

# Wetlands: champions of ecosystem services

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- Why are wetlands champions?
- Current debates:
  - Provisioning services (debate: water provisioning)
  - Nutrient regulation: ( debate: does nutrient retention have side effects?)
  - Climate regulation (debate: C storage vs. methane emissions)
- Multiple wetland services and livelihoods:
  - constructed wetlands Florida
  - Inner Niger delta

# Definition of wetlands

- Areas with water level near soil surface (at least 6 months per year)
- Sediments with indications for anaerobic conditions (rusty brown and/or black-grey mottling)
- Vegetation consists of plants with special adaptations: submerged life form or flood tolerance

# Ramsar Convention for wetland protection and wise use



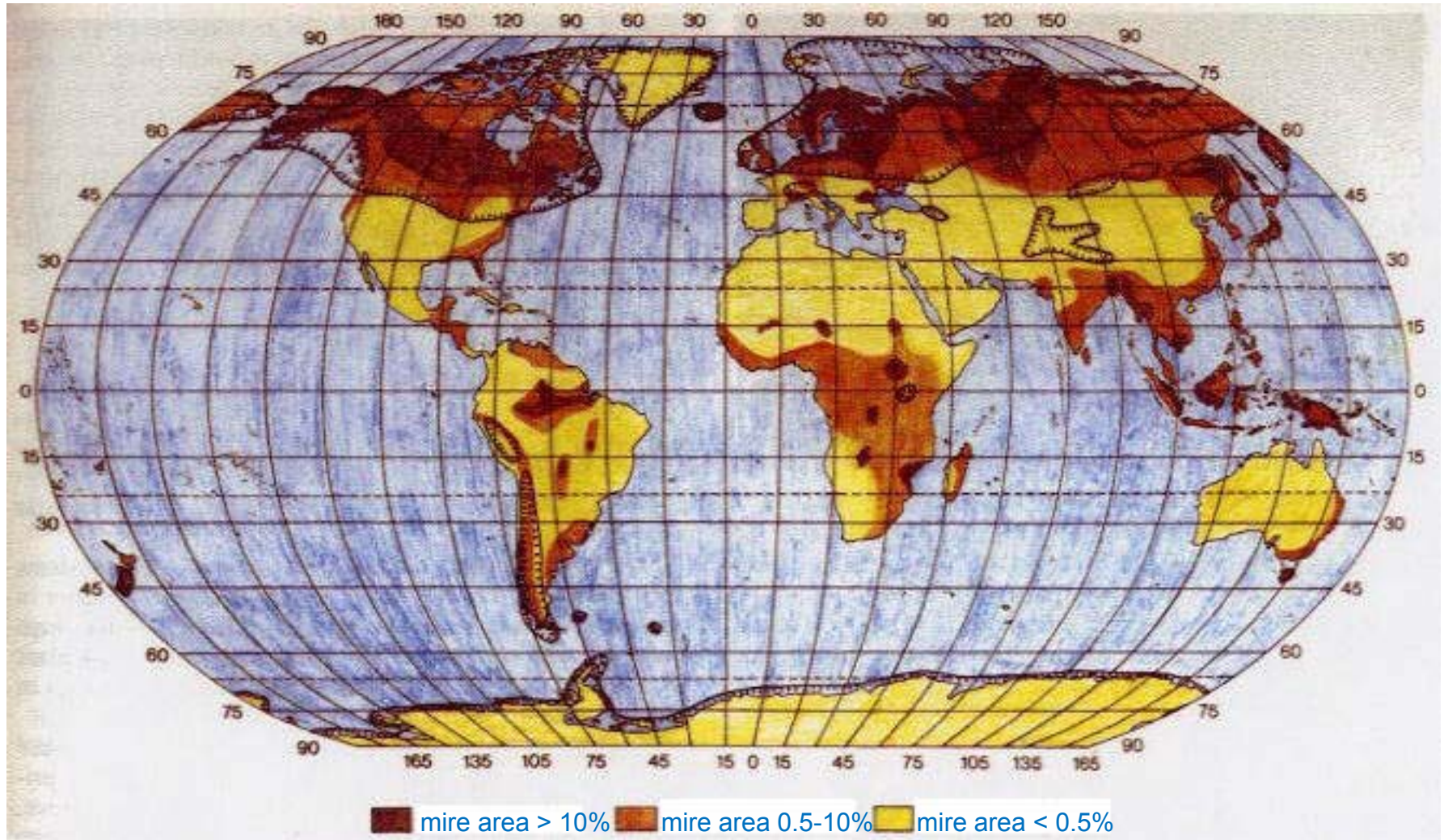
CONVENTION ON WETLANDS

CONVENTION SUR LES ZONES HUMIDES

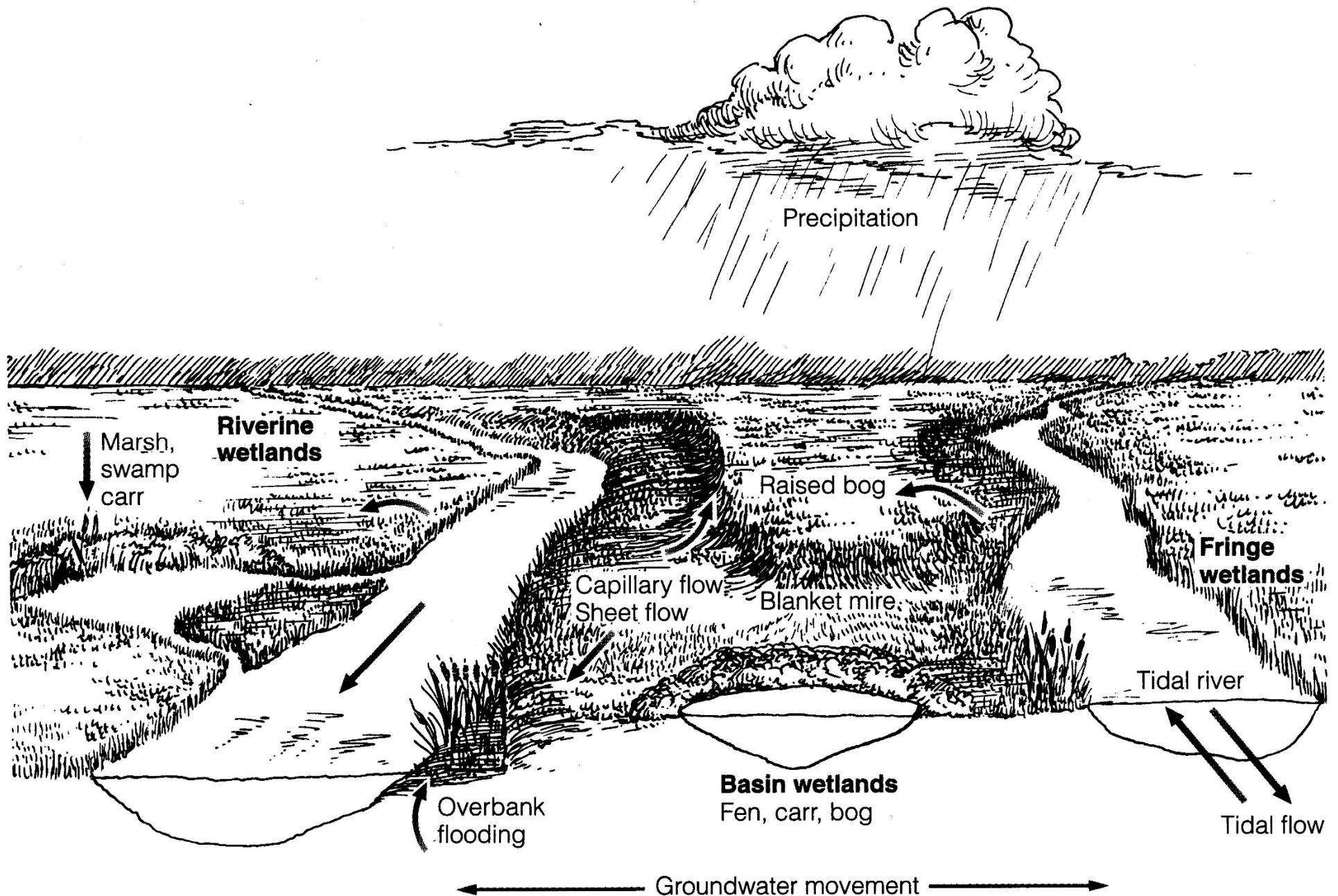
CONVENCIÓN SOBRE LOS HUMEDALES

(Ramsar, Iran, 1971)

# Wetlands of the world



# Wetland types and hydrology



# Ecosystem Services vs. Ecosystem Functions

- Ecosystem Services: benefits (goods and services) that people obtain from the functioning of ecosystems
- Ecosystem Functions: interactions between ecosystem structure and processes that underpin the capacity to provide goods and services
- Millennium Ecosystem Assessment (2005)

# Wetland ecosystem services

- Provisioning:
  - Biomass/ food production
  - Enhancement of fisheries (riverine, coastal)
  - Water?
- Regulating:
  - Flood detention and storm protection
  - Nutrient/sediment retention: better water quality
  - Carbon storage vs. GHG emissions (climate)
- Cultural:
  - Heritage and use by livelihoods
  - Biodiversity, esthetics and ecotourism



Combinations?



# Why are wetlands champions?

- Wetlands have water: abundant life!
- Many wetlands have a catchment → rich in nutrients
- Combination of water and nutrients → high productivity
- Fish and crustacean production! Waterfowl!
- Wetlands have water-logged soils → anaerobic conditions
- Slow decomposition and organic matter storage
- Complex biogeochemistry resulting in denitrification and methane emission

# Provisioning and food chain support



# Provisioning services: examples

- Spawning and nursery habitat for fish: saltmarsh & mangrove



- Reeds for thatching, paper or woodwind instruments



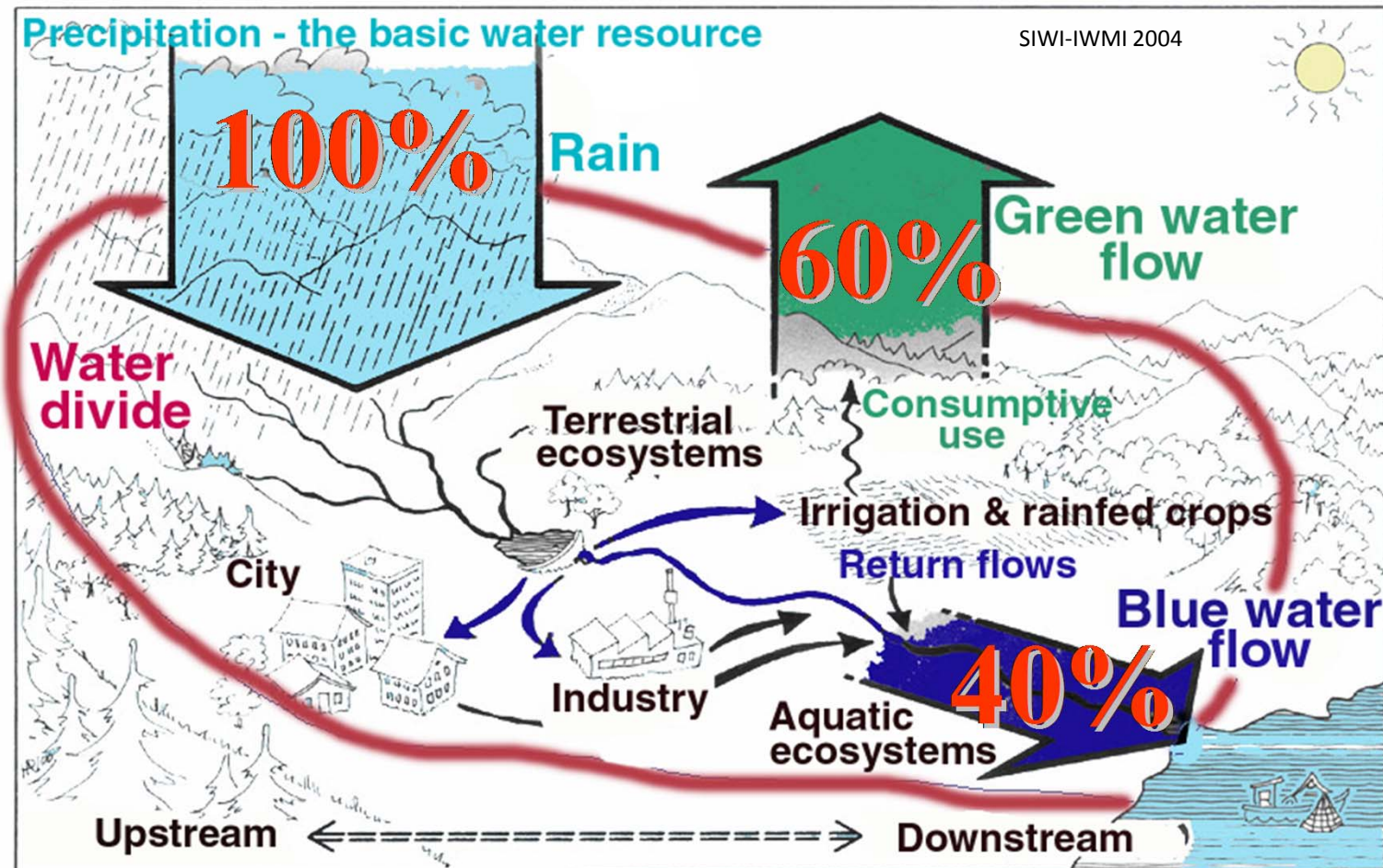
- Waterfowl: ducks, geese



# Are wetlands provisioning water?

- Confusion over the relation between wetlands and water
- “Wetlands have a water-provisioning function”
- In reality, wetlands lose water through evaporation or groundwater seepage
- Wetlands need much water
- Withdrawal of water from rivers is detrimental for wetlands
- Current paradigm in water resource management: “Blue” and “Green” water

# The Blue and Green water catchment perspective



Need for 50% increased crop production in 2035 will create a world water crisis

- Agriculture and wetland ecosystems are dependent on water
- Irrigation is using Blue water for agriculture
- This Blue water is extracted from rivers at the expense of natural wetlands

# Protecting wetlands' water needs

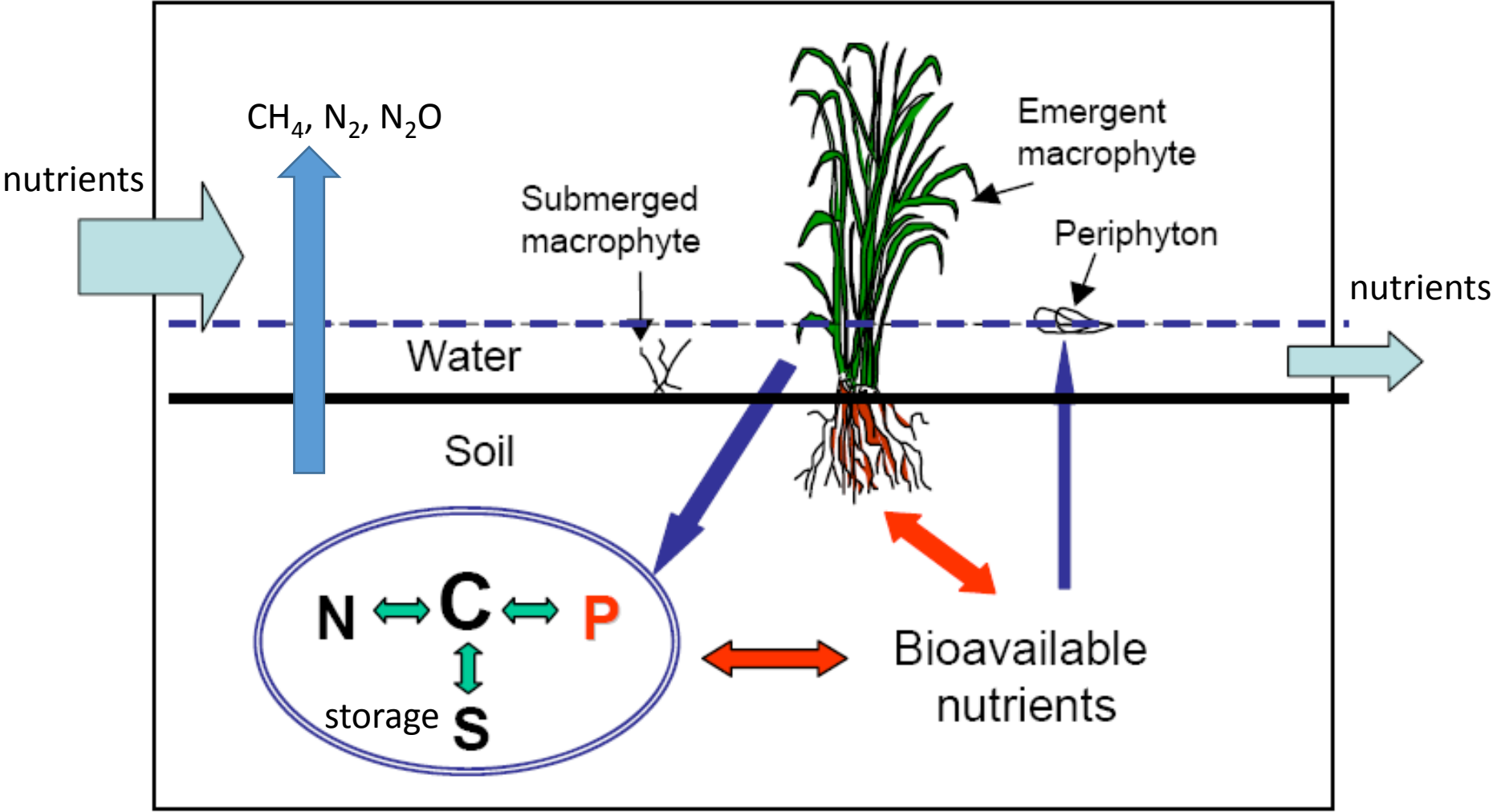
- 'Environmental flow' approach in river basins helps protecting the mere existence of wetlands
- Loss of wetland ecosystem services may outnumber short-term economic benefits
- Integrated water resources management needed

# Irrigation or flooding? rice fields versus floodplains





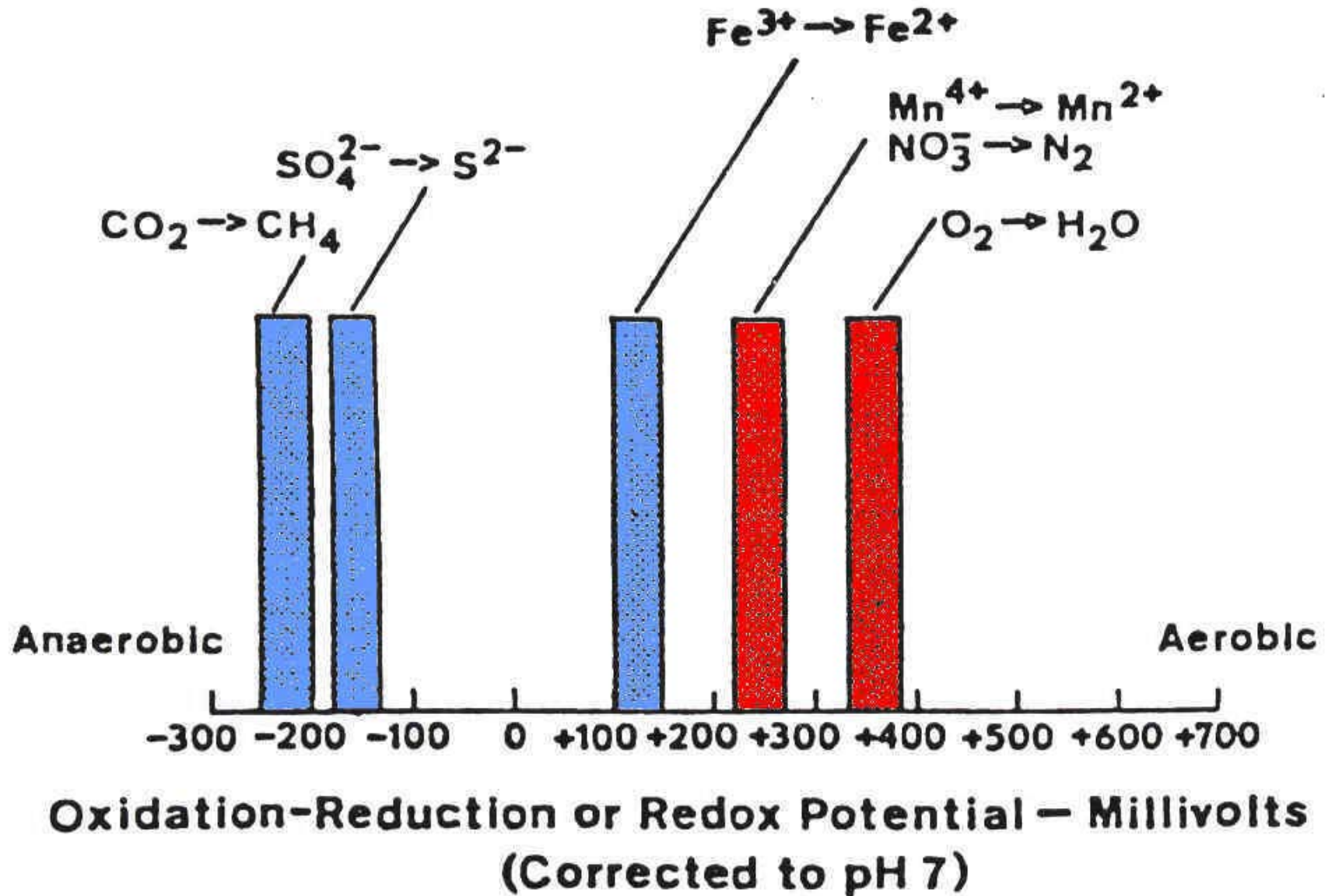
# Regulating services: biogeochemistry



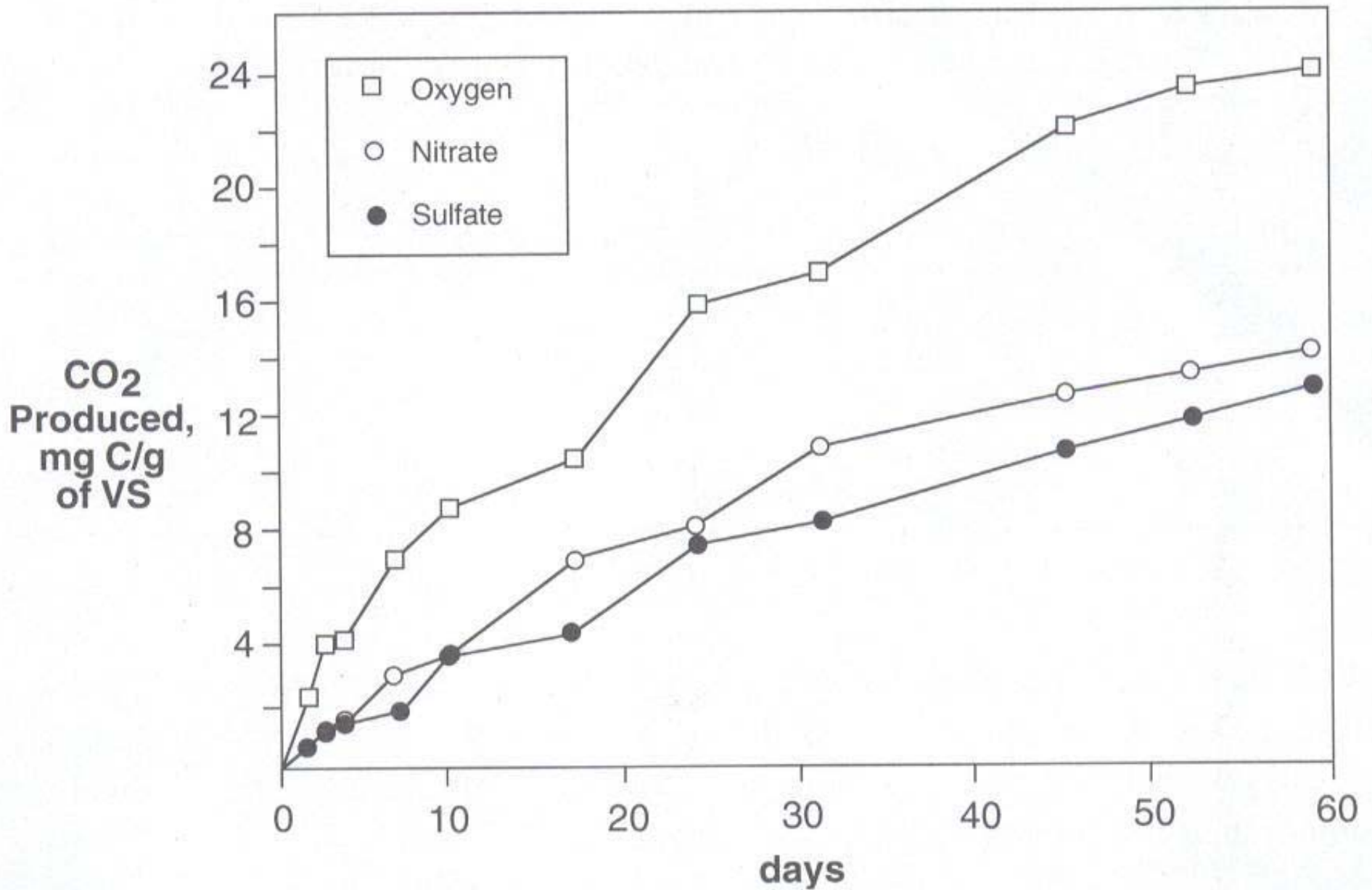
# Element cycles in wetlands

- Wetlands: surplus of water, shortage of oxygen in the soil
- Drastic consequences for biogeochemistry: anaerobic decay processes
- Electron acceptors other than oxygen: nitrate, iron, manganese, sulphate, carbon dioxide

Redox-couples show a sequence:



## Decomposition rate declines in anoxic conditions



# Key wetland biogeochemical processes

- In anaerobic wetland soils:
  - Nitrate is denitrified towards  $\text{N}_2\text{O}$  and  $\text{N}_2$ ↑
  - Sulphate is reduced to sulfide
  - Methane is produced
  - Carbon is sequestered because of incomplete decomposition
  
- Water quality enhancement ( $\text{N}_2\text{O}$ ?)
- Climate regulation (carbon? methane?;  $\text{N}_2\text{O}$ ?)

# Nutrient loading of wetlands

- Increase of primary productivity
- Shifts in species composition of algae, aquatic plants and fauna

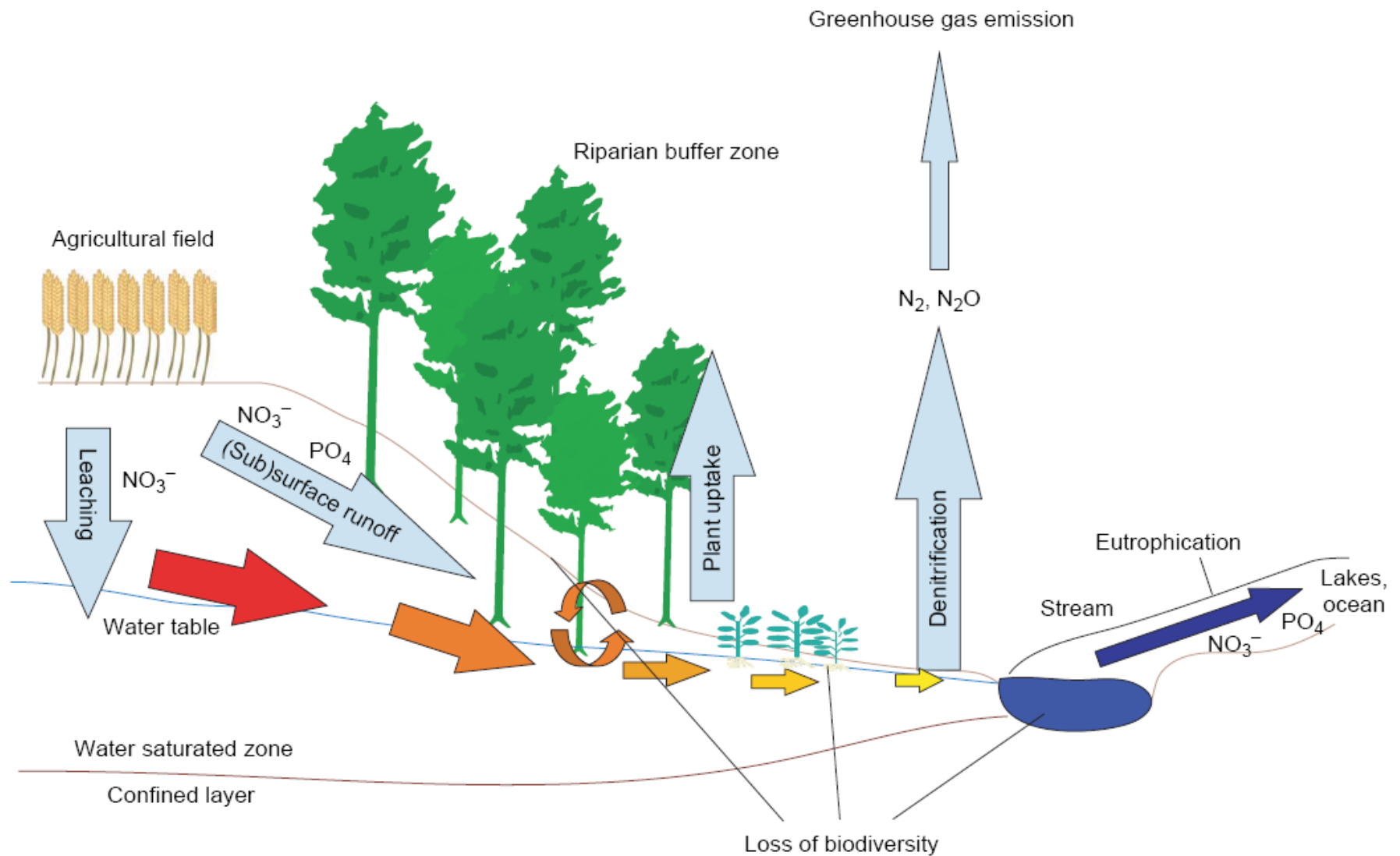
Overloading 

- Loss of functional integrity, dramatic fish kills and nutrient flush

- Wetlands for nutrient retention:

(1) Riparian zones; (2) Constructed wetlands

# Nutrient flows in agricultural landscapes

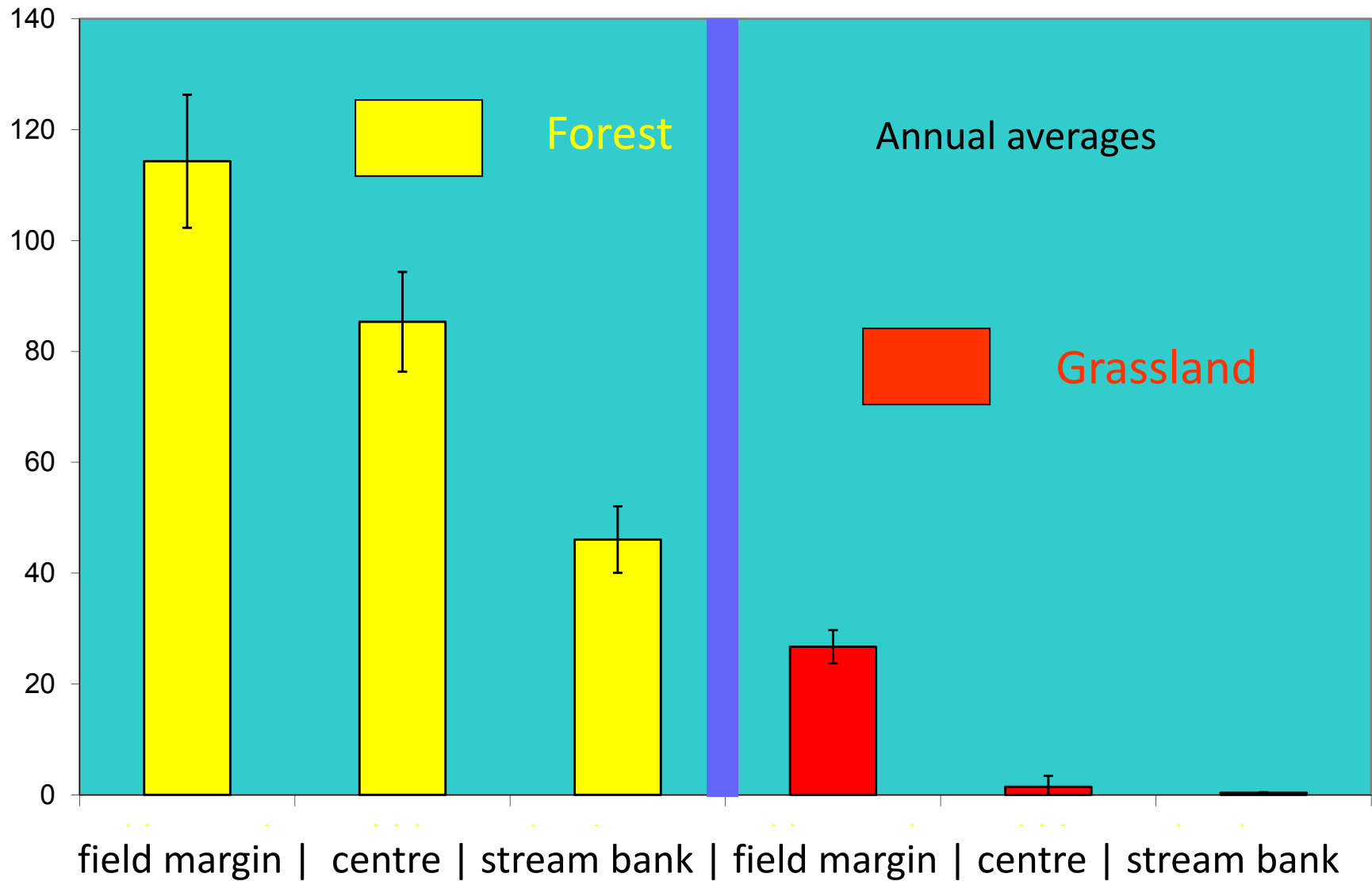




Riparian carr forest

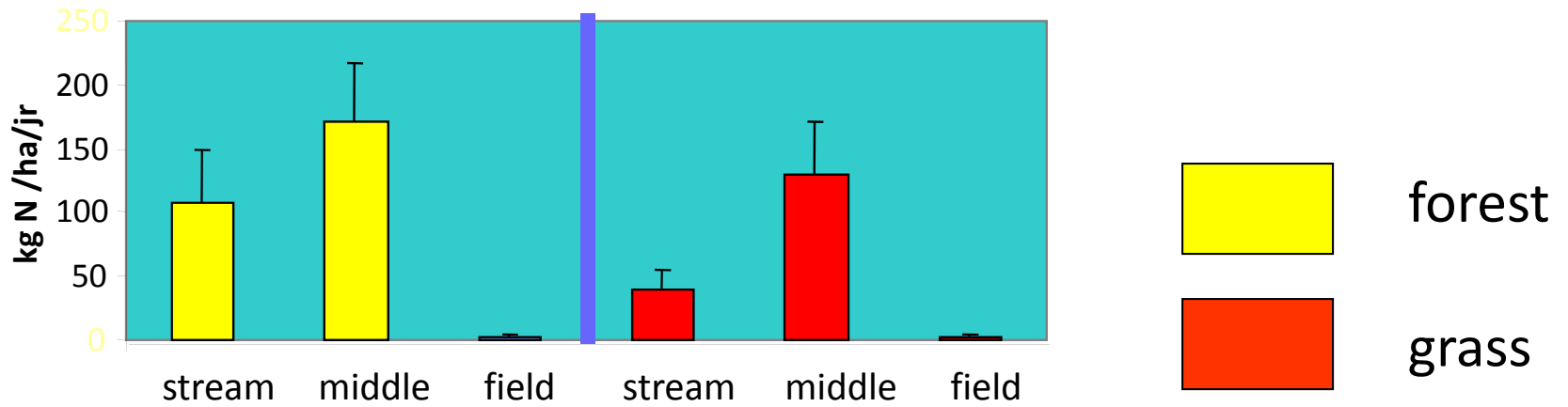


# Nitrate concentrations in riparian zones

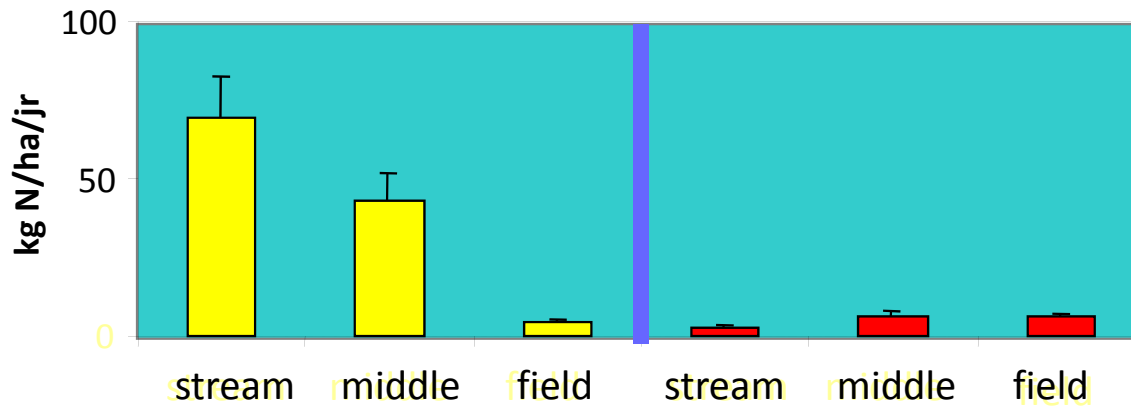




## Denitrification in upper 10 cm



## Nitrous oxide emission

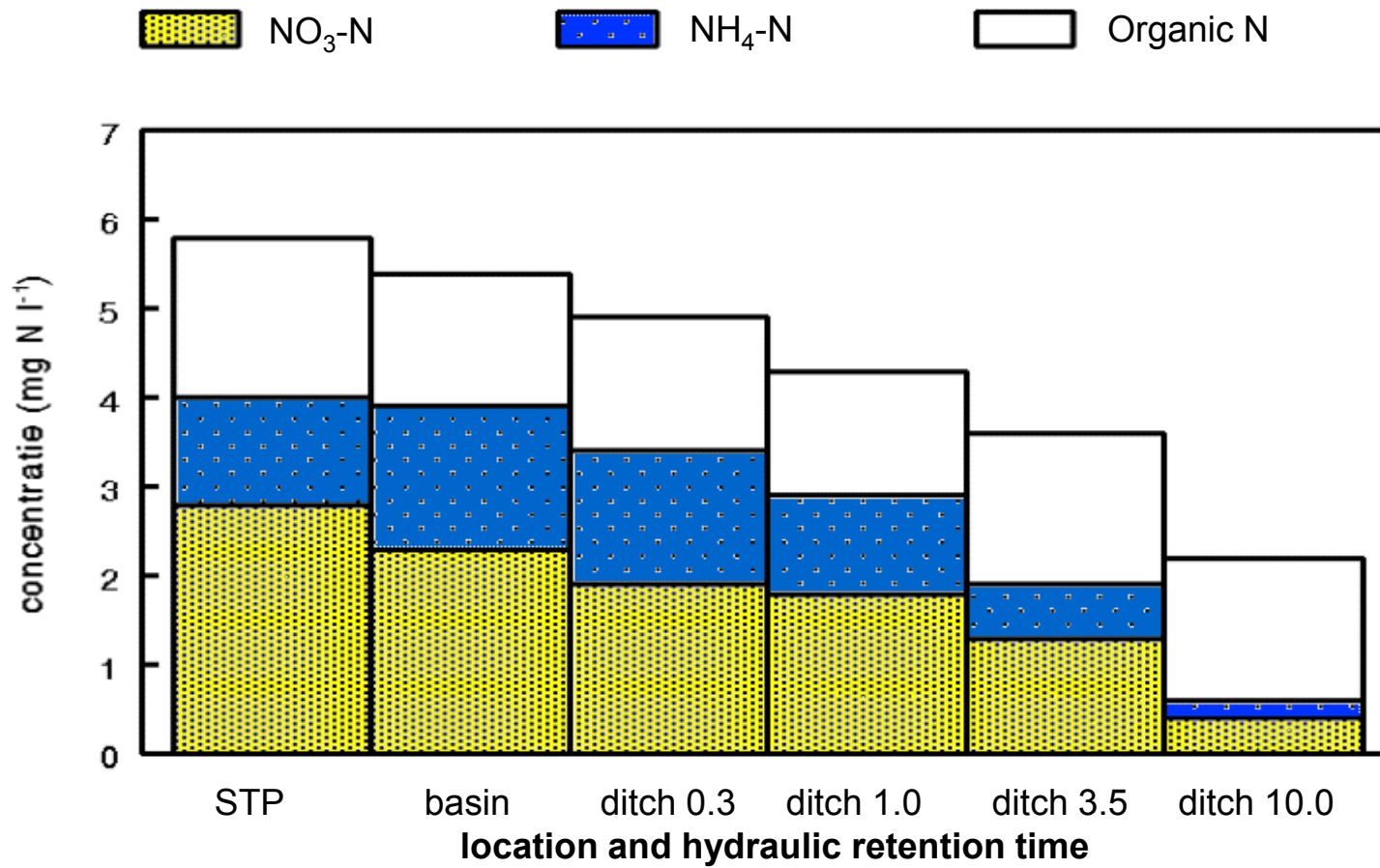


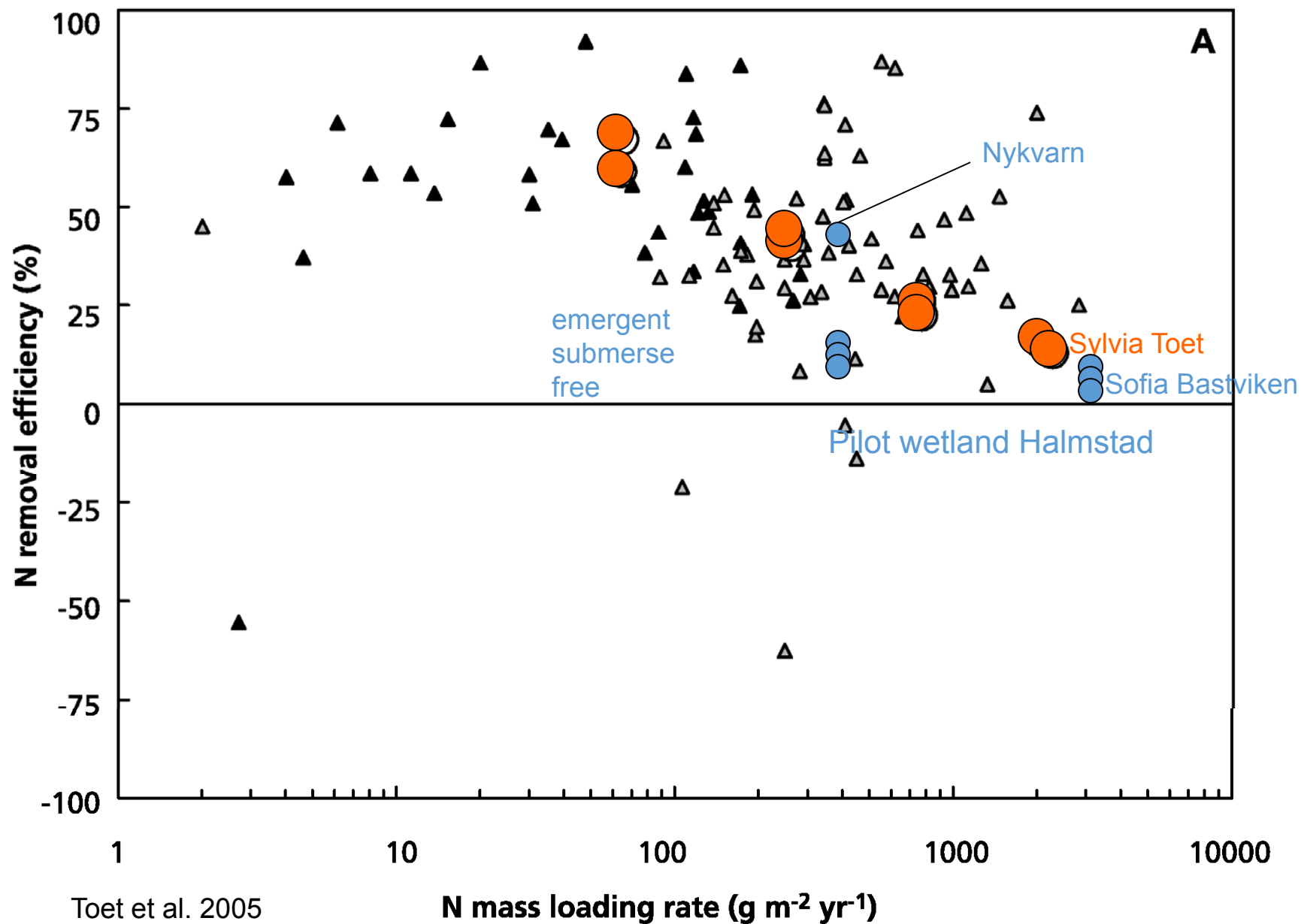
# Sewage Treatment Plant plus Wetland



# Water quality and hydraulic retention time

## Nitrogen





# The Water Harmonica

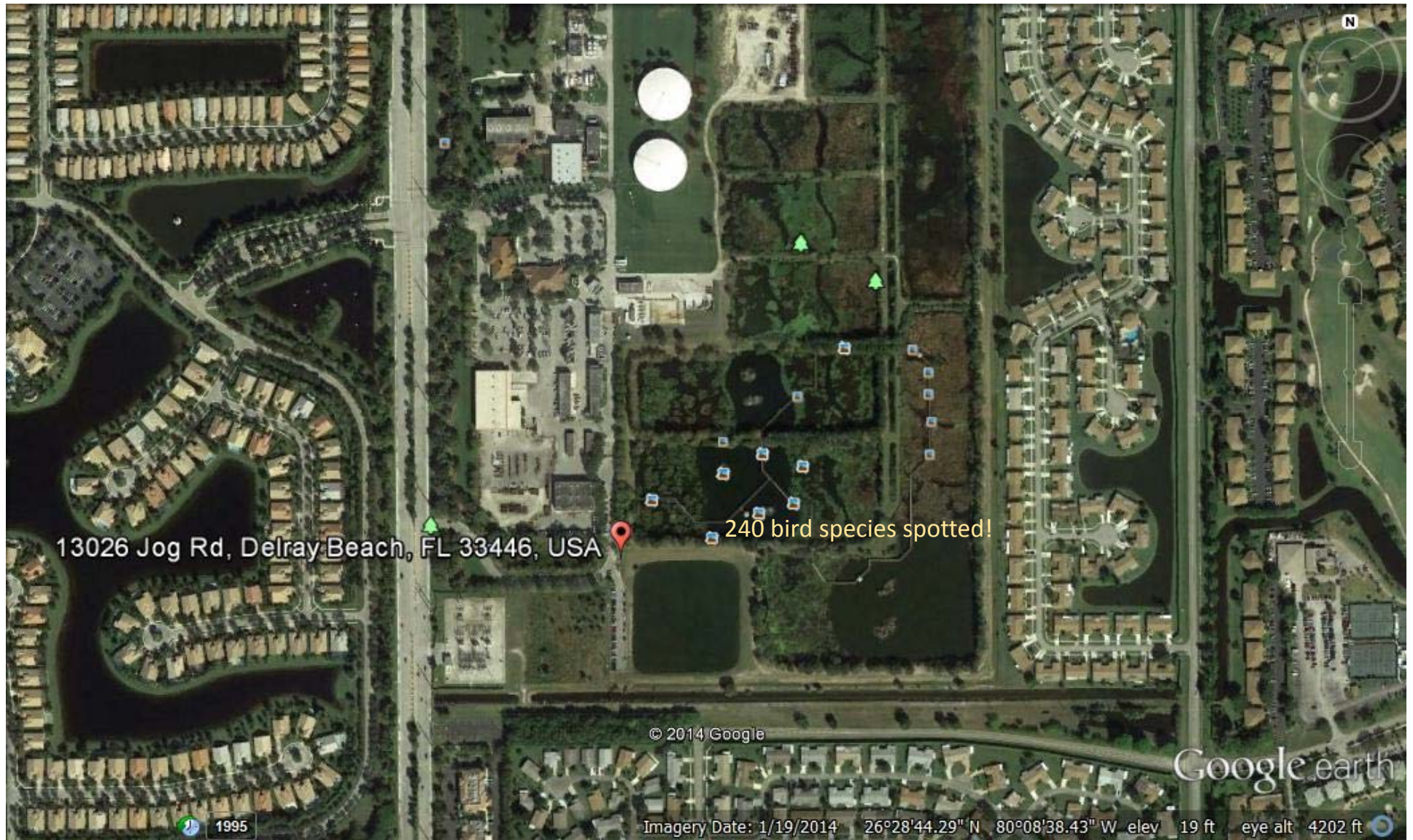
- Water from sewage treatment plant was polished effectively:
- 99.9% removal of E. coli
- 25% additional N removal
- No additional P removal
- Particles in water changed from sewage sludge to freshwater biota (phytoplankton and zooplankton)

Multiple services: STP effluent polishing + Biodiversity





# Residential area, South Florida



## Water Recycling, Wildlife Habitat and Open Green Space



Constructed wetlands like the ones here at Wakodahatchee are important for a number of reasons. These wetlands serve as a water treatment facility for the Water Utilities Department to recycle water, they provide habitat for wetland wildlife species, and they also offer open green space for people to enjoy.



## Breeding colonies of herons, egrets, anhinga's



Often visited by local residents.....



.....And now part of the Florida Birding Trail



# Wetland ecosystem services: some perspectives

- Wetlands do provide many services because they have (1) water (2) nutrients (3) anoxic soils
- Wetlands do NOT have a water-provisioning function; they compete for water with agriculture
- Wetlands (riparian, constructed) have a robust nitrogen retention function with little side effects
- As long as they are not loaded beyond critical limits
- Wetlands have a **cooling** effect on climate, if they are long-term carbon accumulators
- Multiple services are often important for livelihoods