Recent ecological trajectory of lake Taihu and land-use history reconstructed from lake sediment DNA

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Context of the study

Shallow lakes along the Yangtze flood plain:
→ important metallic pollutions from the 60's and severe eutrophication from the 80's
→ loss of ecosystem services (e.g. drinking water)

Algal bloom (*Microsystis sp.*)

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Journal of Paleolimnology **32:** 41–51, 2004.
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Sedimentary evidence for changes in the pollution status of Taihu in the Jiangsu region of eastern China

N.L. Rose[1,*], J.F. Boyle[2], Y. Du[3], C. Yi[3], X. Dai[4], P.G. Appleby[5], H. Bennion[1], S. Cai[3] and L. Yu[4]
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Using sedimentary diatoms to identify reference conditions and historical variability in shallow lake ecosystems in the Yangtze floodplain

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Front. Earth Sci.
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RESEARCH ARTICLE

Losses of Ecosystem Service Values in the Taihu Lake Basin from 1979 to 2010

Science of the Total Environment 671 (2019) 66–75

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Integrating long-term dynamics of ecosystem services into restoration and management of large shallow lakes

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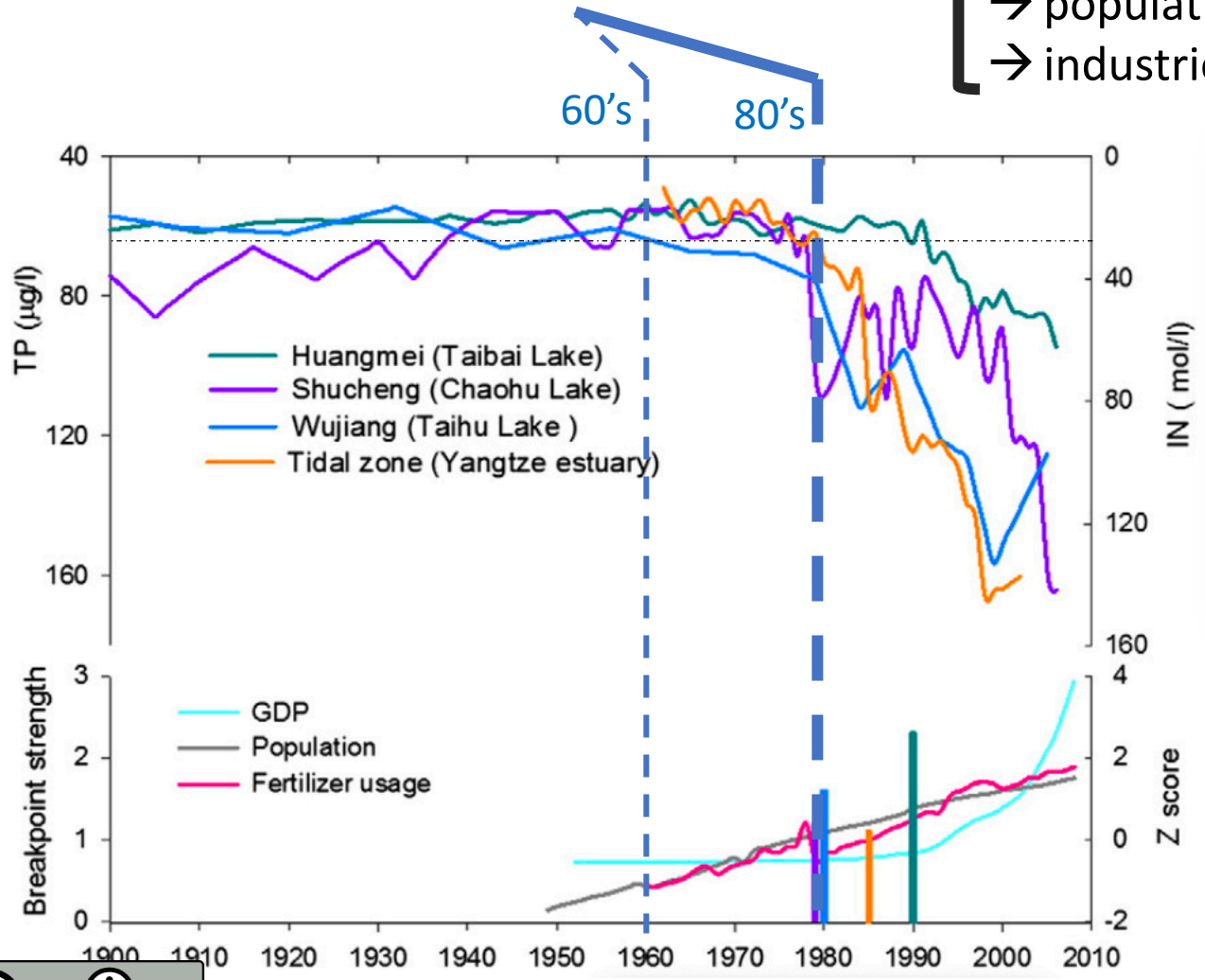
Context of the study

High nutrient inputs due to

- → Use of fertilizers in agriculture (*incl*. fish farming)
- → Dairy farm effluents
- → population growth and concentration in cities (sewage waters)
- → industries



Ke Zhang et al. 2015

Science of the Total Environment 506–507 (2015) 164–181

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Poverty alleviation strategies in eastern China lead to critical ecological dynamics

Ke Zhang [a,1], John A. Dearing [a,*], Terence P. Dawson [b], Xuhui Dong [c], Xiangdong Yang [c], Weiguo Zhang [d]

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The causes of lake ecosystem degradation were mostly determined by comparsion with historical data on land use and anthropogenic activities

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Aim of the study and methods

Aims: Document the interactions between the land use, erosion and lake ecological changes to better undersand the causes of the lake ecosystem degradation

Methods:

- **Analyses of lake sediment geochemical composition (XRF core scanning)**
  → Changes in sediment quality (pollutions)
- **Analyses of lake sediment DNA from plants (extracellular DNA, exDNA)**
  → land cover/use changes

Interest of lake sediments:
Allow to document the sediment sources to the lake and thus potentially to better define the sources of nutrients

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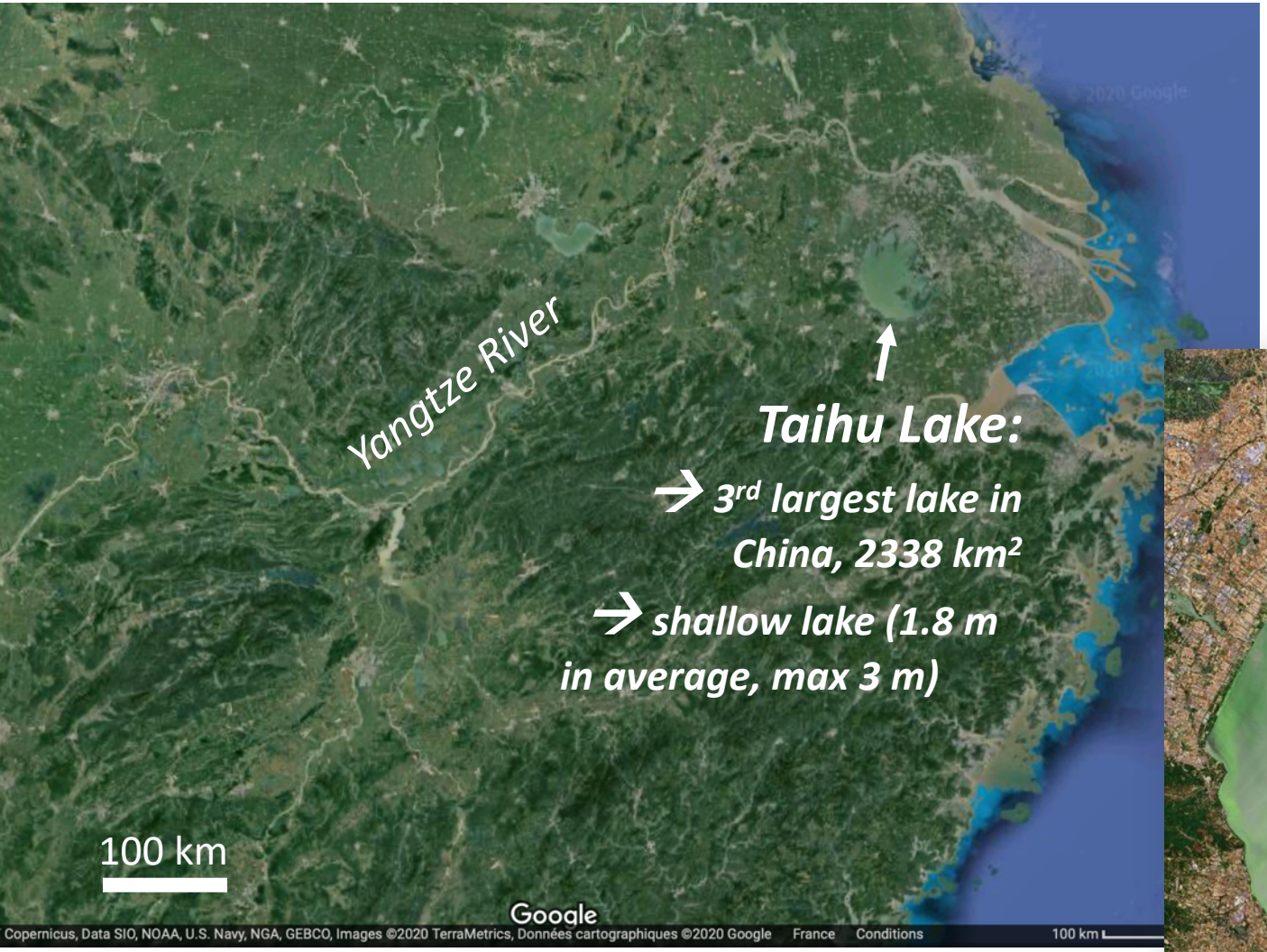
Study site: Lake Taihu and catchment



Coring site

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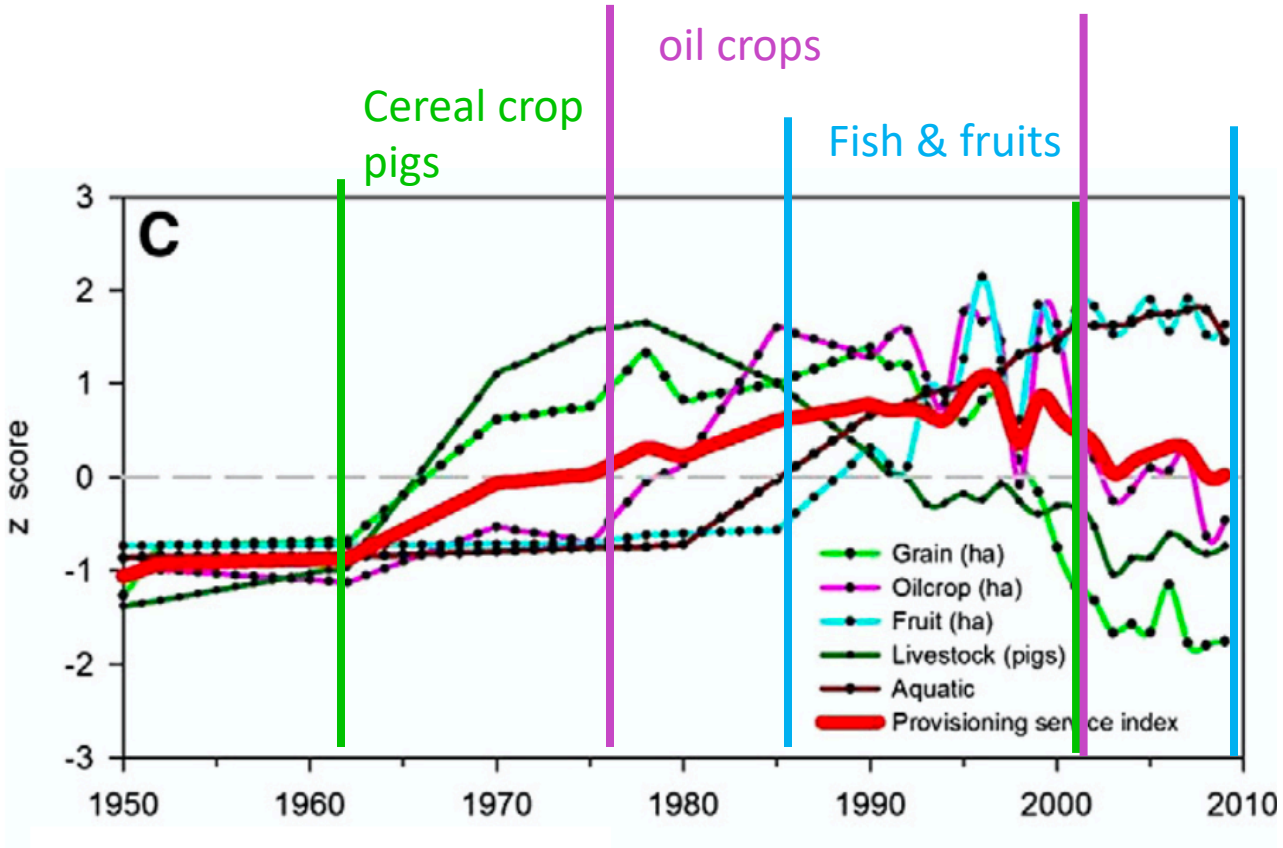
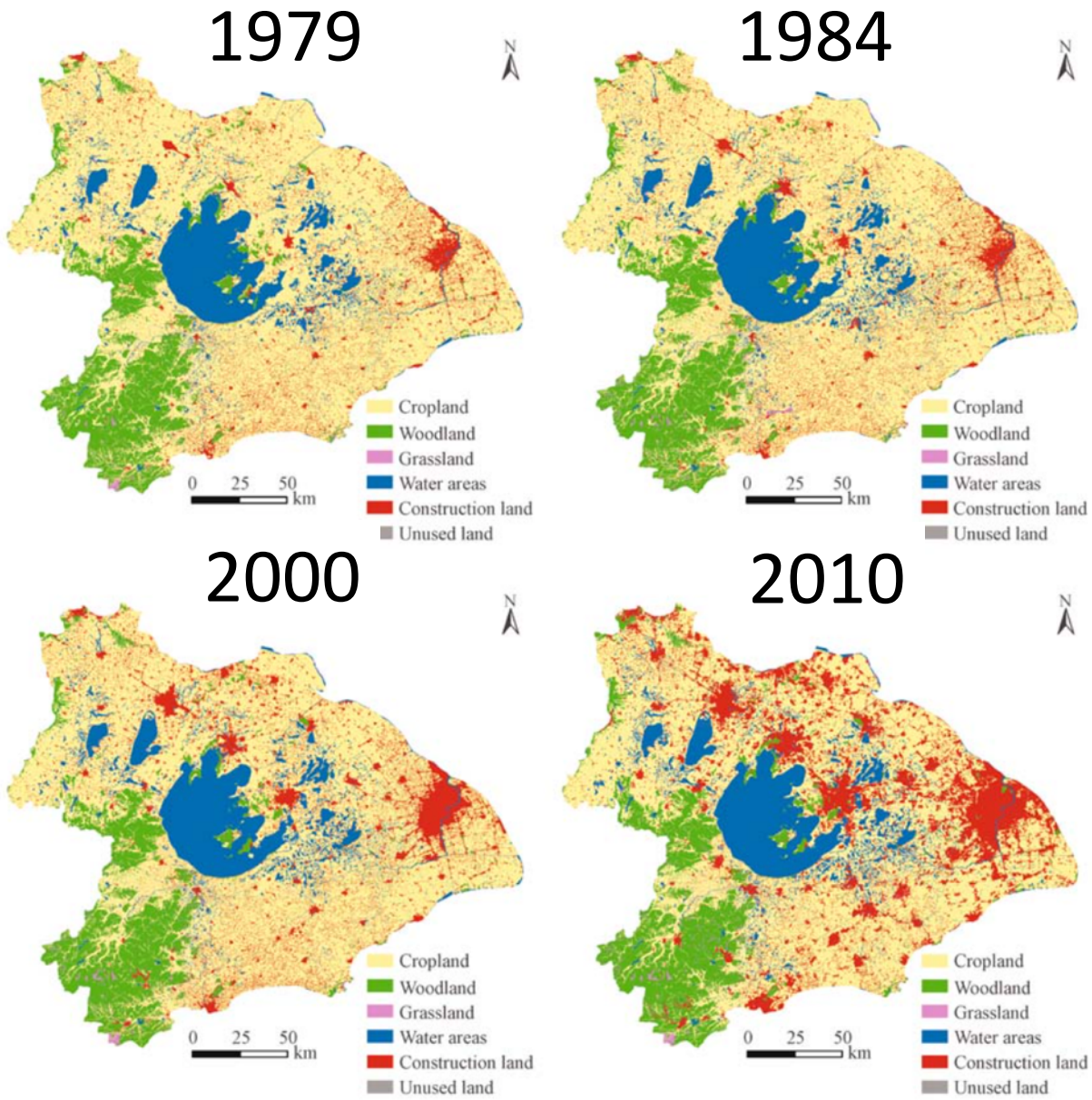
Study site: Agriculture and land cover changes

woodland **cropland** **urban areas**

The catchment covers two provinces (Jiangsu and Zhejiang), where agriculture history and land cover changed a lot from the 60's.



Ke Zhang et al. 2015



Hui Zhang et al. 201

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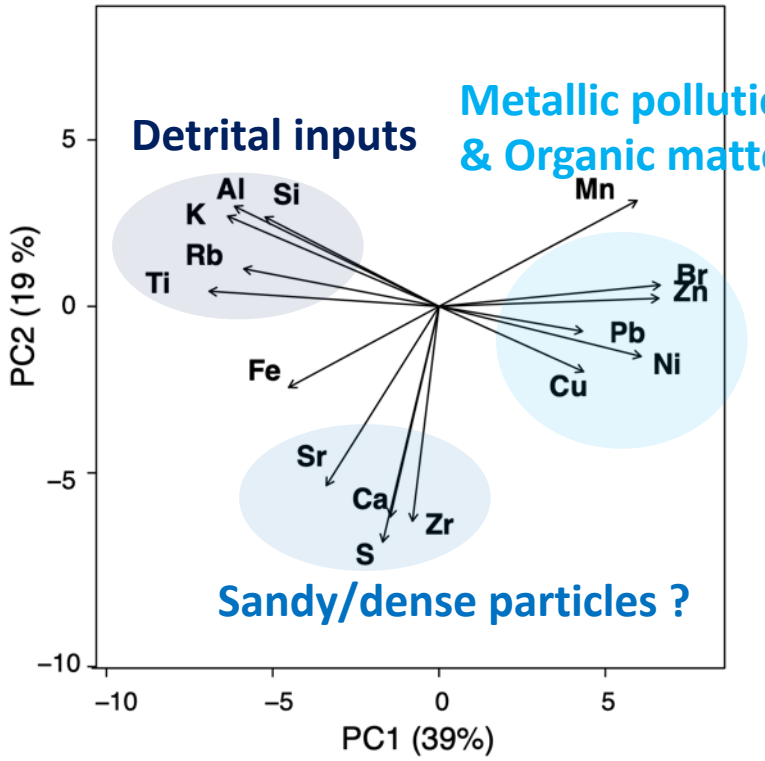
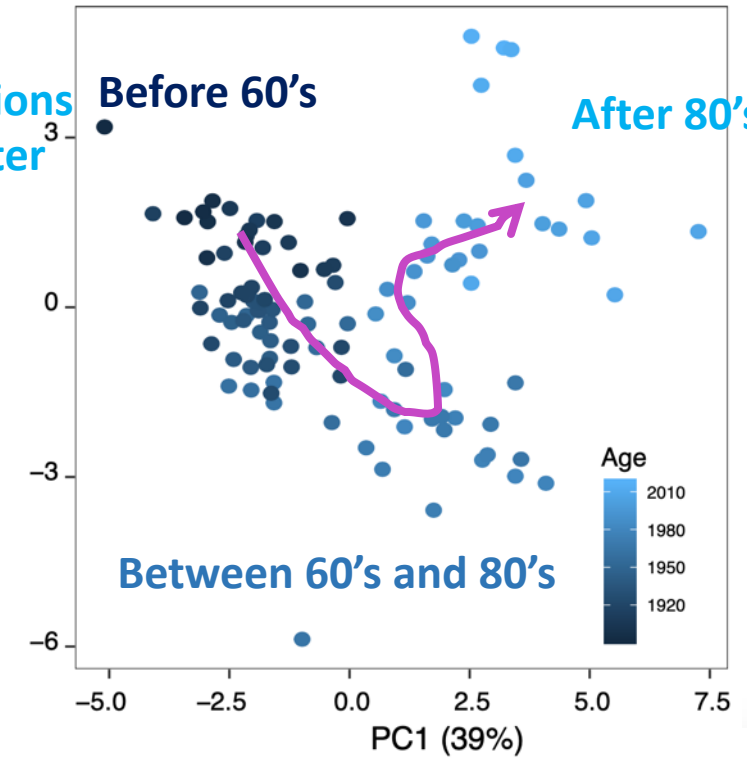
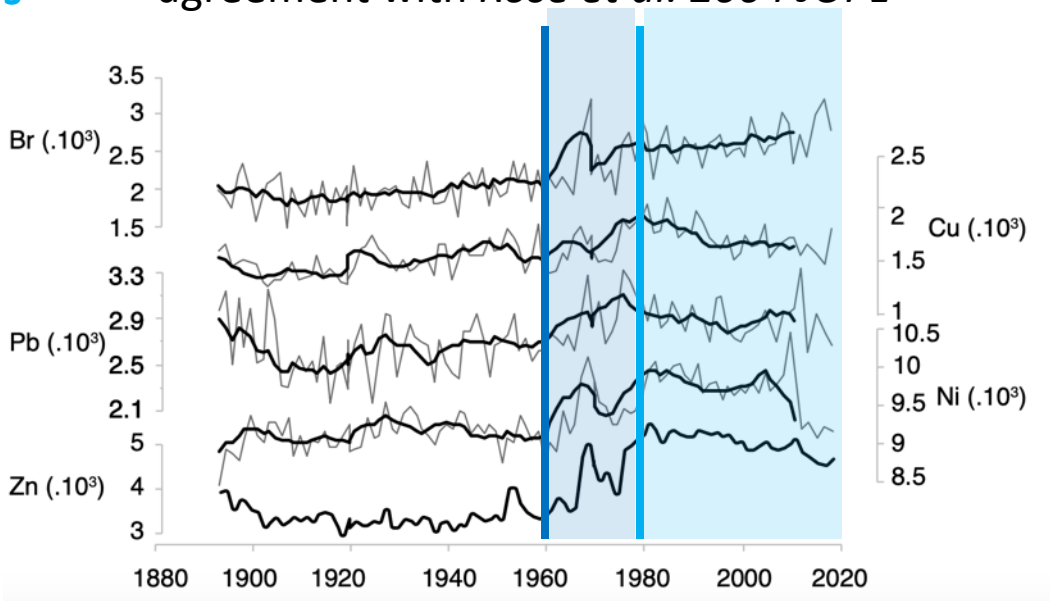
Geochemical record





- Enrichment of organic matter (OM) probably due to the higher productivity
- Enrichment in metals (may be favoured by OM accumulation). Increase in agreement with *Rose et al. 2004 JOPL*



The trends in detrital elements (K, Ti, Rb, Al, Si) and Zr and Ca (here, interpreted as potentially reflecting coarser particles) are different than that previously recorded in the same area (*Rose et al. 2004 JOPL).*

→ **This results highlight the complex sedimentation in such very large and shallow lakes**

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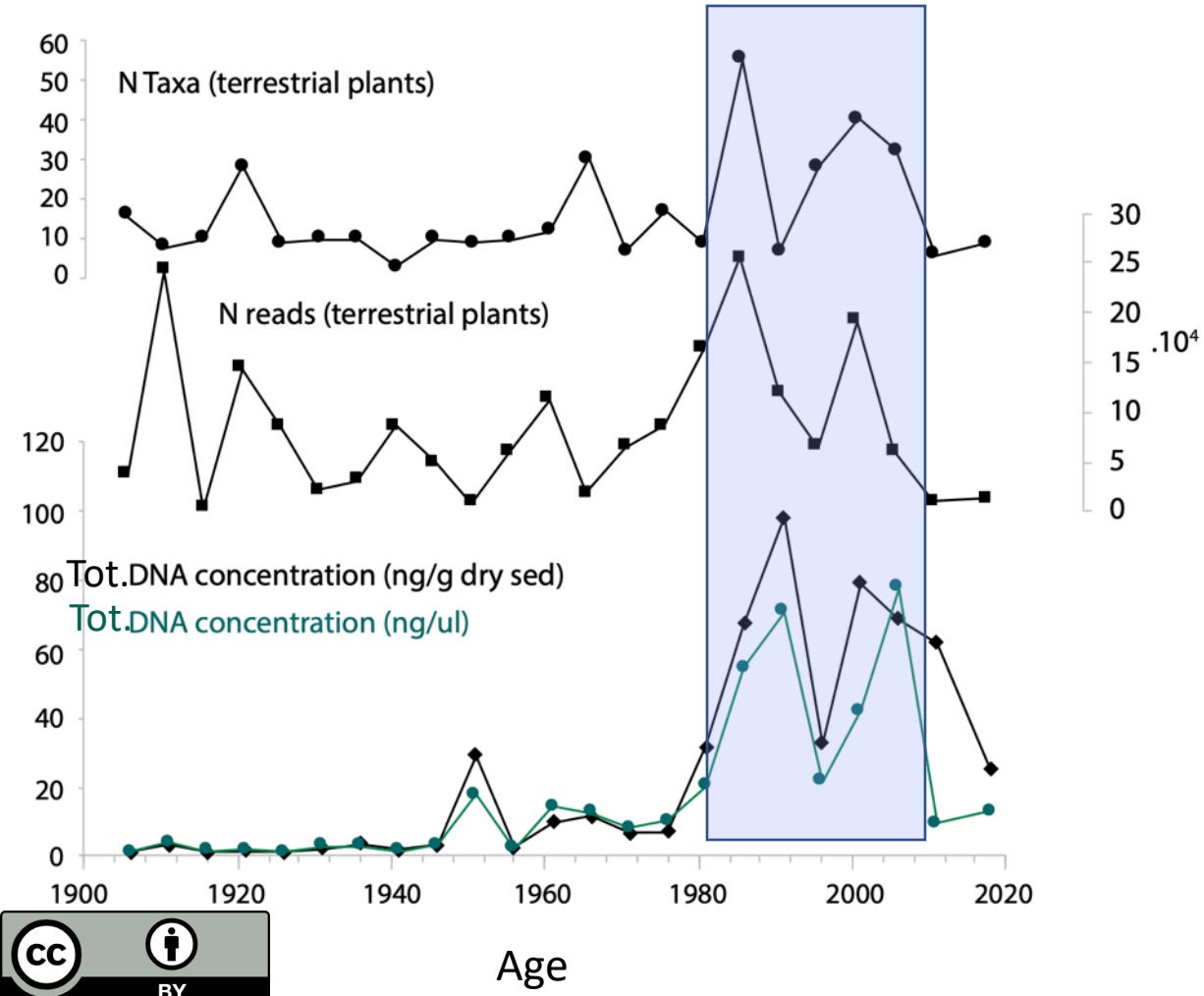
DNA « quantity and quality »

After bioinformatic treatments (obitools) and check for contaminants using our controls and comparing with the “Flora of China” (listed in Jiangsu and/or Zhejiang provinces), we retained 57 taxa (from 3 to 55 taxa by samples, integrating the 4 PCR replicates).



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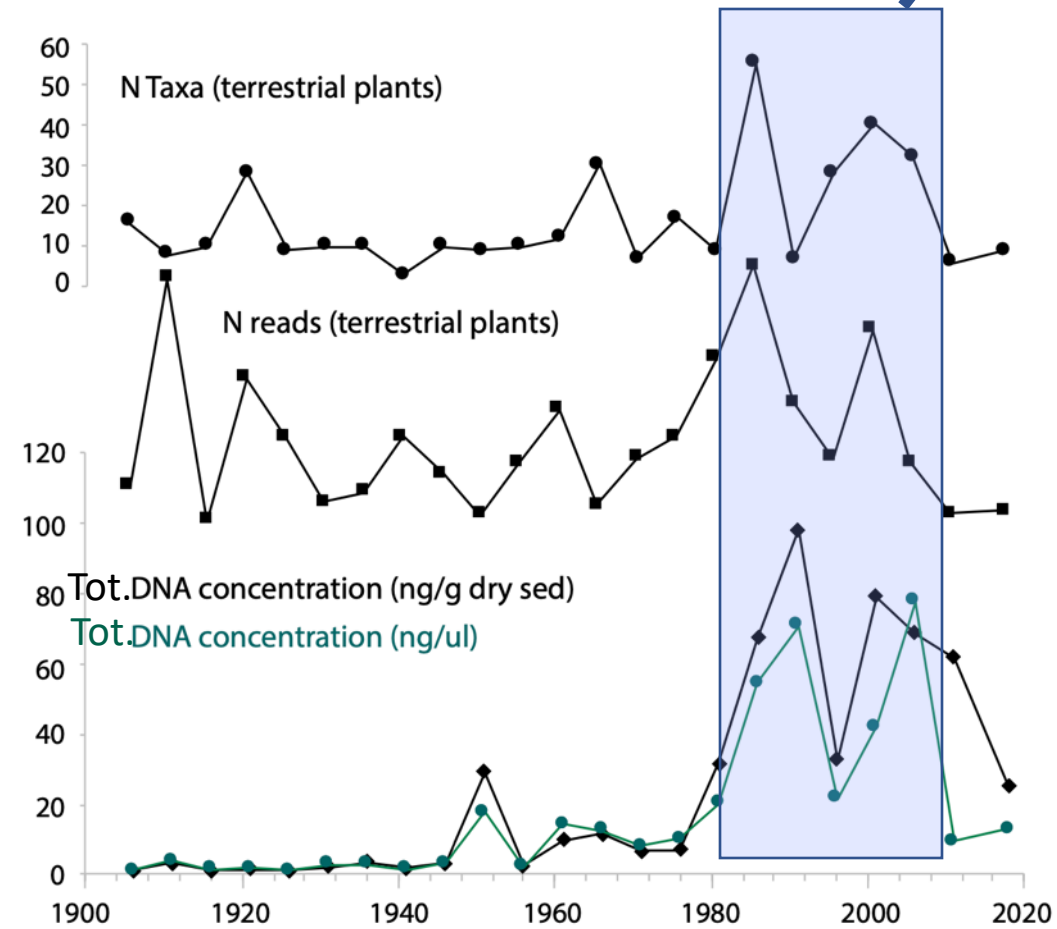
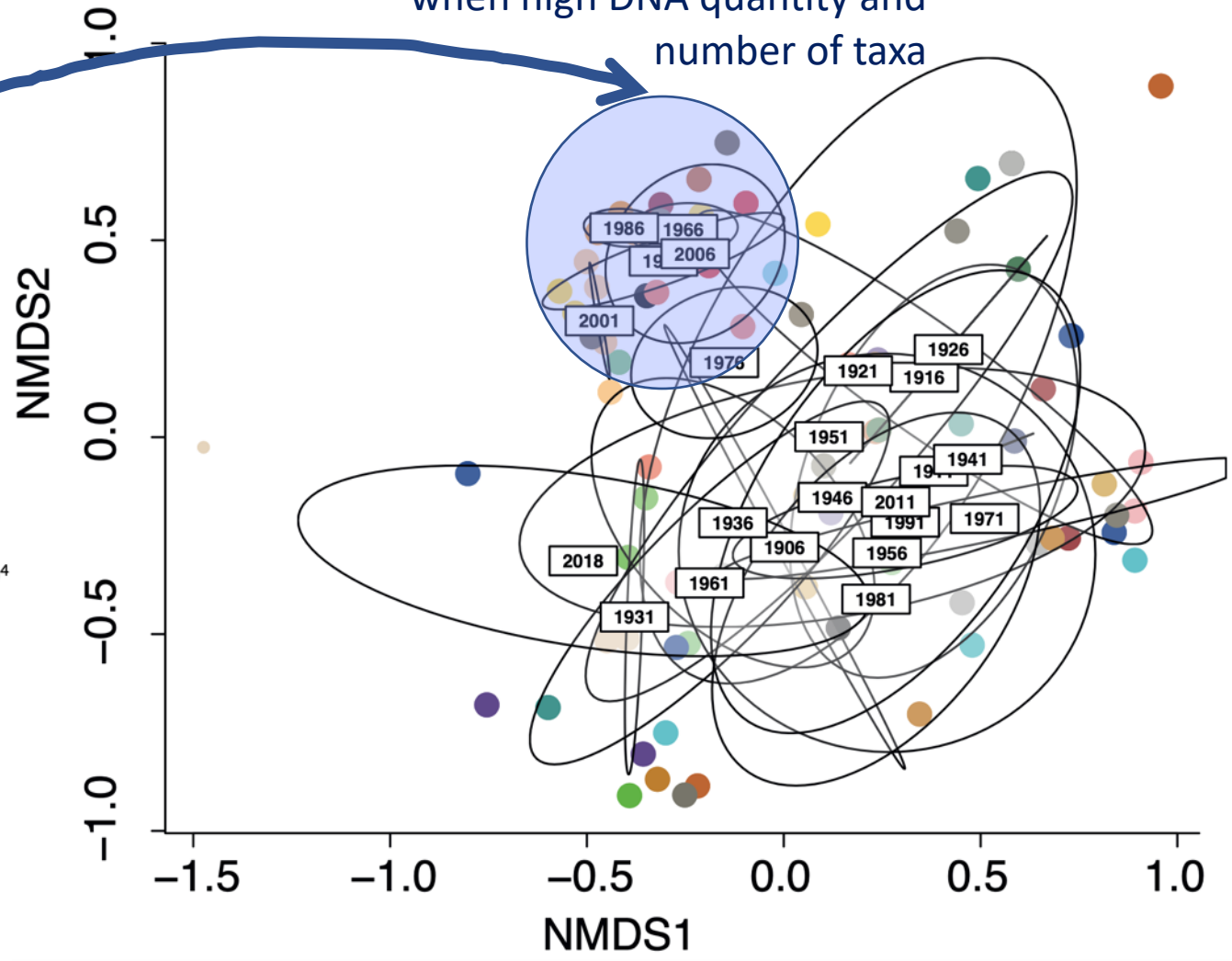
DNA « quantity and quality »

Higher replicate reproducibitity when high DNA quantity and number of taxa





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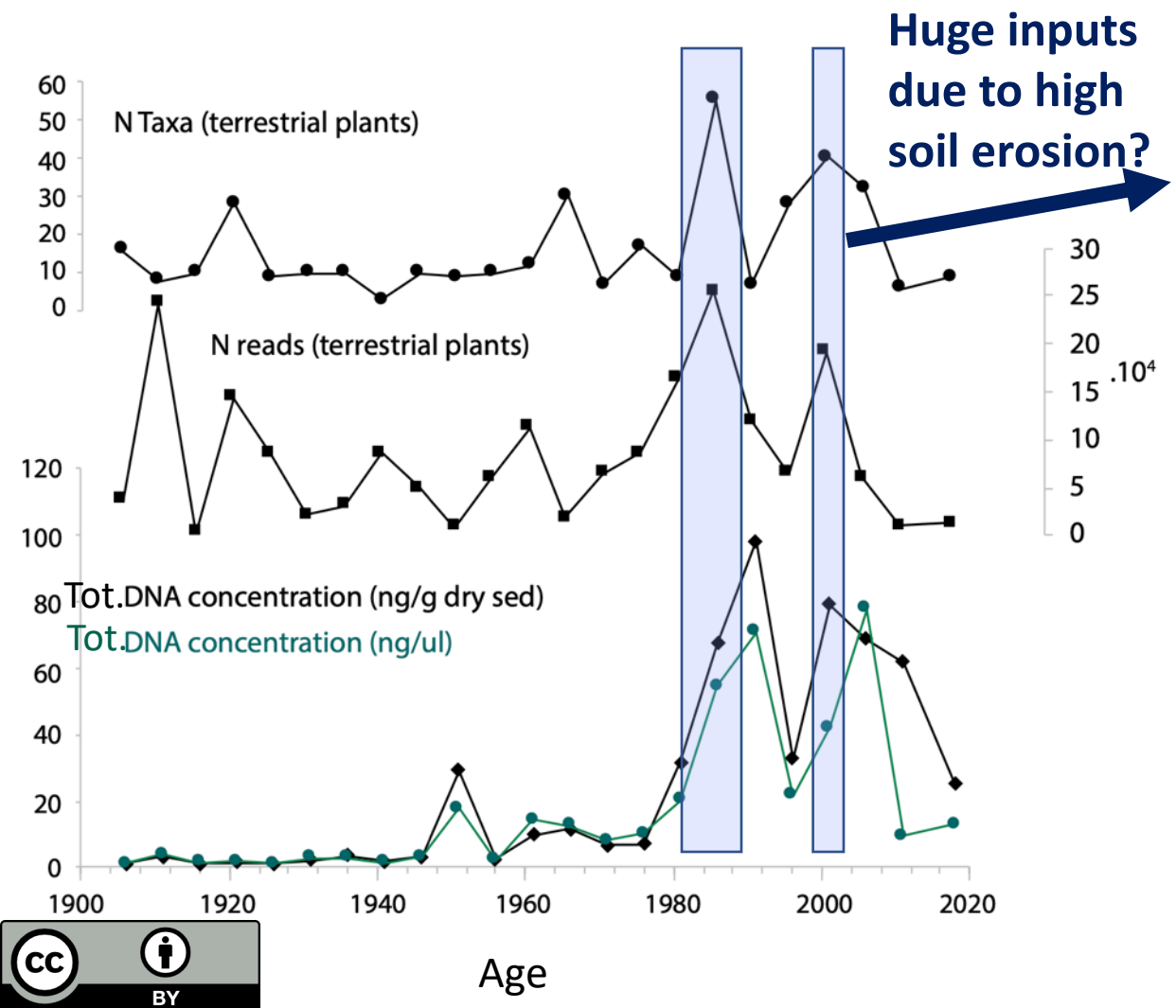
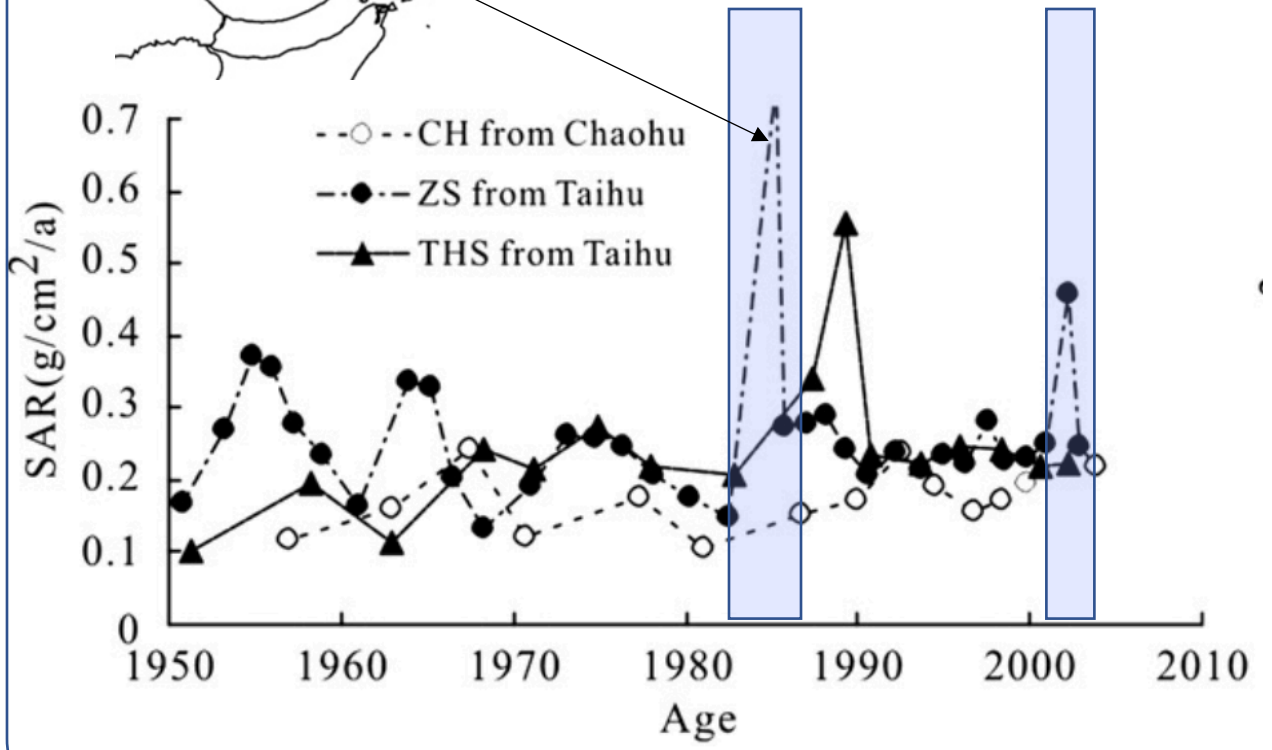
DNA « quantity and quality »



Huge inputs due to high soil erosion?

TAI-18-02

High sediment accumulation rates recorded in a core from the northern part of the lake *(from ^{210}Pb, ^{137}Cs dating)* **at the same time**



Xue & Yao, 2011

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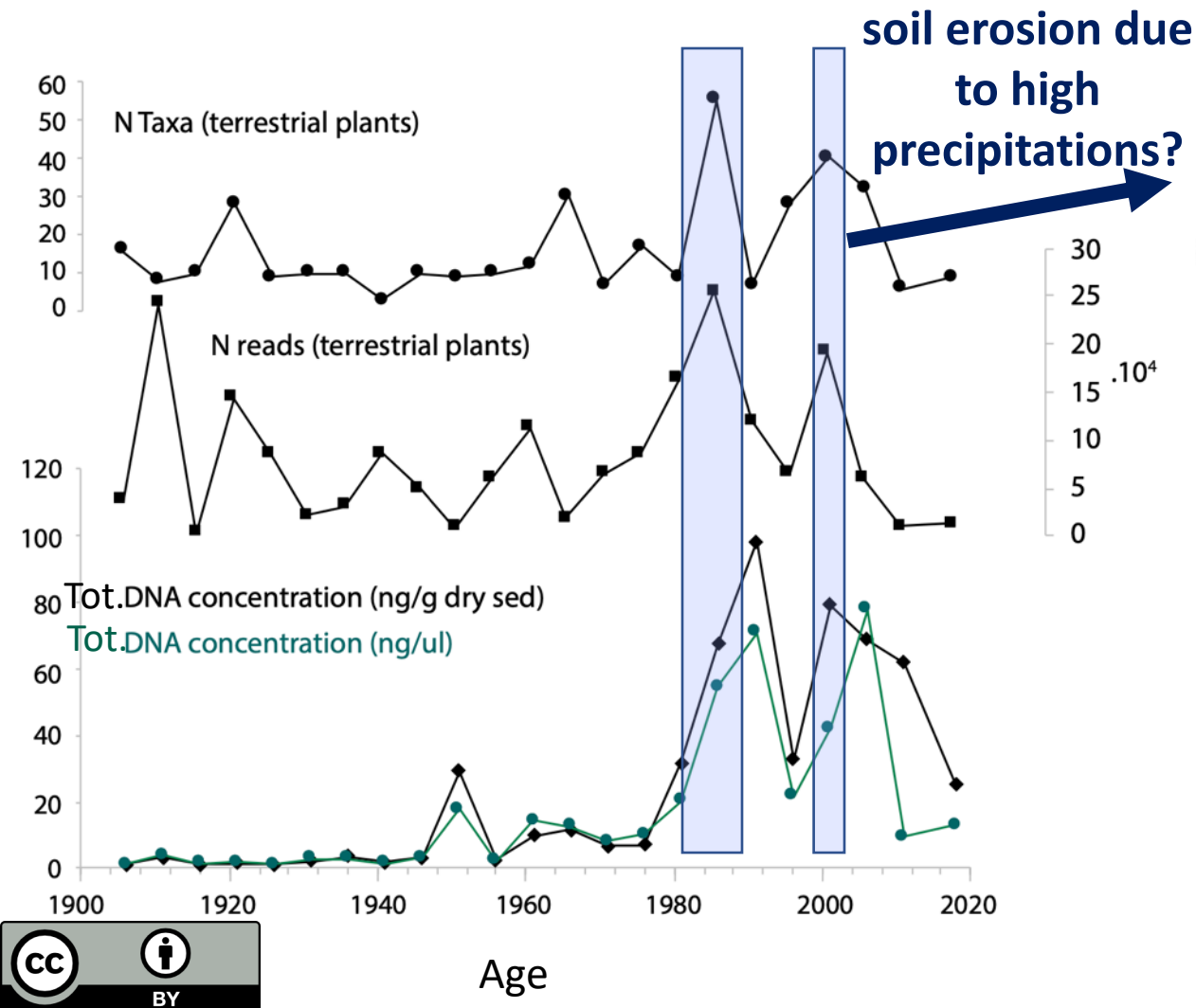
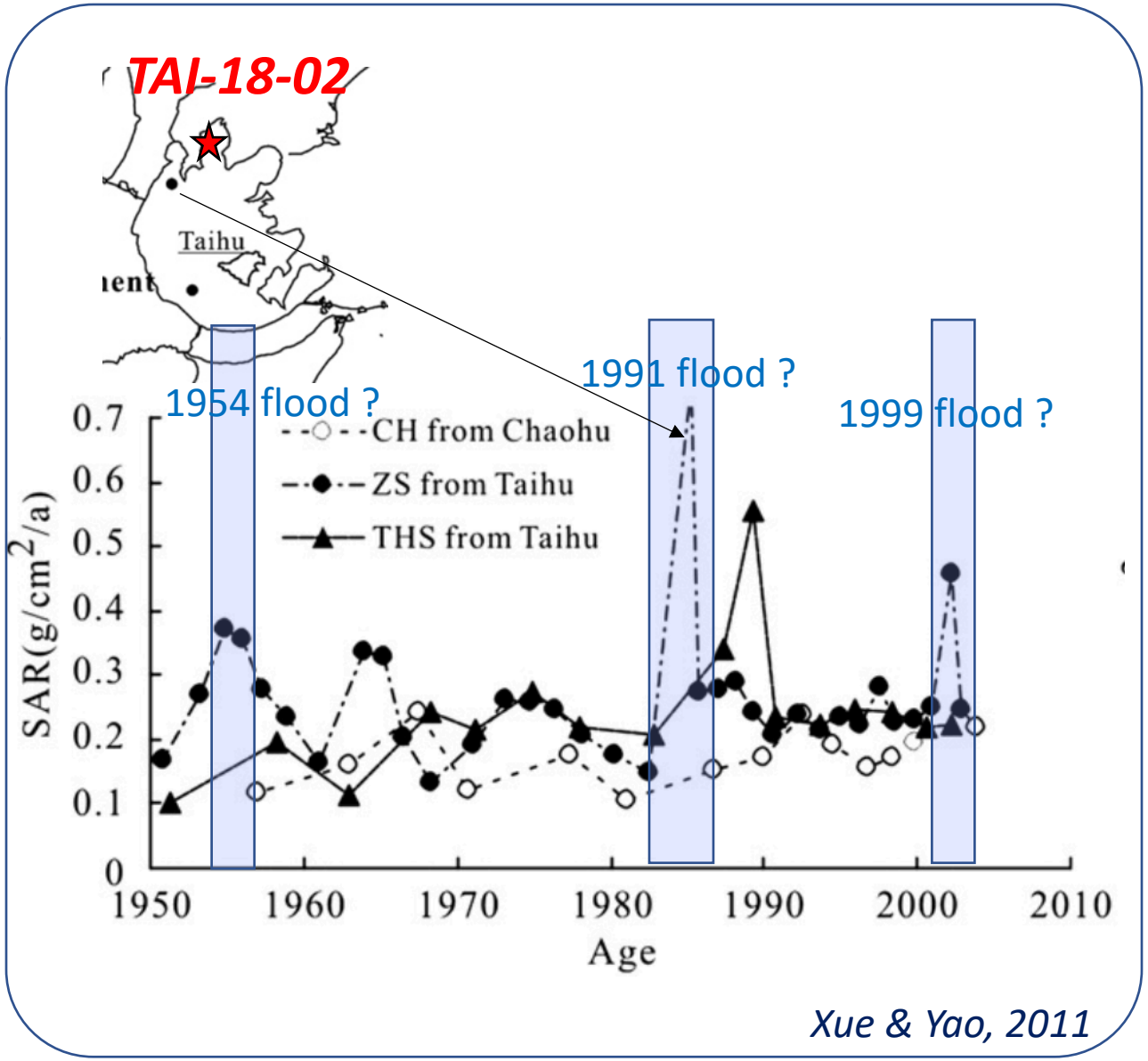
DNA « quantity and quality »

Major floods causing disaster in the basin

1931 1954 1991 1999



soil erosion due to high precipitations?



Xue & Yao, 2011

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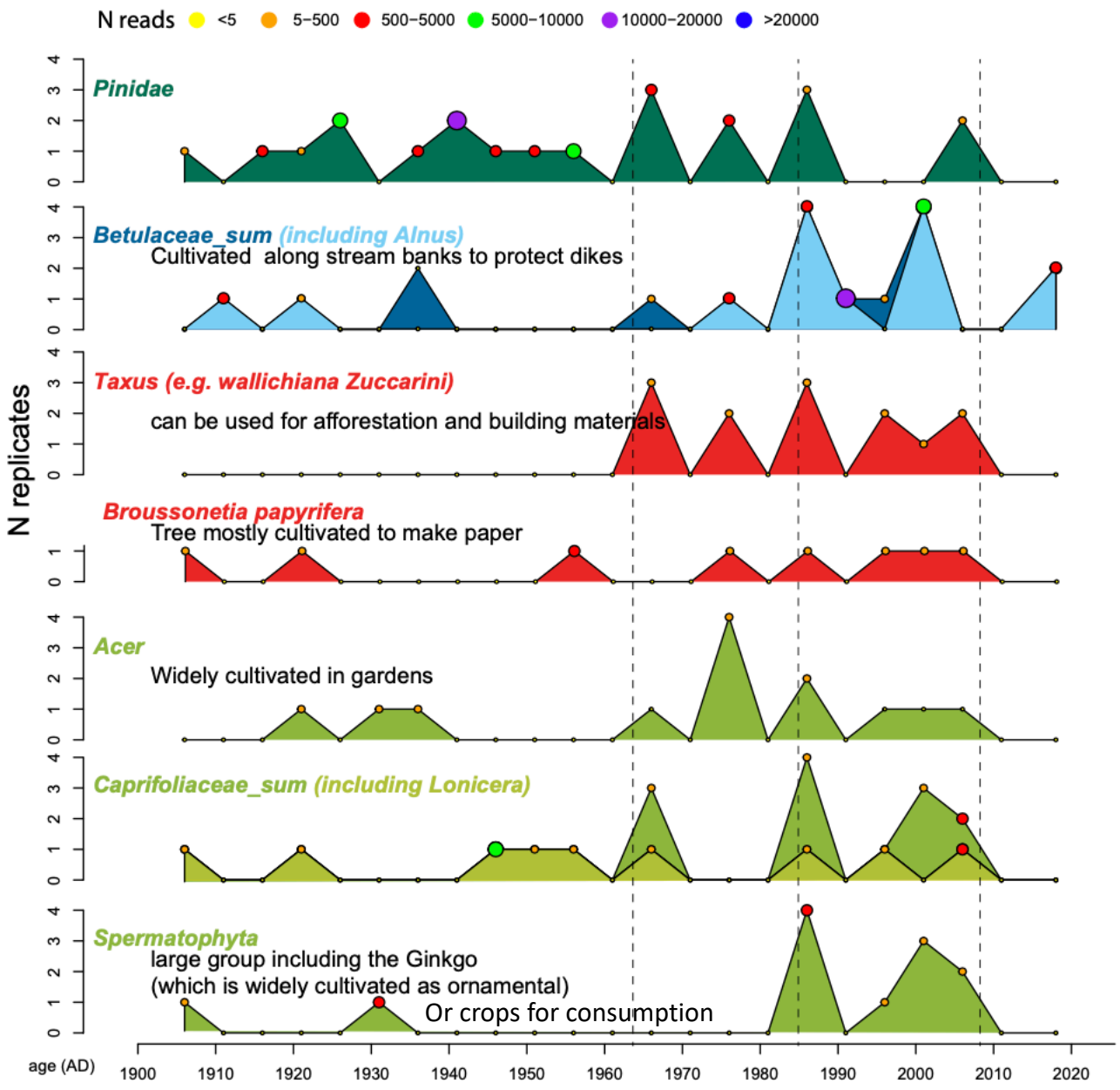
Landscape evolution and human activities: trees



Trees dominated by coniferous species until the 60's

Then, trees reflecting:

- **Dike protection:** increase in mid 80's as in historical data), but the presence of such taxa also reflect erosion of the river bank, which may have been triggered by the big floods in 1991 and 1999.
- **Afforestion for erosion control and/or industry**
- **Paper industry**

- **Gardens → urbanisation** (first increase in mid 60's and then in mid 80's as highlighted by historical data)

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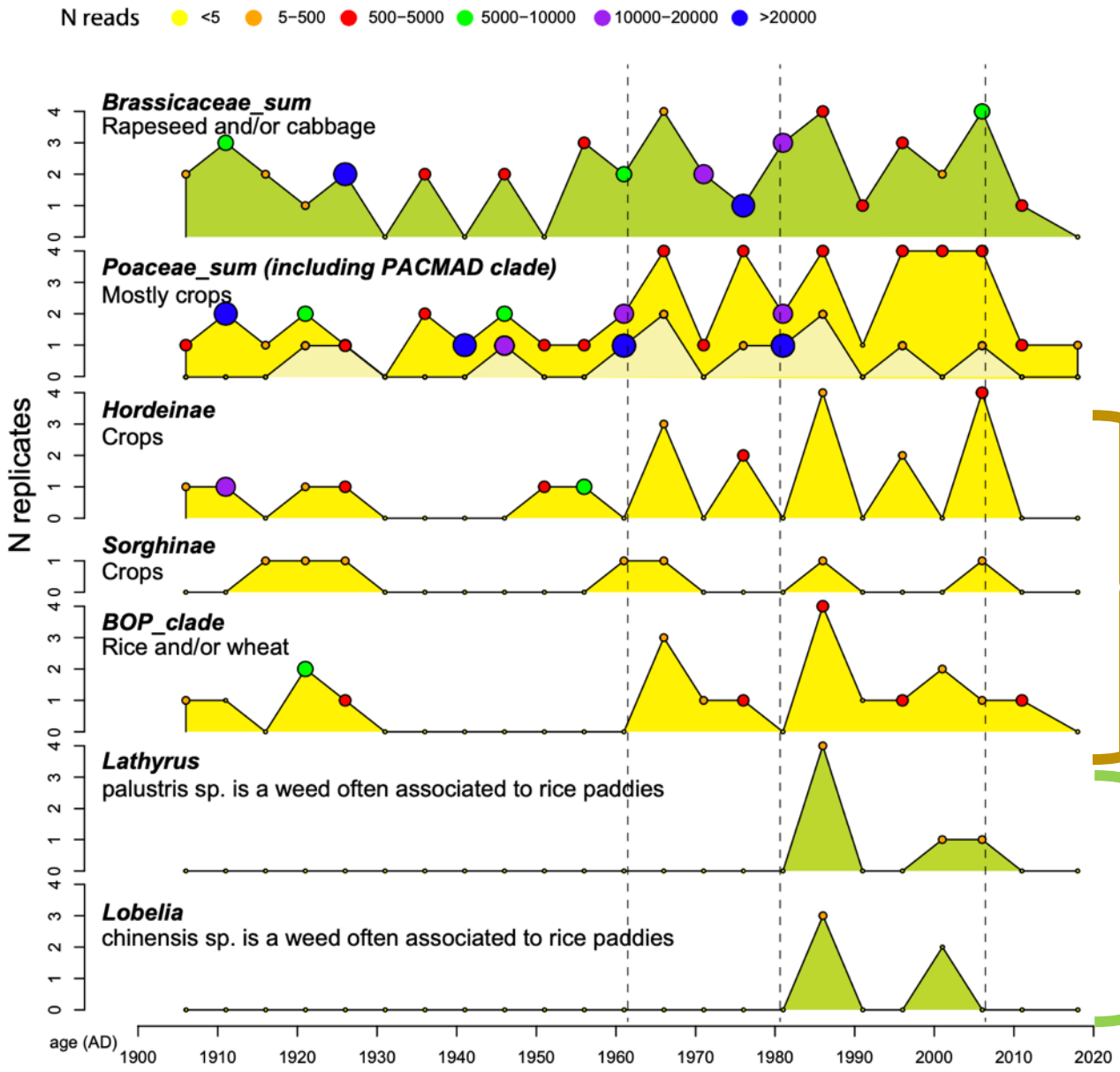
Landscape evolution and human activities: agriculture



Cabbages (rapeseed from 1975 as known in historical data?**)**

Cereal crops?

Barley, wheat, rice and sorgho

May be associated to paddy fields

The increase in agriculture in 60's is in agreement with historical data presented before

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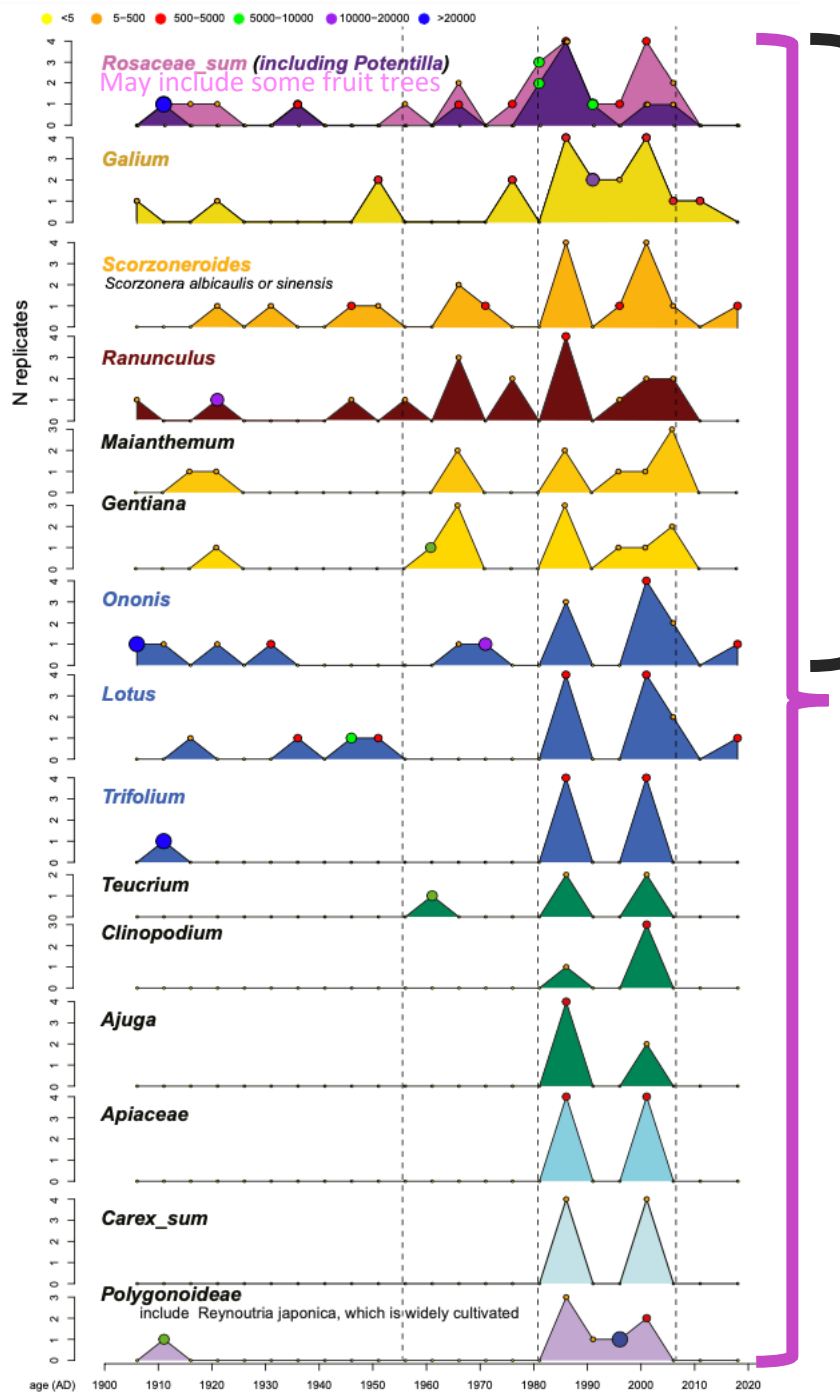
Landscape evolution



More herbaceous plants detected from the 60's

Even much more in mid 80's and 2000 (corresponding to high erosion events discussed before).
→ According to DNA, this erosion affected agricultural soils (maybe more rice paddies), but also meadows and river banks

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Conclusion and perspectives

Lake sedDNA provided:

→ Information on landscape/land use changes in agreement with historical data

→ But also information about the sources of eroded sediments, because the exDNA is fixed on particles as clays and is transfered to the lake with these particles.

→ The beginning of nutrient enrichment started in 60's, which coincides with the increase in agricultural activities.

→ The eutrophication from the 80's was probably caused by the use of fertilizers and urban development (sewage waters), but the huge erosion events in mid 80's and 2000 probably triggered very high nutrient inputs (from fertilizers) toward the lake and can explain the peaks in TP that were recorded at that times (*Ke Zhang et al. 2015*).

But:

→ the taxonomic resolution of Plant DNA data is limited by the by the lack of species in the reference database, which limit our interpretations especially on the origin of the sediments and erosion dynamic in the catchment

Thanks!!