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Ecohydrology for sustainable wetlands under global change – data, models, management

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Title of this talk contains terms

"ecohydrology"

and

"sustainable development"

but definitions of either of these two notions are not ubiquitously and unanimously accepted and may mean different things to different people.

Ecohydrology links **ecology**,

i.e. science on interrelationships of organisms and their environments,

and **hydrology**,

i.e. science on water cycling (hydrological cycle) in the nature, dealing with the properties, distribution, and circulation of water.

Alternative perceptions of the compound discipline:

(1) overlap between the ecology and hydrology;

(2) impact of ecology on hydrology.

Zalewski's concept of integration of ecology and hydrology (ecohydrology paradigm): *within Platonian superorganism consisting of a catchment (geosphere), water (hydrosphere) and biota (biosphere*)**, serving *"elimination of threats and amplification of chances"*.**

Indeed ecohydrology can contribute to alleviation of all three types of water problems – having too much, too little, and too dirty water.

Several early uses of the notion are restricted to "wet" ecosystems – wetlands, marshes, peatlands, and aquatic ecosystems.

Ingram (1987): ecohydrology of peatlands;

Wassen & Grootjans (1996) "Ecohydrology: an interdisciplinary approach for wetland management and restoration".

Generalization by Baird & Wilby (1999): "[*a*]*lthough the term 'eco-hydrology' has been coined to describe interactions between water tables and plant distributions in wetlands, it can be used to describe plant-water interactions in other environments*". Fauna?

Apart from the notion of ecohydrology, there are several uses of a term “hydroecology”.

Baird & Wilby (1999): “*study of ecological and hydrological processes in rivers and floodplains*”.

Acreman (2001): “*the linkage of knowledge from hydrological, hydraulic, geomorphological and biological/ecological sciences to predict the response of freshwater biota and ecosystems to variation of abiotic factors over a range of spatial and temporal scales*”

"Ecohydrology" or "hydroecology"?

Rules of the English language:

the prefix "eco" in the term "ecohydrology" can be interpreted as a modifier of the word "hydrology", i.e. this term is more about hydrology than ecology, e.g. representing the impacts of ecology on hydrology.

Sustainable development

Although the notion of has been in broad use for over 15 years, there is still no common understanding of this term.

Because of the ambiguity, it is not possible to delineate the borders between what is "sustainable" and "non-sustainable".

As the notion is amorphous, and its borders are fuzzy, manipulations and differing interpretations are possible.

Both supporters and opponents of many a project are equipped with the same weapon - arguments related to sustainable development.

Among a large number of existing definitions of sustainable development are:

- assuring that the development meets the needs of the present without compromising the ability of future generations to assuring their own needs (best known definition, after WCED, 1987);

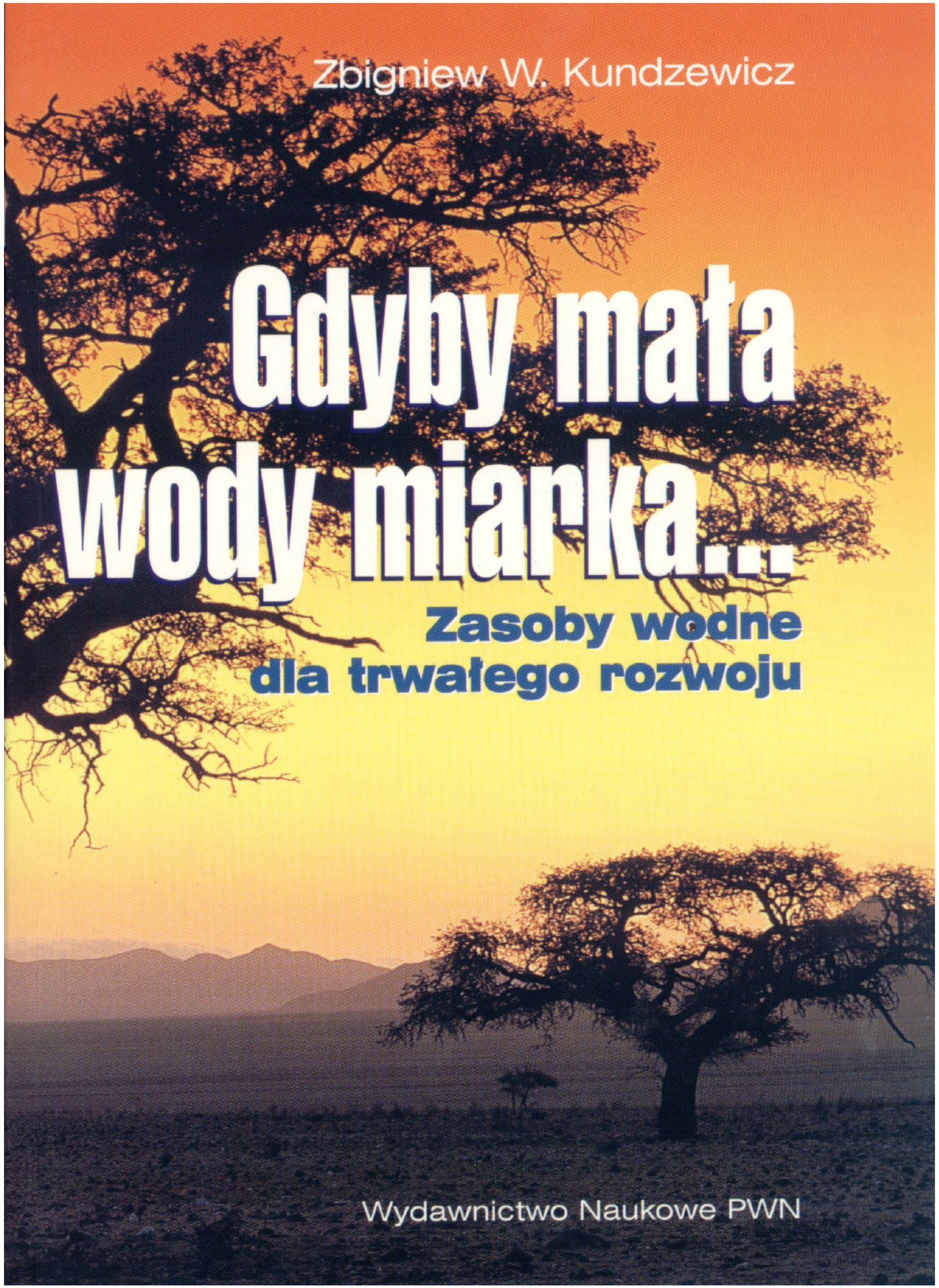
- improving the quality of human life (attaining non-decreasing human welfare over time) within the carrying capacity of supporting ecosystems (IUCN);

- living on interests from the Earth´s capital, without depleting the capital itself;

- development minimizing probability of future regret for decisions taken today.

Gardiner (1995) compared options for flood defence and channelized rivers and assessed their performance from the viewpoint of sustainable development.

In his rating, **source control** received **very good** marks in all categories, while **channelized river** was found **bad to very bad** according to all criteria considered.


Zbigniew W. Kundzewicz
Gdyby mała wody miarka...
Zasoby wodne dla trwałego rozwoju
Wydawnictwo Naukowe PWN

Information for sustainable development

Accurate and reliable hydrological information is necessary for water development and management. Without it, uninformed decisions are likely to be made that may lead to unsustainable situations. Therefore, hydrological observations should be recognized as an **essential component of sustainable development** and management of water resources and a basis for early warnings if sustainable development is threatened.

The inadequacy of hydrological networks grows and in many countries, especially of the Third World, the **networks are in decline**. Hydrological data collection and analysis worldwide are not keeping pace with the actual water development and management needs. Even if the data are collected, their availability is often limited.

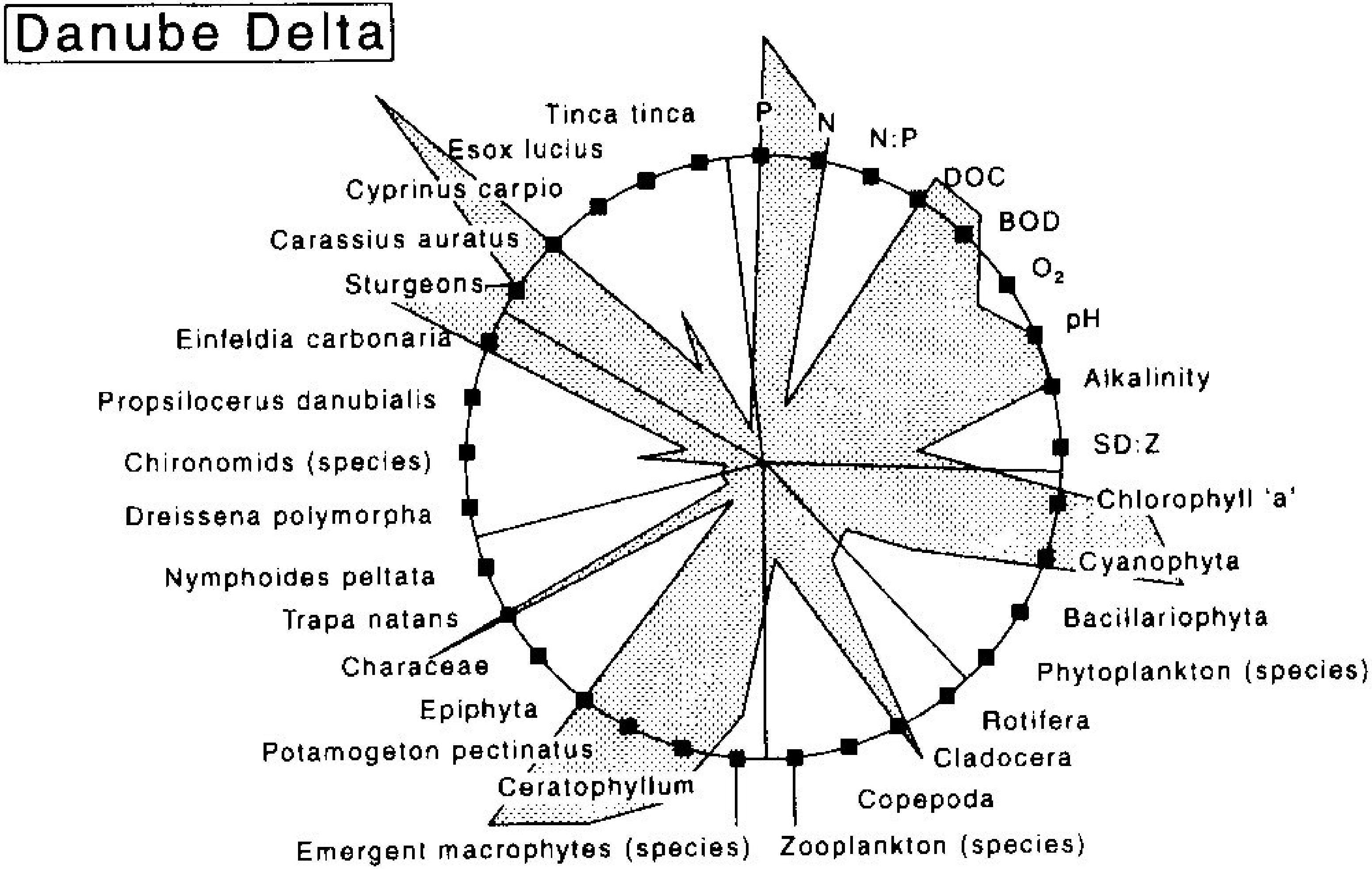
MEASURING WETLANDS:

- Areal extent and changes in wetland boundaries.
- Vegetation distribution: changes in occurrence of particular (indicator) species or in the distribution of various plant communities
- Surface morphology
- Hydrology. Seasonality (stage and flow), water budgets, and hydrochemistry: monitored via piezometers, wells, and weirs; variations in the water chemistry (salinity, heavy metals)
- Changes in the rates of buildup of organic material and sediment or in erosion.

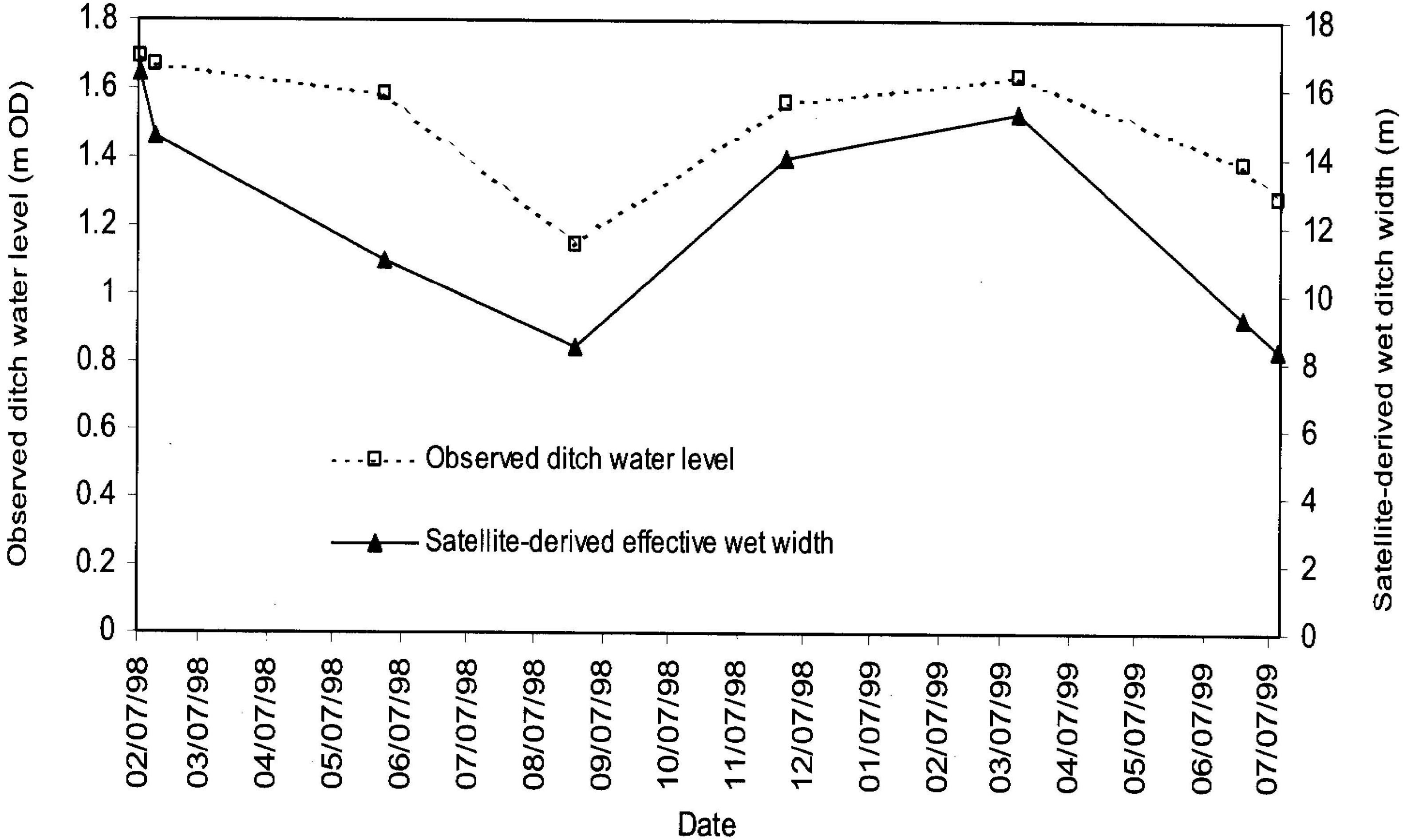
FREQUENCY OF MEASUREMENT:

Water budget and hydrochemistry, initial measurements should be weekly to monthly (more frequently in times of rapid change such as spring thaw) until important times and parameters have been identified, then less frequently.

Comparison of air photos, maps, charts and field surveys undertaken at different times

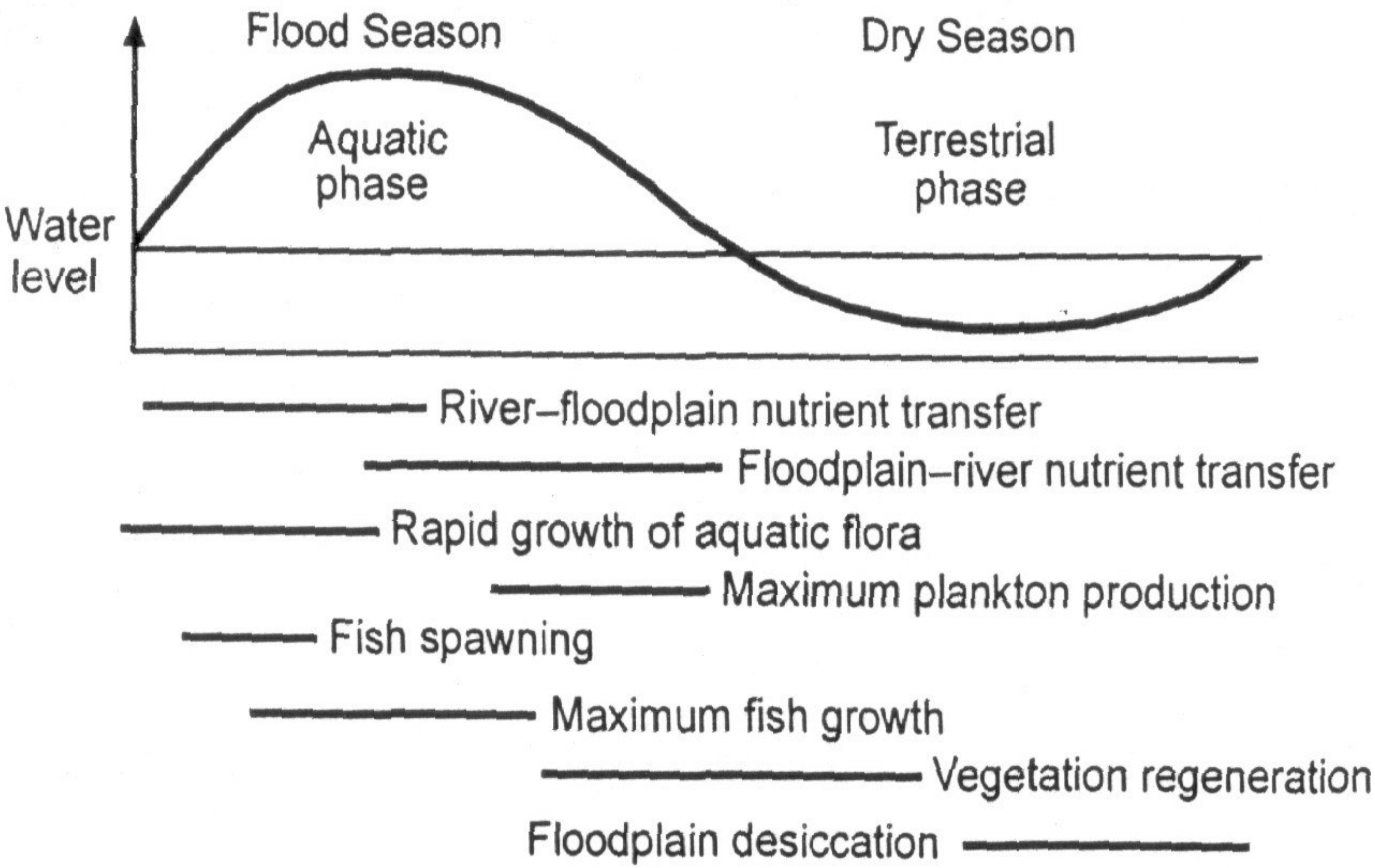


Changes between the reference period (1952-1965) and 1990-1994 (from Khaiter *et al*. in Boon *et al*.)



Temporal changes in satellite-derived effective wet ditch width and ditch water levels measured at site h in the Elmley Marshes using an automatic water level recorder (from Al-Khudairy *et al.*, HSJ, 2001)

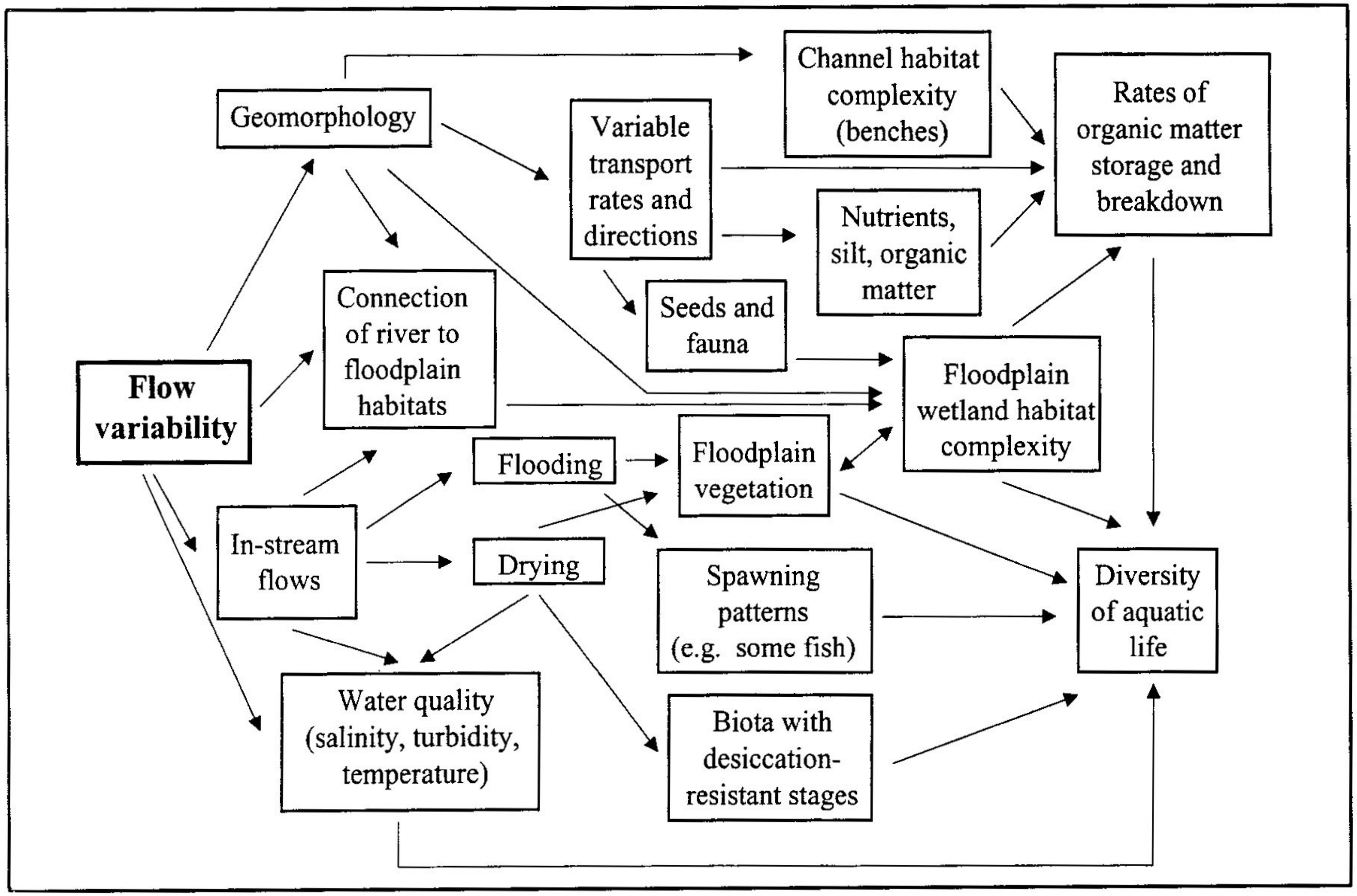
The influence of the flood pulse within the ríver-floodplain system (after Large & Prach in Baird & Wilby)



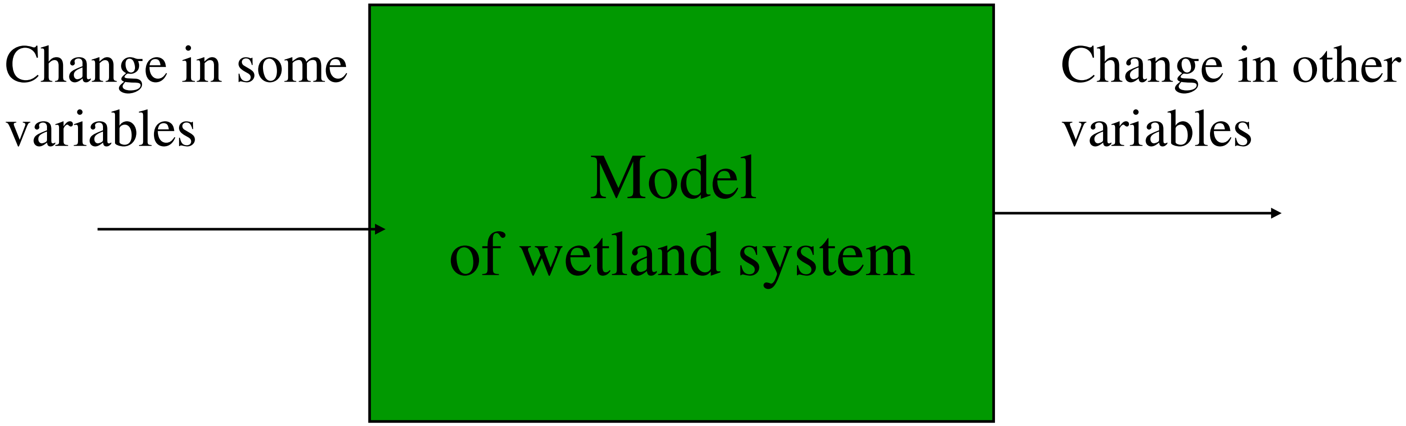
Floodplain destruction and lack of flood pulse:

Nile – marshes and wetlands relied upon annual flooding, necessary for (vulnerable) wildlife, fodder, grazing. Annual cycle of flooding and sediment transport necessary for fertility and productivity of soils.

Tigris and Euphrates – Mesopotamian marshes – decrease in the magnitude of seasonal floods when filling Atatürk reservoir in Turkey led to loss of productivity and biodiversity.



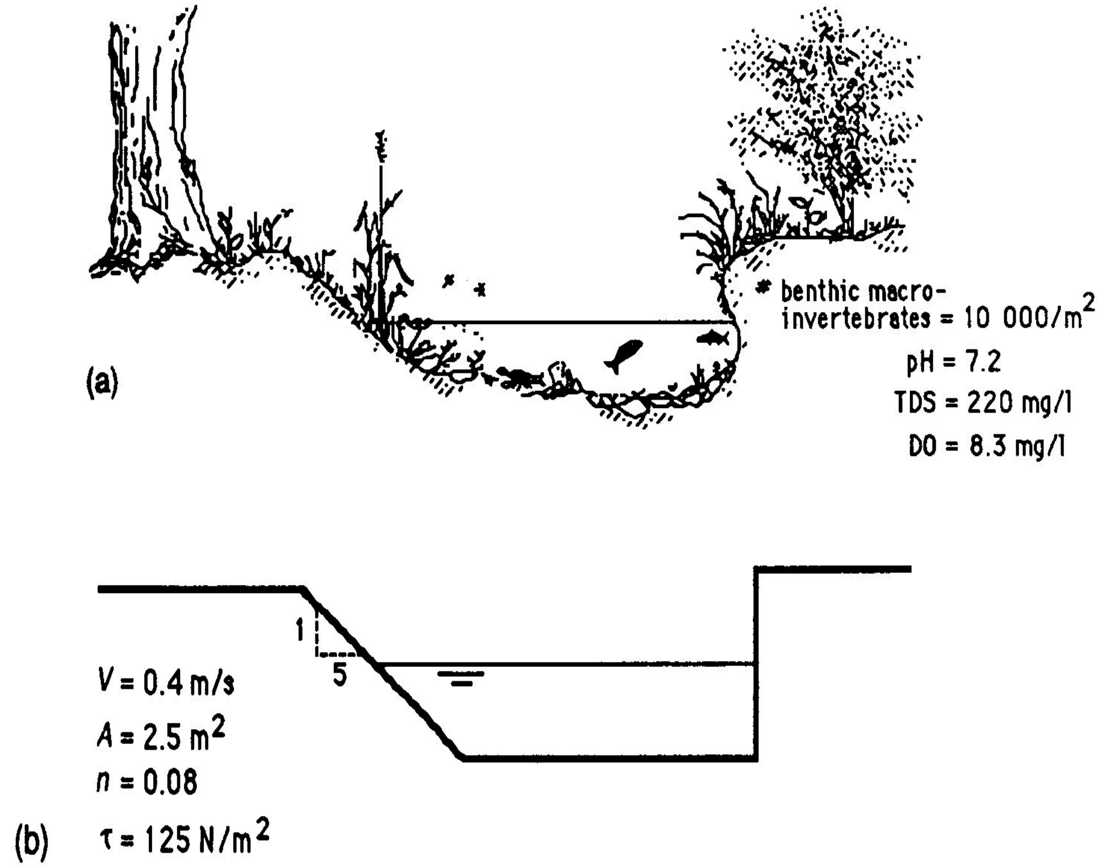
Importance of flow variability to biota and ecosystem processes in rivers (simplified scheme). From Boulton *et al.* in Boon *et al.*



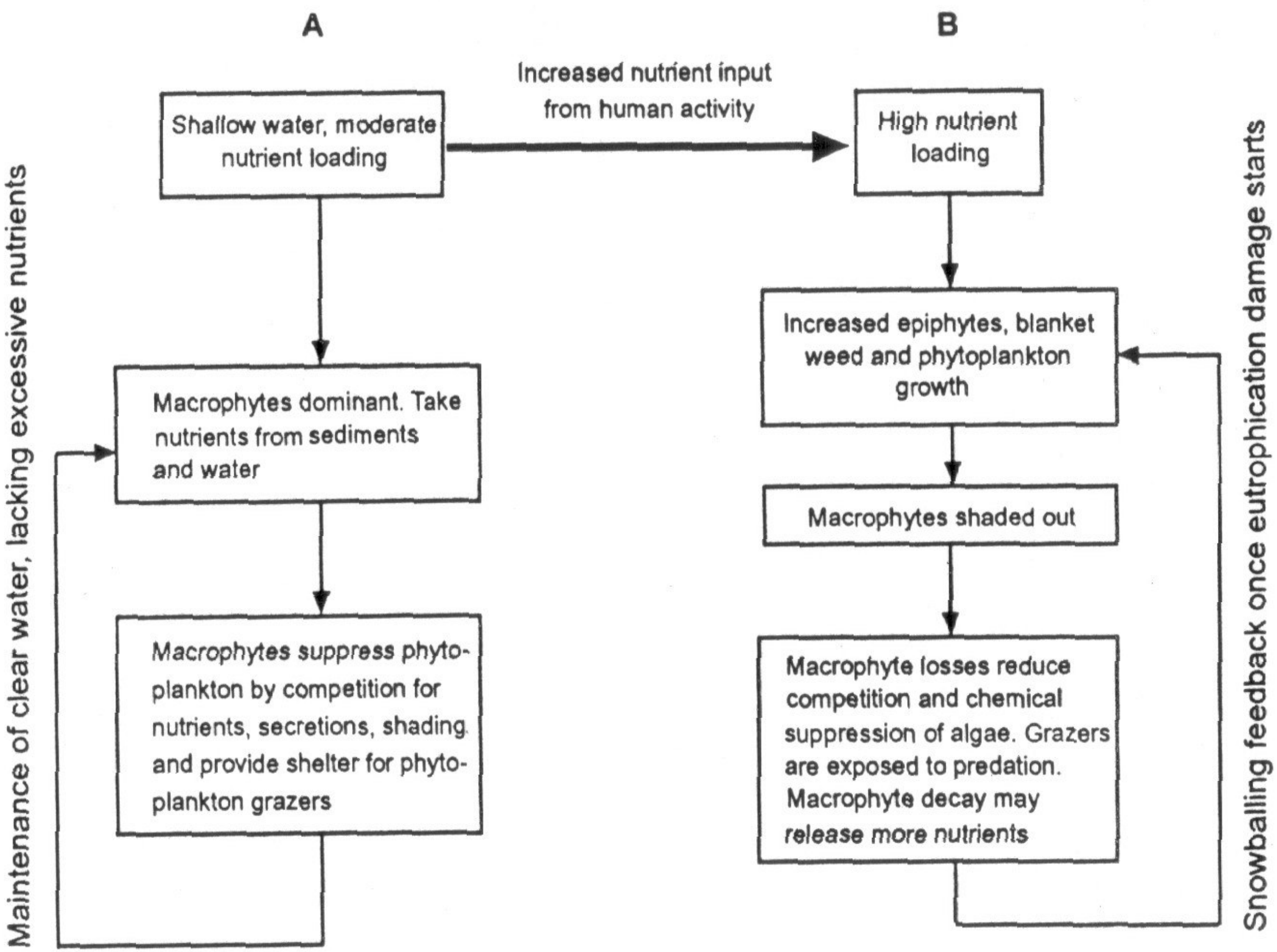
Inflow (flow in terminating cross-section upstreams)

River and wetlands

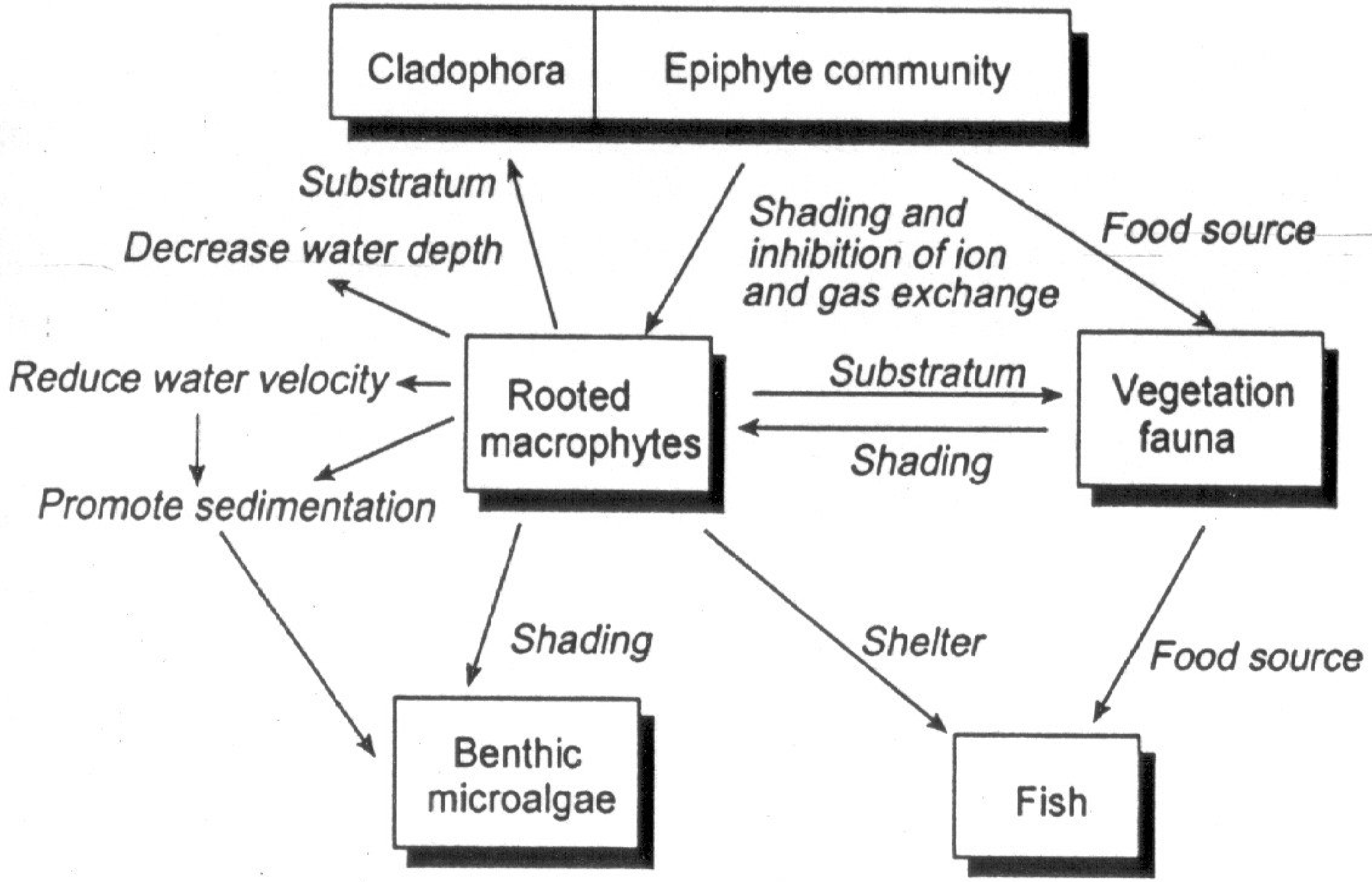
Outflow (flow in terminating cross-section downstreams)



Ecologist‘s and engineering hydrologist‘s view of a stream (from Gordon *et al*.)



Influence of eutrophication on water plants (after Large & Prach in Baird & Wilby)



The roles played by rooted macrophytes in lowland streams (after Large & Prach in Baird & Wilby)

Ecosystems provide essential services for life support systems and water plays the pivotal role in this process. Costanza *et al.* (1997) attached monetary values to ecosystem services and evaluated ecosystem functions in economic terms on a global scale. Seventeen groups of ecosystem services were considered, and the value of their annual output amounted to 16-54 trillion US$ per year, being comparable with the value of the global product.

Value of global wetland ecosystem services, in 1994 US$

(included: swamps/floodplains and tidal marshes/mangroves)

Area	330 mln ha
Value of services per ha per year	14 785 US$
Total global value of services	4.879 trillion US$

Source: Costanza *et al.*

Value of global ecosystem services of freshwater wetlands (swamps and floodplains), in 1994 US$

Area	165 mln ha
Value of services per ha per year	19 580 US$
Total global value of services	3.231 trillion US$

Specification of value of ecosystem services provided by global freshwater wetlands, in 1994 US$

Service	Value in US$ per ha per year
Gas regulation	265
Disturbance regulation	7240
Water regulation	30
Water supply	7600
Water treatment	1659
Habitat/refugia	439
Flood production	47
Raw materials	49
Recreation	491
Cultural	1781

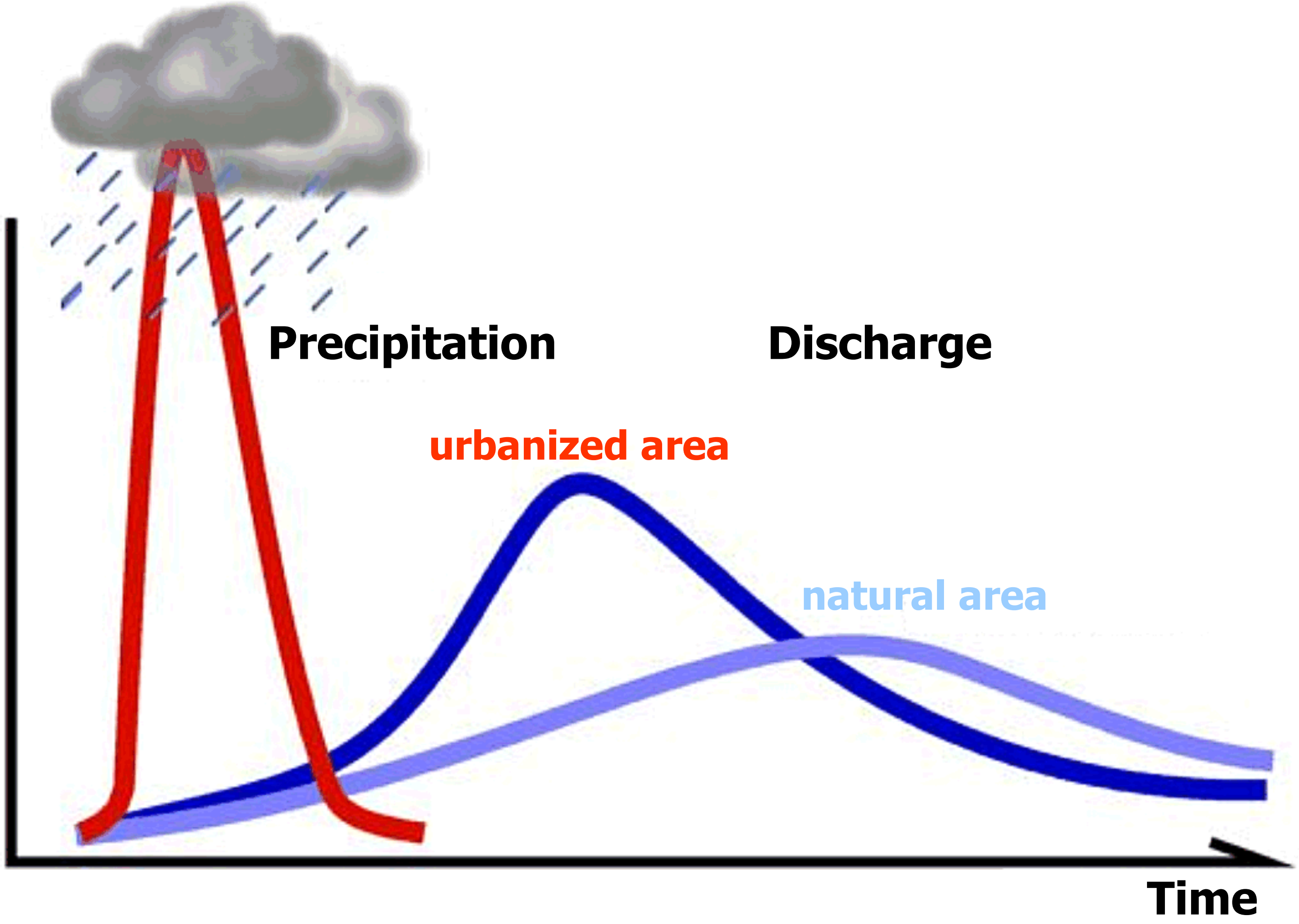

Precipitation
Discharge
urbanized area
natural area
Time

Table 23.1 *Human impacts on rivers in the UK (modified after Petts* et al.*, 1989)*

Date (years BP)	Impact
5000–1000	Clearance of the uplands
2000–1000	Deforestation of the lowlands and loss of floodplain wetlands
2000–350	Drainage schemes and channelization for navigation and water power (mills)
700–	Overfishing
350–100	Extensive land drainage Channelization, dredging Extensive floodplain reclamation Pollution of small streams and, from 1750, larger rivers; mainly faecal pollution
250–	Introduction of exotic species (especially after 1850). Problem species today include: giant hogweed (*Heracleum mantegazzianum*), Japanese knotweed (*Fallopia japonica*) and Himalayan balsam (*Impatiens glandulifera*)
100–	Era of large schemes; storage reservoirs and interbasin transfers Pollution increasingly involving industrial as well as domestic wastes; many large rivers (e.g. lower Thames) 'dead' by 1965
30–	Post 1965 period of 'clean-up' and restoration; 1988–92 drought in south-east England drew attention to problem of over-abstraction, especially in groundwater-dominated catchments

Threat to wetlands: loss or degradation

Activities that cause wetlands impairment:

Drainage for agriculture and silviculture

Water engineering (river regulation, e.g., strengthening and shortening of the Rhine by Tulla, levees for flood control, structures, canals, impoundment)

Commercial and residential development, industrial siting, road construction

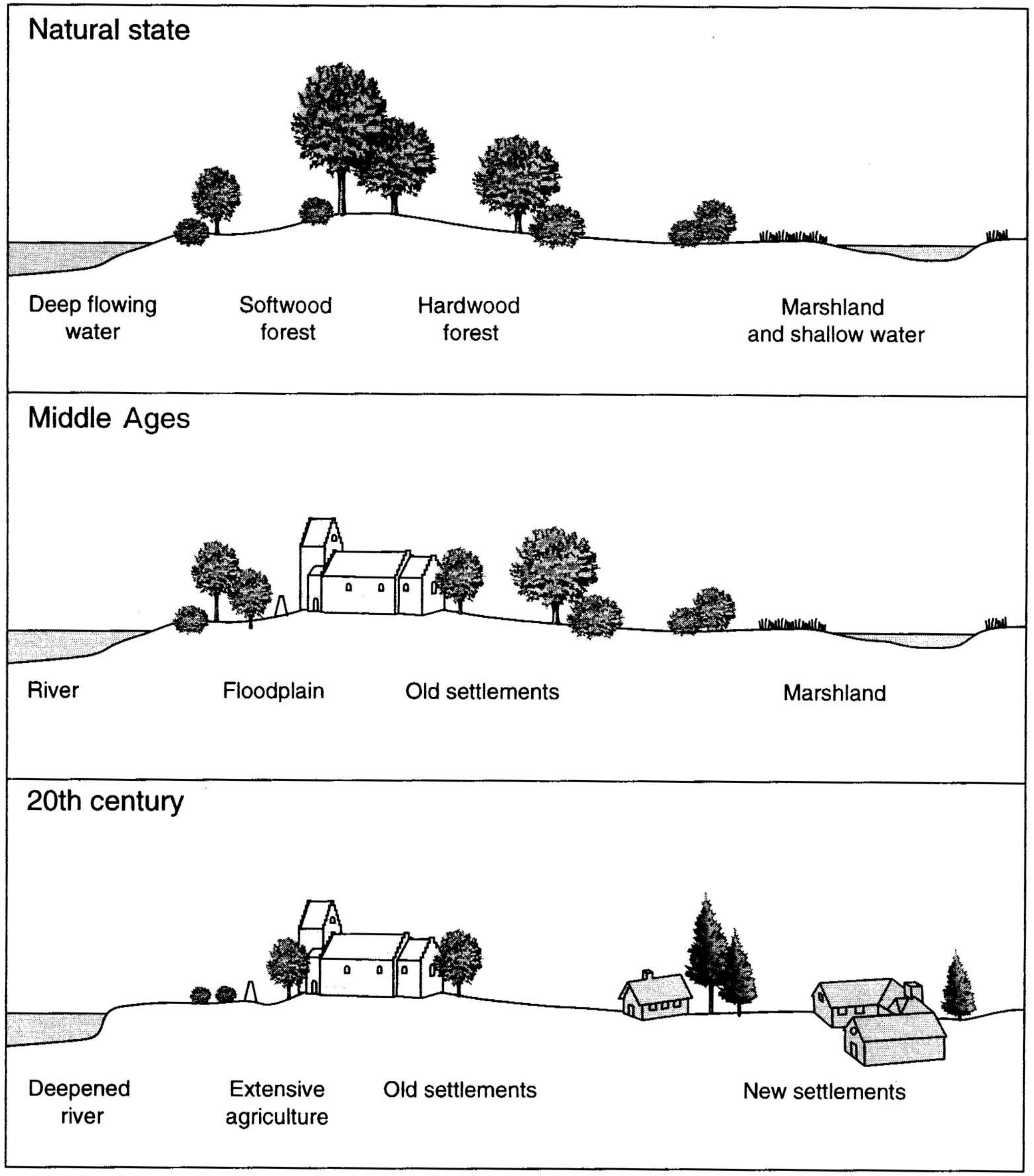
Competition for water (excessive withdrawal, groundwater overexploitation)

Resource extraction, waste, dredge disposal, mosquitos control, atmospheric deposition, marinas-boats, hunting / fishing

Invasion of wetlands by shrubs and trees, non-native plants and animals (aggressive, highly tolerant plant species, carp, nutria)

Climate change

Progressive human impact on a lowland river. After Iversen *et al.* (in Boon *et al.*)



Worldwide - 50% of wetlands are estimated to be lost, mostly drained for agriculture.

In Europe and the USA this percentage is even higher.

California and Iowa lost 99% of their wetlands.

Drying out of small prairie wetlands after conversion from cultivation to permanent brome grass (with the purpose of providing improved bird nesting habitat). Within the area of permanent grass cover springtime snowmelt runoff essentially ceased. Conclusion: **water balance of prairie wetlands is very sensitive to the land use on the surrounding uplands**.

(van der Kamp *et al*., *HSJ*)

The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources as a contribution towards achieving sustainable development throughout the world. There are presently 136 Contracting Parties to the Convention, with 1284 wetland sites, totaling 108.9 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance.

The wise use of wetlands is their sustainable utilization for the benefit of humankind in a way compatible with the maintenance of the natural properties of the ecosystem (Nature knows best)

www.ramsar.org

Ramsar List of Wetlands of International Importance

(… of significant value … for humanity as a whole):

Poland (8 entries):

Biebrza National Park

Słowiński National Park

Słońsk Reserve

Seven-Islands Lake

Stawy Milickie Nature Reserve (Milicz fishponds)

Świdwie Lake

Karaś Lake

Łuknajno Lake

Wetlands International, NGO

www.wetlands.org

The Socio-Economics of Wetlands

(Report by Wetlands International & RIZA)

Valuing wetlands

Monetary – non-monetary

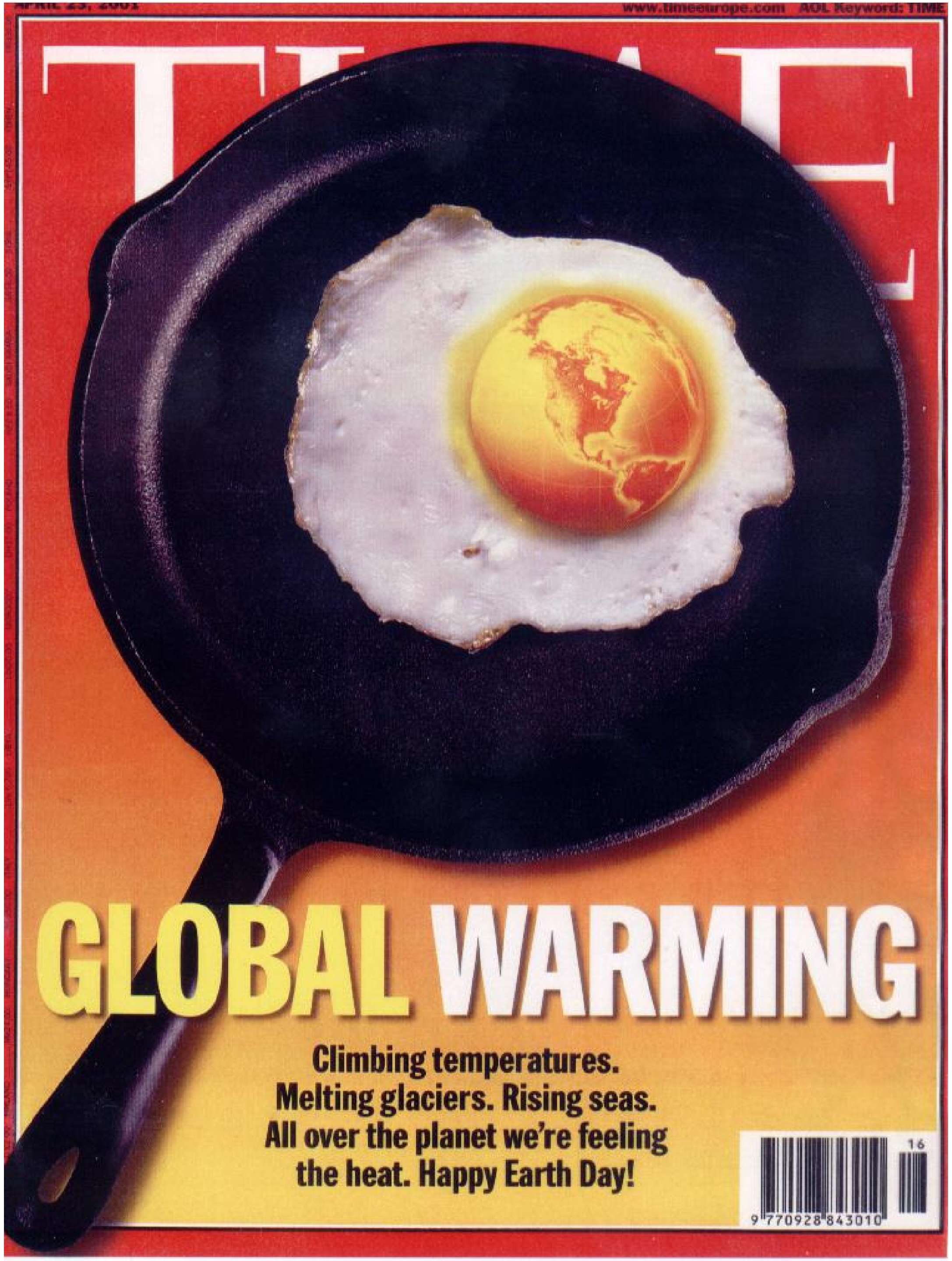
Nomadic groups in Sahelian Africa have a culture based on the seasonal inundation of wetlands

But: lack of market, public good, no clear ownership of wetlands and their resources

Wetland restoration– flood preparedness strategy: **retreat** (USA)

Re-naturalization of rivers; re-creating water storage in wetlands and natural depressions

Created (constructed) wetlands for non-point source pollution control


TIME
GLOBAL WARMING
Climbing temperatures.
Melting glaciers. Rising seas.
All over the planet we're feeling
the heat. Happy Earth Day!

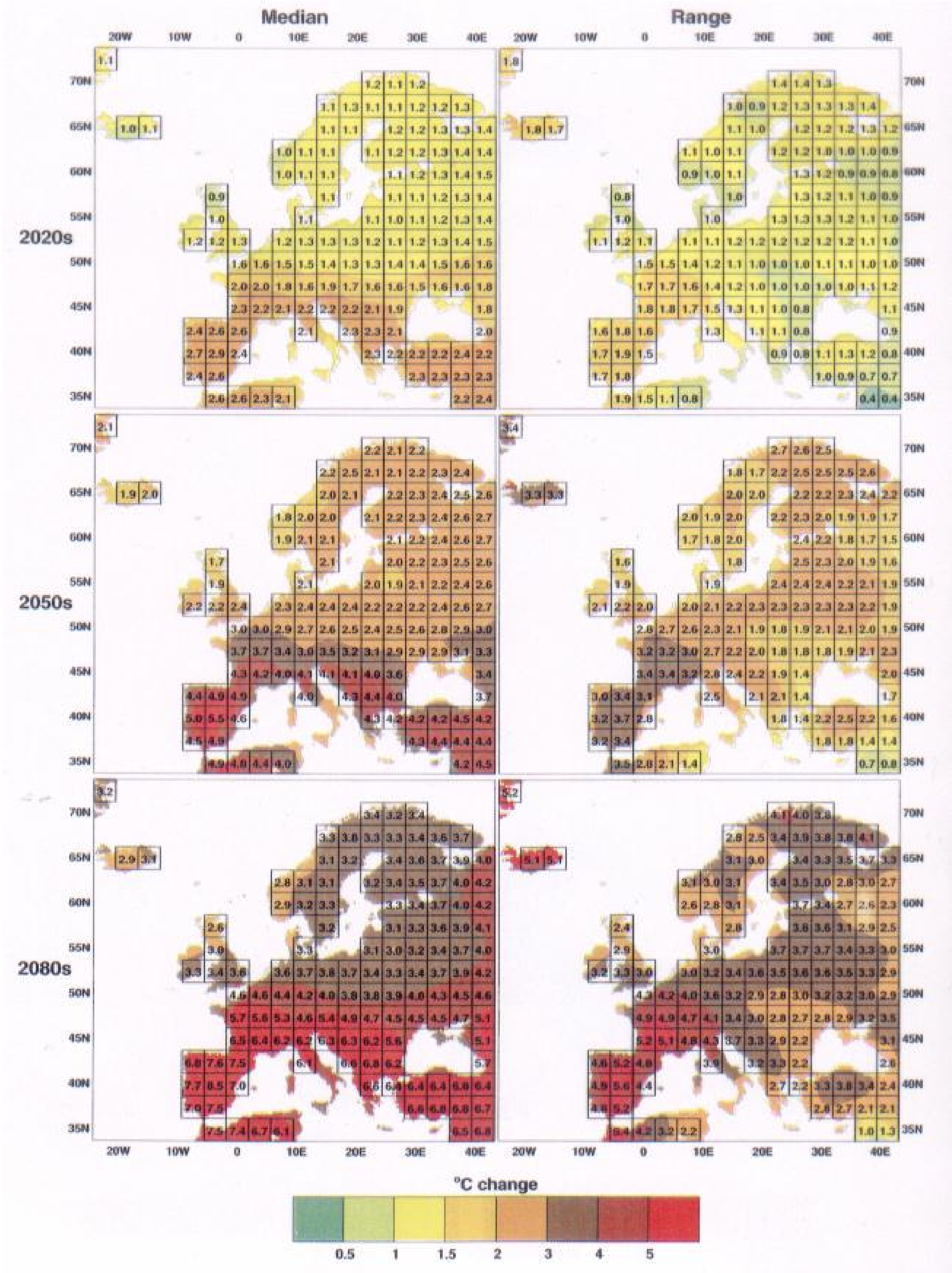
Findings in climate change impact research indicate that all three problems related to freshwater, i. e. having **too little, too much, or too dirty** water, can be exacerbated in the warmer world, with obvious implications to sustainable development.

Climate change impacts: increase in frequency and severity of summer droughts

ACACIA,

A2 high,

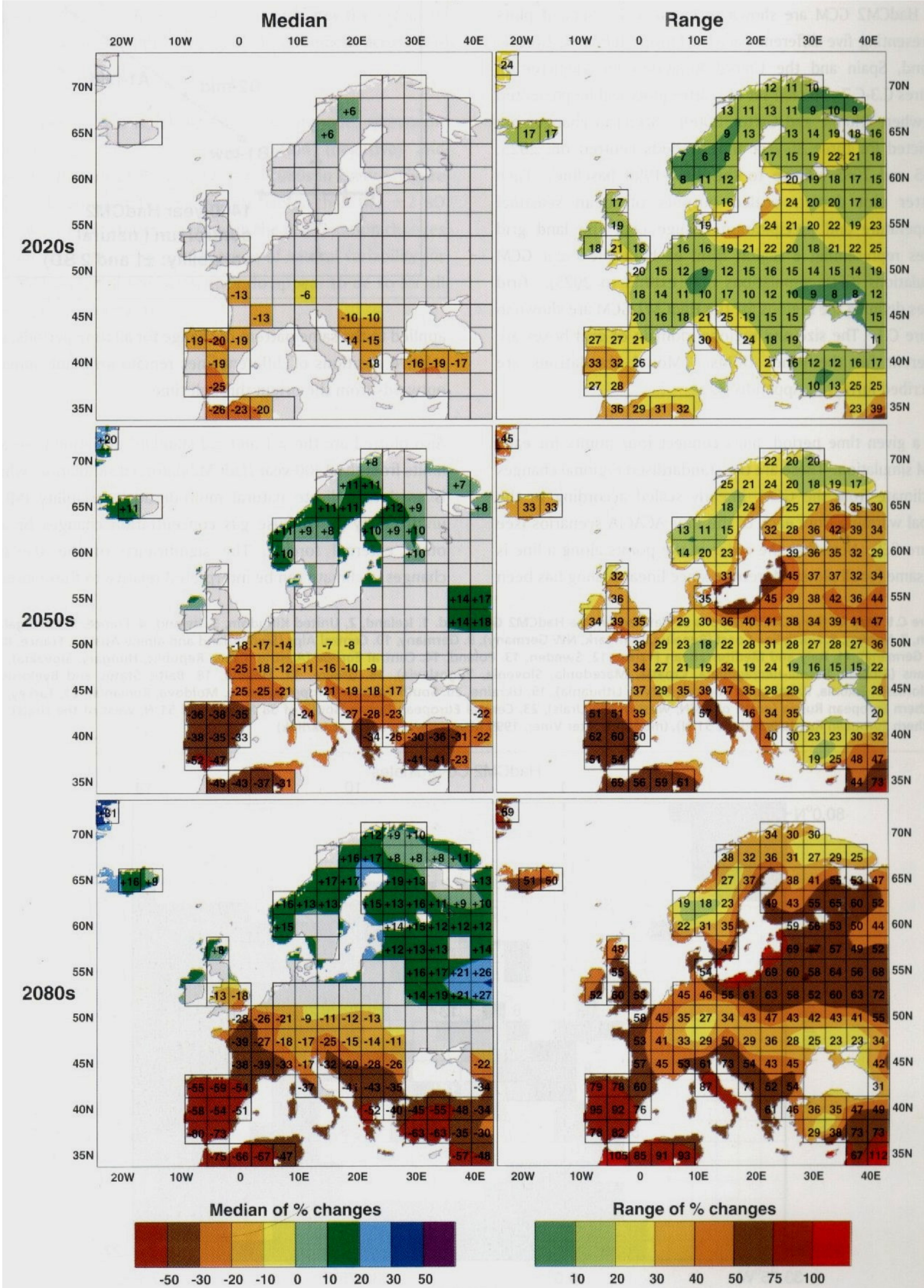
summer temperature



ACACIA,

A2 high,

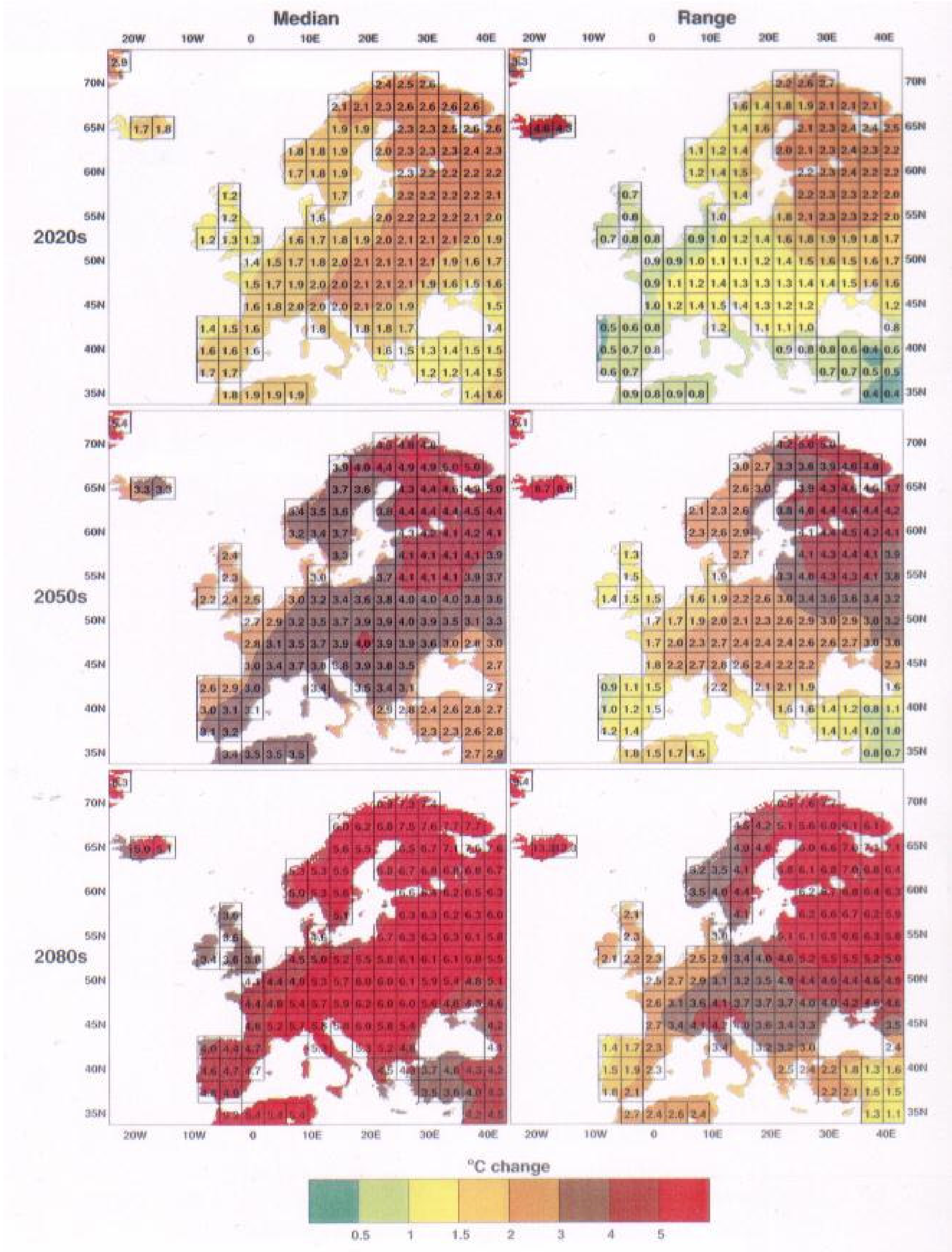
summer precipitation



ACACIA,

A2 high,

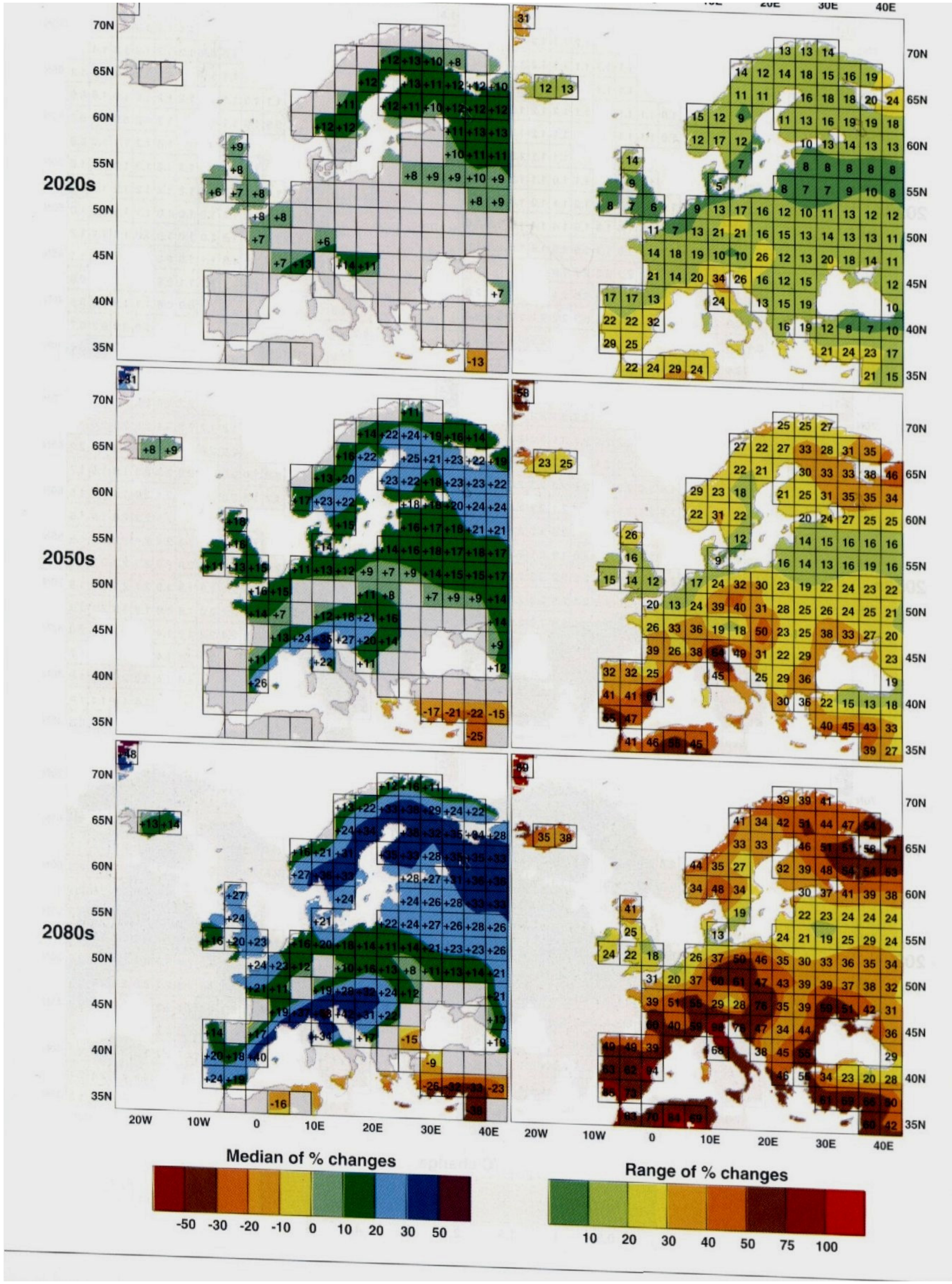
winter temperature

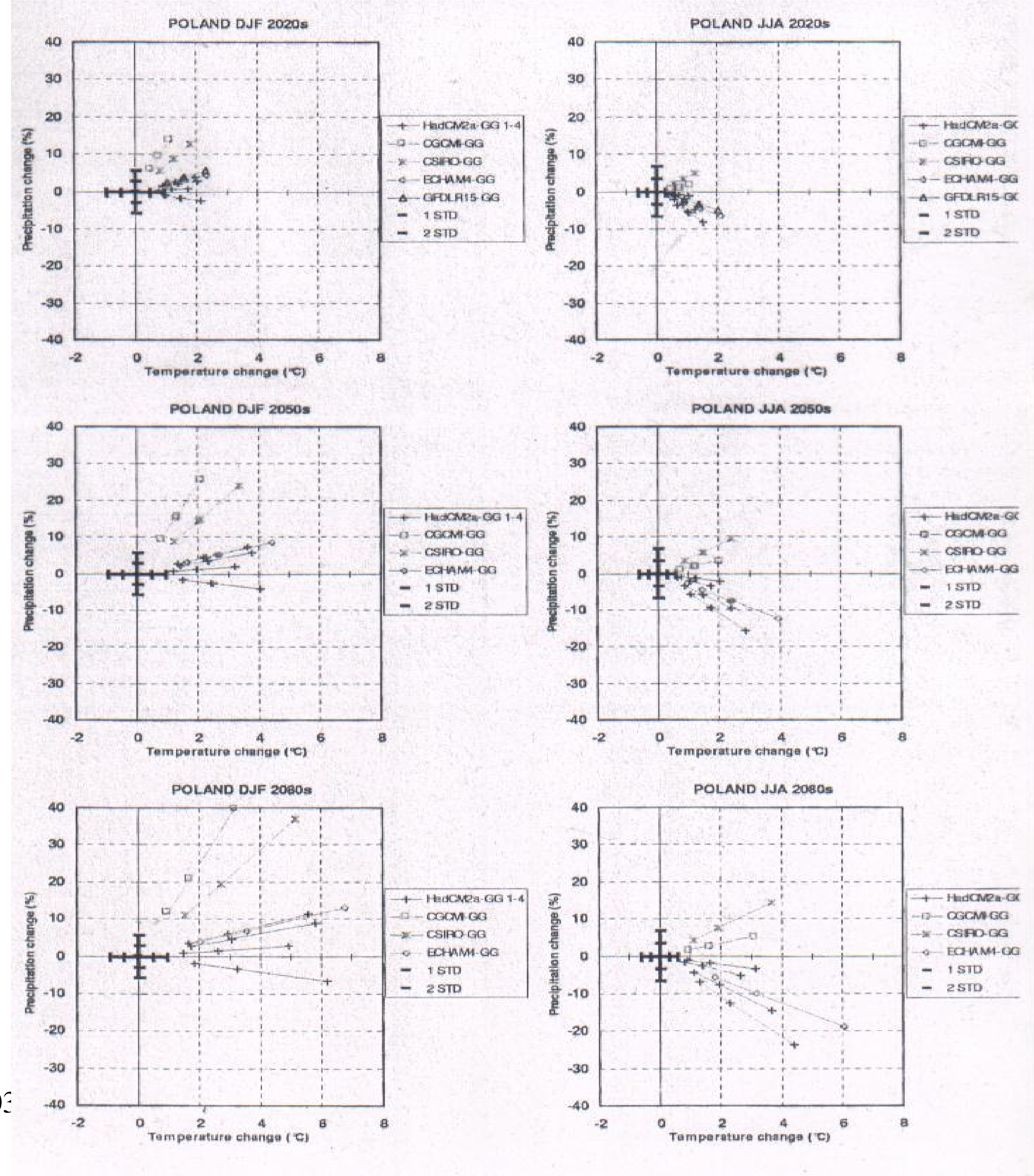


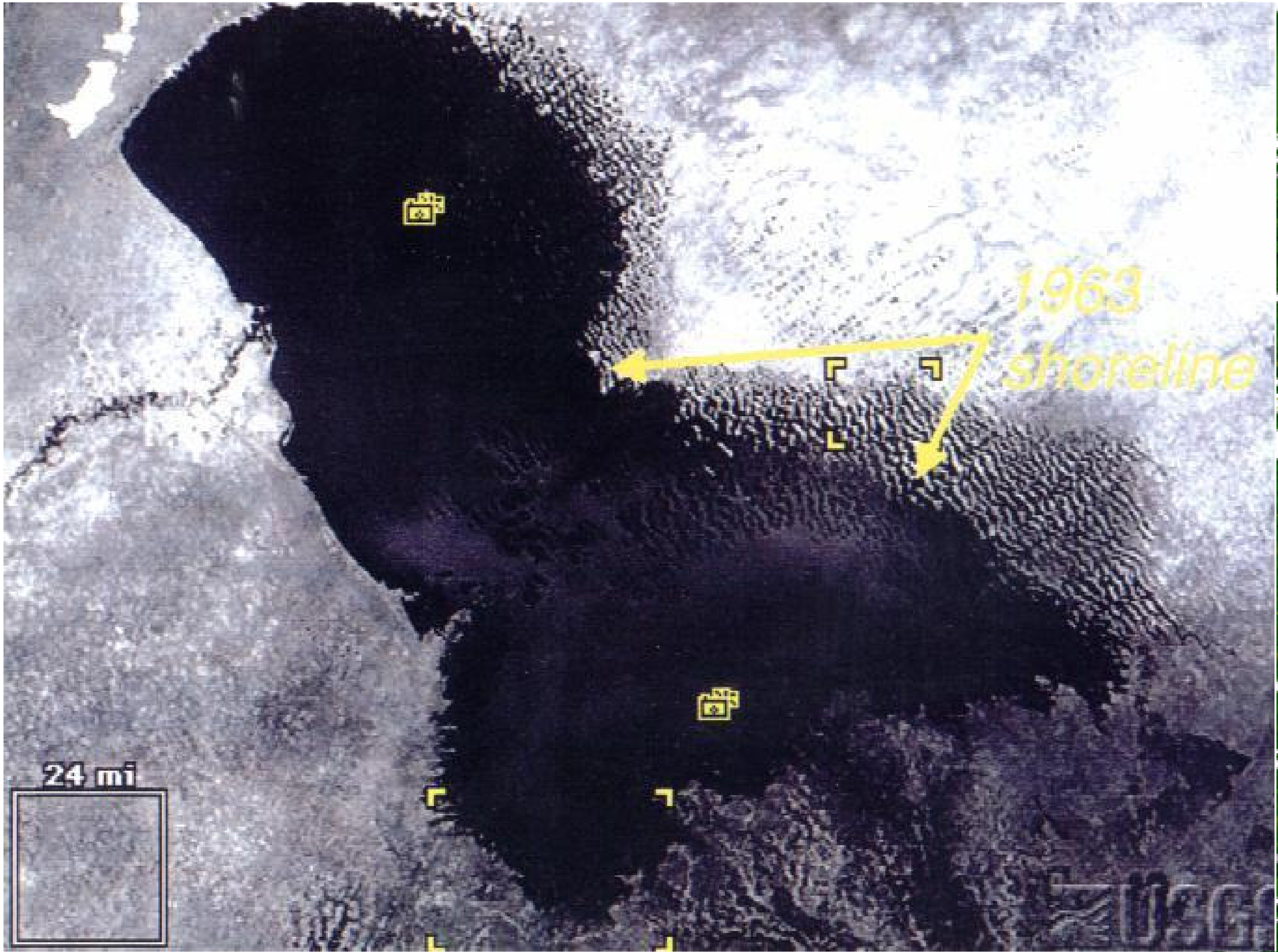
ACACIA,

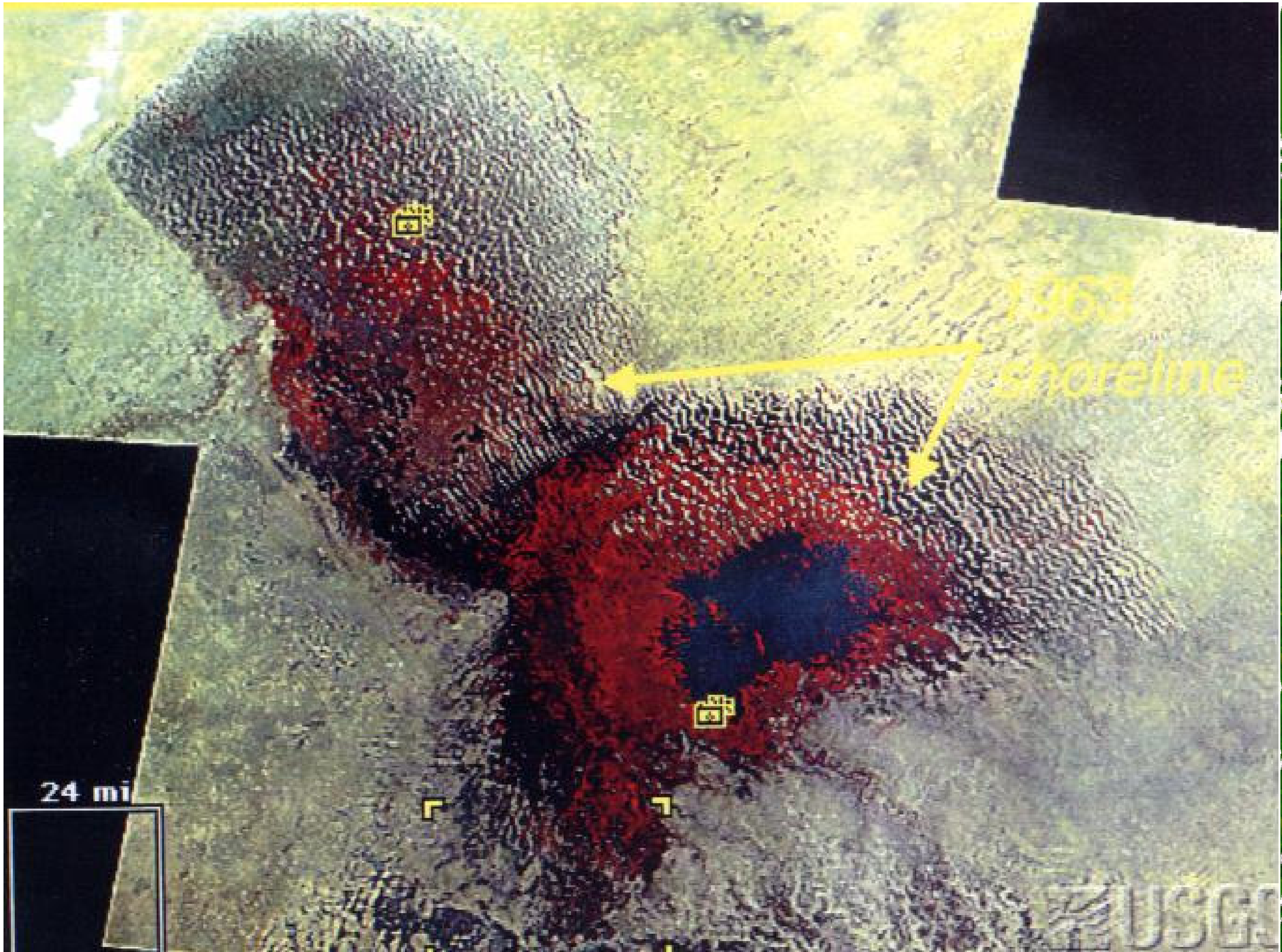
A2 high,

winter precipitation




POLAND DJF 2020s
POLAND JJA 2020s
POLAND DJF 2050s
POLAND JJA 2050s
POLAND DJF 2080s
POLAND JJA 2080s
Precipitation change (%)
Temperature change (°C)
HadCM2a-GG 1-4
CGCMI-GG
CSIRO-GG
ECHAM4-GG
GFDLR15-GG
1 STD
2 STD


1963
shoreline
24 mi


1963
shoreline
24 mi

Sea-level transgression scenarios for Bangladesh

Adapted from Milliman *et al.* (1989).

Met Office

Wetlands can act as a **carbon sink**, storing organic carbon in waterlogged sediments. Even slowly growing peatlands may sequester carbon at the rate between 0.5 and 0.7 tonnes/ha/yr.

Wetlands can also be a **carbon source**, when it is released via degassing during decay processes, or after drainage and cutting, as a result of oxidation or burning. Globally, peatlands have shifted over the past two centuries from sinks to sources of carbon, largely because of human exploitation.

Models of **future** climate change suggest that **widespread thawing of permafrost peatlands** due to climate warming, may lead to **further emissions of** greenhouse gases such as **methane.**