Catchment land cover and soil as predictors of organic carbon, nitrogen, and phosphorus levels in temperate lakes

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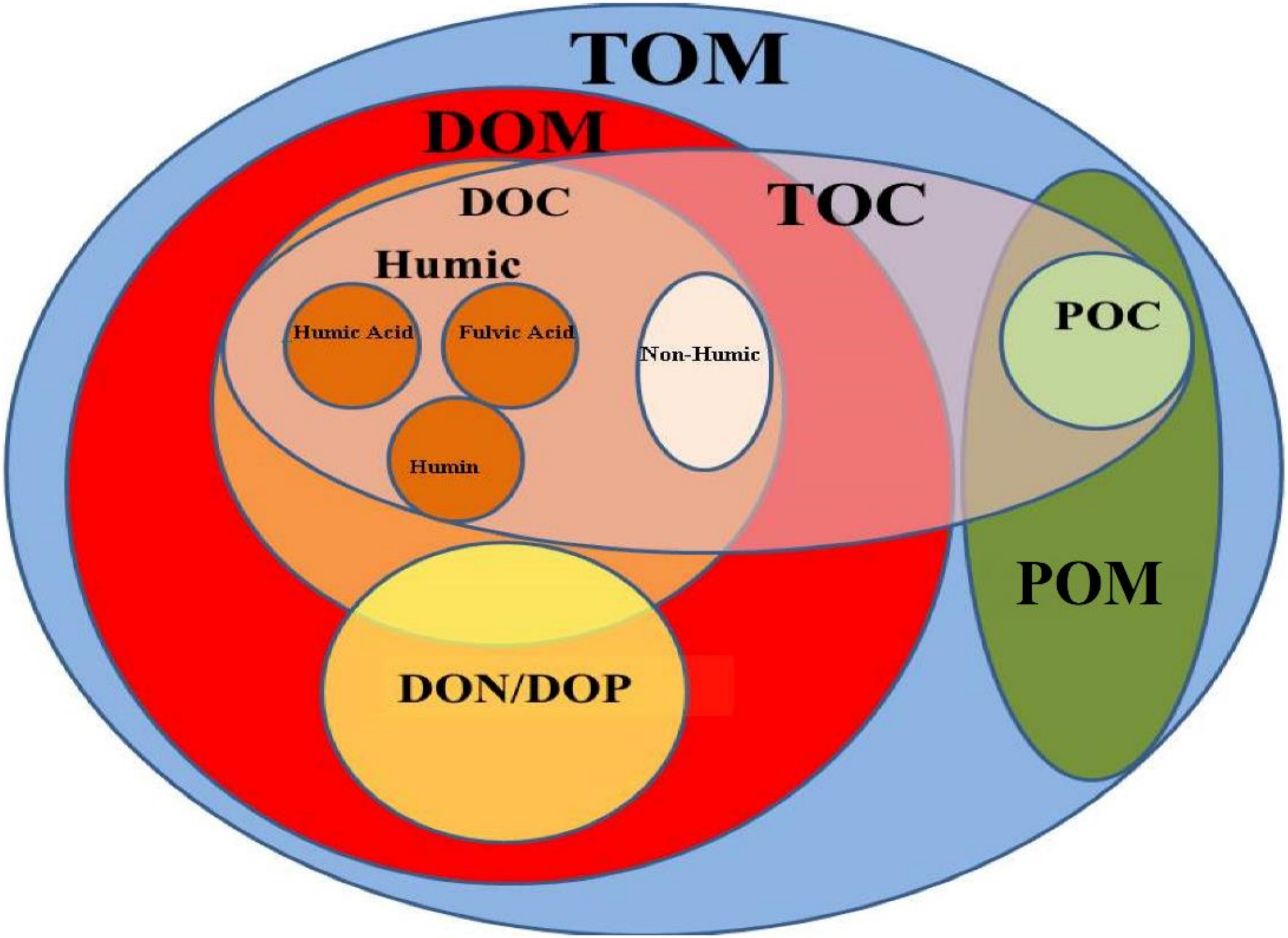
Shallow Lakes 2021

Introduction

- Dissolved organic matter (DOM) affects physical and chemical properties of lake water
- Substantial impact on lake ecosystem functioning
- DOM sources in lakes:
  - allochthonous inputs from the catchment
  - autochthonous in-lake production
- DOM main component: dissolved organic carbon (DOC)
- DOM is also an important source of nitrogen (N) and phosphorus (P) to water bodies

Various forms of organic matter found in natural waters



Pagano et al. 2014

Introduction

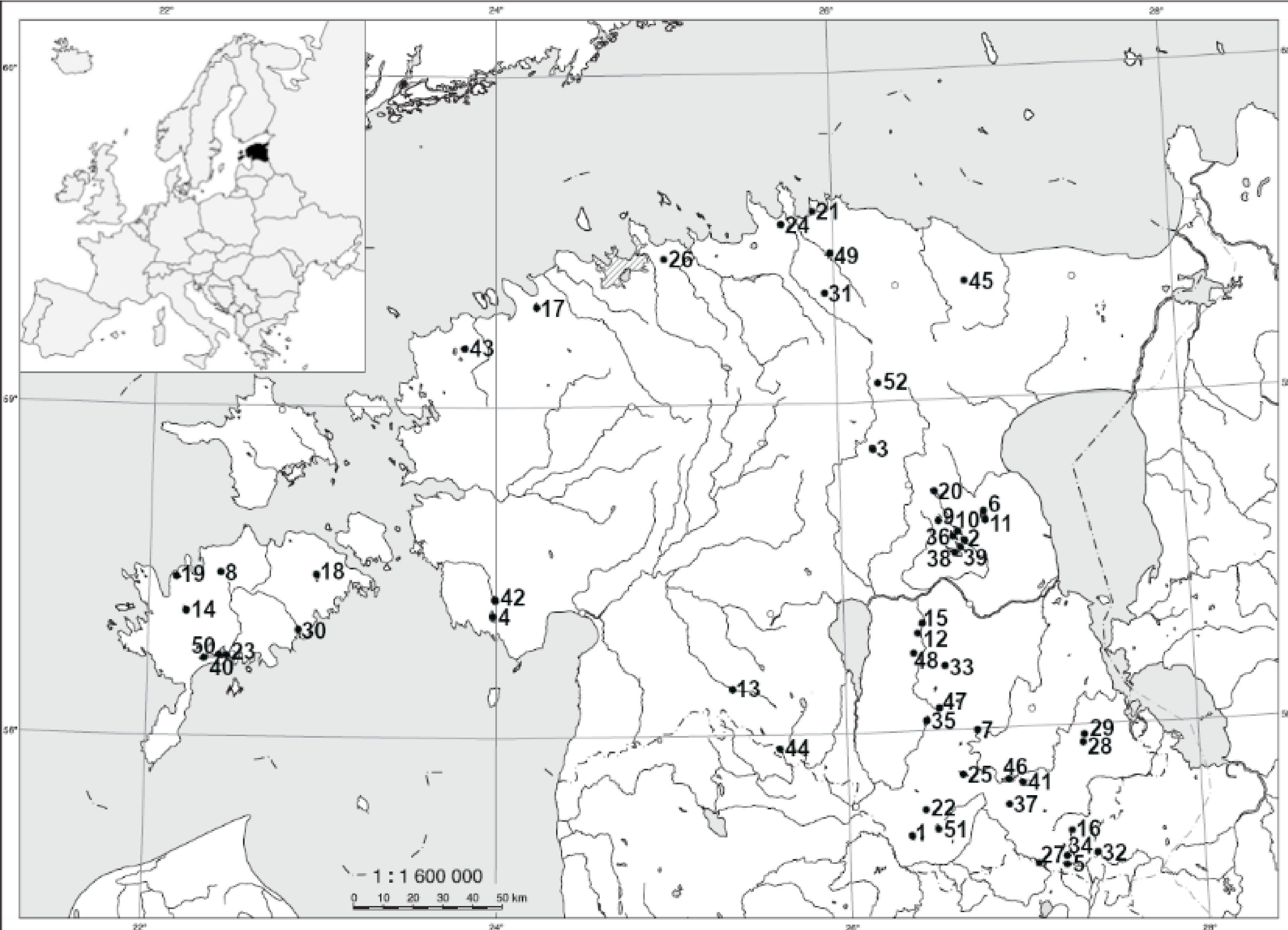
- Increasing DOC concentrations – brownification
- Dominating trend in Northern Hemisphere lakes
- Possible drivers: climate change, decreased atmospheric sulfur deposition, land use changes
- Enrichment with N and P causes eutrophication
- Consequences: algal blooms, oxygen depletion, loss of aquatic biodiversity, etc.
- Nutrient pollution originates from agriculture, industry, and domestic sources

Aims of the study

- Transport of DOM and nutrients is affected by different catchment characteristics
- The role of land cover has been thoroughly studied
- Only few studies have evaluated the role of soil types
- We used cartographic and chemical data for 52 lakes to:
  - relate catchment characteristics to DOC, TON, and TP levels
  - assess the relative importance of land cover and soil types as sources of these substances to lakes

Water sampling

- Surface water samples (~0.3 m)
- 4 times during growing season (May, July, August, September)
- In 2015–2018
- Samples were collected under state monitoring program
- Data from Estonian Environment Agency database
  - https://kese.envir.ee/kese/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Used parameters

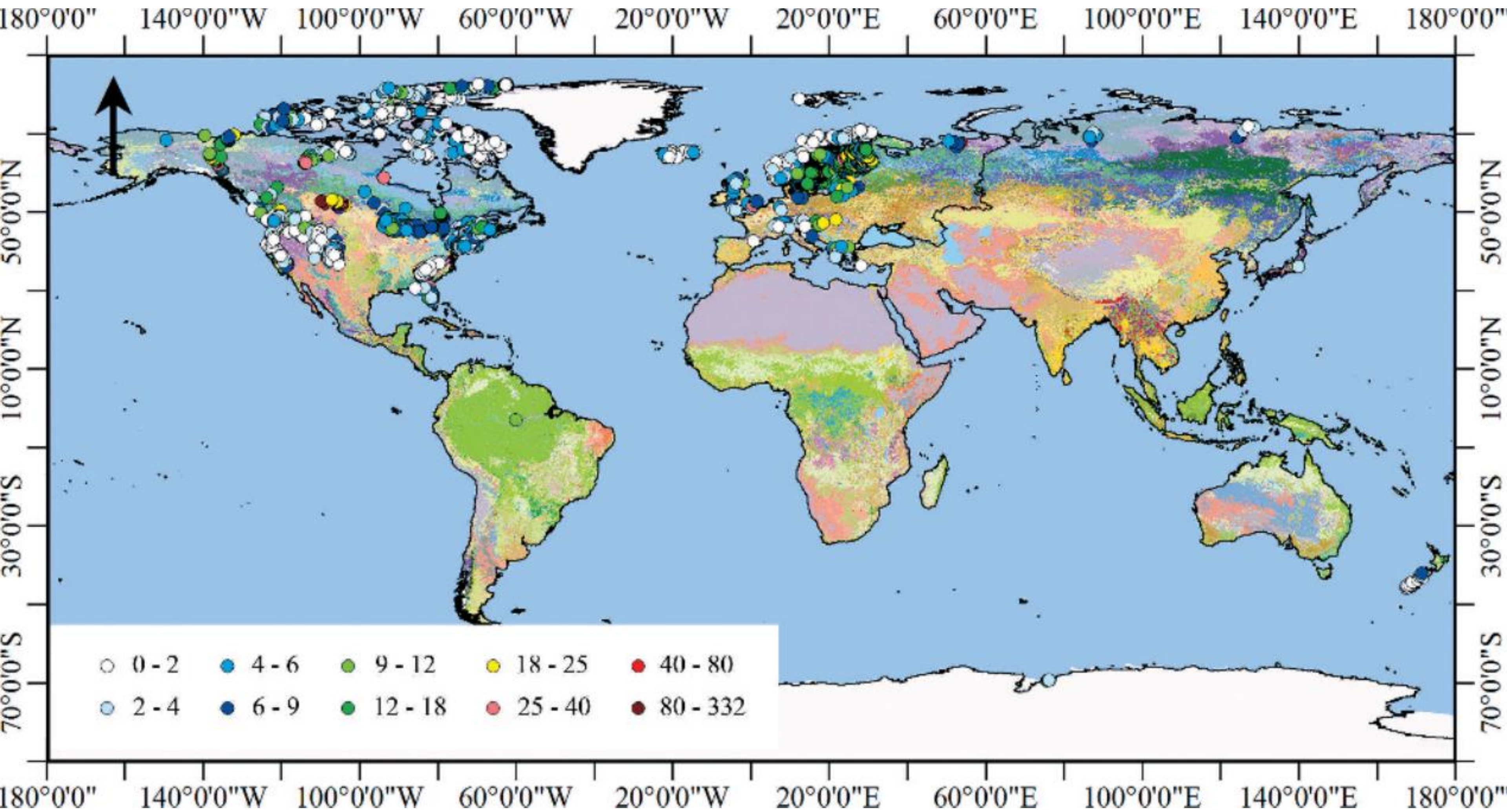
- DOC (mg/L)
- Color (mg Pt/L)
- TON (mg/L)
- TP (mg/L)
- DOC:TON

- Alkalinity (meq/L)
- Water exchange rate (WE, X/yr)
- Drainage ratio (DR)
- Land cover types (%)
- Soil types (%)
- Soil organic carbon (SOC) stock (Mg/ha)

Results: DOC

- Mean DOC in studied lakes: 4.6–47.7 mg/L
- Color: 13–586 mg Pt/L
- Range of DOC and color: similar to other hemiboreal and boreal lakes
- Upper limit higher than in most central and western European lakes
- Reason: organic-rich soils

DOC in lakes over the world

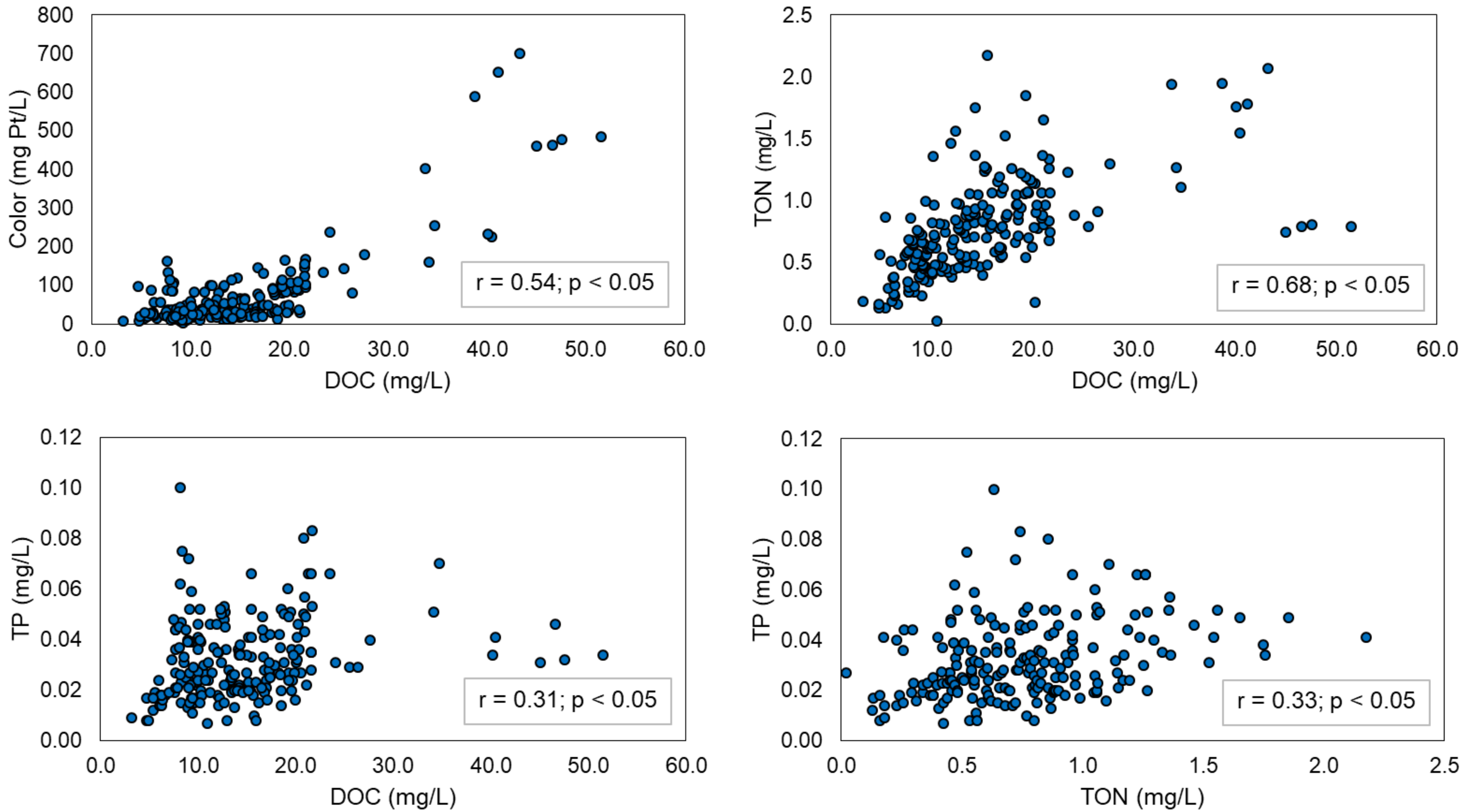


Sobek et al. 2007

Results: TON and TP

- Mean TON in studied lakes: 0.22–1.94 mg/L
- TON was the most abundant component of TN
- TP: 0.010–0.070 mg/L
- DOC:TON (molar): 11.3–174.7, avg 27.8
- Indicates mostly allochthonous origin of DOM
- Studied lakes ranged over almost the entire trophic scale, according to TON and TP concentrations
- Most lakes were meso-eutrophic or eutrophic

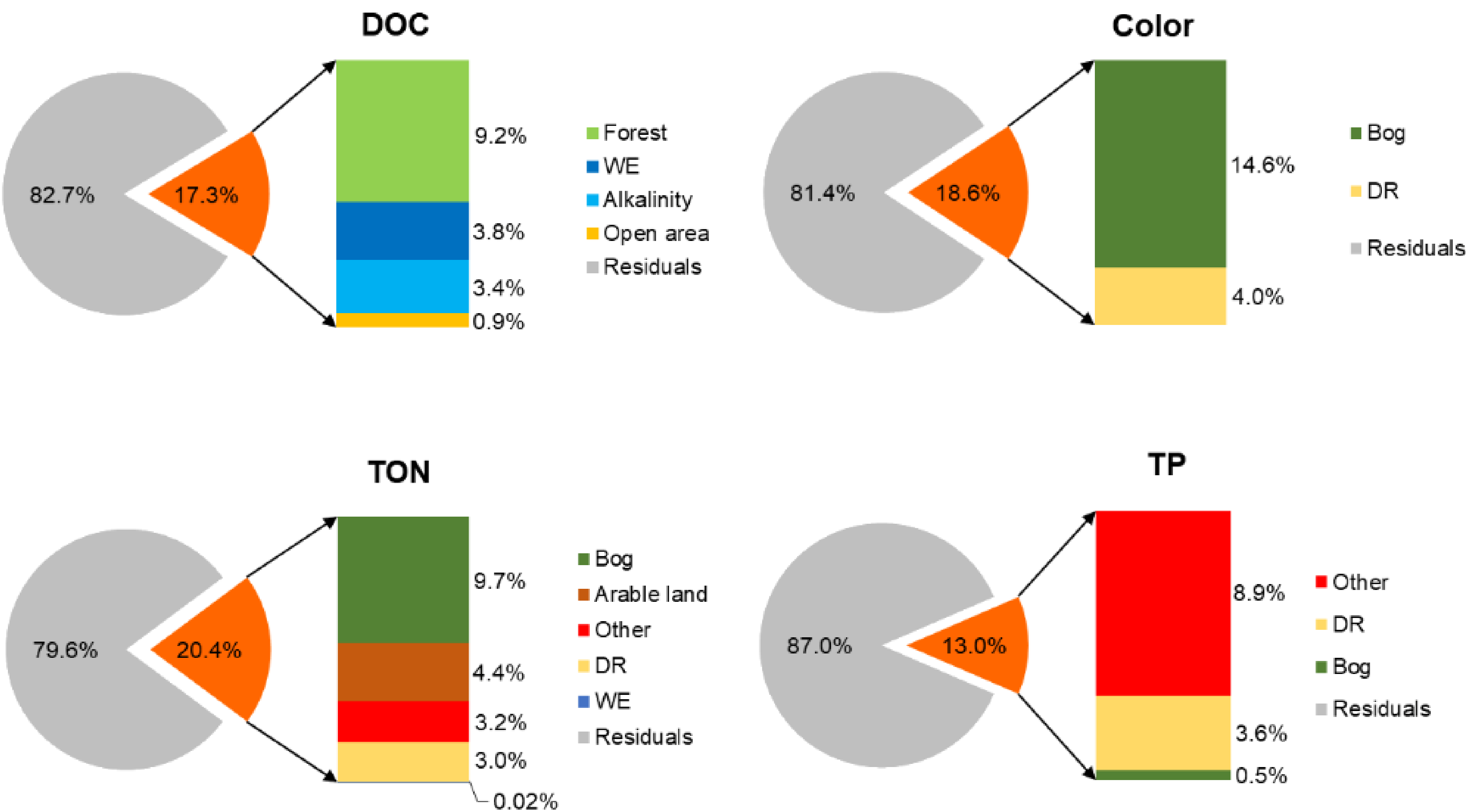
Relationships between measured values of DOC and color, TON, and TP; and between TON and TP



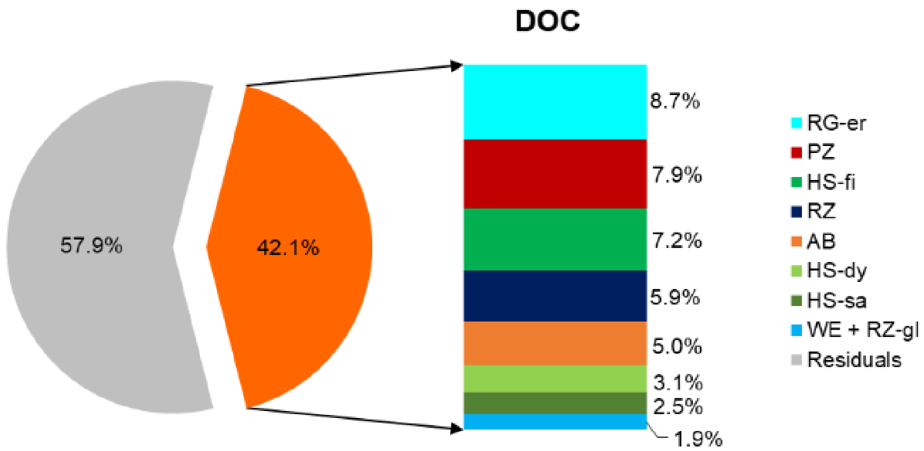
Results: effect of catchment characteristics

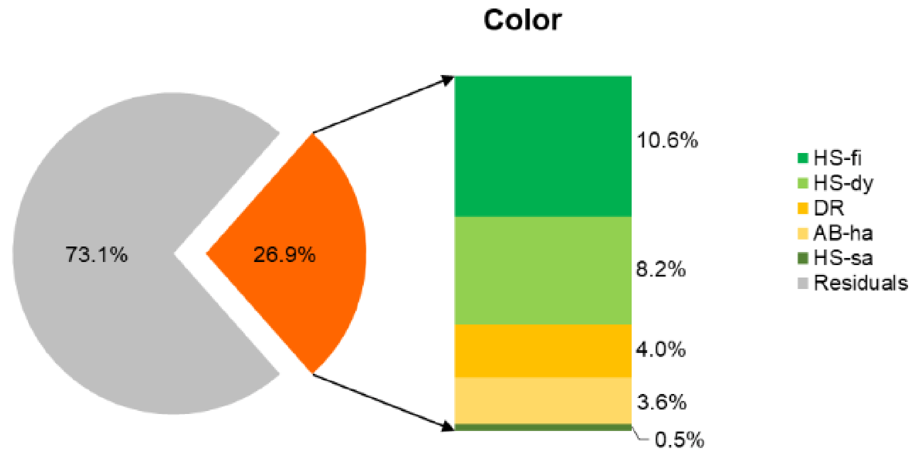
- Moderate to strong positive correlations between DOC, TON, and TP showed similar concentration patterns
- Their variability was driven by similar factors
- Soil cover was better predictor of DOC, TON, and TP levels in lakes than land cover
- It explained up to 41% of the variability
- One reason: different SOC stocks of soils
- SOC was positively related to lake DOC, TON, and TP

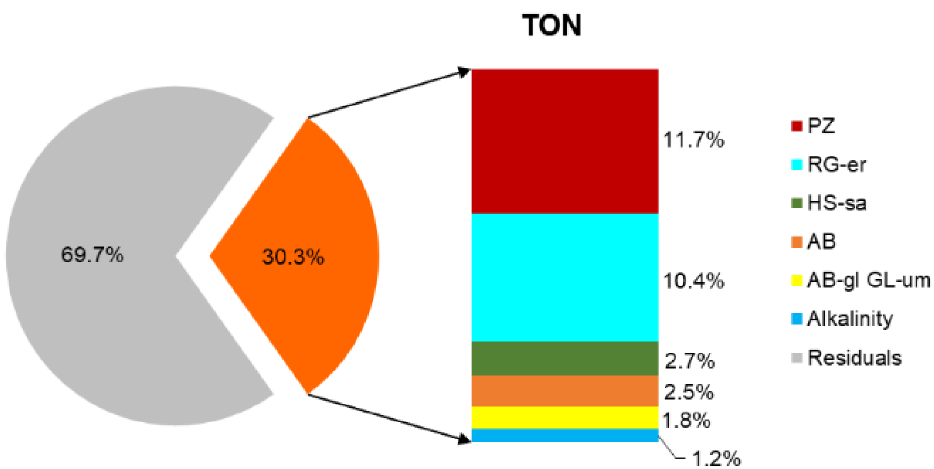
Variance partitioning in the multiple linear regression models of DOC, color, TON, and TP: land cover types

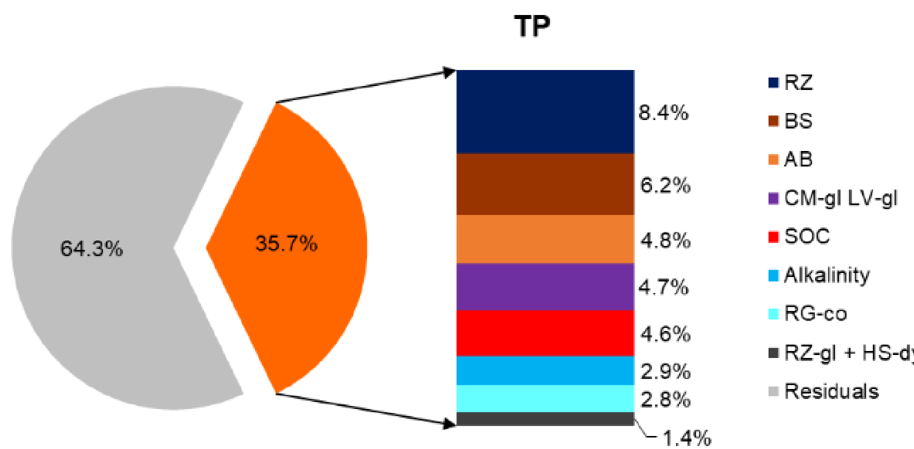


Variance partitioning in the multiple linear regression models of DOC, color, TON, and TP: soil types



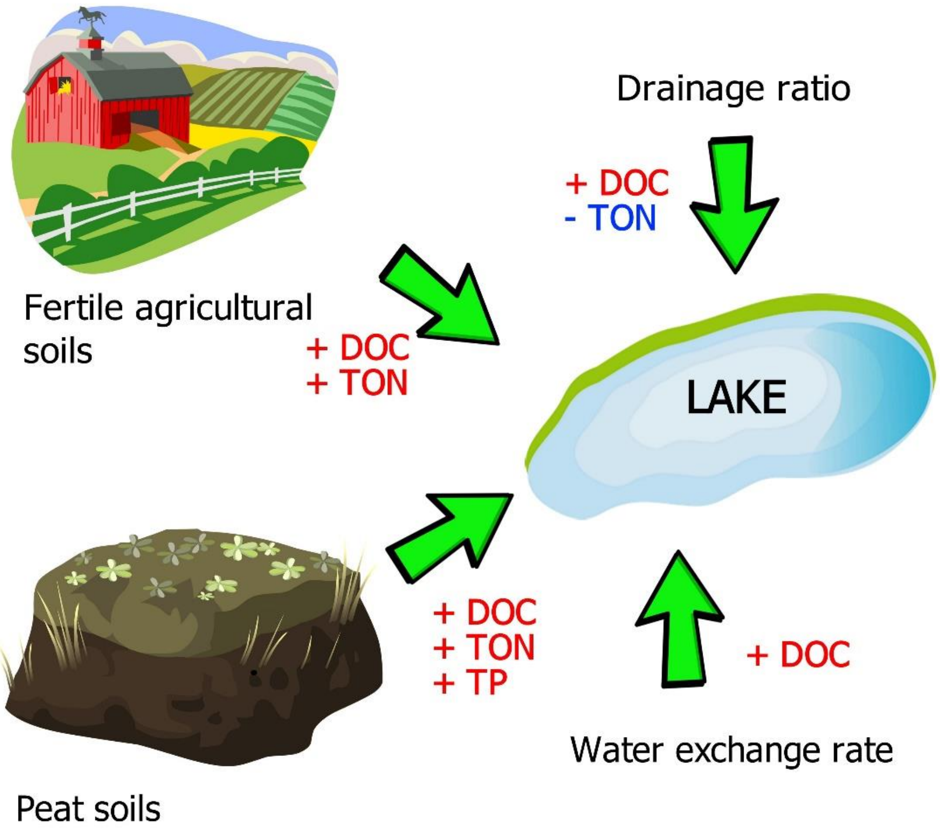






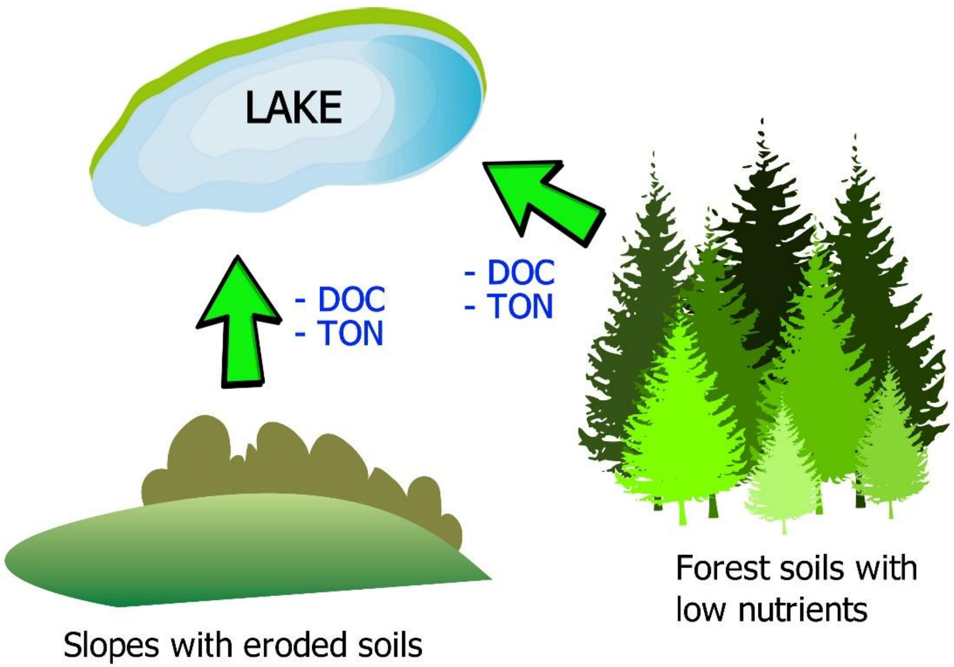
Results: effect of catchment characteristics

- Bogs and peat soils were the major source of DOC, TON, and TP
- Agricultural catchments also exhibited higher DOC and TON export to lakes
- DR was a strong predictor of allochthonous DOM
- Intensive WE also increased allochthonous DOM in lakes



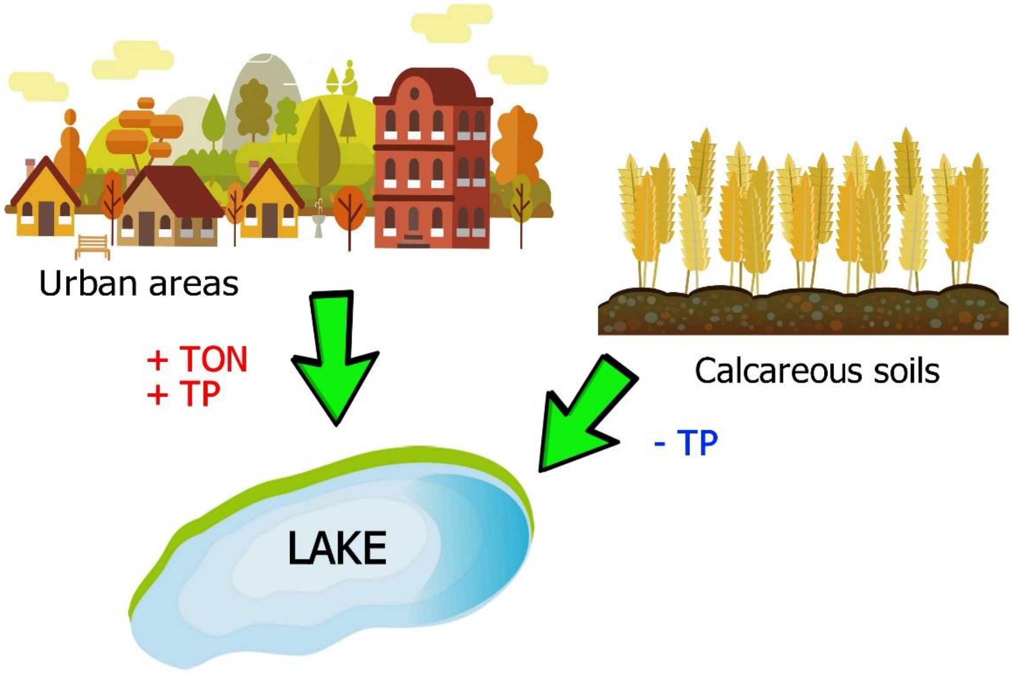
Results: effect of catchment characteristics

- DOC and TON were negatively related to soils with low SOC stock:
  - eroded soils on slopes
  - forest soils with very low nutrient levels
- Soil cover is thin on slopes and DOM leaching is limited
- In some studies, forests were an important source of DOM to lakes



Results: effect of catchment characteristics

- TON and TP were positively related to urban areas
- Shows the importance of human impact on their concentrations
- Calcareous soils had negative effect on TP concentrations in lakes
- Reason: P retention in soils with high Ca content



Conclusions

- DOC, TON, and TP variability was driven by similar factors
- Catchment soil cover was the best predictor of DOC, TON, and TP levels in lakes
- Land cover types are too broad and less informative than specific soil types
- Understanding the impact of catchment characteristics on DOC, TON, and TP levels in temperate lakes is crucial for developing transport models
- These models are necessary for predicting future levels of DOM and nutrients under changing climate and land use

Thank You for Your Attention!

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