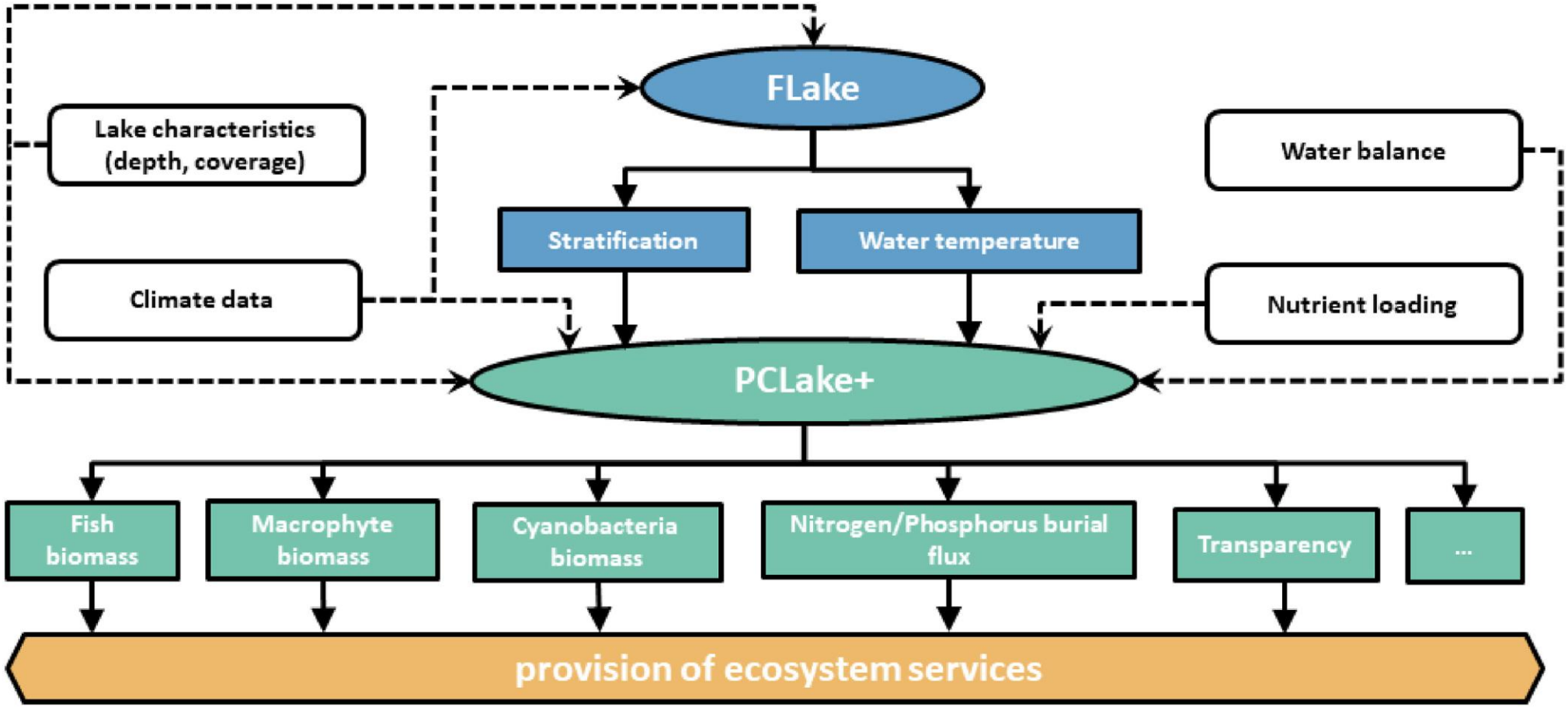
Rainwater drainage systems

10 infiltration reservoirs
4 water squares
2 retention squares

Sewage overflows
515

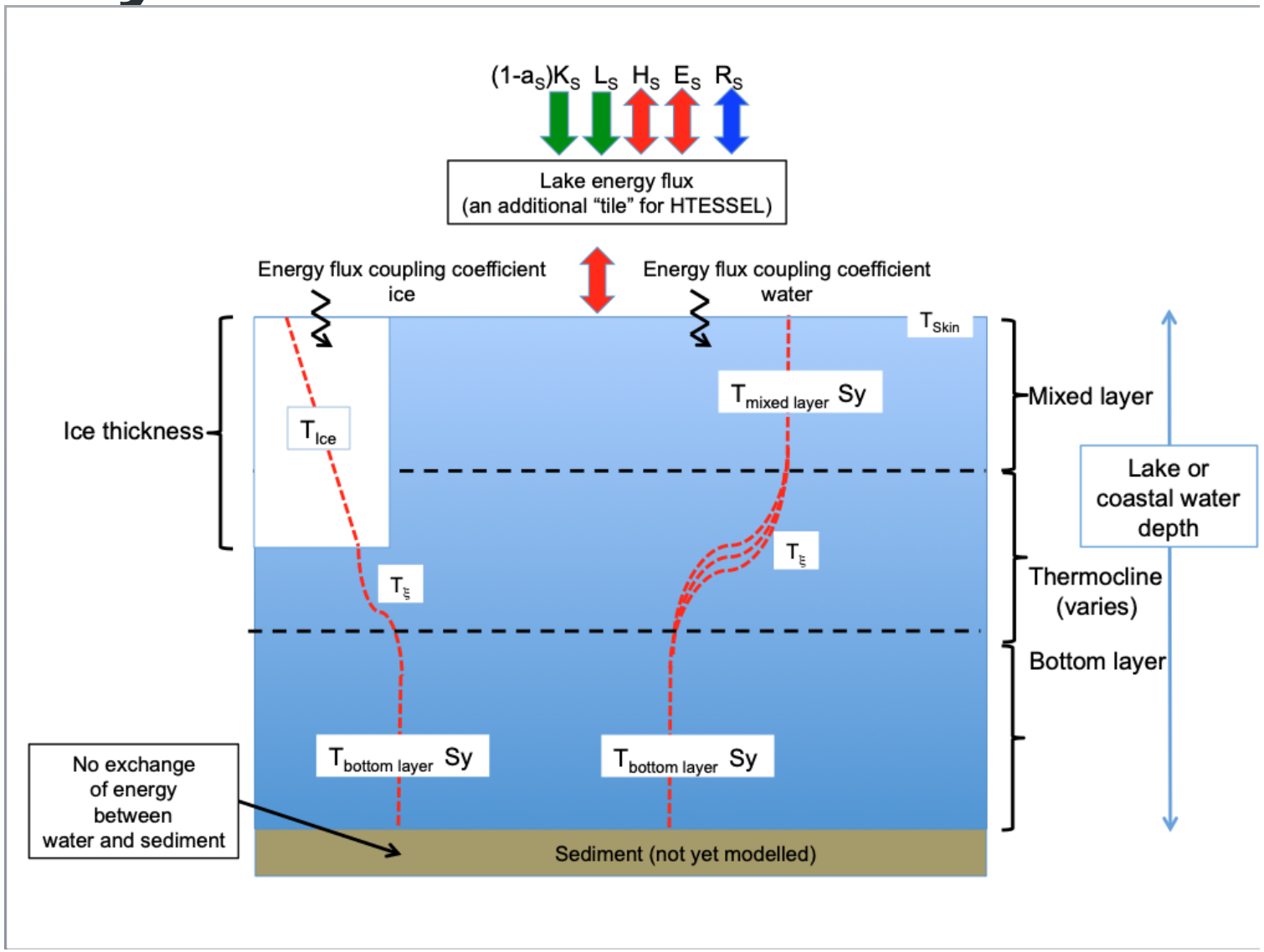


Modeling CSO Impacts: *Flake-PCLake-ES module*



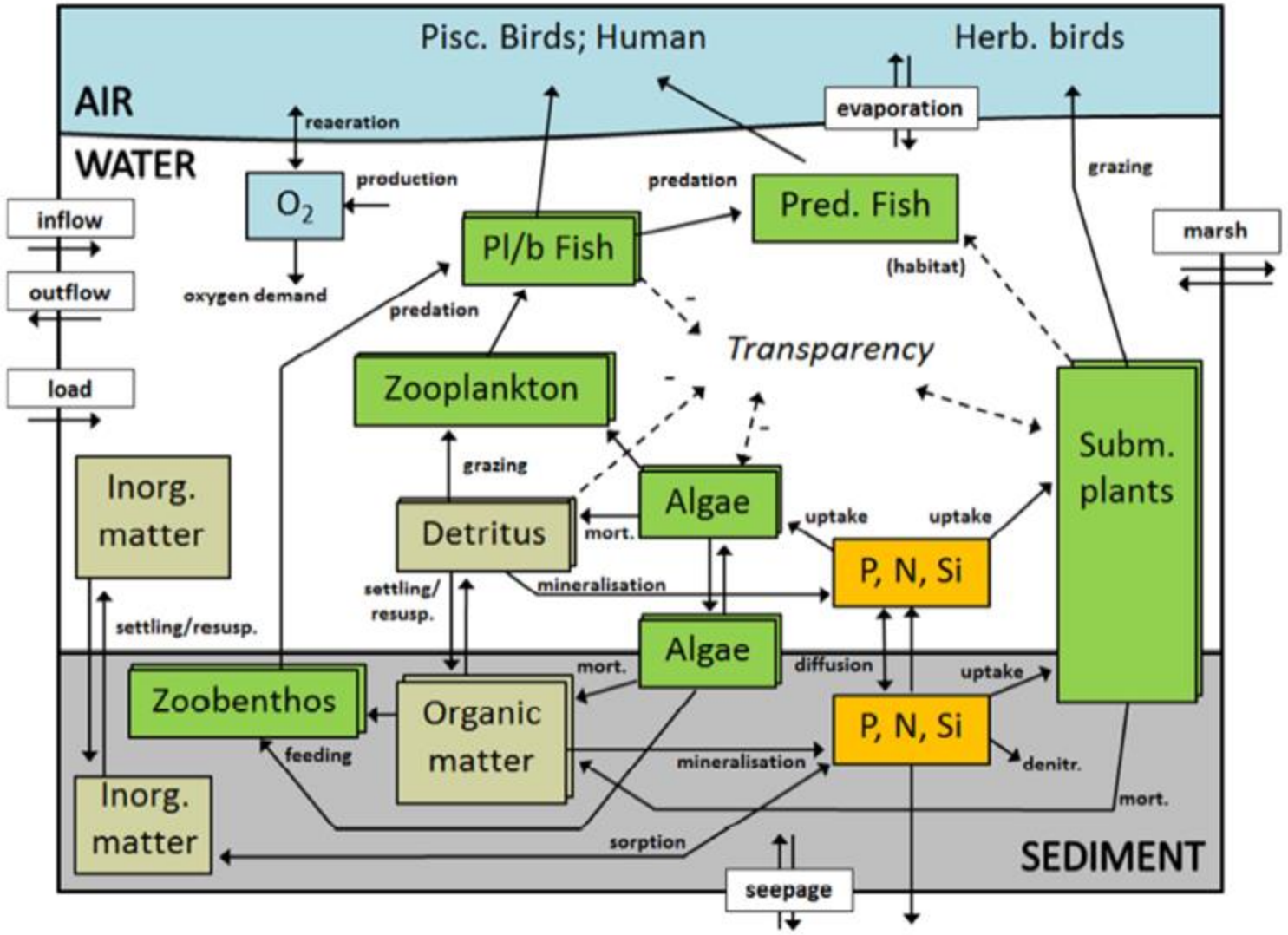
Zhan, Q., de Senerpont Domis, L. N., Lürling, M., Marcé, R., Heuts, T. S., & Teurlincx, S. (2023). Process-based modeling for ecosystem service provisioning: Non-linear responses to restoration efforts in a quarry lake under climate change. *Journal of environmental management*, *348*, 119163.

FLAKE: Physical model



Mironov, D., Heise, E., Kourzeneva, E., Ritter, B., Schneider, N., & Terzhevik, A. (2010). Implementation of the lake parameterisation saheme FLake into the numerical weather prediction model COSMO. *Boreal environment research*, *15*(2).

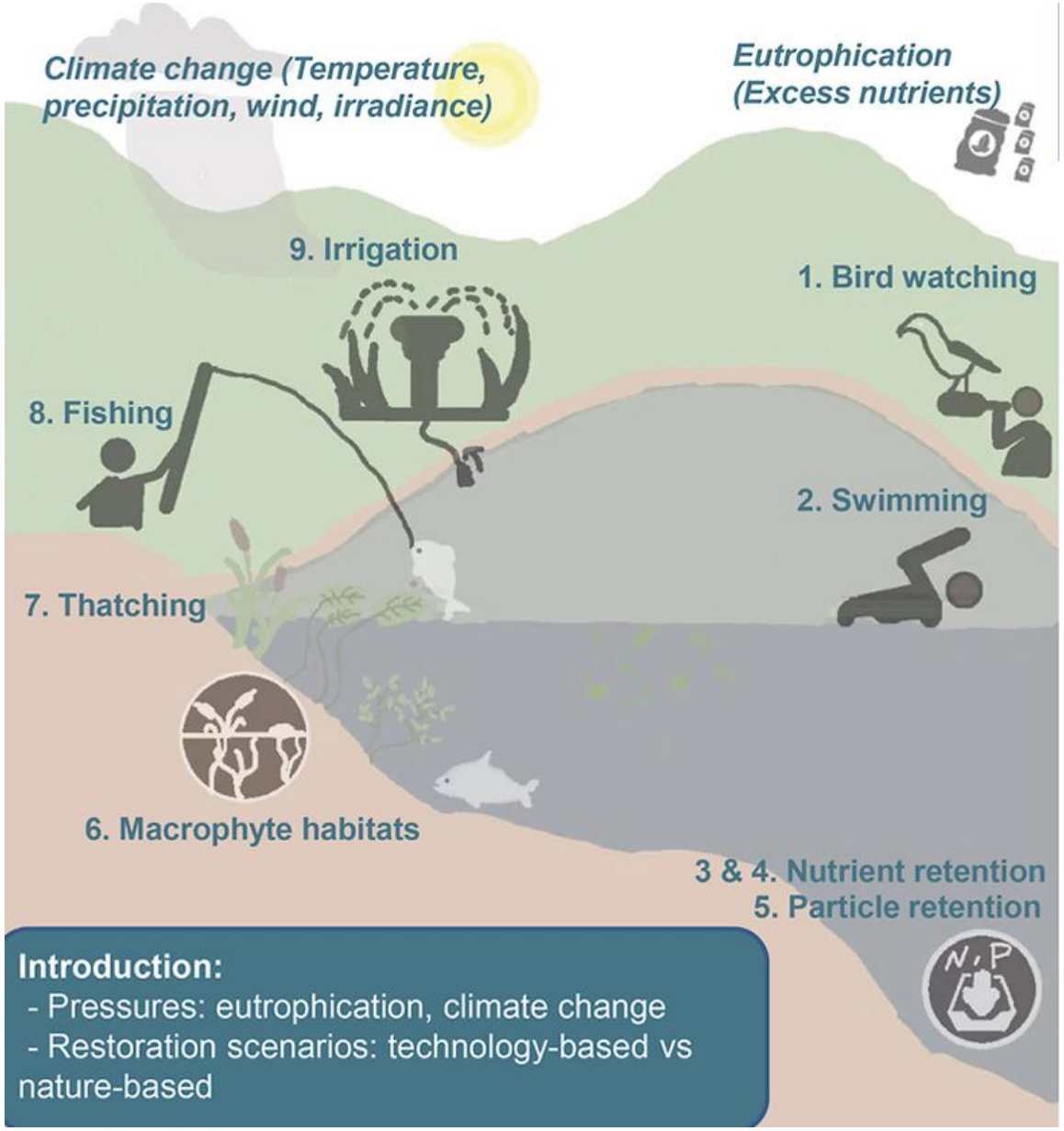
PCLake+: Ecosystem model



Janssen, A. B., Teurlincx, S., Beusen, A. H., Huijbregts, M. A., Rost, J., Schipper, A. M., ... & Janse, J. H. (2019). PCLake+: A process-based ecological model to assess the trophic state of stratified and non-stratified freshwater lakes worldwide. *Ecological modelling*, *396*, 23-32.

ES module

- *Functioning to services*: Links to PCLake+ outcomes
- *Thresholds*: Suitability based on socially acceptable norms and regulations (e.g. WHO, EU-WFD)



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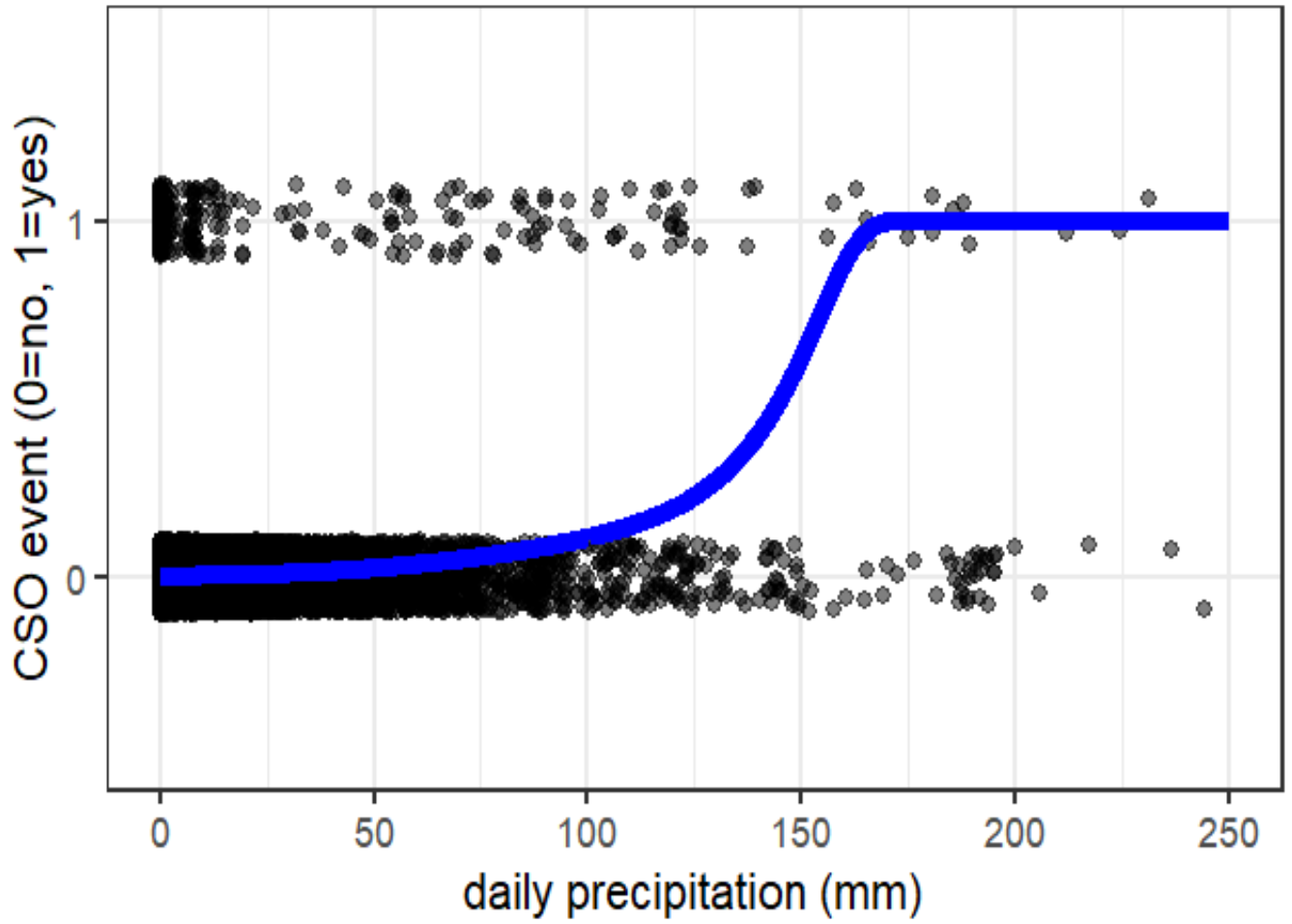
Precipitation and CSO events

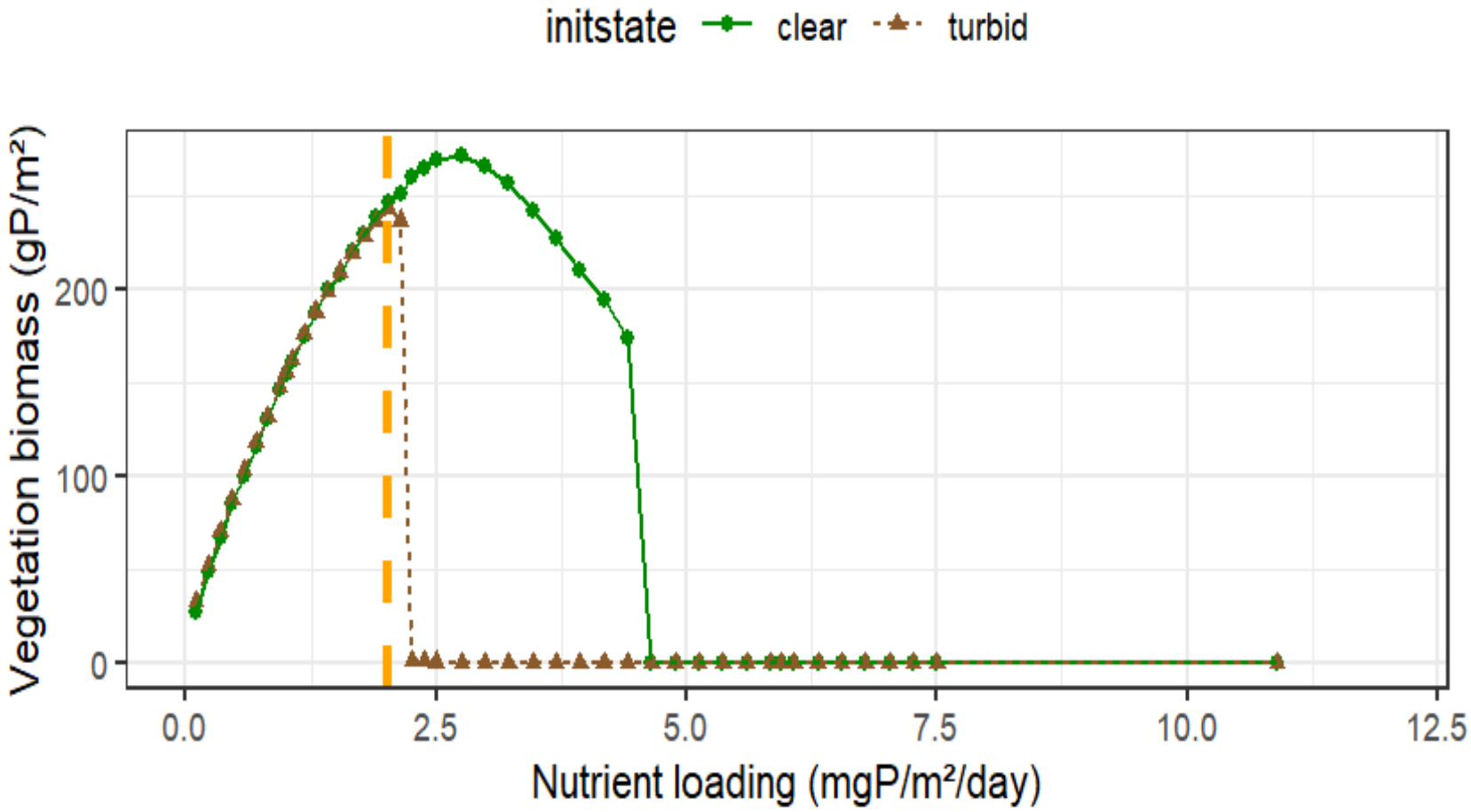


- *Time scales:* Model includes short (hour) and longer term rainfall (up to 7 days)
- *Local meteo:* localized rainfall rasters
- Risk of CSO events

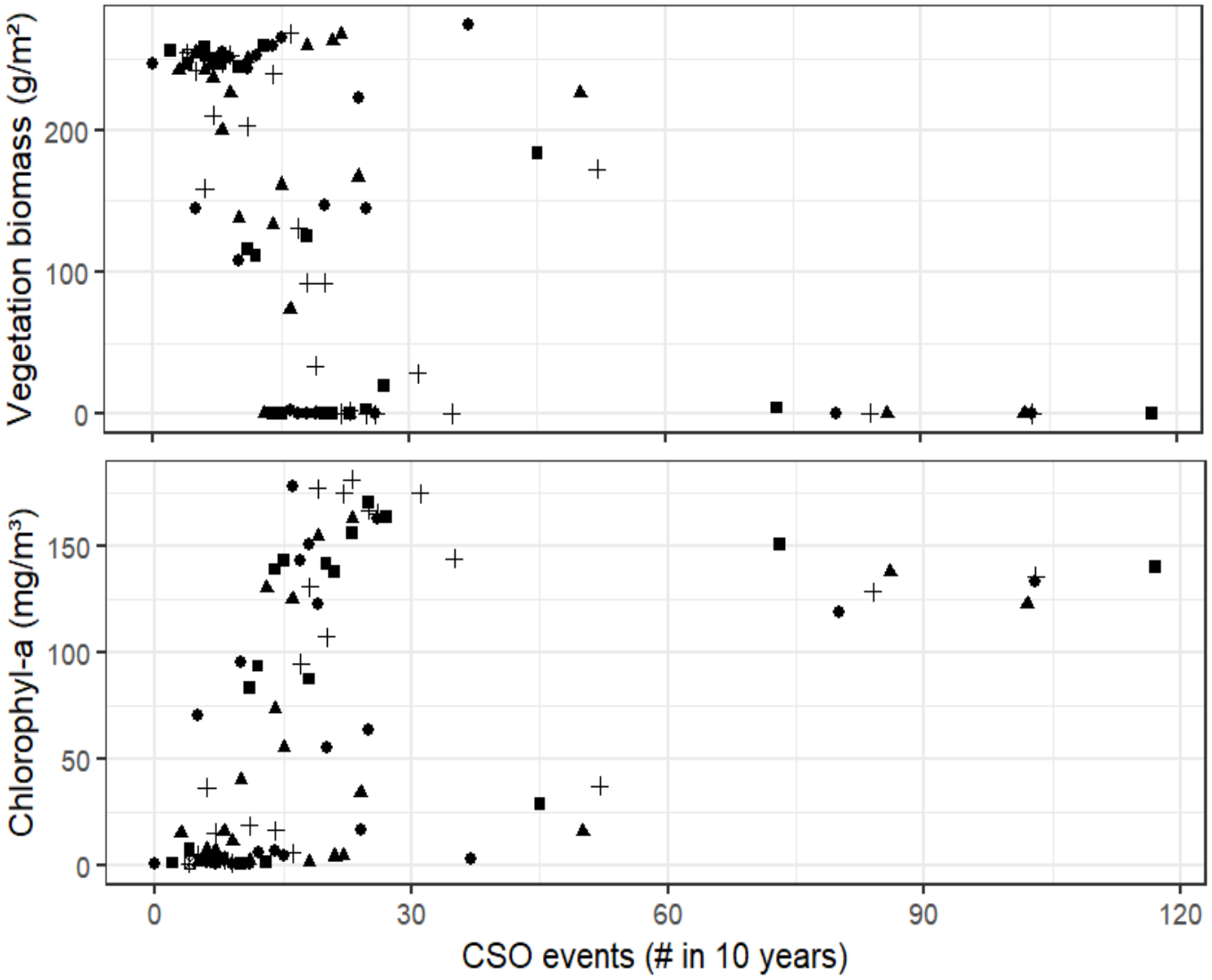
Teurlincx, de Senerpont Domis, in prep

Ecological impact of CSO events

- *Standard Rotterdam urban water*: Small, shallow, 20 day residence time

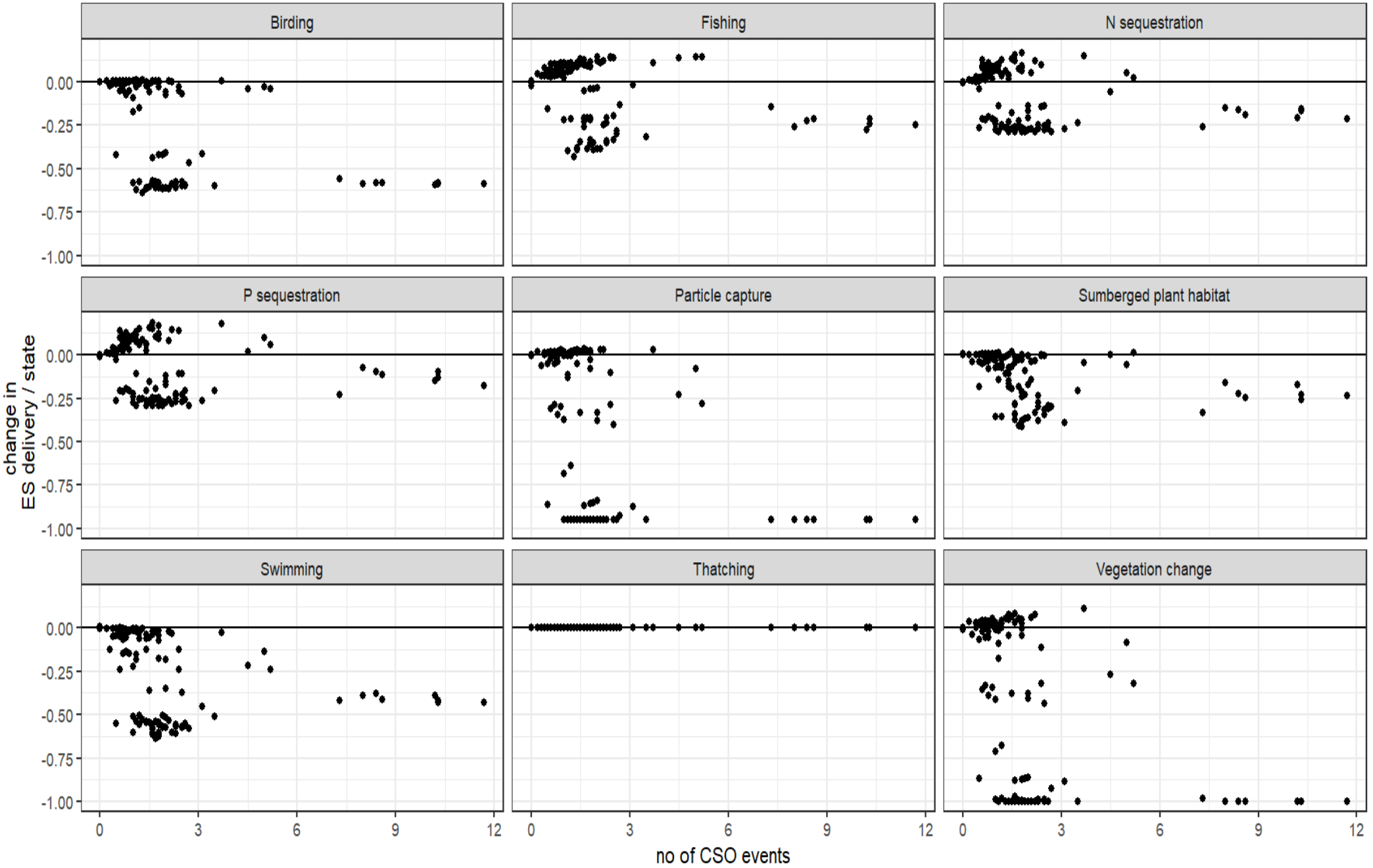


Impact of gradients of CSO frequency on ecological vulnerability

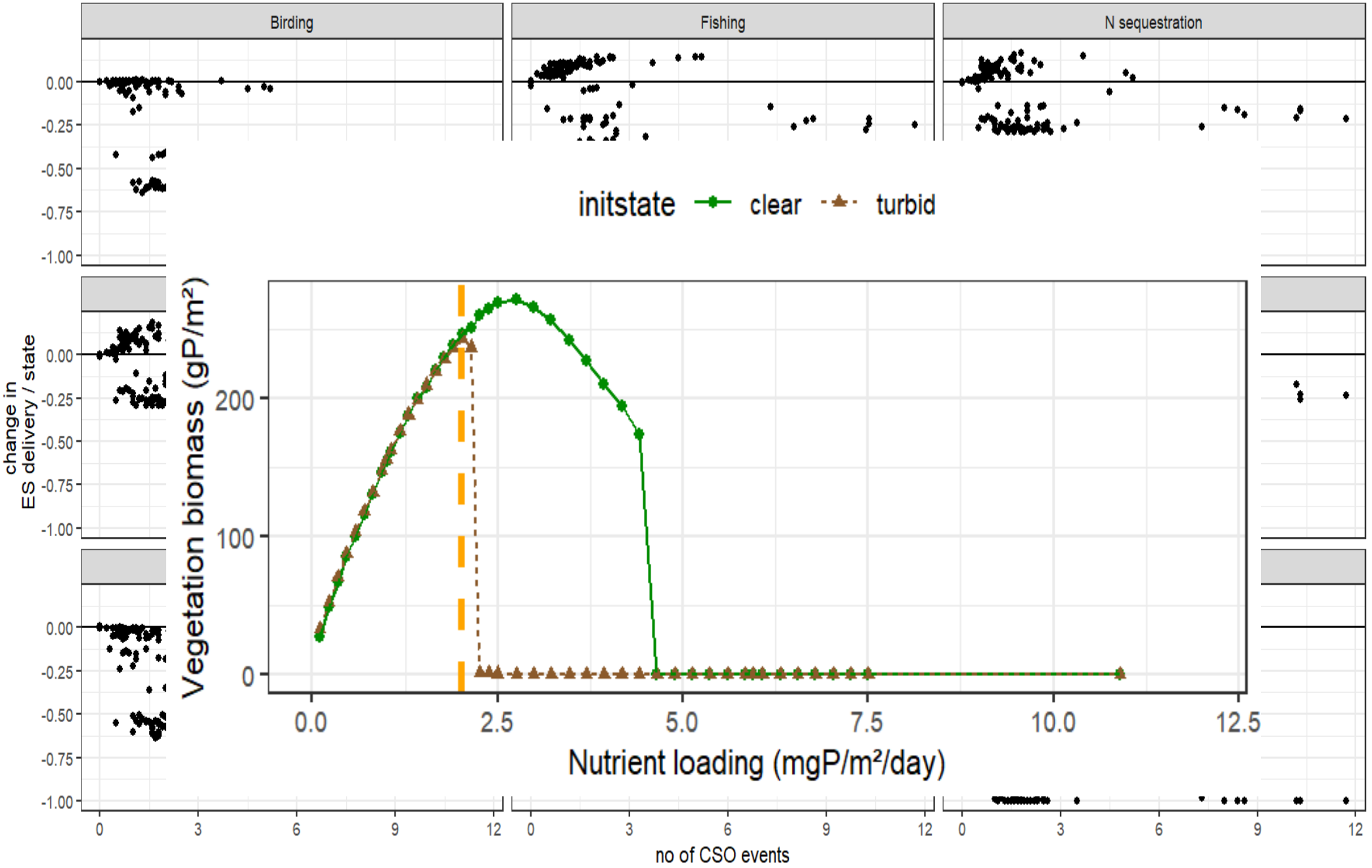


- *Increasing rainfall intensity:* increases chances of CSO occurrance
- 500 model runs

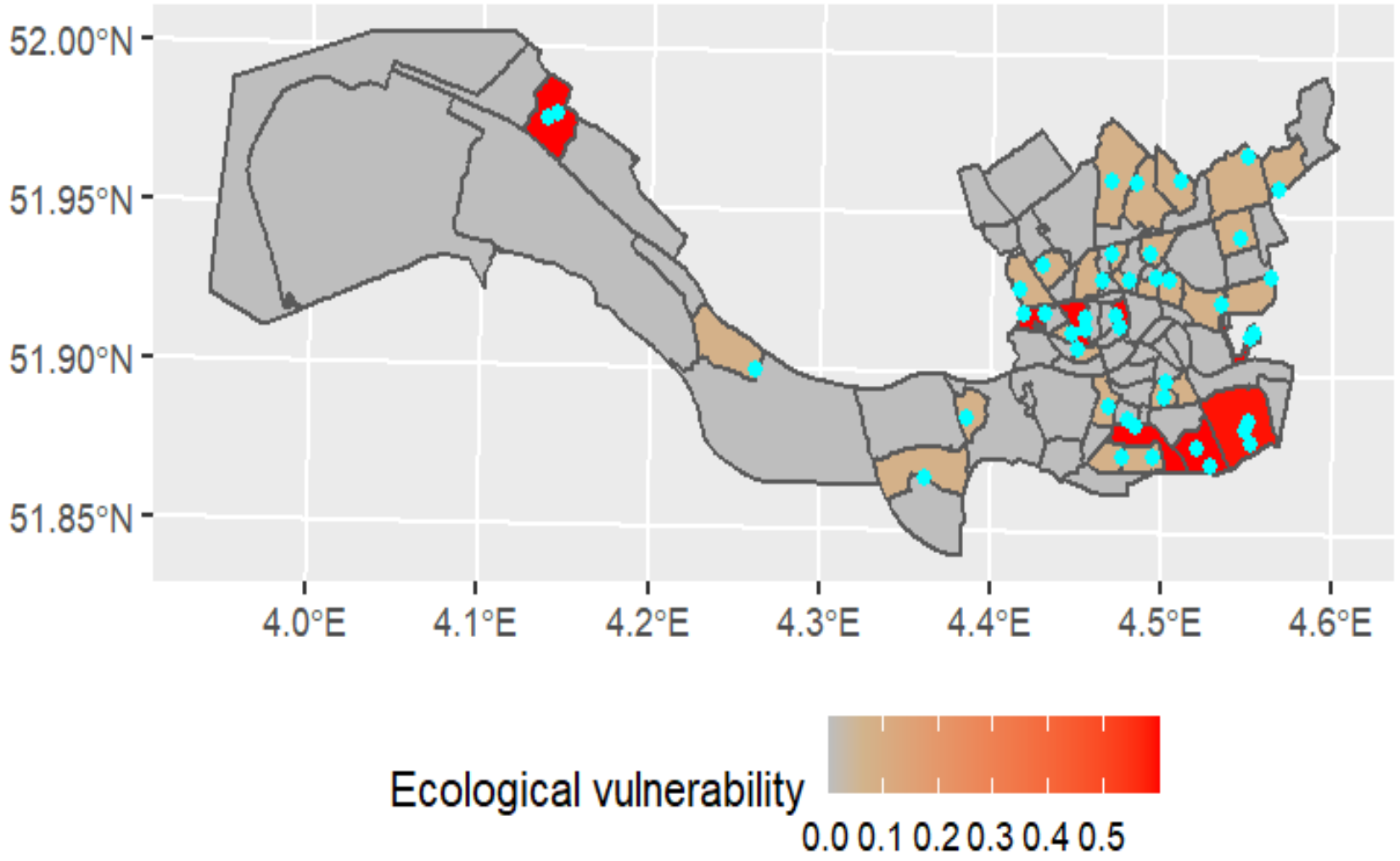
ESs


Birding
Fishing
N sequestration
P sequestration
Particle capture
Sumberged plant habitat
Swimming
Thatching
Vegetation change
0.00
-0.25
-0.50
-0.75
-1.00
0
3
6
9
12
change in ES delivery / state
no of CSO events

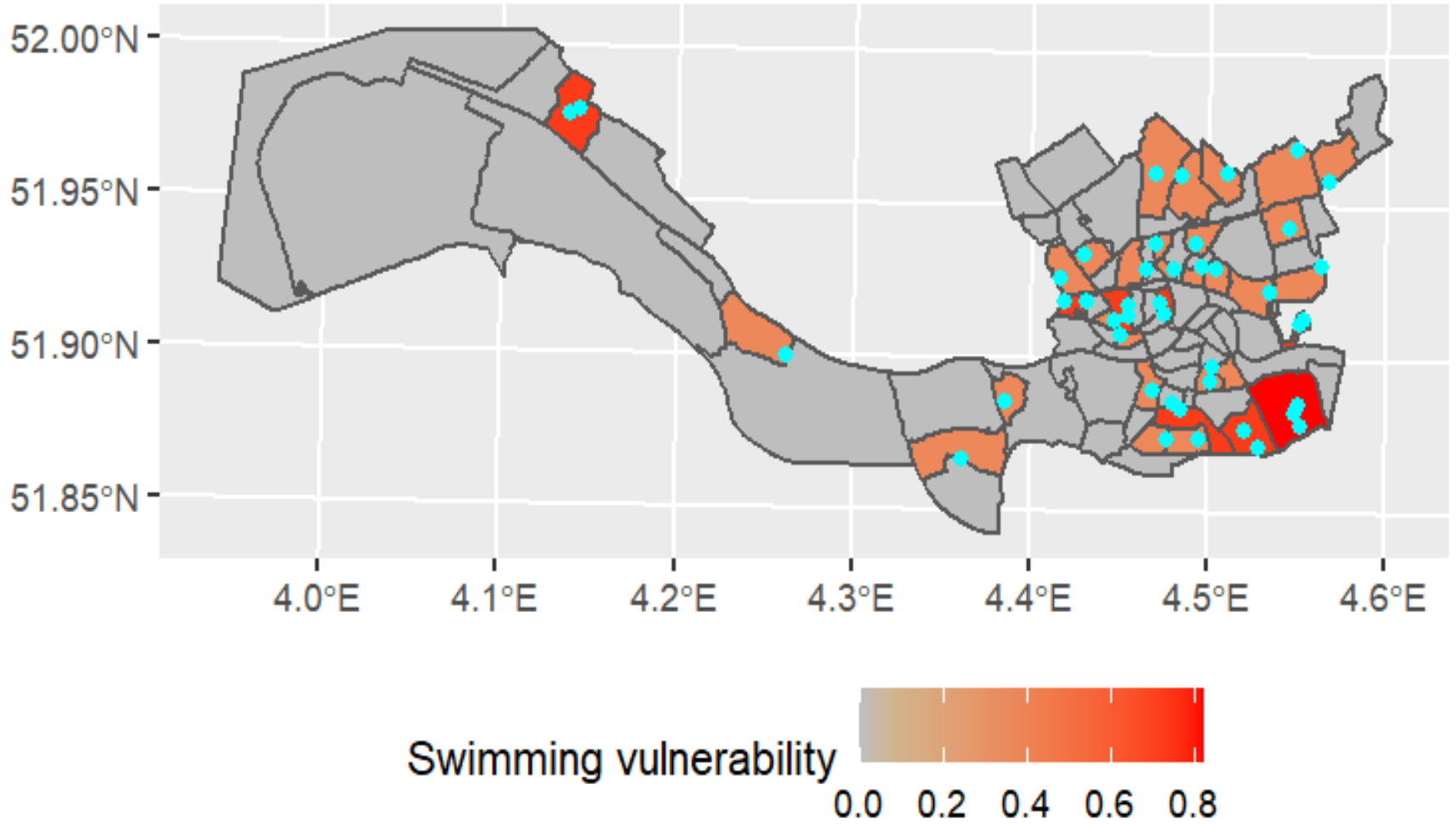
ESs


Birding
Fishing
N sequestration
initstate
clear
turbid
Vegetation biomass (gP/m²)
Nutrient loading (mgP/m²/day)
change in ES delivery / state
no of CSO events

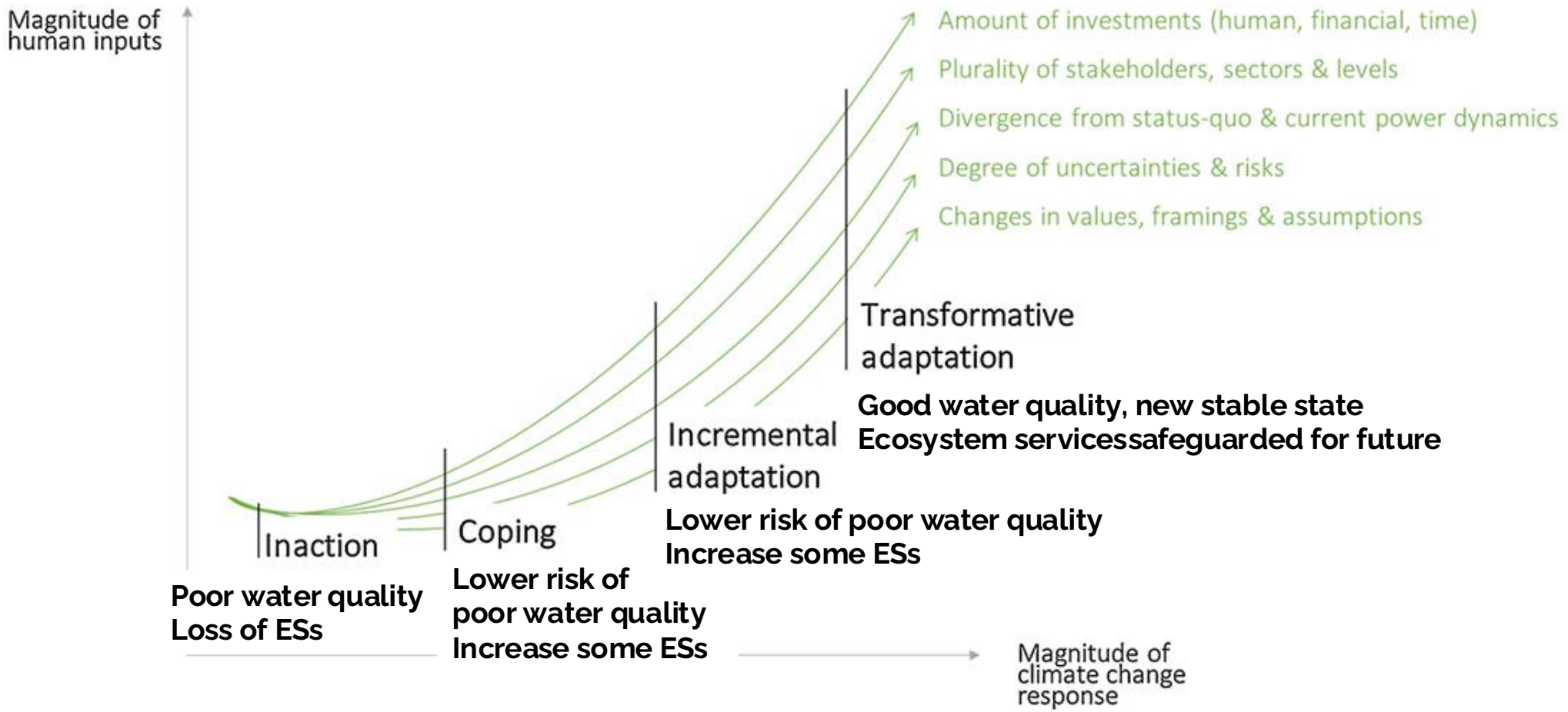
Spatial risk assessment: Ecological vulnerability



Spatial risk assessment: Swimming service vulnerability



Adaptation strategies and resilience thinking



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Turbidity


Turbidity
Photo Gertrud Schlag


Transparency
Photo Willem Kolvoort

NICHES

Nature's integration in cities' hydrologies, ecologies and societies

Thank You!

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NICHES Newsletter

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