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Aquatic ecosystems

Prof. Tom Battin

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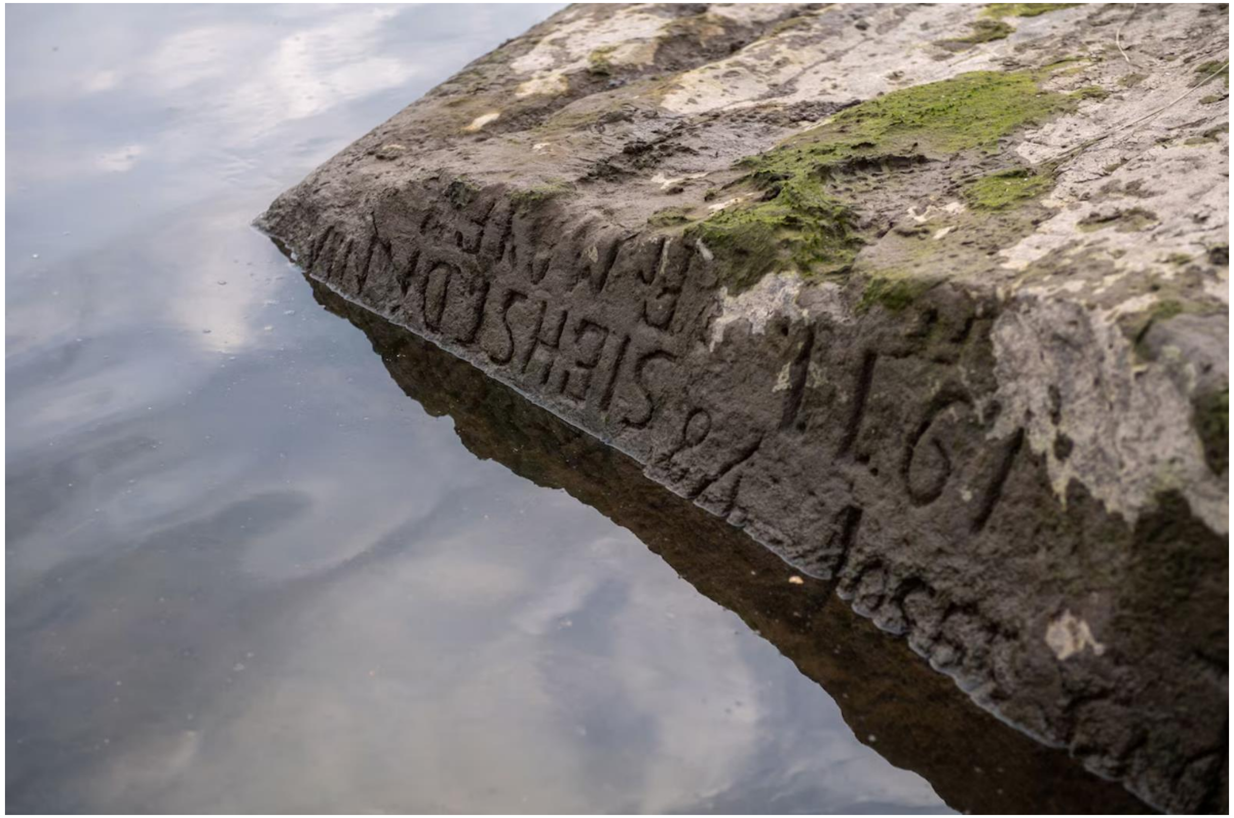
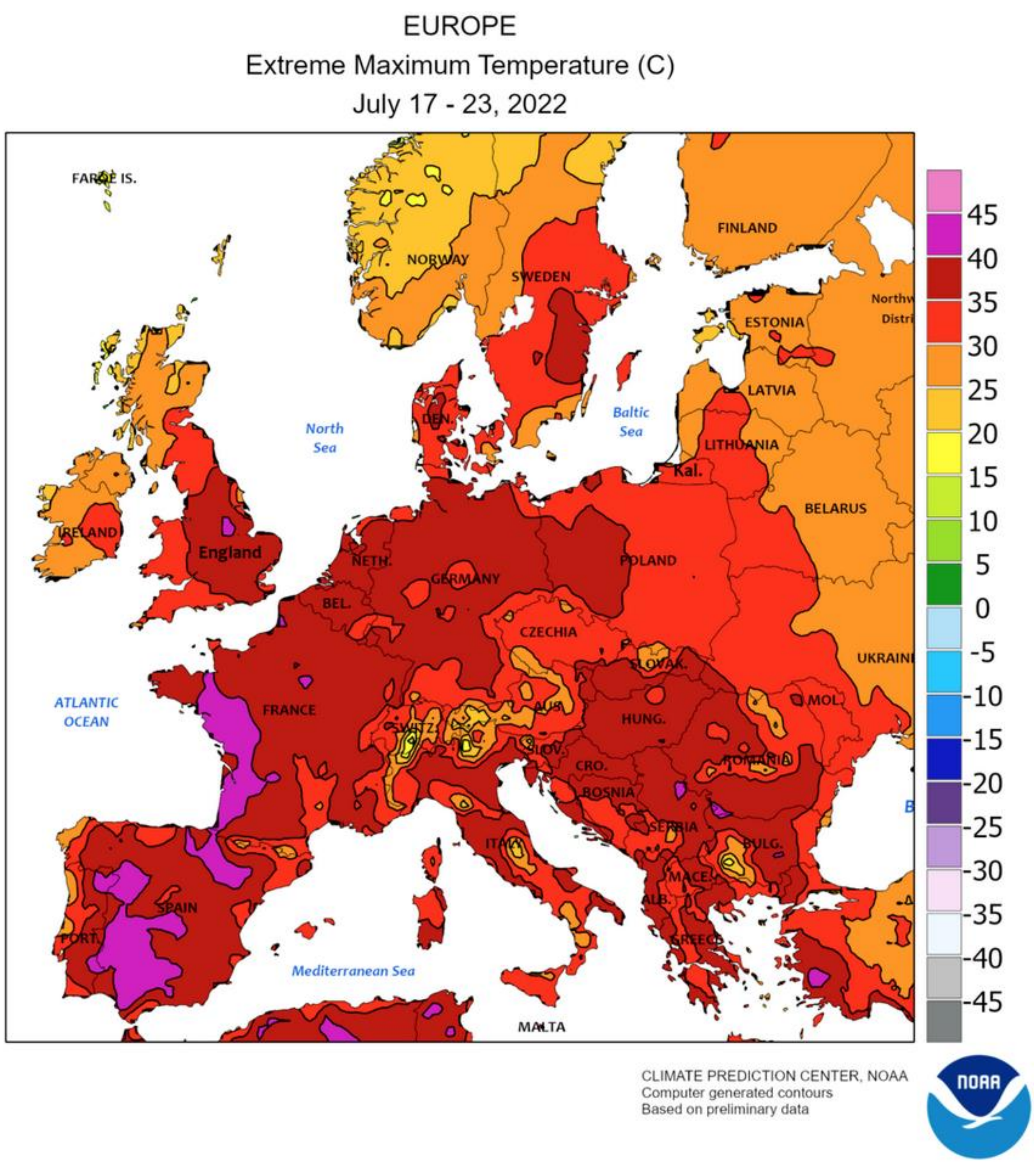
குடம்!
இங்கே
தண்ணீர்
எங்கே?



Prolonged drought lowered the level of the Elbe River so much in summer 2022 that the so-called Hunger Stone, one of the oldest hydrological monuments in Central Europe, appeared in Decin, Czech Republic.

It heralded the famine years—reduced harvests due to drought.

The stone is engraved with the years—the oldest from 1616—and inscriptions. The most distinct is the old German "Wenn du mich siehst, dann weine" ("If you see me, weep").



The drought is revealing "hunger stones" in Germany and the Czech Republic (Credit: Dr. Bernd Gross/CC-BY-SA-3.0/Wikipedia.org)

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Environmental awareness and stewardship towards a sustainable planet Earth

More than just Water Resources Management

Understand how our planet works
Understand how aquatic ecosystems work

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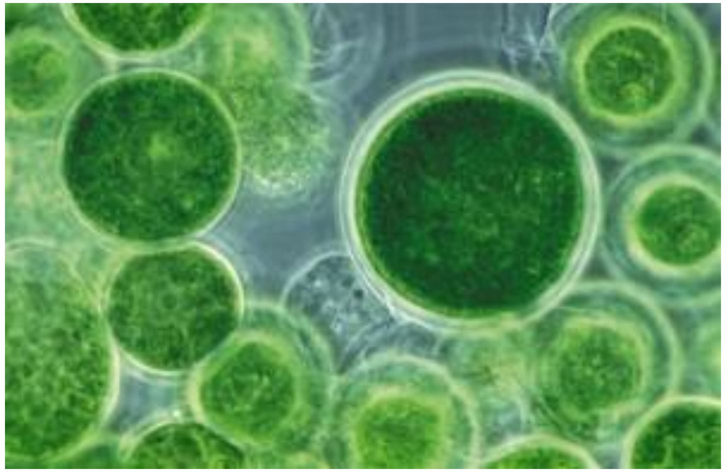
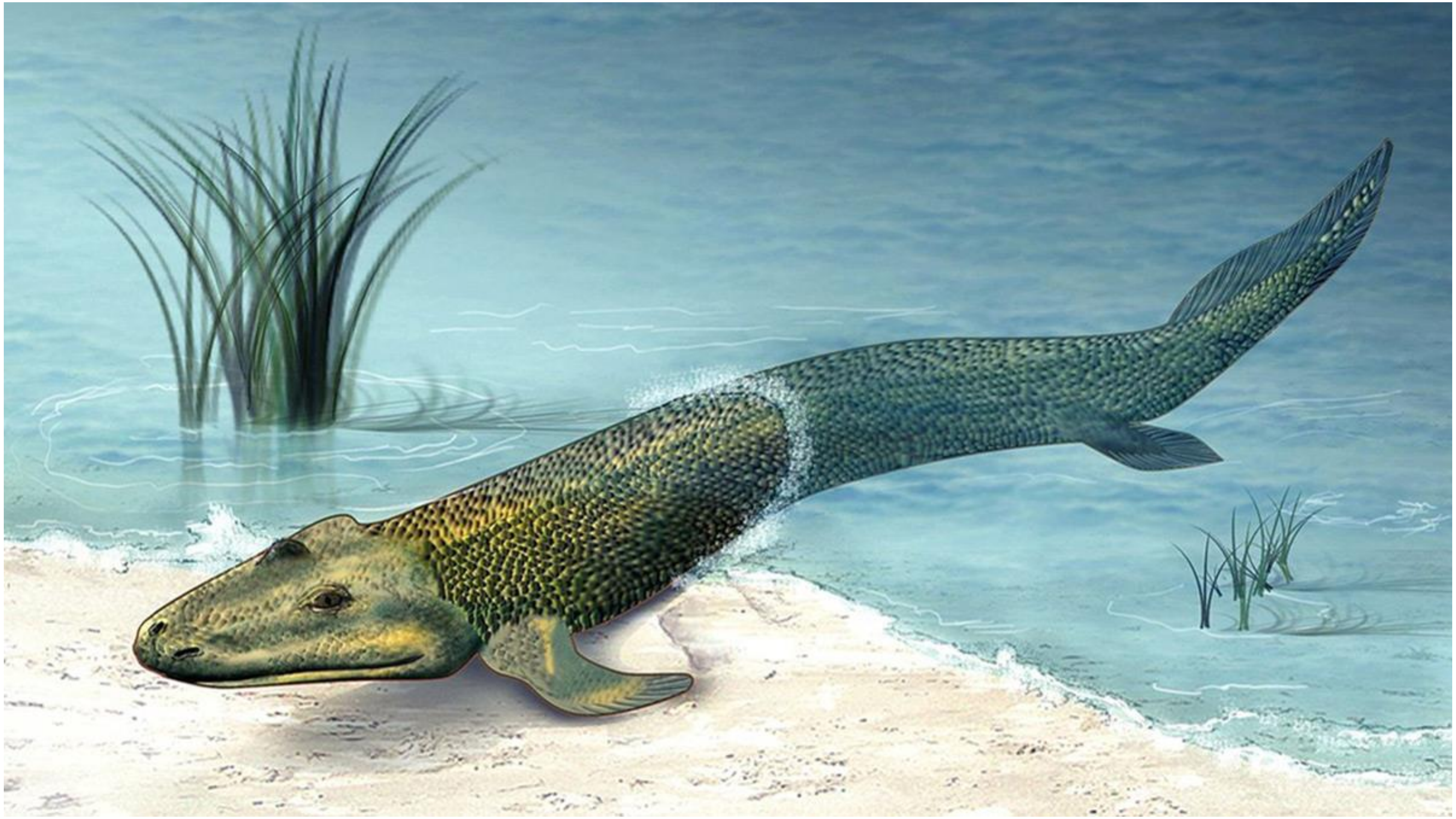
Early life on Earth



Early life on Earth



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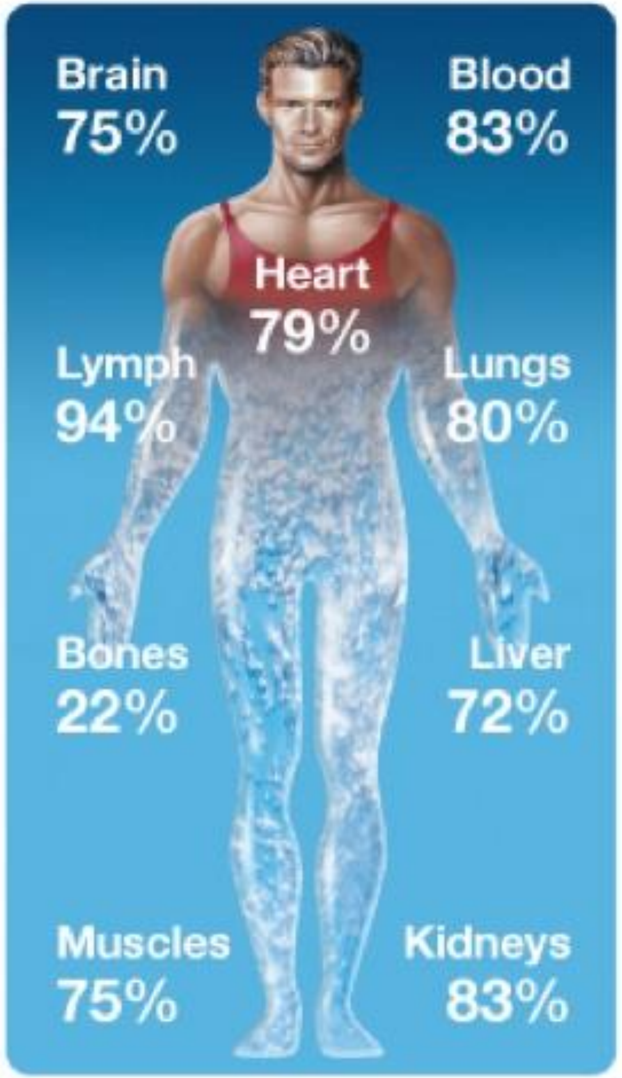
‘We are water…’



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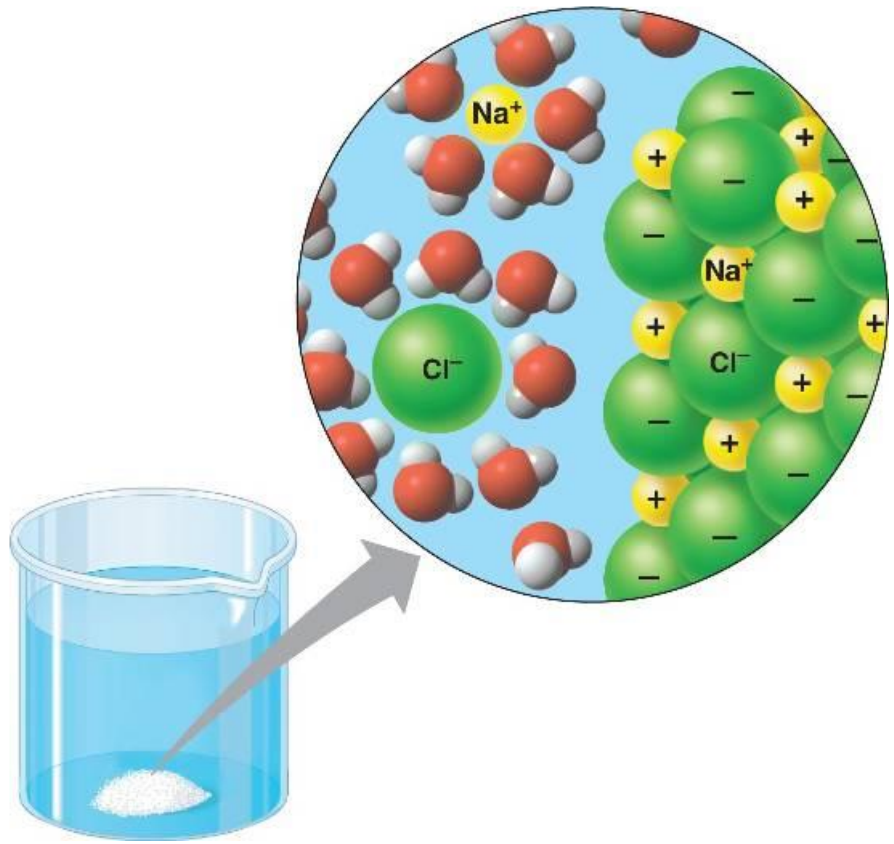
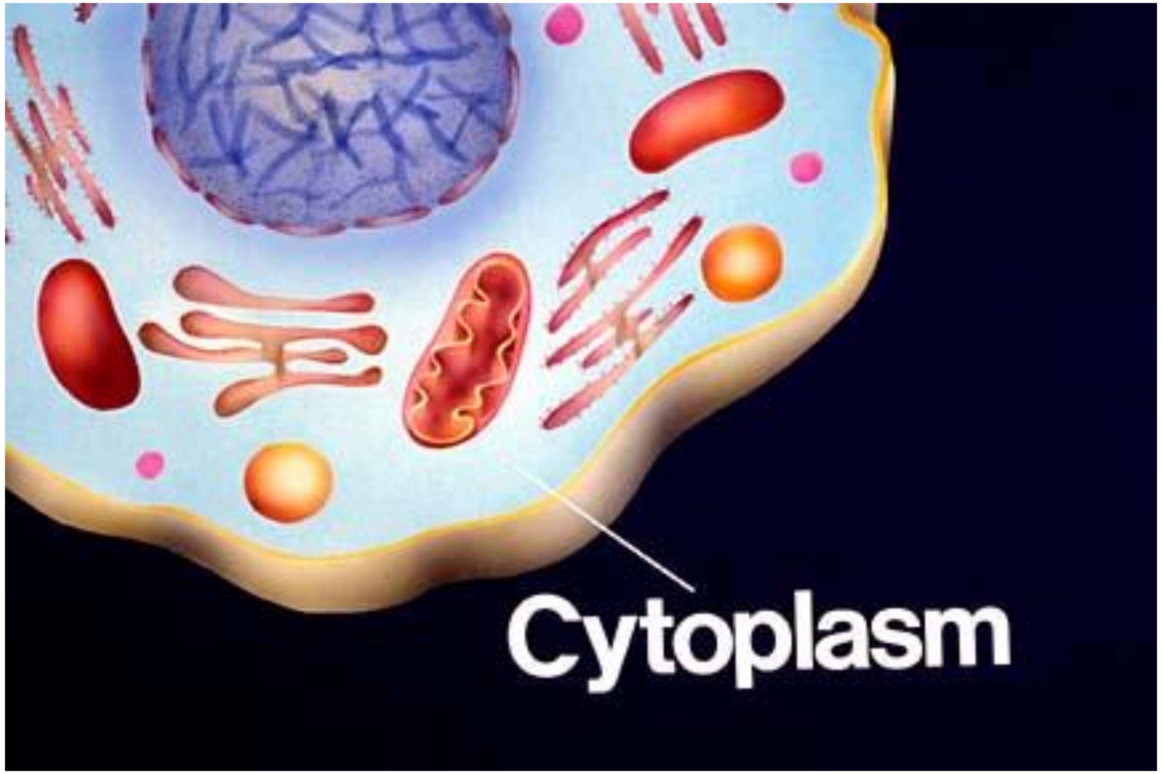
Water as a solvent
Enabling life



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Water
should not
be a privilege
unicef
for every child

Looming water crisis

Aquatic ecosystems

Ecosystem services

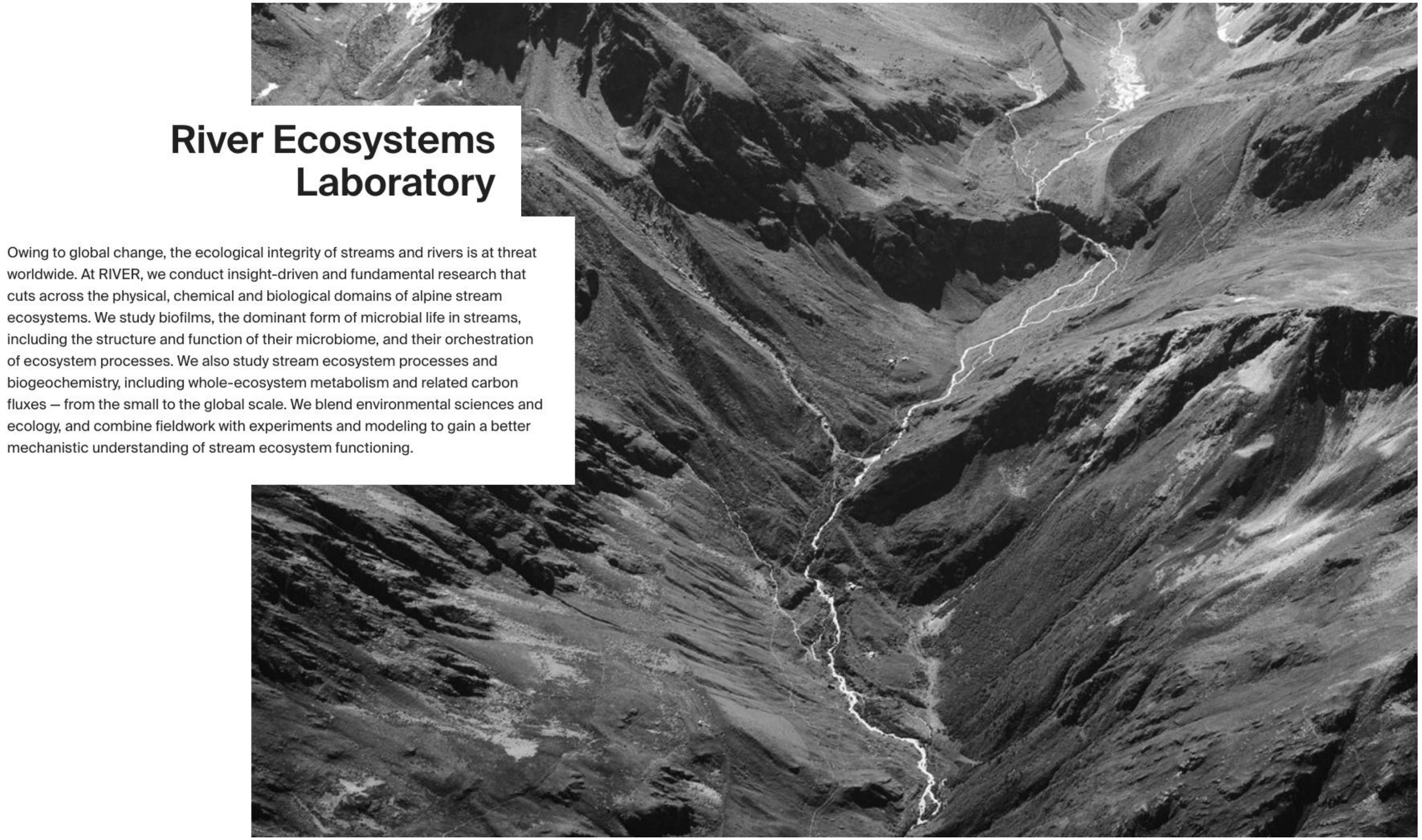
Aquatic Ecosystems

- Introduction and a brief history of freshwater science
- Fundamental physical and chemical properties of water – what makes aquatic ecosystems so special?
- The physical basis of lakes and rivers
- Ecosystem metabolism
- Nutrient cycling
- Inland waters and global biogeochemical cycles
- Biodiversity and ecosystem services

Field trip +/- 1 Day

…or ALPOLE, Rhône

The River Ecosystems Laboratory at EPFL



- Ecosystem processes
- Biogeochemistry
- Carbon cycling
- Microbiome structure and functioning
- Ecohydraulics

Lab at ALPOLE, Sion

China, Russia, Columbia, France, Austria, Switzerland, Germany, Malaysia, Italy, Argentina, Canada, Poland, Luxembourg

https://www.epfl.ch/labs/river/

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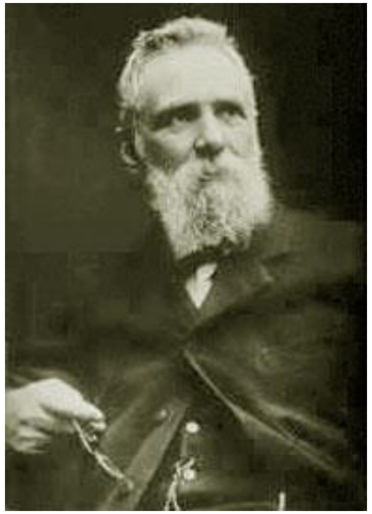
A brief history of freshwater sciences

Francois Forel
(1841-1912)



Hydrobiology/
Limnology

Stephen A Forbes
(1844-1930)

„The lake as
a microcosm“

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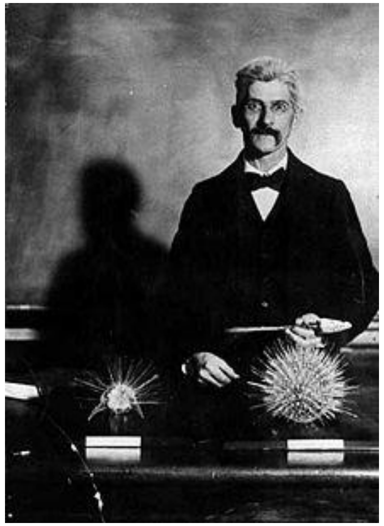
A brief history of freshwater sciences

Edward Asahel Birge
(1851-1950)



Thermal stratification
recirculation

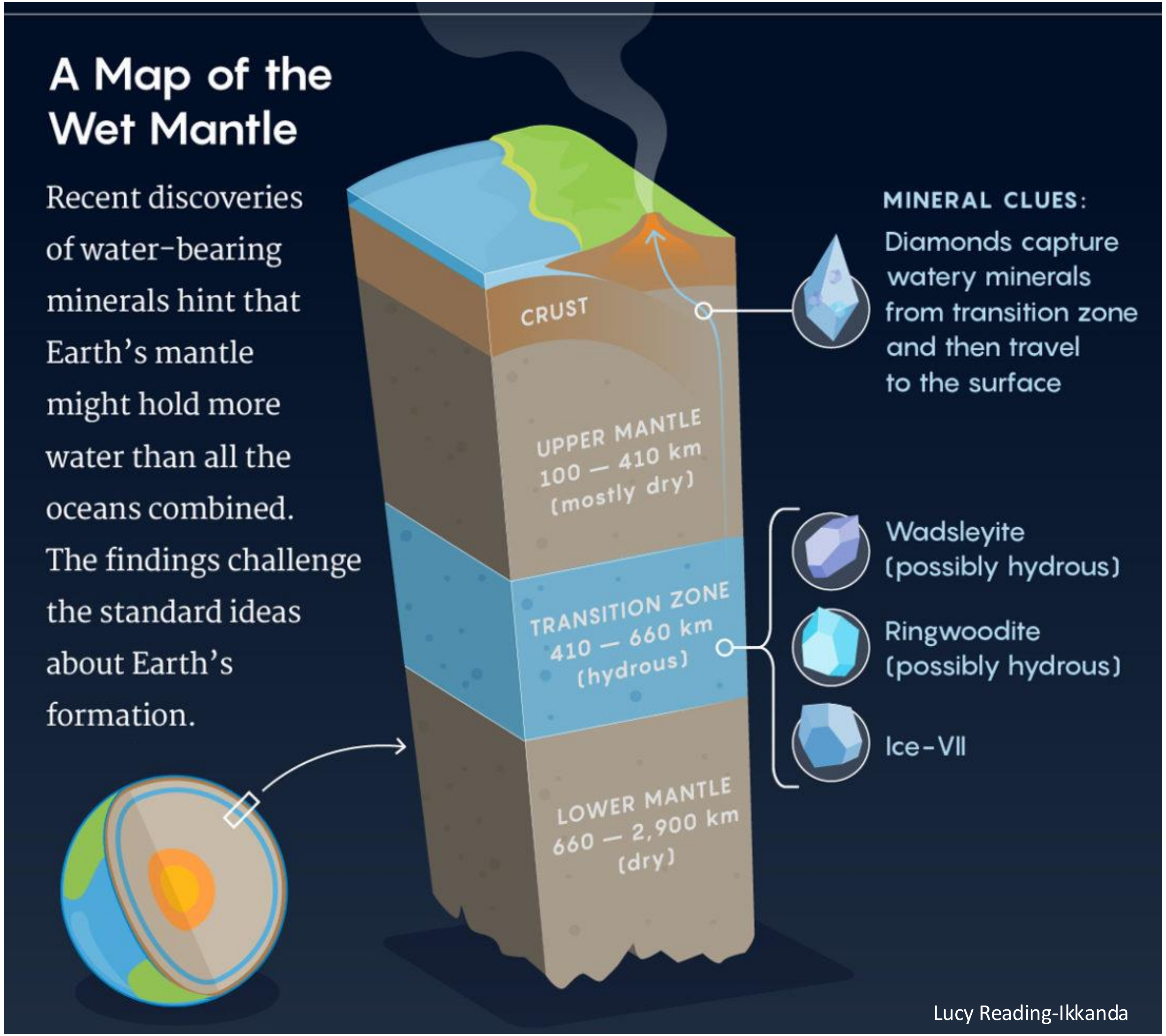
August Thienemann
(1882-1960)

Plankton ecology

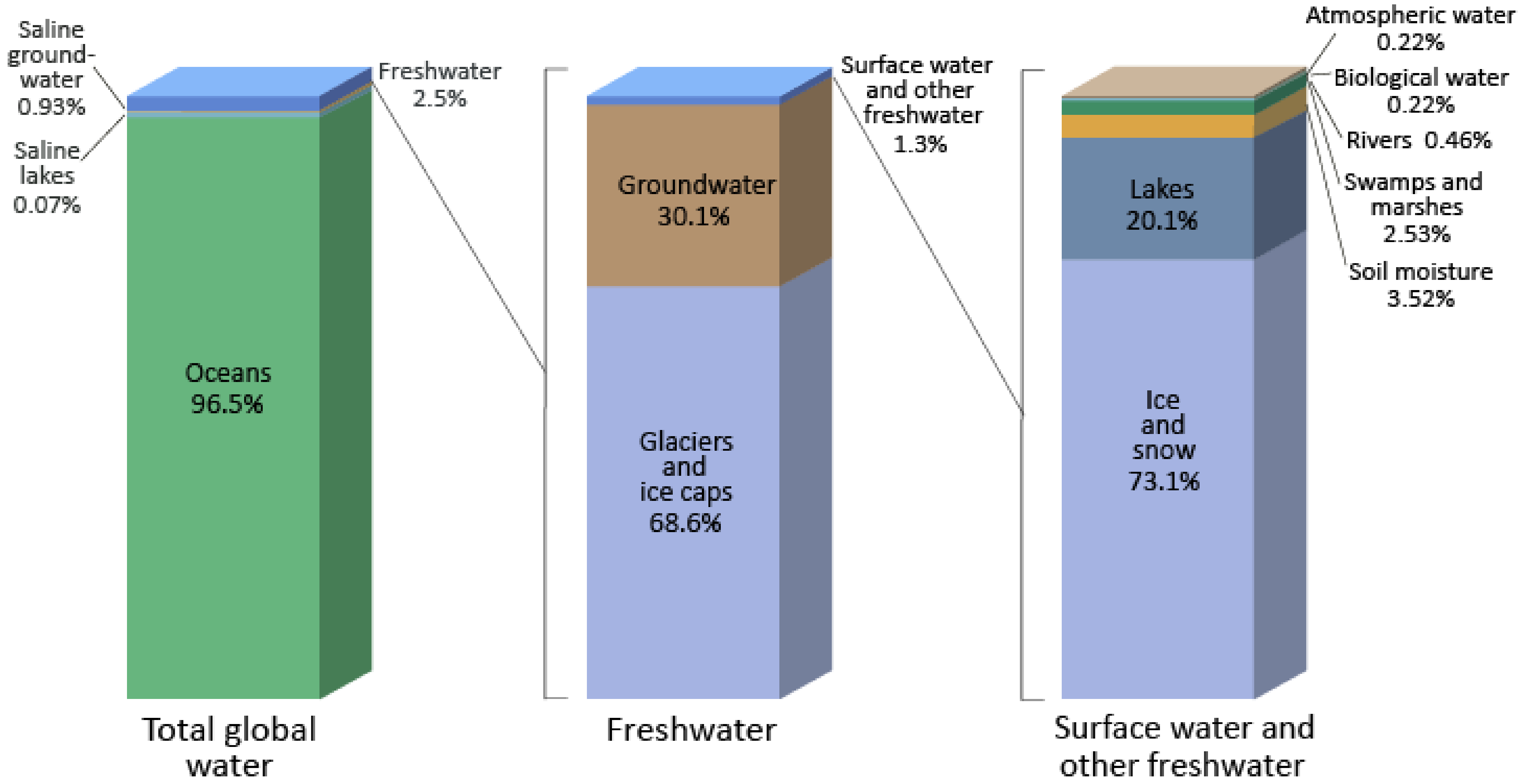
G Evelyn Hutchinson
(1903-1991)

Biogeochemistry
Palaeolimnology

How is water distributed on Earth?



Deep water
In Earth's mantle



Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources.

Table 10.4 **Estimated mean residence times (storage to throughput) and stored water volumes of the main components of the Earth's hydrosphere**

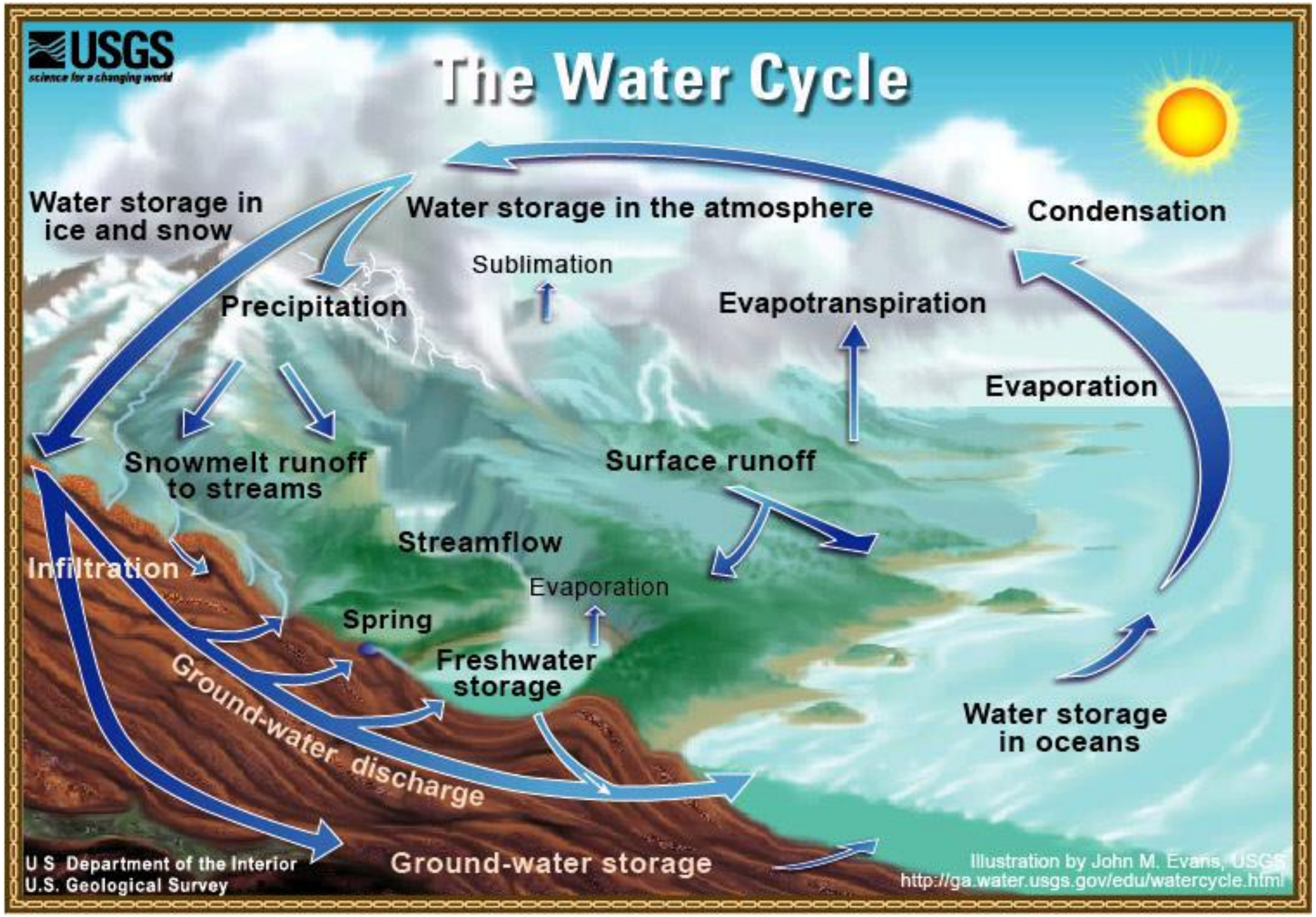
Component	Mean residence time	Total water stored (thousands of cubic kilometres)	Freshwater stored (thousands of cubic kilometres)
Permafrost zone, ground ice	10,000 years	300	300
Polar ice	9,700 years	24,023	24,023
Oceans	2,500 years	1,338,000	na
Mountain glaciers	1,600 years	40.6	40.6
Groundwater (excluding Antarctica)	1,400 years	23,400	10,530
Lakes	17 years	176.4	91.0
Swamps	5 years	11.5	11.5
Soil moisture	1 year	16.5	16.5
Streams	16 days	2.1	2.1
Atmosphere	8 days	12.9	12.9
Biosphere	Several hours	11.2	11.2
Total		1,385,985	35,029

Turnover of water in aquatic ecosystems

Storage and residence times

Why does it matter?

- Physical and chemical stability
- Biogeochemical reactions
- Habitat diversification and biodiversity



Storage and fluxes
Interactions between aquatic ecosystems

- Atmosphere
- Surface flow
- Subsurface flow

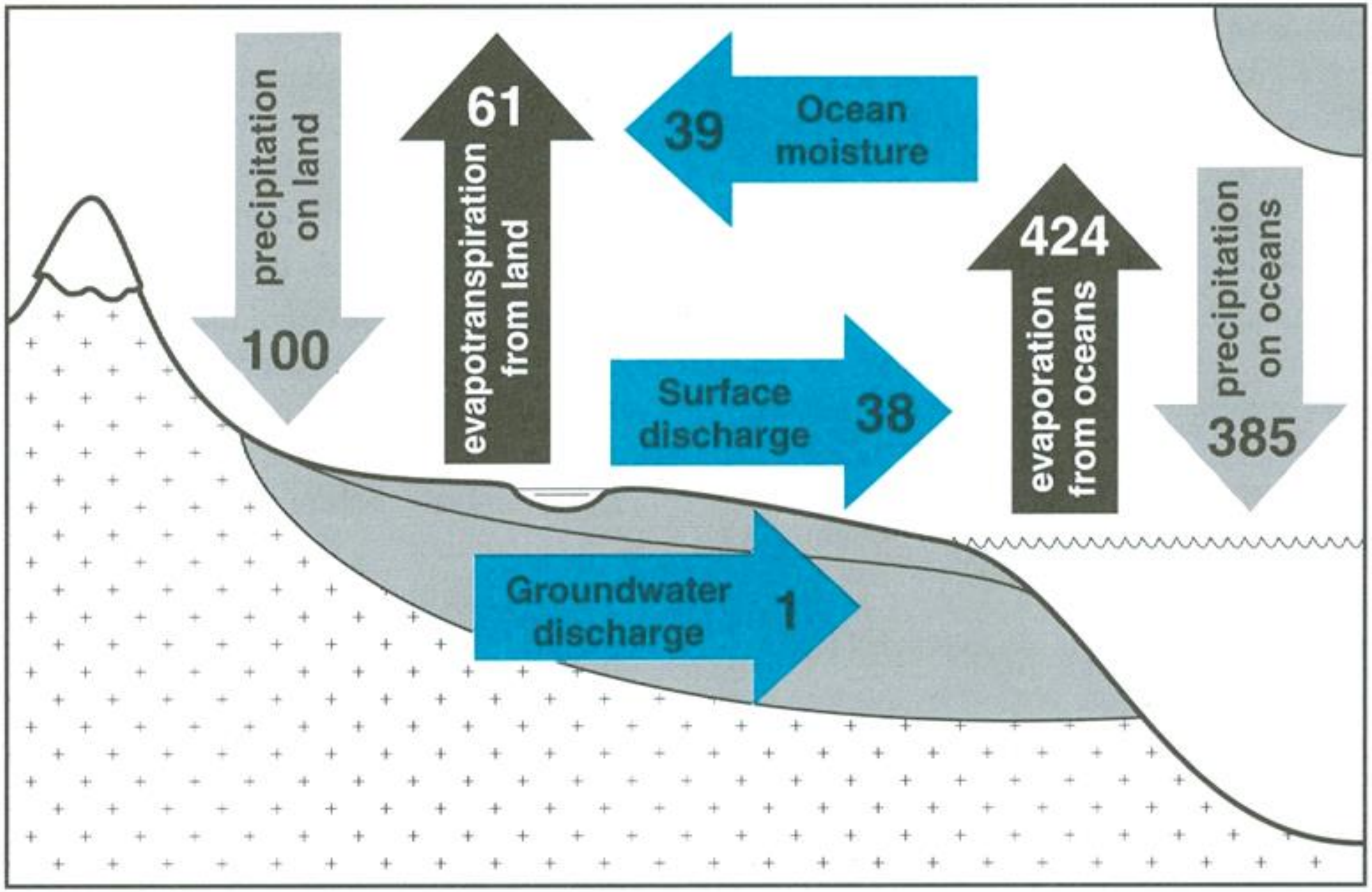


Figure 1.4 Flows within the hydrological cycle. Units are relative to the annual precipitation on the land surface (100 = 119,000 km^3 yr^{-1}). Black arrows depict flows *to* the atmosphere, gray arrows depict flows *to* land or oceans, and blue arrows indicate lateral flows. Data from Maidment (1993).

Storage and fluxes
Interactions between aquatic ecosystems

- Atmosphere
- Surface flow
- Subsurface flow

What is an ecosystem?

An ecosystem can be categorized into its abiotic components, including minerals, climate, soils and water, and all other non-living elements, and its biotic constituents, consisting of all its living members.

Linking these constituents together are two major forces: the flow of energy through the ecosystem and the cycling of nutrients within the ecosystem.

Ecosystems are embedded in the landscape, with transition zones between other ecosystems.

CellPress
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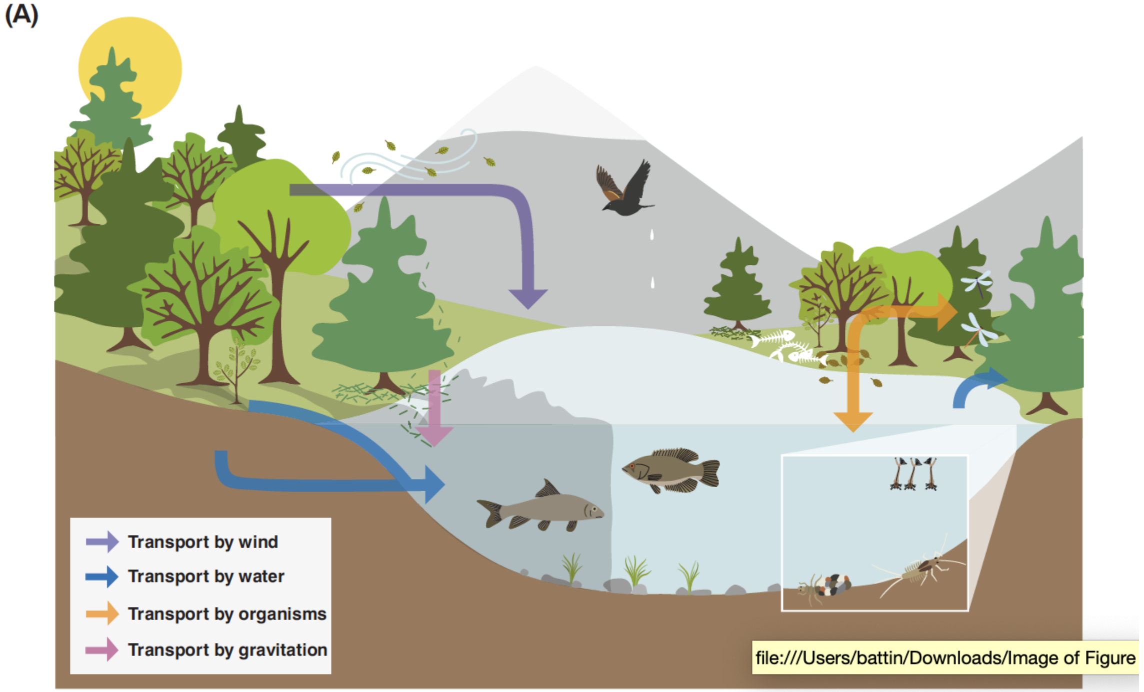
Trends in
Ecology & Evolution

Review

Pathways for cross-boundary effects of biodiversity on ecosystem functioning

Michael Scherer-Lorenzen,[1,12,20,*] Mark O. Gessner,[2,3,4,13,20] Beatrix E. Beisner,[5,6,14,@] Christian Messier,[5,7,8,15] Alain Paquette,[5,7,16,@] Jana S. Petermann,[9,17,@] Janne Soininen,[10,18,@] and Charles A. Nock[1,11,19,20,@]



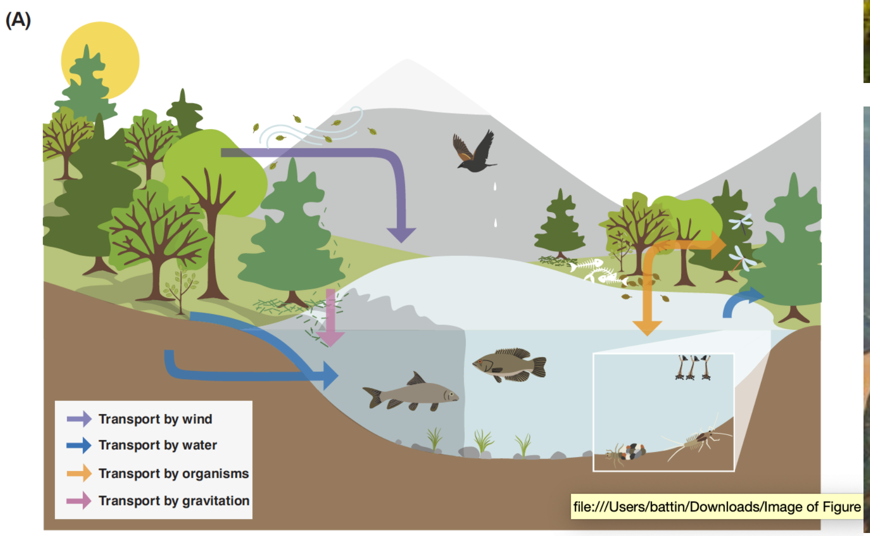
Aquatic ecosystems
Freshwater ecosystems

Surface waters (*versus* groundwater)

- Lakes
- Rivers
- Wetlands

Different transitions to terrestrial environment

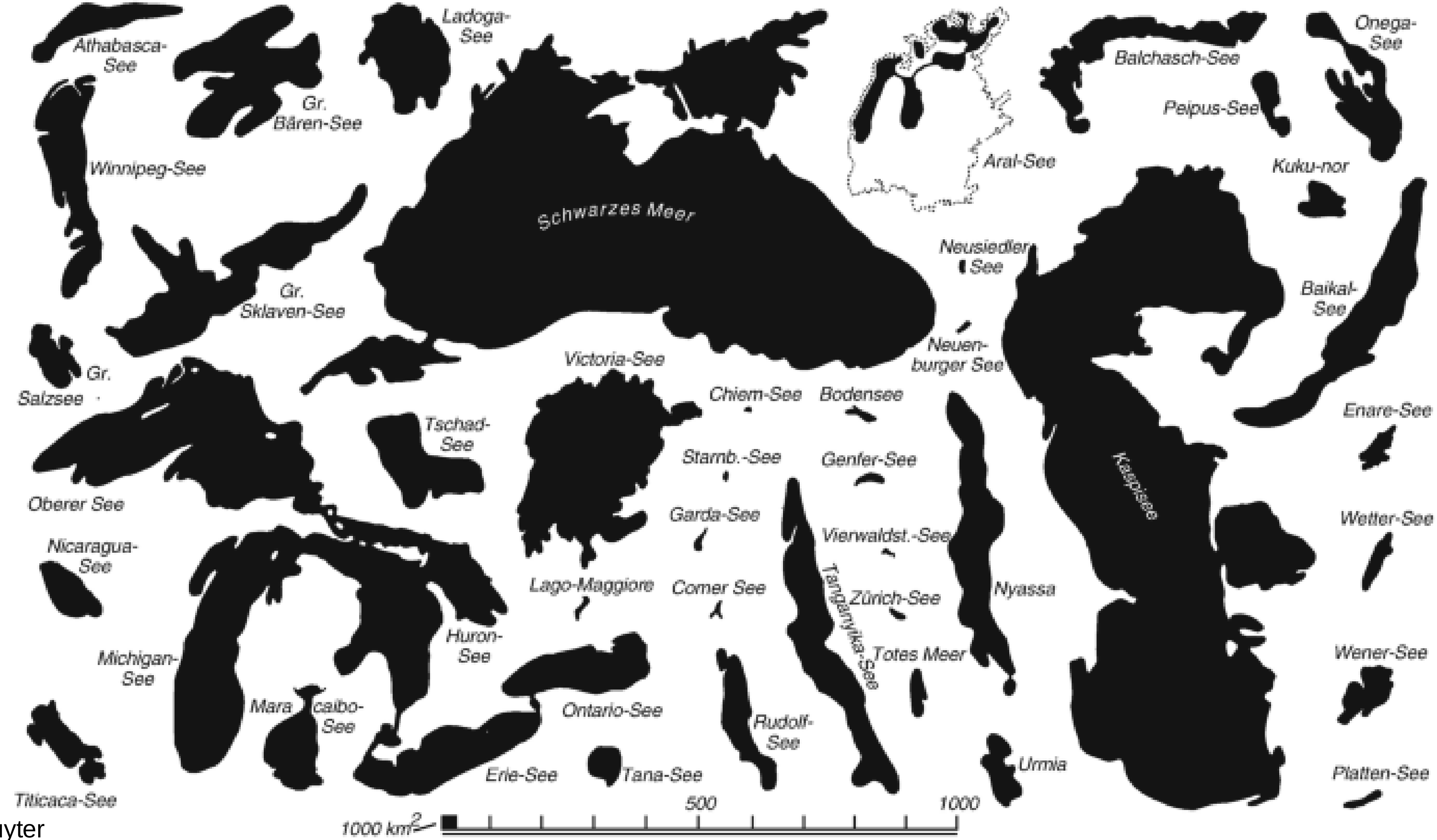
Key driver for habitat diversification, biodiversity, material fluxes



Lakes and ponds

Lentic ecosystems

Biologische Station Lunz am See, Austria



Ruttner, F.: Grundriß der Limnologie. – Gruyter u. Co., Berlin. (1962).

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Global distribution of lakes

A legacy of the last glaciation

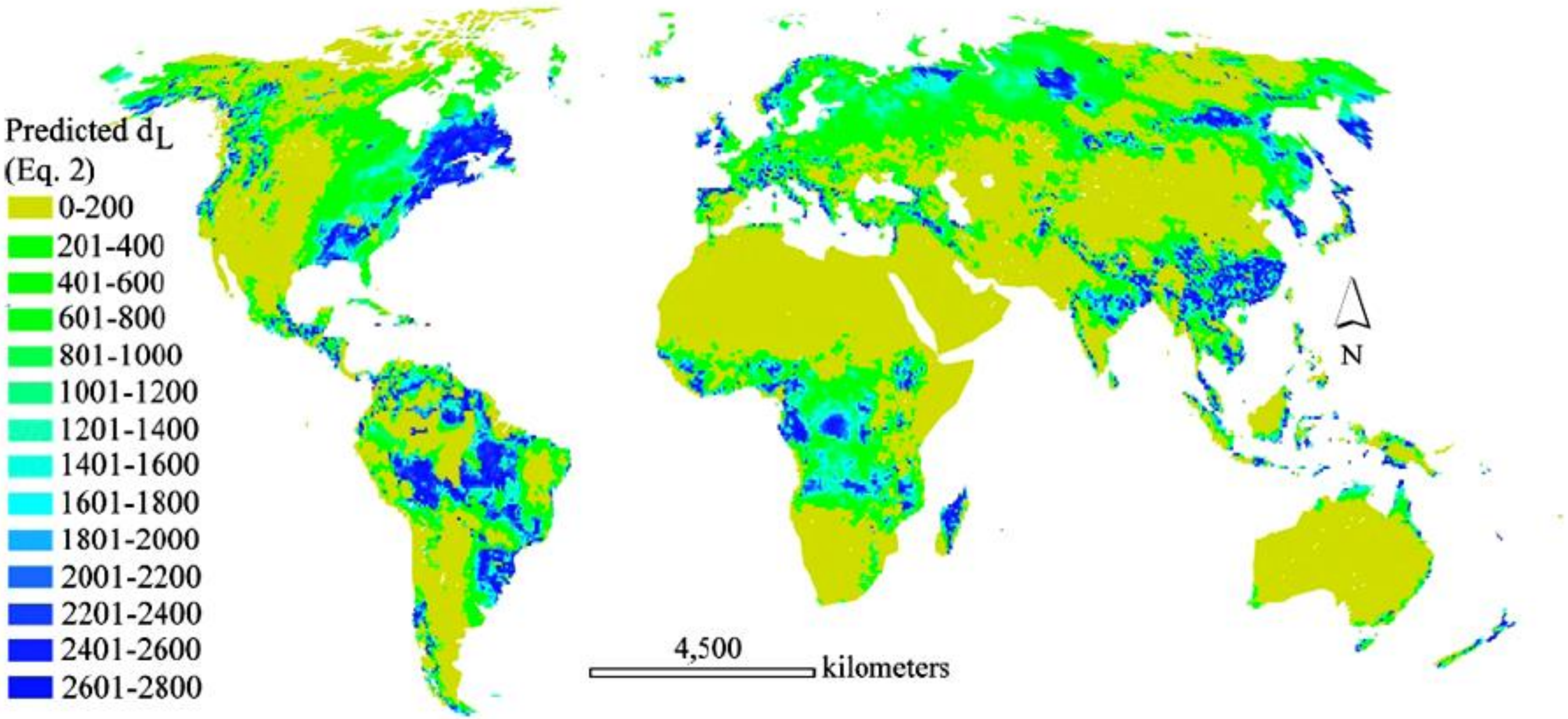


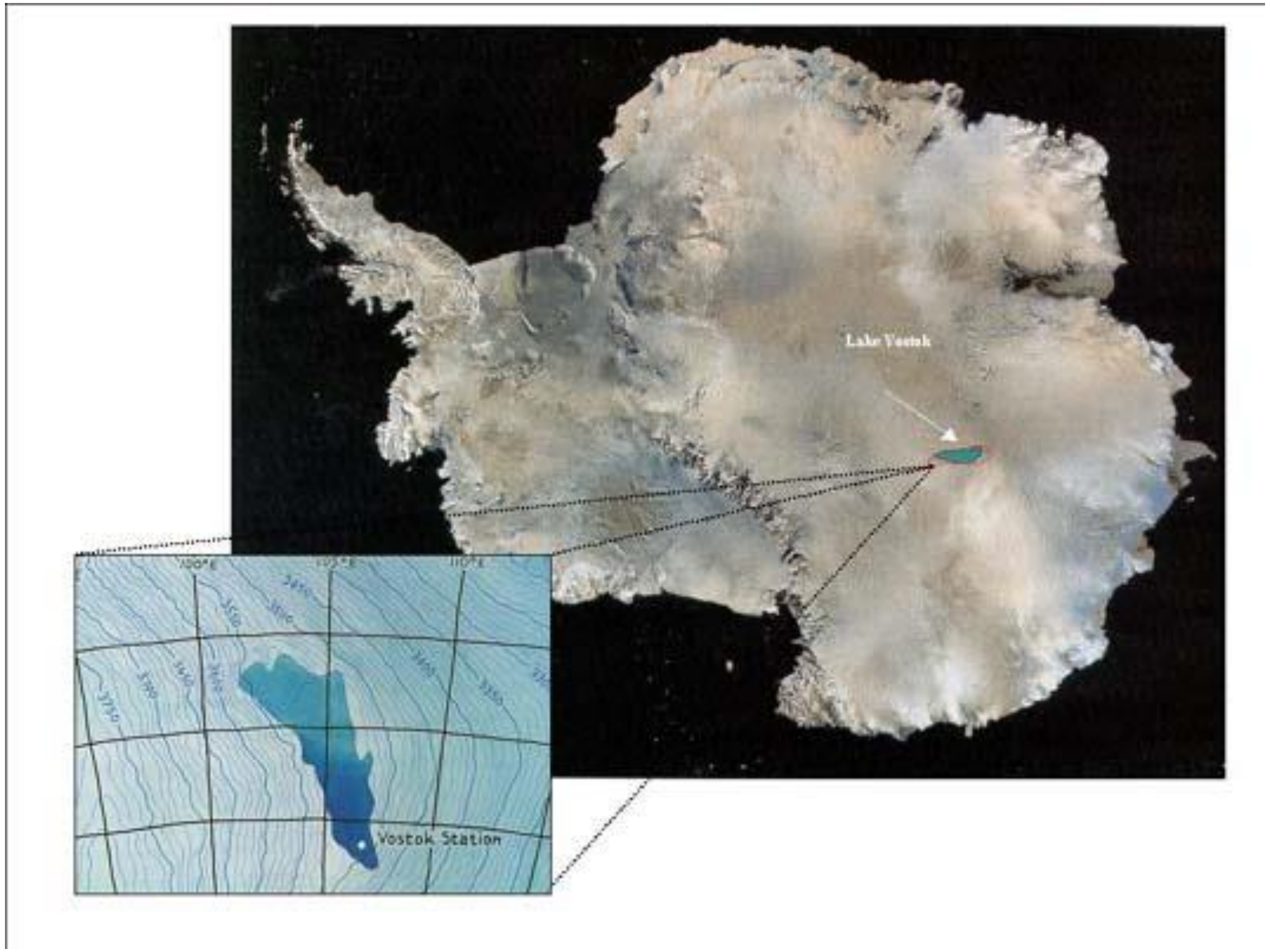
Fig. 3. Geographical analysis of the predicted world distribution of densities (d_L; Eq. 2) of lakes between 1 km^2 and 10 km^2 surface area. Predictions follow a world GIS model of annual run-off (Fekete et al. 2005) with a geographical resolution of 0.5° of latitude and longitude. Lake densities are shown in lakes per 10^6 km^2.

Downing et al. 2006

Brief portaits of some enigmatic lakes

Lake Vostok (восток, "east")

- 4,000 meters under the surface of the central Antarctic ice sheet
- 250 x 50 km
- 15,690 km^2
- 5,400 km^3
- average depth 344 m
- 35 million years old



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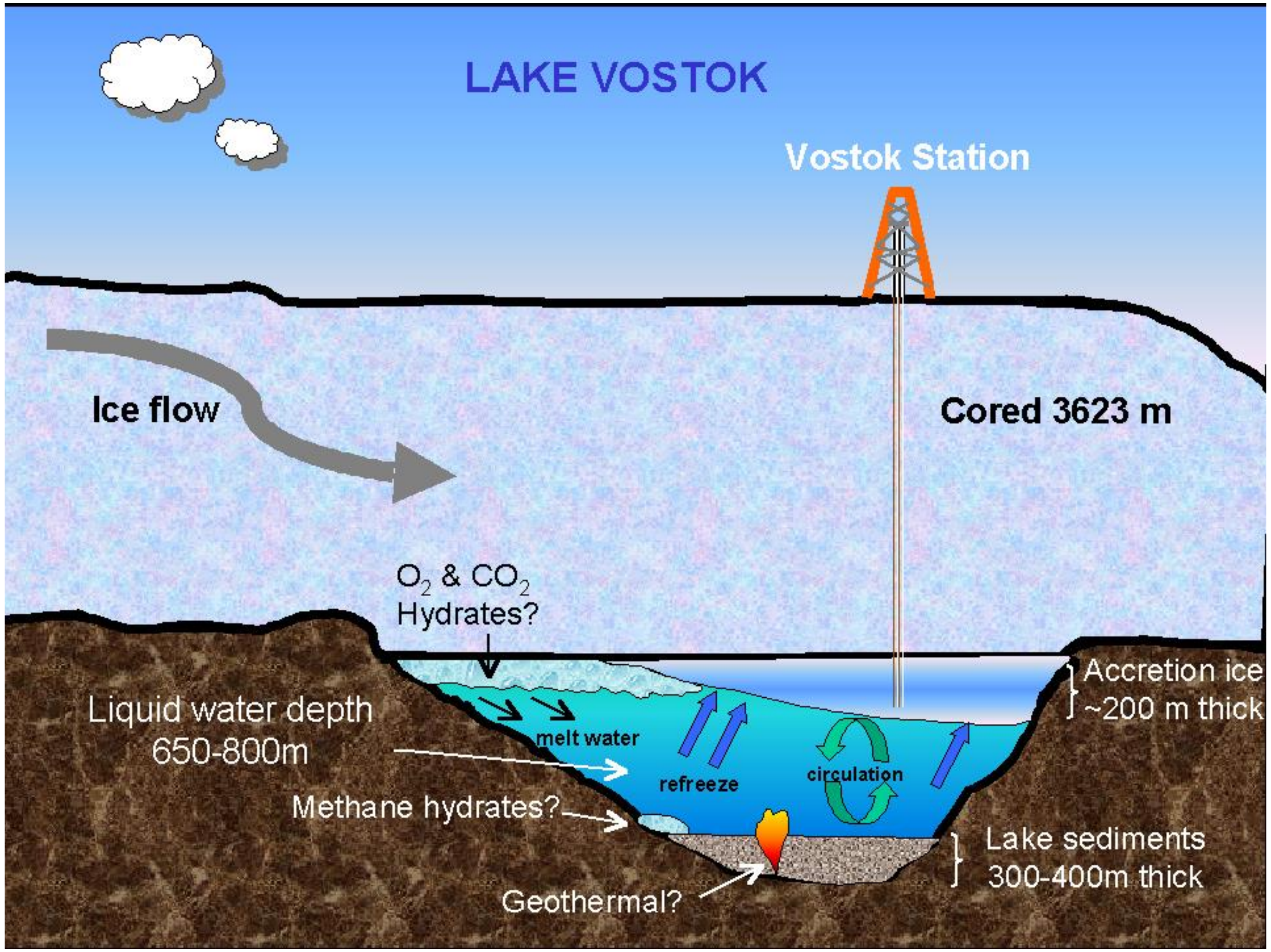
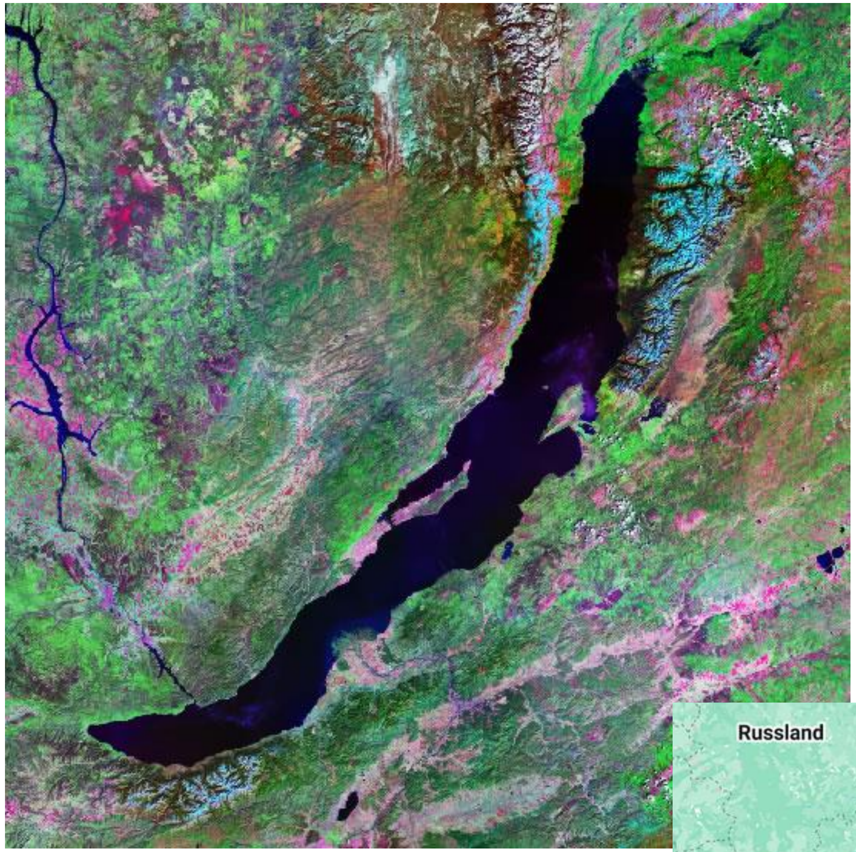


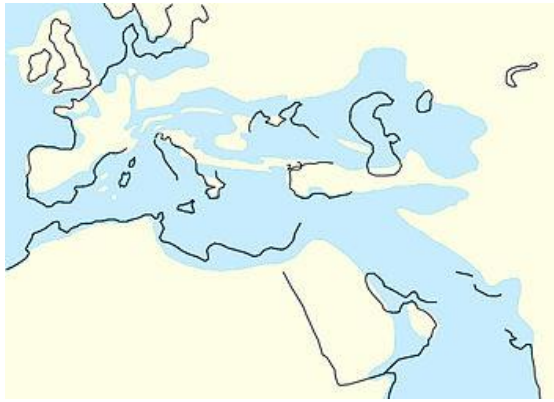
Lake Baikal

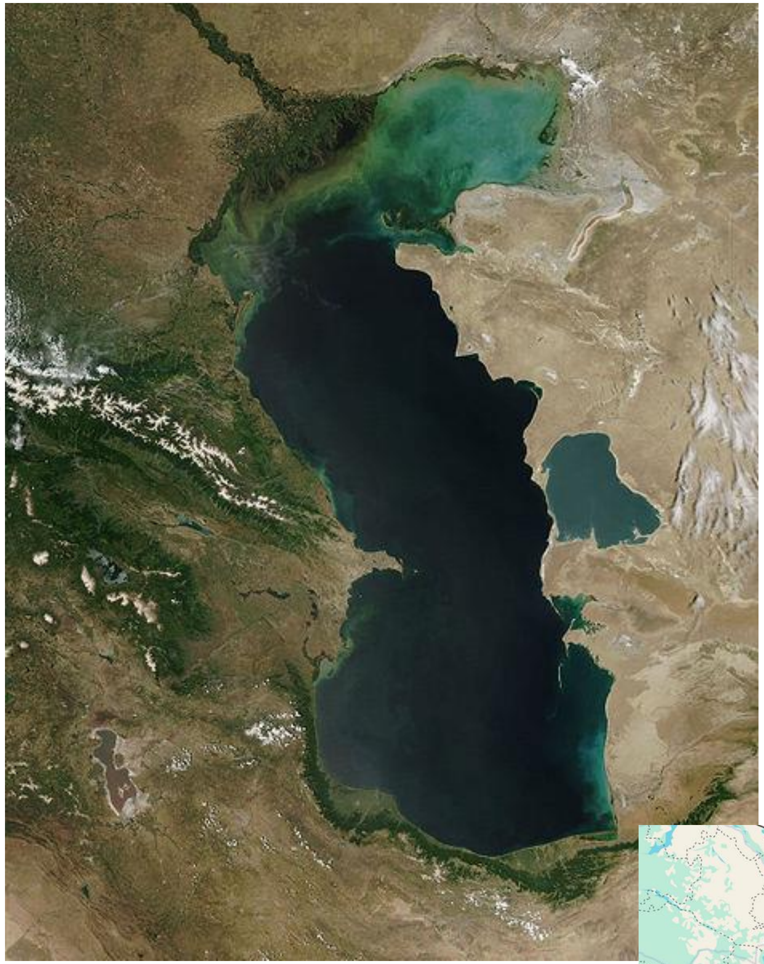


- deepest lake on Earth (1,642 m)
- ca. 20% of the world's freshwater
- oldest lakes (20 – 25 M years)
- 1,700 species, ca 60% endemic

Caspian lake

- Largest lake: 371,000 km^2
- 78,200 km^3
- endorheic basin
- Taratethys Sea (Oligocene ca 34 M years)
- drying out





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Lake Tanganjika

- East-African rift valley
- ca. 20 M years
- 18,880 km³
- 32,893 km^2 (50 km wide)
- “fossile” water
- large sink of organic carbon

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Lac Léman

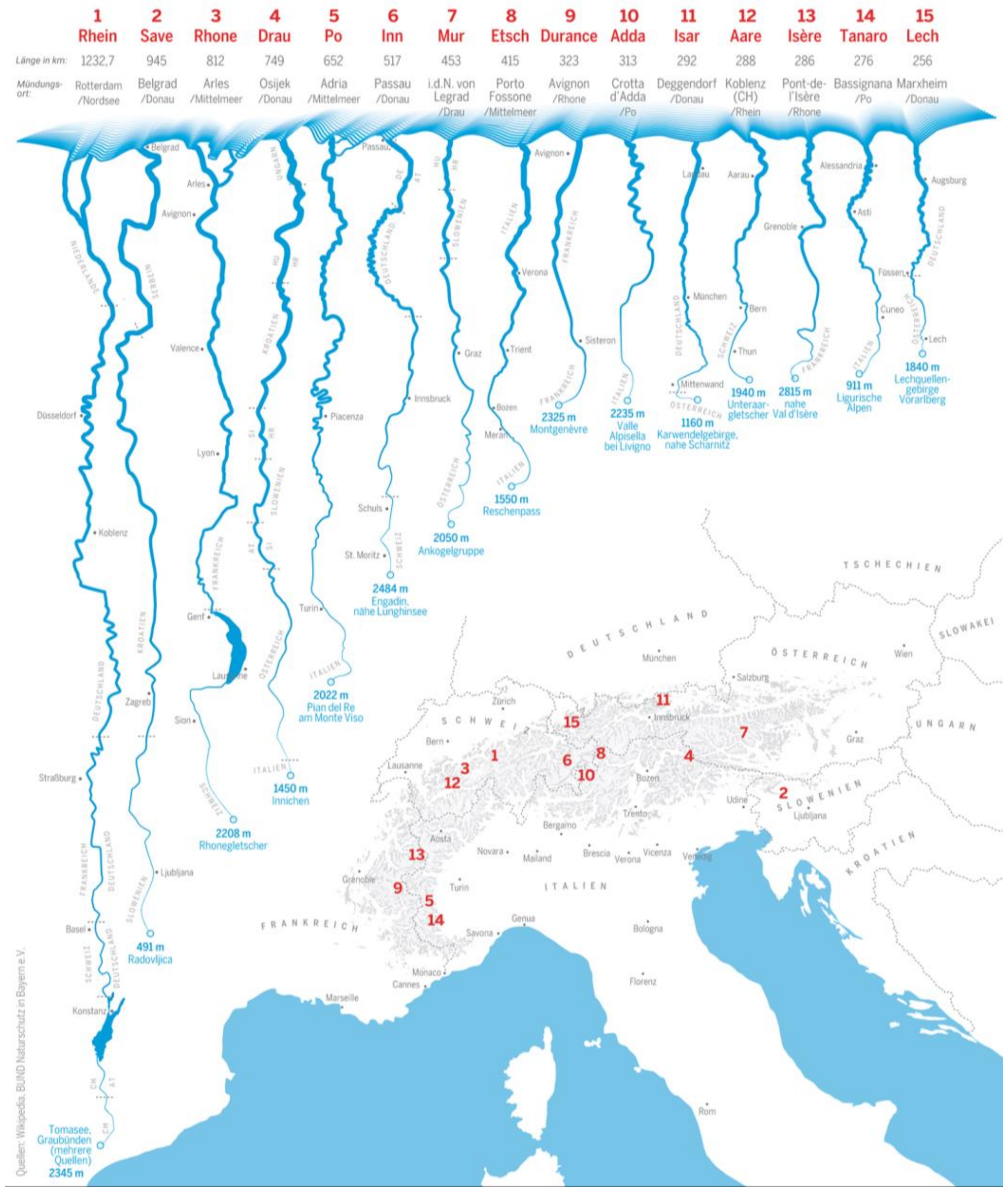
580 km^2

310 m deep

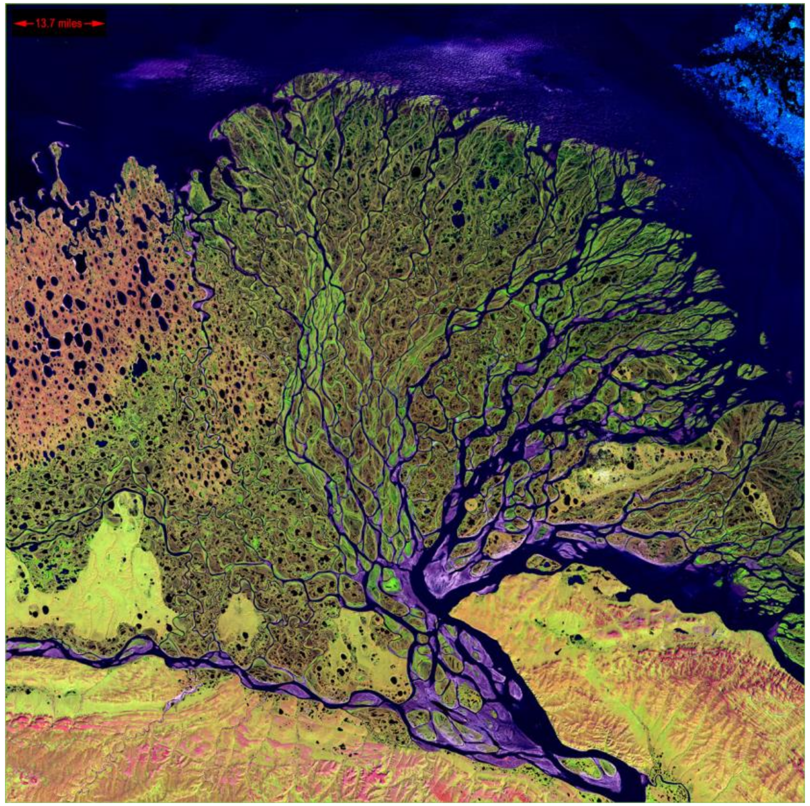
Rivers

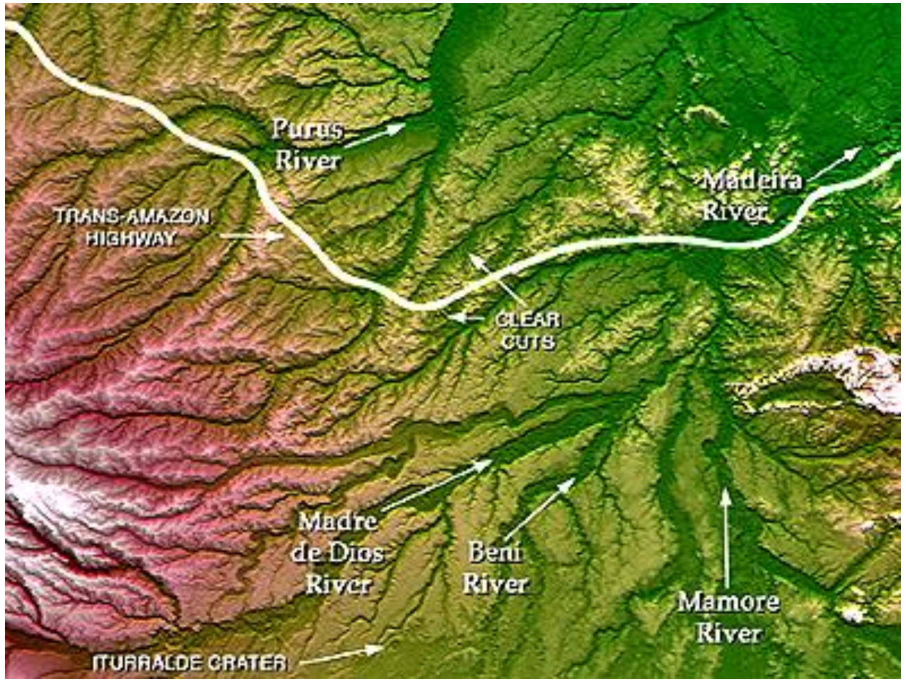
Large Alpine rivers

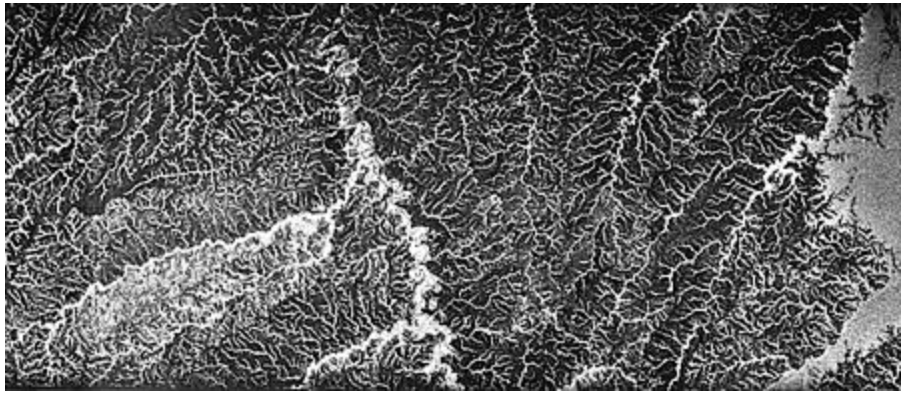
Cutting across national borders and biomes



Stream networks







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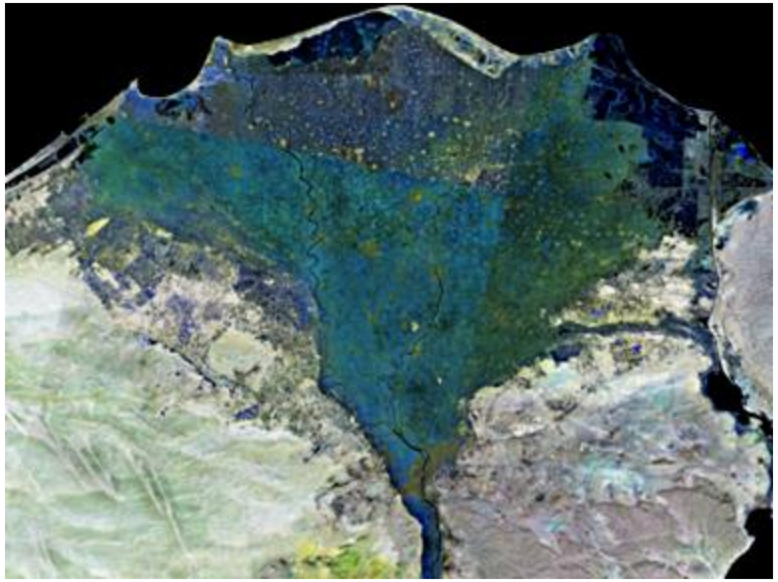
River floodplains and corridors

Connected to the terrestrial milieu

Nile River

- 6,671 km length
- discharge: ca. 1200 m^3/s
- Delta: 24.000 km^2
- Catchment size: 3,254,853 km^2

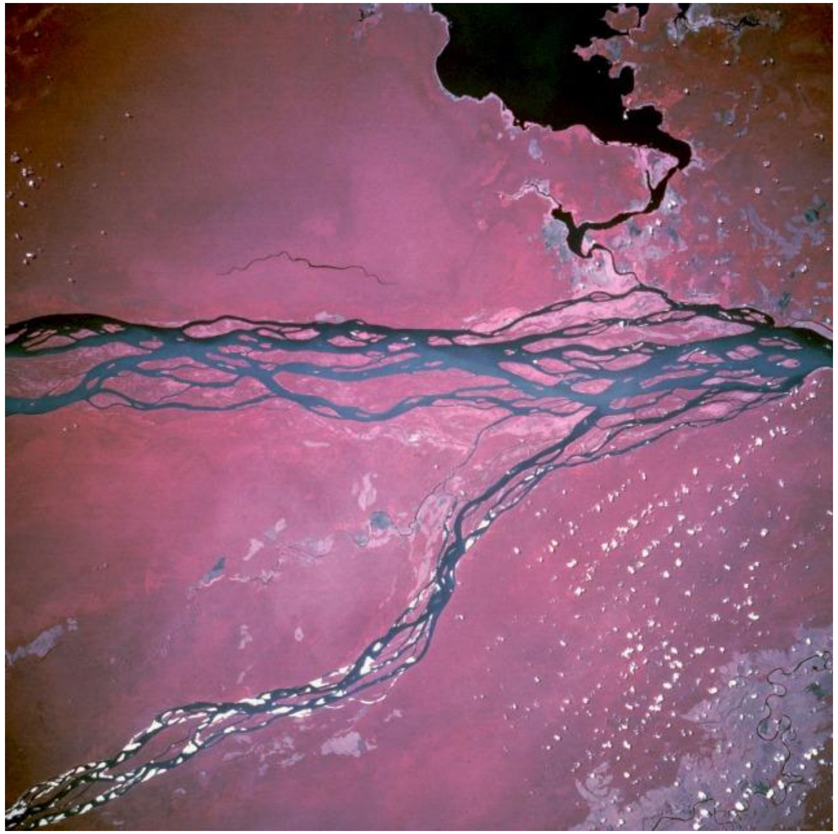


Amazon River

- Length: 6,448 km
- Discharge: ca. 209.000 m^3/s
- Catchment size: 6,112,000 km^2

Congo River

- Length: 4,700 km
- Discharge: ca. 41,000 m^3/s
- Catchment size: 4,014,500 km^2
- Black water

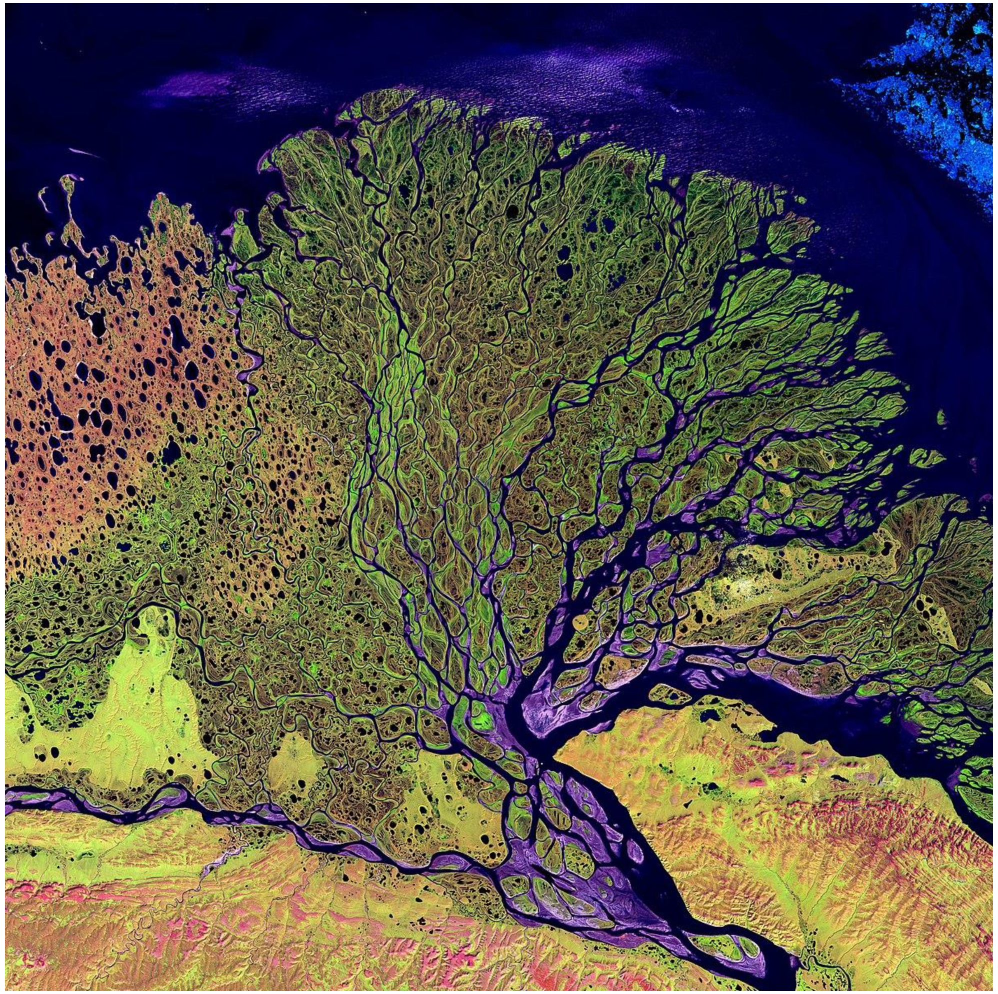


Rhone River

Length: 812 km
Discharge: ca. 1,710 m^3/s
Catchment size: 100,200 km^2

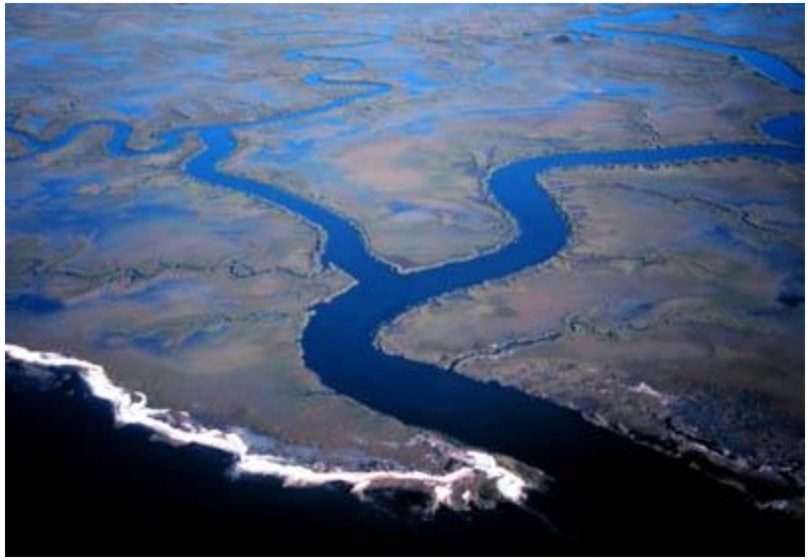
Estuaries

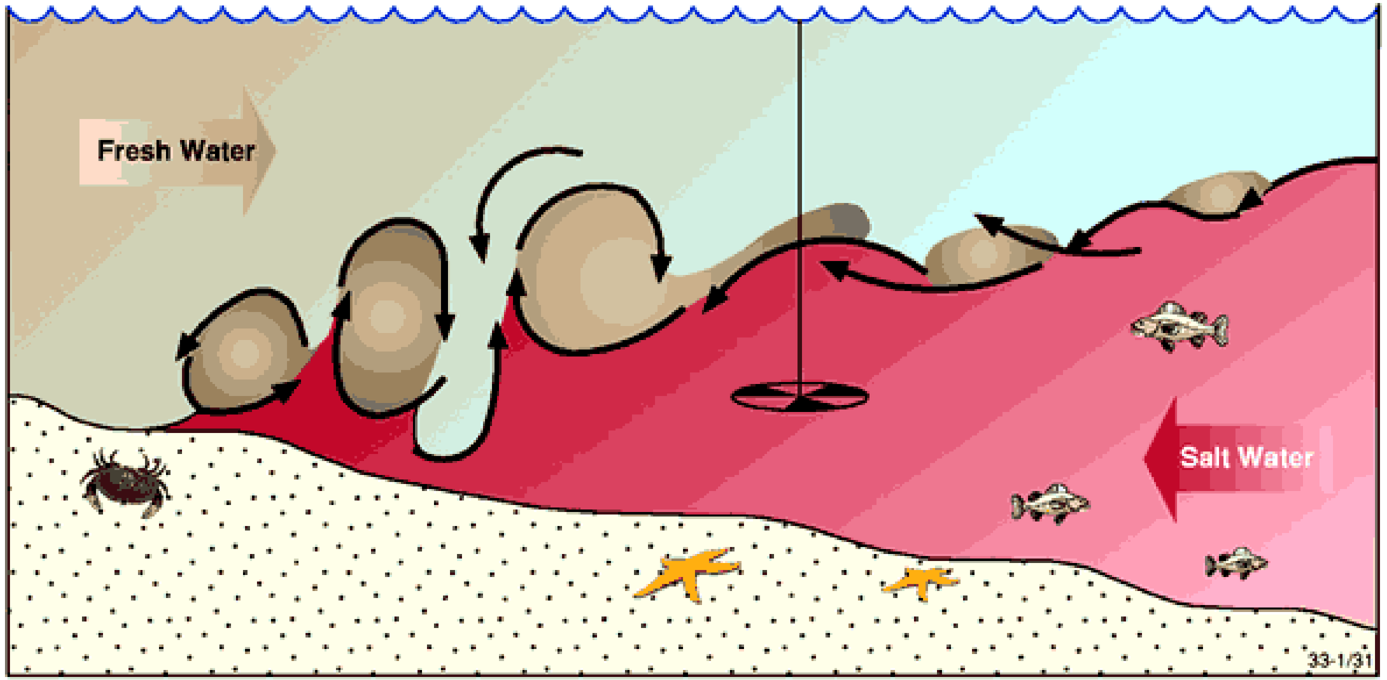
- Transition from freshwater to marine water
- Various geometries and geomorphologies



NASA Lena Delta

Estuaries





- Mixing zone between freshwater and saltwater
- Internal wakes with extended residence times and flocculation of organic matter
- High productivity and biodiversity
- Large cities built next to eastuaries worldwide

Wetlands

Wetlands

Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season.

Water saturation largely determines how the soil develops and the types of plant and animal communities living in and on the soil.

Wetlands are transition zones (in space and time) that may support both aquatic and terrestrial species.

The prolonged presence of water creates conditions that favour the growth of specially adapted plants (hydrophytes) and promote the development of characteristic wetland (hydric) soils.

EPA