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ECOHYDROLOGY
Control of hydrological processes as a management tool

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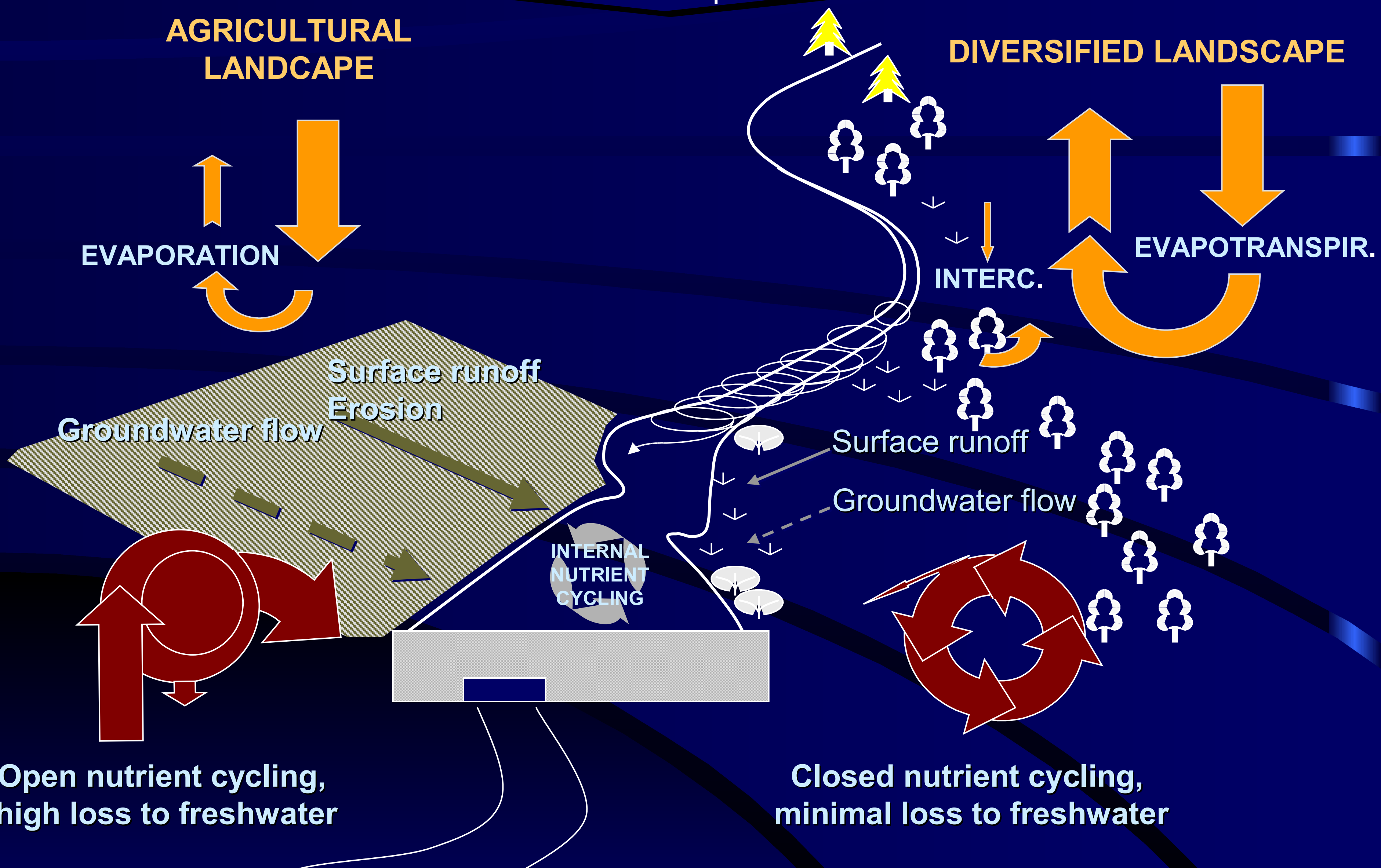
Earth at the beginning of XXI Century

- Almost 80% of the surface of the Earth has been modified by Man (NASA);
- Freshwater ecosystems situated in the lowest points of the landscape – exposed to cumulative impact due to various forms of catchment exploitation;
- More then 50% of wetlands – the catchments' kidneys - have been lost due to land transformations.

GLOBAL CLIMATE CHANGES

instability of hydrological processes
increase of temperature



IDENTYFICATION OF ECOLOGICAL PROBLEMS in global, regional and local scale

IMPACT ON BIOSPHERE

Overexploitation
of natural resources
and pollution emission

Degradation
of evolutionarily established
energy, water and biogeochemical cycles

MECHANISTIC APPROACH

„OVER-ENGINEERING"
and progressive degradation of the environment

IDENTYFICATION OF ECOLOGICAL PROBLEMS in global, regional and local scale

IMPACT ON BIOSPHERE

Overexploitation of natural resources and pollution emission

Degradation of evolutionarily established energy, water and biogeochemical cycles

Technical approach

Ecological approach and environmental sciences

SUSTAINABLE MANAGEMENT & DEVELOPMENT

XXI Century Science

Research and scientific analyses must become more problem focused and apply an interdisciplinary approach to sustainable development issues in order for science to become more policy relevant.

T.Rosswall ICSU

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ECOHYDROLOGY

E C O H Y D R O L O G Y

VENICE OFFICE

IHP-V

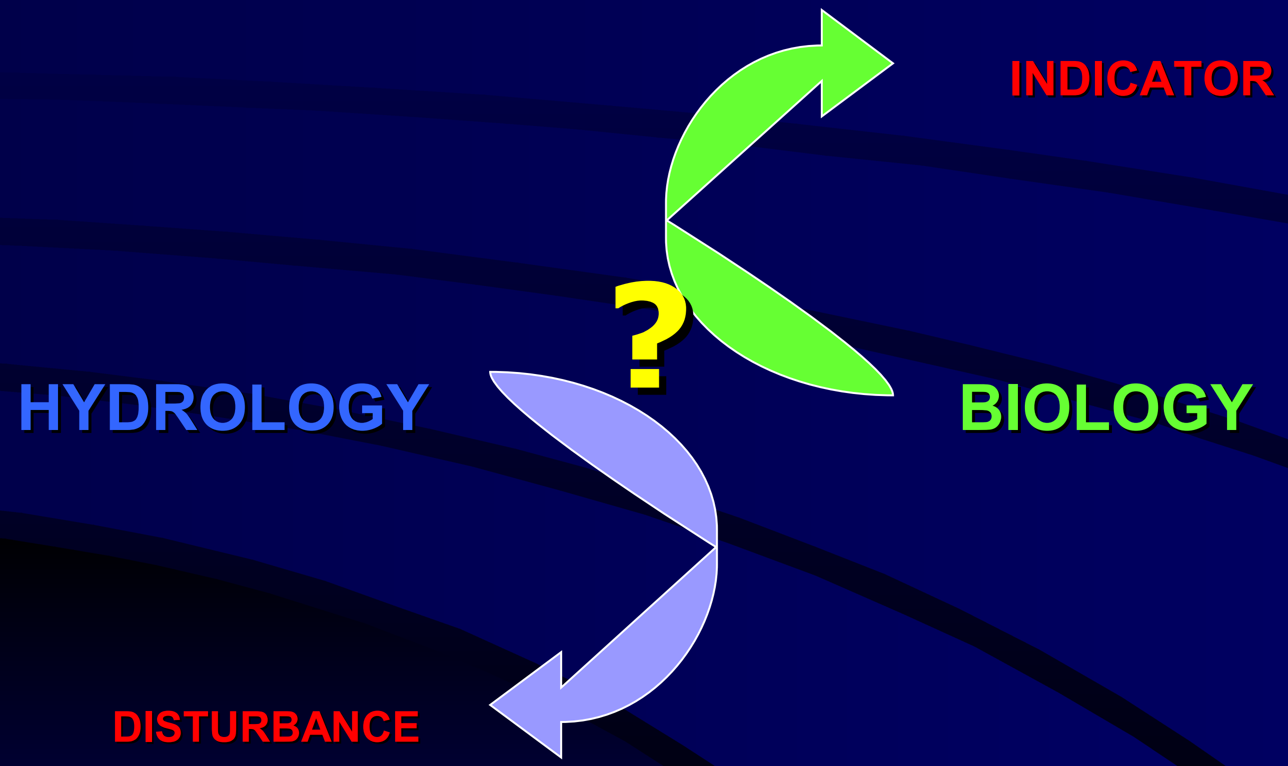
UNEP

A new paradigm for the sustainable use of aquatic resources

INTERNATIONAL HYDROLOGICAL PROGRAMME -V, 1996 - 2001

European Regional Centre for Ecohydrology UNESCO / Lodz, Poland

TRADITIONAL PERCEPTION OF BIOLOGY AND HYDROLOGY IN ENVIRONMENTAL SCIENCE



ECOHYDROLOGY:
QUANTIFICATION AND DUAL REGULATION OF E & H

Management of hydrological parameters of an ecosystem/ecosystems to control biological processes

Shaping of biological structure of an ecosystem/ecosystems in a catchment, to regulate hydrological processes

ECOHYDROLOGY

The Ecohydrology theory is based upon the assumption that sustainable water resources management can be achieved by:

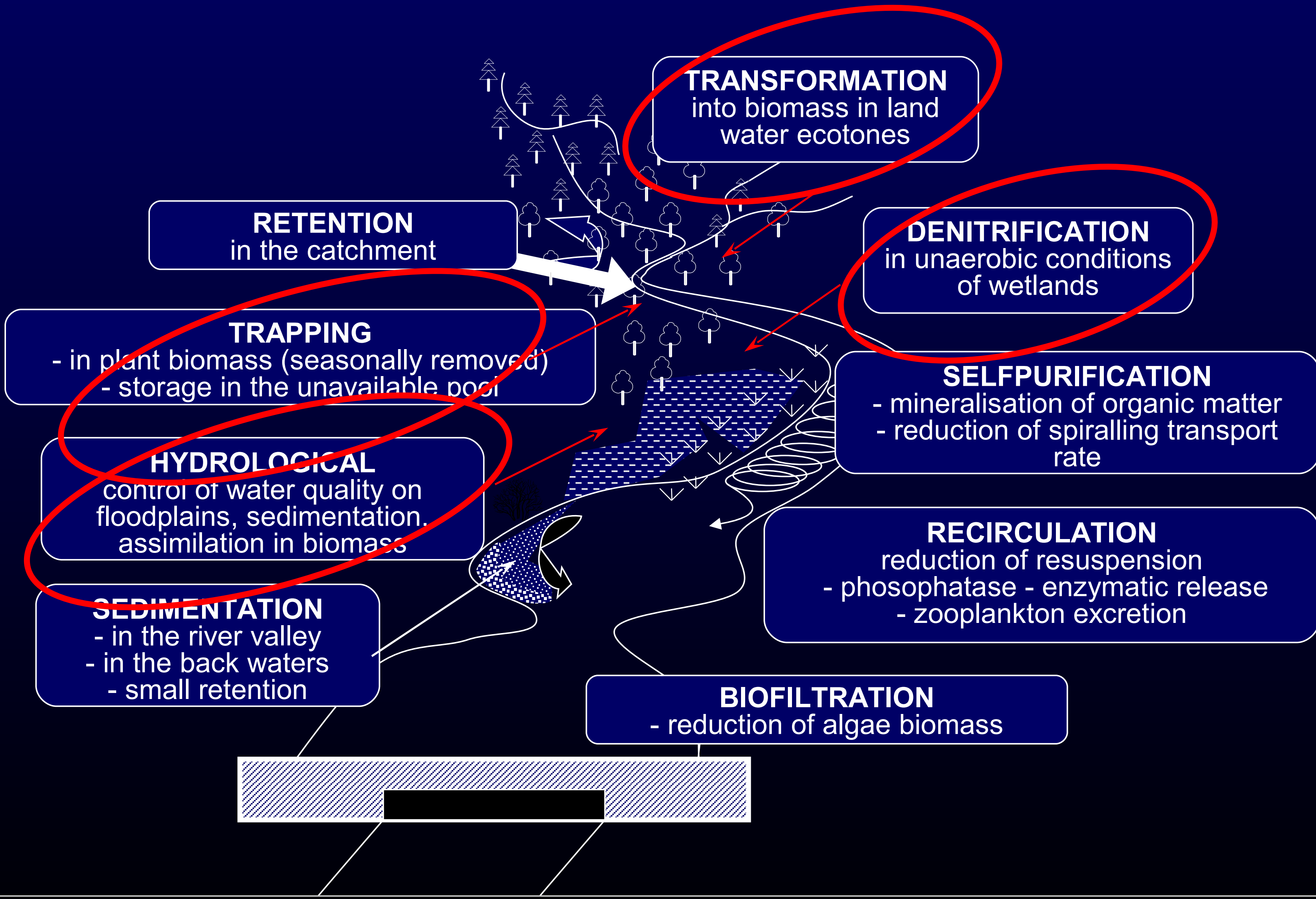
- restoring and maintaining the evolutionarily-established processes of water and nutrient circulation and energy flows at a catchments scale;
- - Understanding the evolutionary established resilience and resistance of ecosystems to stress and
  - enhancing the absorbing capacity (robustness) of some ecosystems against human impact for maintenance of services in a catchment scale;
- using ecosystem properties as water management tools.

ECOHYDROLOGY of WETLANDS

for water quality improvement

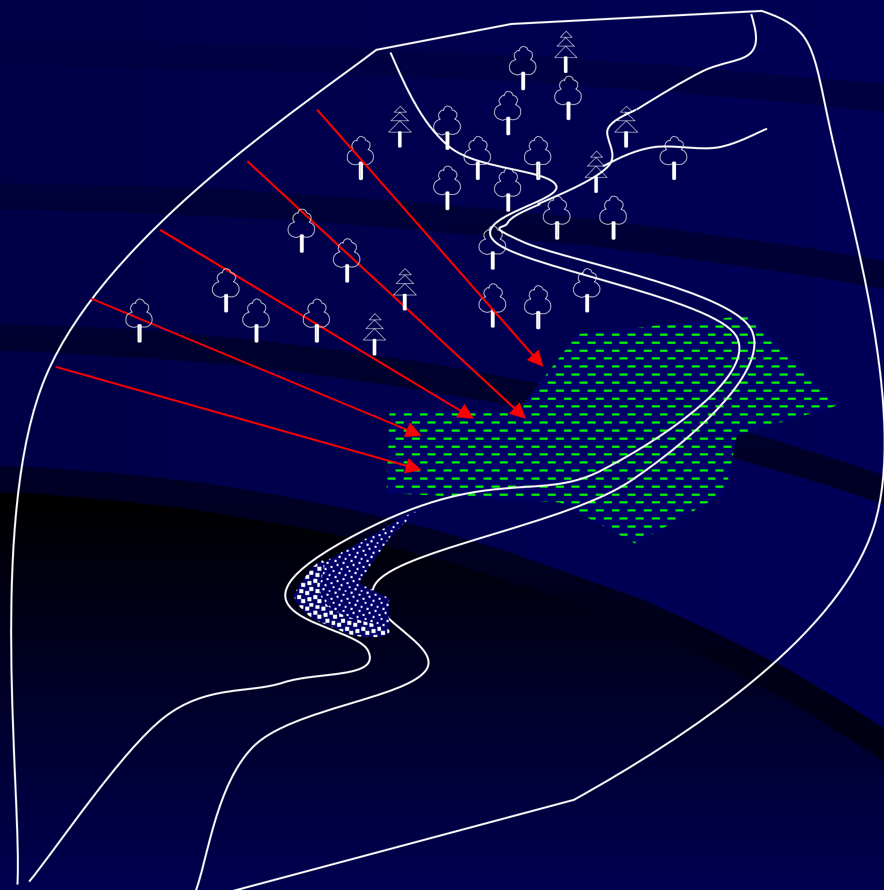
ECOHYDROLOGY

INTEGRATION OF MEASURES IN A CATCHMENT SCALE

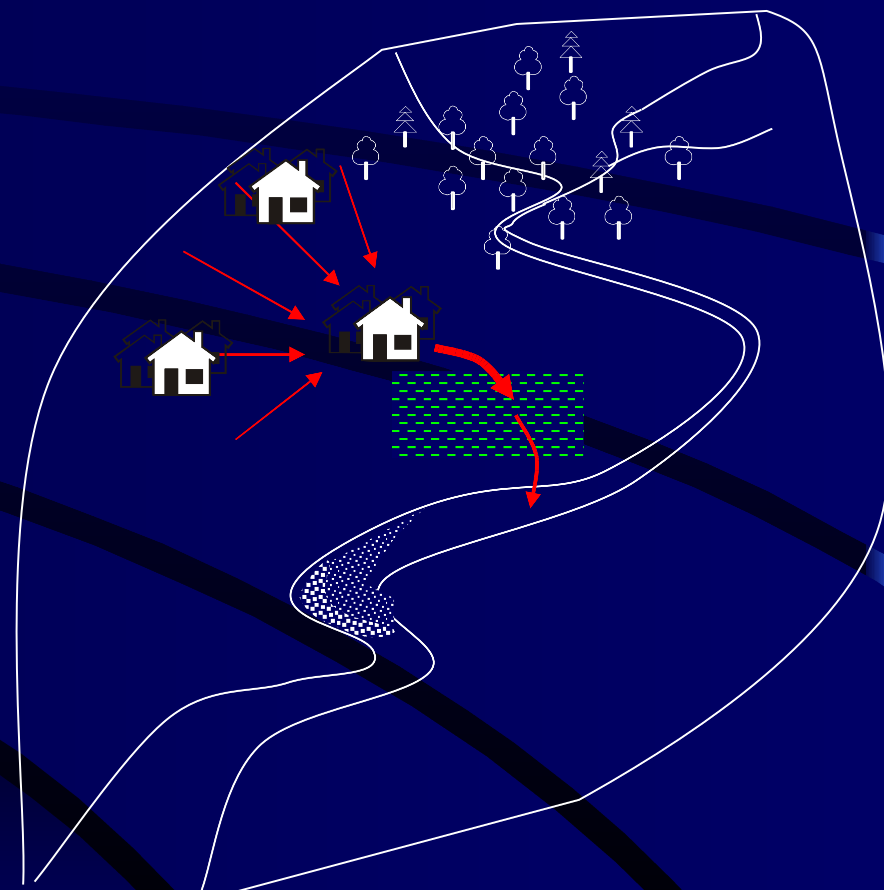


WETLANDS: LAND/WATER INTERFACE

buffering zones, maintaining the natural biogeochemical links between land, water and biota



final step in conventional wastewater treatment technologies



General principles

1. Understanding wetland ecology and its principles (e.g., hydrology, biogeochemistry, adaptations, succession) is essential to create and restore wetlands successfully as a part of a natural landscape

EH! *Maximising efficiency and minimising costs*

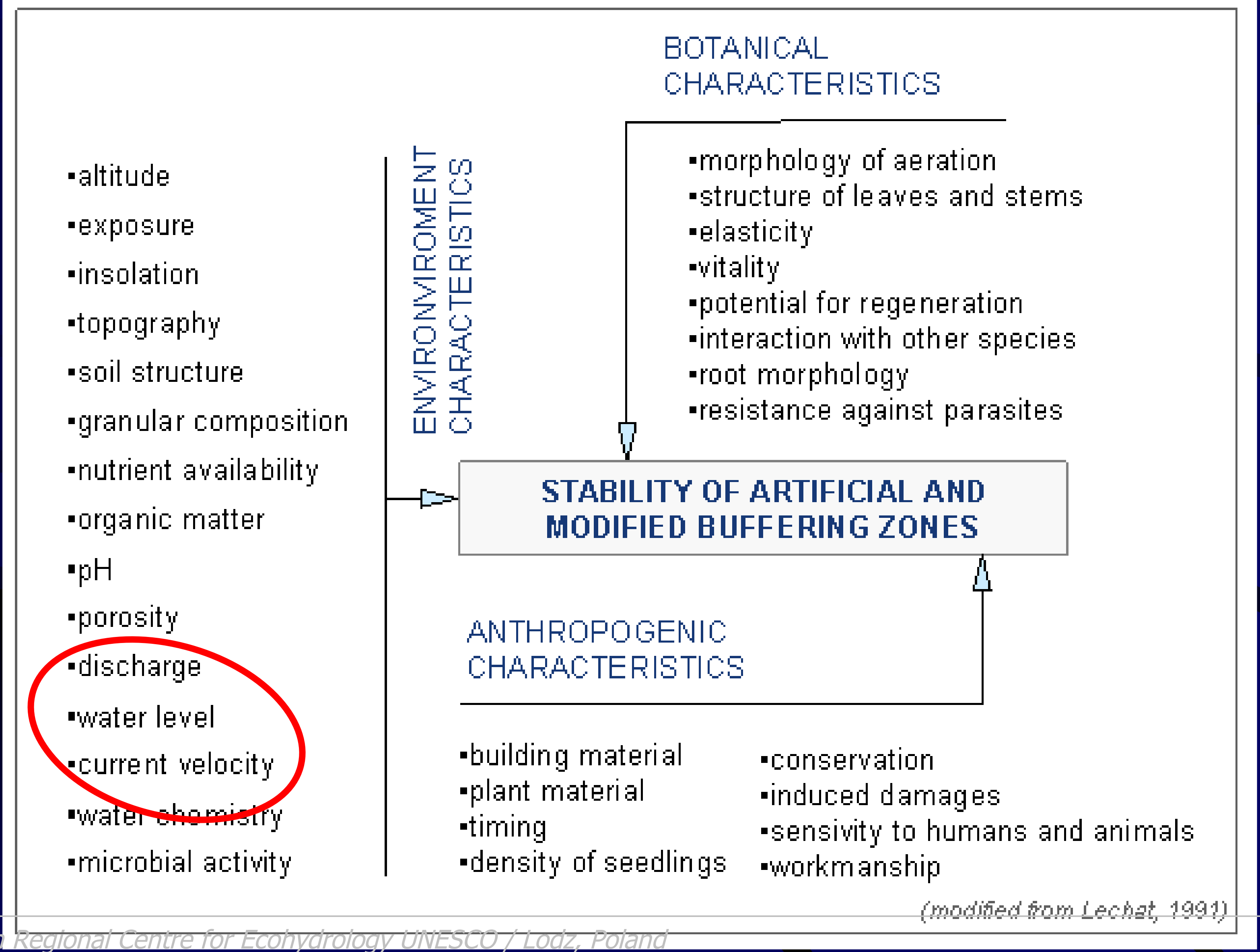
2. Resisting of the ever-present temptation to overengineer wetlands by attempting either to channel natural energies that can not be channeled or introduce species that landscape and climate cannot support

EH! *Simple systems tend to be self-regulating and self-mantiaining*

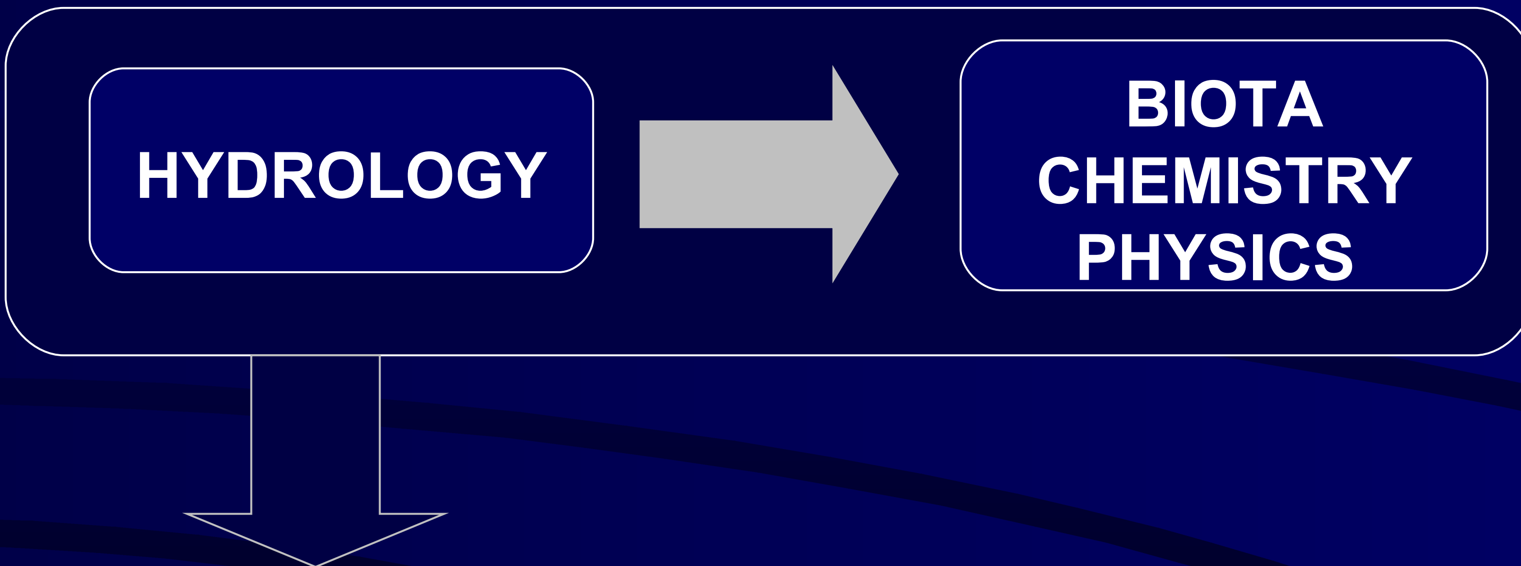
Mitsch & Jorgensen, 2004

Different types of wetlands

Factors determining stability of artificial and modified wetlands



Wetlands hydrology



- Hydroperiod and depth
- Seasonal pulses
- Hydraulics
- Hydraulic loading rates
- Detention time

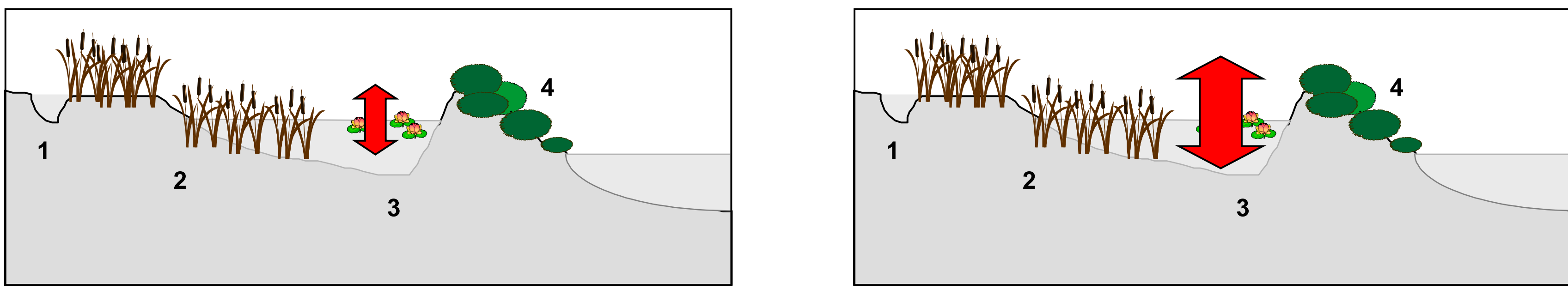
Knight, 1990; Mitsch & Jorgensen, 2004

Hydroperiod and depth

Hydroperiod:
the depth/volume of water in the wetland over time

- Constructed for wastewater treatment

- Constructed for stormwater treatment (or combined)
- Natural (esp., in urban catchments or located upstream)



1. ditch; **2.** rushes *(Phragmites, Typha, Glyceria);* **3.** sedimentation ponds *(Nuphar , Lemna);* **4.** Shrubs *(Salix)*

Hydroperiod and depth

$$\frac{\Delta (d \times A)}{\Delta t} = S_{in} + S_{out} + G_{in/out} + P - ET$$

Δ (d x A) – change of wetland water volume over time
d – average water depth
A – surface area
t - time
S_{in} – water inflow
S_{out} – surface outflow
$G_{in/out}$ – groundwater exchange
P - precipitation
ET - evapotranspiration

EH!

Hydroperiod determinates sedimentation rate, vegetation growth and oxygenation in wetlands

Hydroperiod impact for water quality improvement processes

•Sedimentation, filtration, and sorption of particulate matter within the wetland due to long water retention times and large sediment surface areas;

•Assimilation and retention of dissolved nutrients within the biomass present in the wetland;

•Oxidation and microbial transformation of organic matter in wetland sediments;

•Denitrification of nitrogenous compounds by microbial action within the wetland system.

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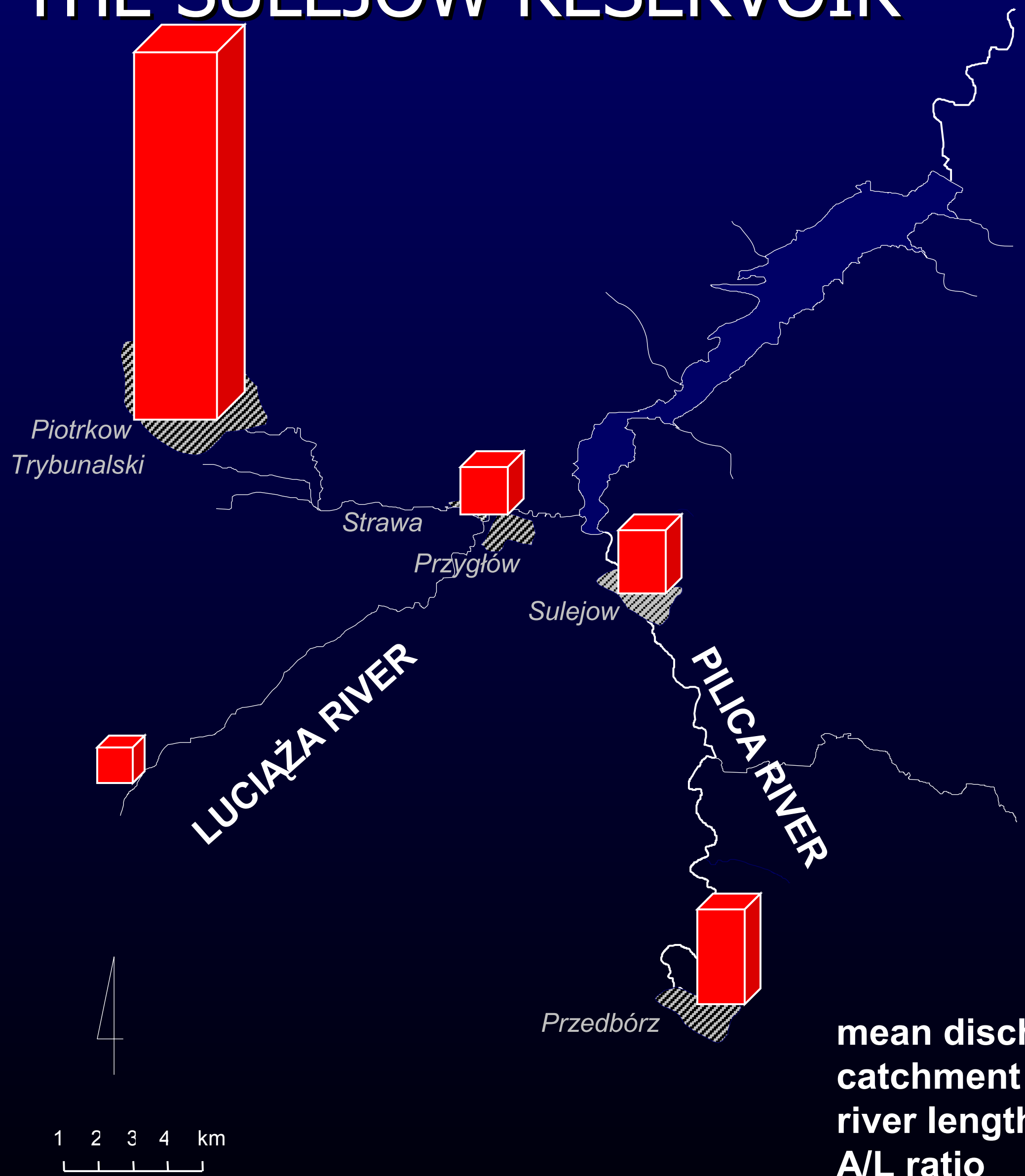
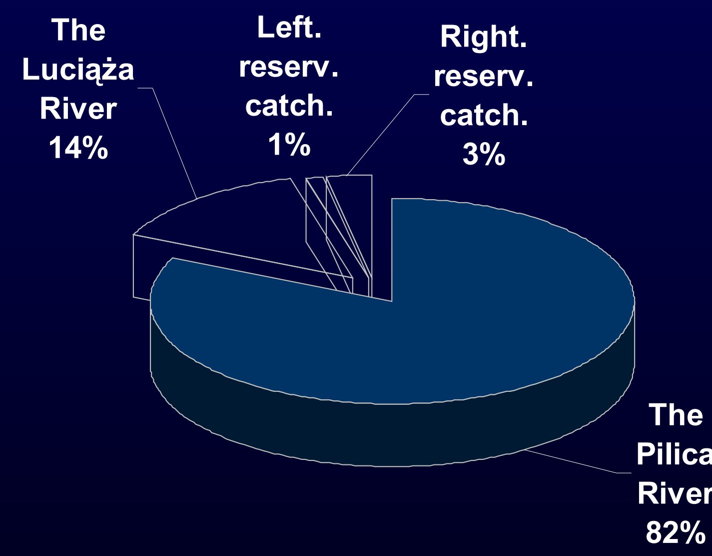
Seasonal pulses
Pilica River case study

THE SULEJOW RESERVOIR





	PILICA	LUCIĄŻA
mean discharge [m^3s^{-1}]	21,2	2,89
catchment area A [km^2]	3921	766
river length L [km]	160	49
A/L ratio	25	16

EUTROPHICATION AND TOXIC ALGAL BLOOMS

Drinking water reservoir (Sulejow, Poland)
photo. M. Tarczynska

CHROMOSOMAL ABERRATION INDUC... ACT FROM CYANOBACTERIA...

in *in vitro* hum...

A - chromatid breaks, B - chromatid exchan... ...tric fragment.

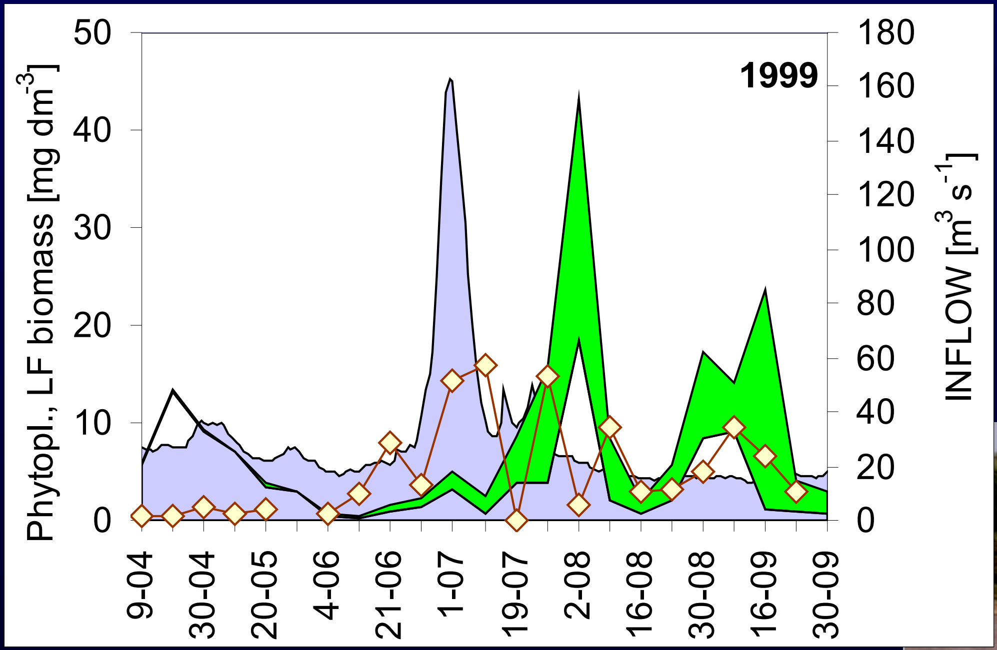
Good chemical and ecological status

2015!

Cooperation with:

- prof. R. Osiecka, Department of Cytogenetics and Molecular Biology of Plant, University of Lodz, Poland

EFFECT OF FLOOD ON PHYTOPLANKTON BIOMASS



inflow | Diatoms and chlorophyta | Cyanobact. | Large filtrators

Fot. M. Tarczyńska

QUESTION?

Can we use flood pulses for regulation of nutrient transport dynamics?

1. What are the relationships between hydrological parameters of tributaries and transport of phosphorus to a reservoir?

2. How can we enhance absorbing capacity of floodplain wetlands against phosphorus loads?

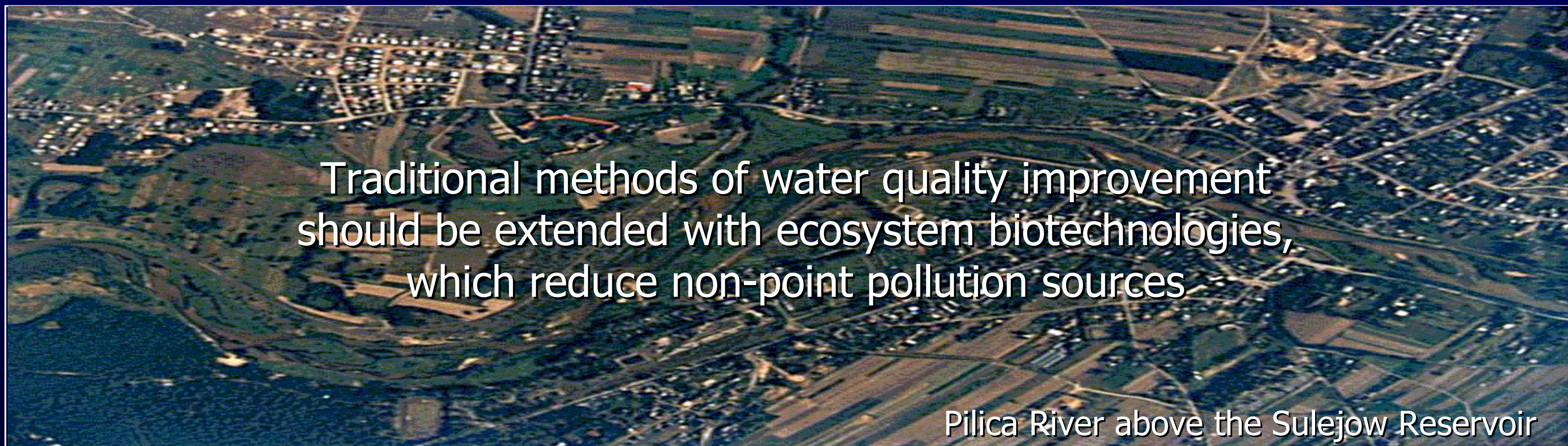
Relationships between hydrological processes and nutrients transport

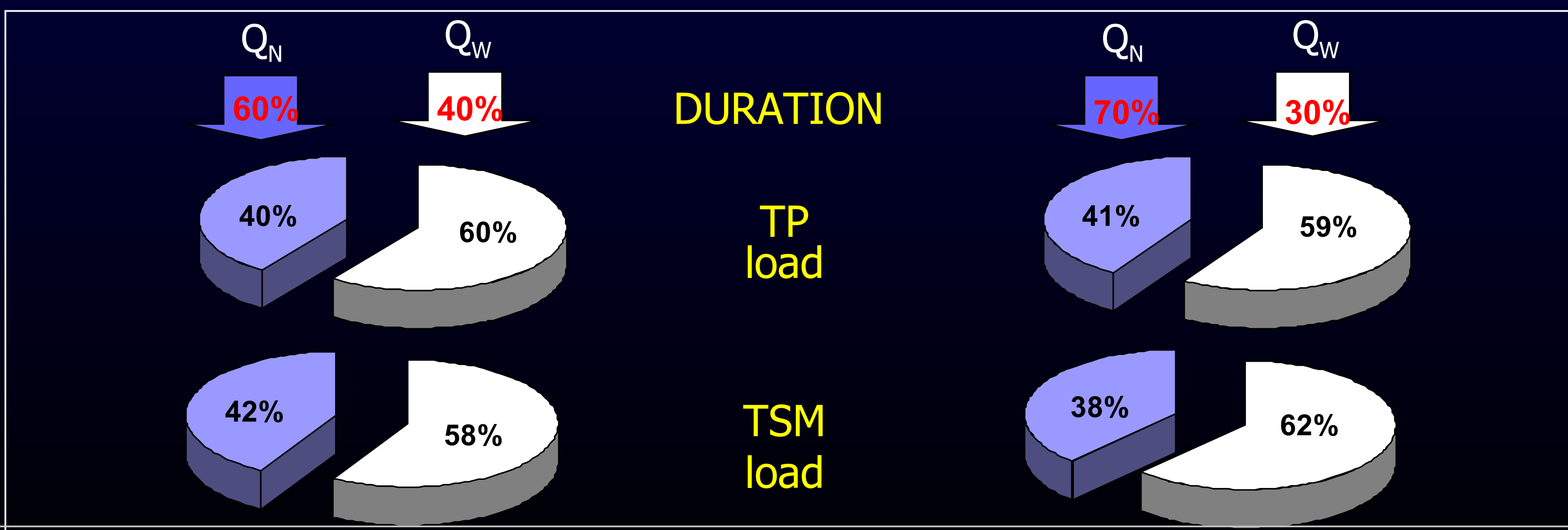
PHOSPHORUS (TP) AND MATTER (TSM) TRANSPORT

during low (Q_N) and high (Q_W) discharge

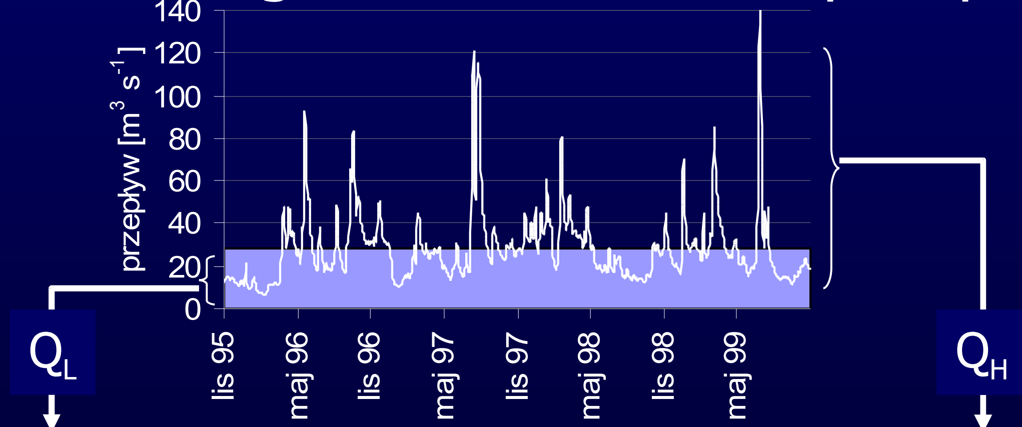
THE PILICA RIVER
SSQ (1996-1999) = 28,3 $m^3 s^{-1}$

THE LUCIĄŻA RIVER
SSQ (1996-1999) = 2,69 $m^3 s^{-1}$





HIERARCHY OF FACTORS
determining concentrations of phosphorus



WINTER

Q_L

	POŁROCZE: **zimowe (XI - IV)**					
	PPO4	DP	TP	TSM	MSM	OSM
ΔQ	0,436	0,540	0,425	0,628	0,581	0,478
Q_1	0,406	0,622		0,648	0,482	0,685
Q_3		0,576		0,580	0,412	0,644
Q_7		0,477		0,476		0,574
Q_30		0,496				0,496
T_1						0,401
T_3						0,448
T_7						0,429
P_1						
P_3						
P_7						
PS	-0,445	-0,498		-0,670	-0,447	-0,785

Q_H

	POŁROCZE: **zimowe (XI - IV)**					
	PPO4	DP	TP	TSM	MSM	OSM
ΔQ	0,355	0,442	0,459	0,488	0,500	
Q_1						-0,360
Q_3						-0,454
Q_7			-0,299	-0,617	-0,490	-0,609
Q_30	-0,456	-0,573	-0,522	-0,770	-0,732	-0,425
T_1						
T_3						
T_7						
P_1						-0,371
P_3	0,294	0,374	0,506	0,524	0,517	
P_7						
PS						

HYDROLOGICAL FACTORS

TEMPERATURE

PRECIPITATION

SUMMER

	POŁROCZE: **letnie (V-X)**					
	PPO4	DP	TP	TSM	MSM	OSM
ΔQ						
Q_1				0,488	0,343	0,574
Q_3				0,453		0,575
Q_7	0,316			0,440		0,487
Q_30	0,406	0,399		0,369		0,404
T_1		0,538	0,359	0,377		
T_3		0,423		0,349		
T_7		0,430		0,366	0,347	
P_1						
P_3						
P_7						

	POŁROCZE: **letnie (V-X)**					
	PPO4	DP	TP	TSM	MSM	OSM
ΔQ				0,691	0,528	0,551
Q_1						
Q_3						
Q_7				-0,550	-0,559	
Q_30						
T_1	0,482	0,548				
T_3	0,594					
T_7	0,604	0,581	0,470			
P_1						
P_3			0,522			
P_7				0,685	0,449	0,610

HYDROLOGICAL FACTORS

TEMPERATURE

PRECIPITATION

HIERARCHY OF PROCESSES
determining concentrations of phosphorus

IMPORTANT ROLE OF BIOTIC STRUCTURE OF CATCHMENT AND RIVER BED IN NUTRIENT RETENTION

WINTER

WINTER

PHYSICAL PROCESSES OF PHOSPHORUS TRANSPORT FROM A CATCHMENT

Fot. I. Wagner-Łotkowska

HYDROLOGICAL FACTORS

SUMMER

SUMMER

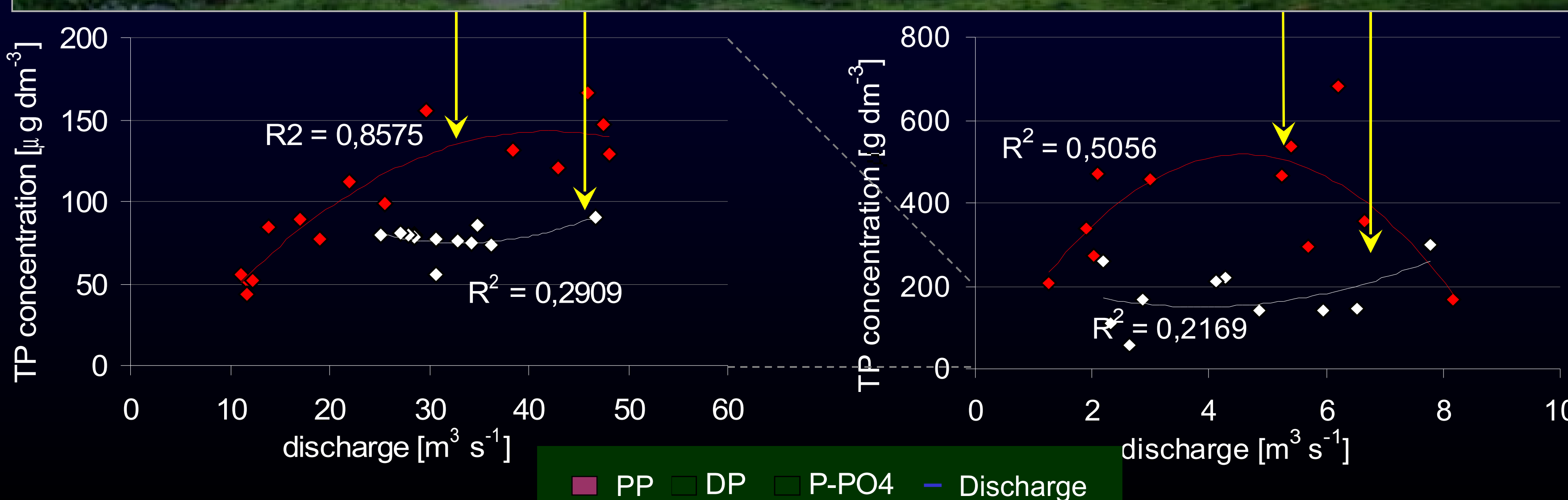
RETENTRION OF PHOSOHORUS IN BIOTIC STRUCTURE OF A RIVER BED

Fot. I. Wagner-Łotkowska

TEMPERATURE

SPRING FLOOD, III 1996

relationship between discharge and TP concentration



Seasonal pulses

•The highest nutrient concentrations and loads are observed during the rising hydrograph limb (nutrient-condensing stage);

•Before river discharge reaches its maximum, nutrient concentrations and loads start to decrease and continue to decrease during falilng hydrograph limb (nutrient-dilution stage);

•During high/moderate floods of short duration but with an high amplitude, the nutrients loads transported are greater than during lower amplitude and longer duration events;

•Flash floods may result with dilution of concentrations of the transported contaminants, however the loads are still high due to high hydraulic load. This may periodically lower the efficiency of wetlands in water quality improvement.

EH!

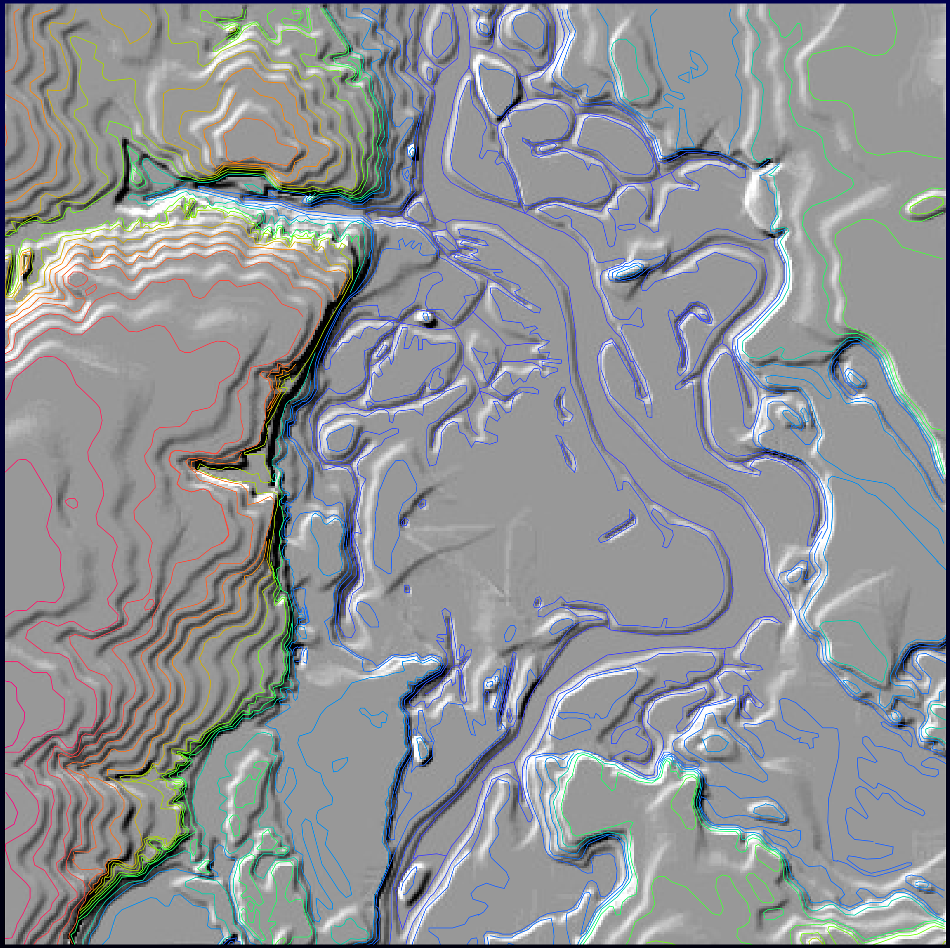
Seasonal pulses determine nutrient supply, regulate oxygenation and may rejuvenate system for nutrient retention

The enhancement of river self-purification potential by control of hydrological and biotic processes

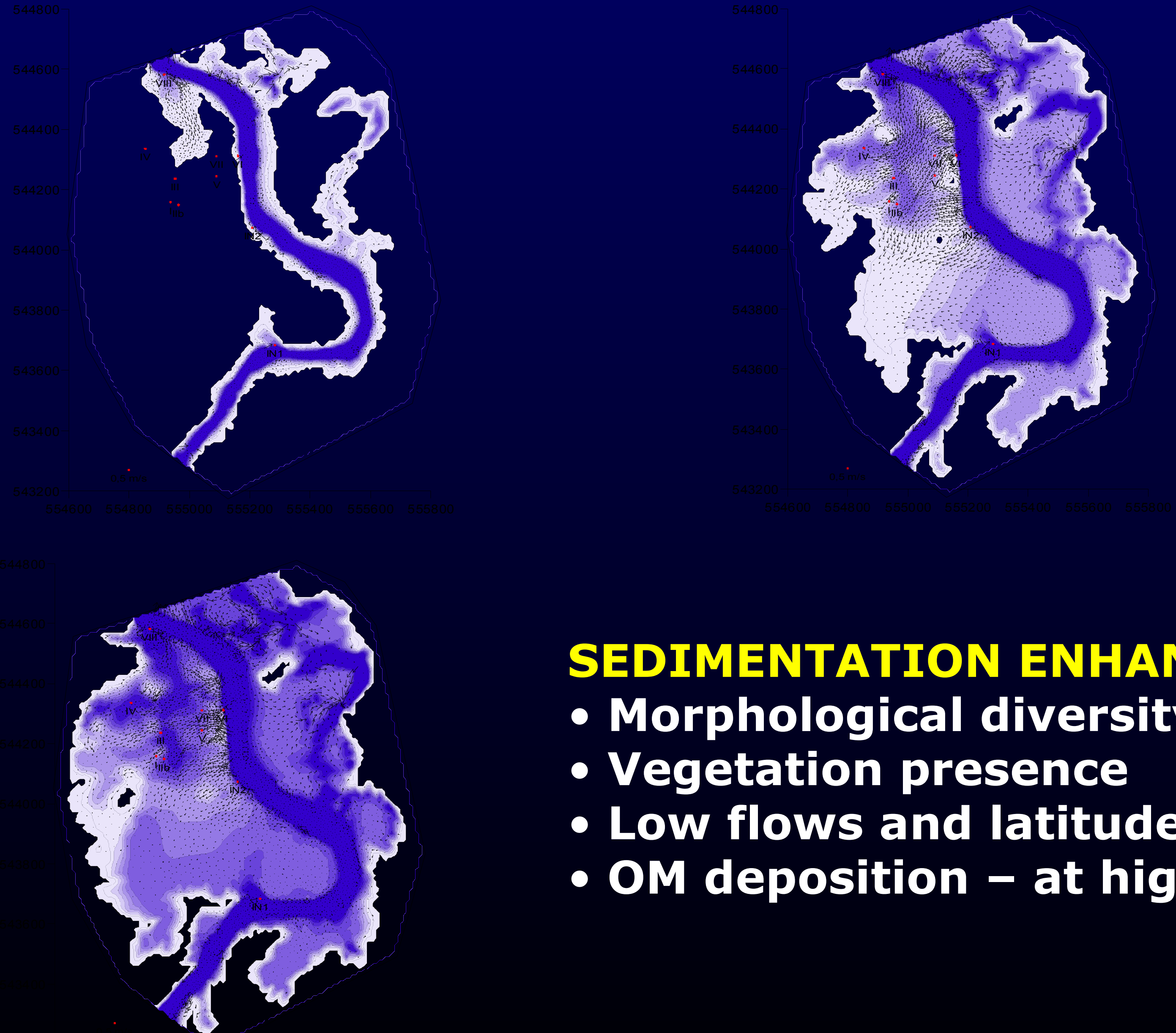
European Regional Centre for Ecohydrology UNESCO / Lodz, Poland

USE OF FLOODPLAIN CHARACTERISTICS AS A TOOL HYDROLOGICAL MANAGEMENT

Digital Terrain Model of a floodplain



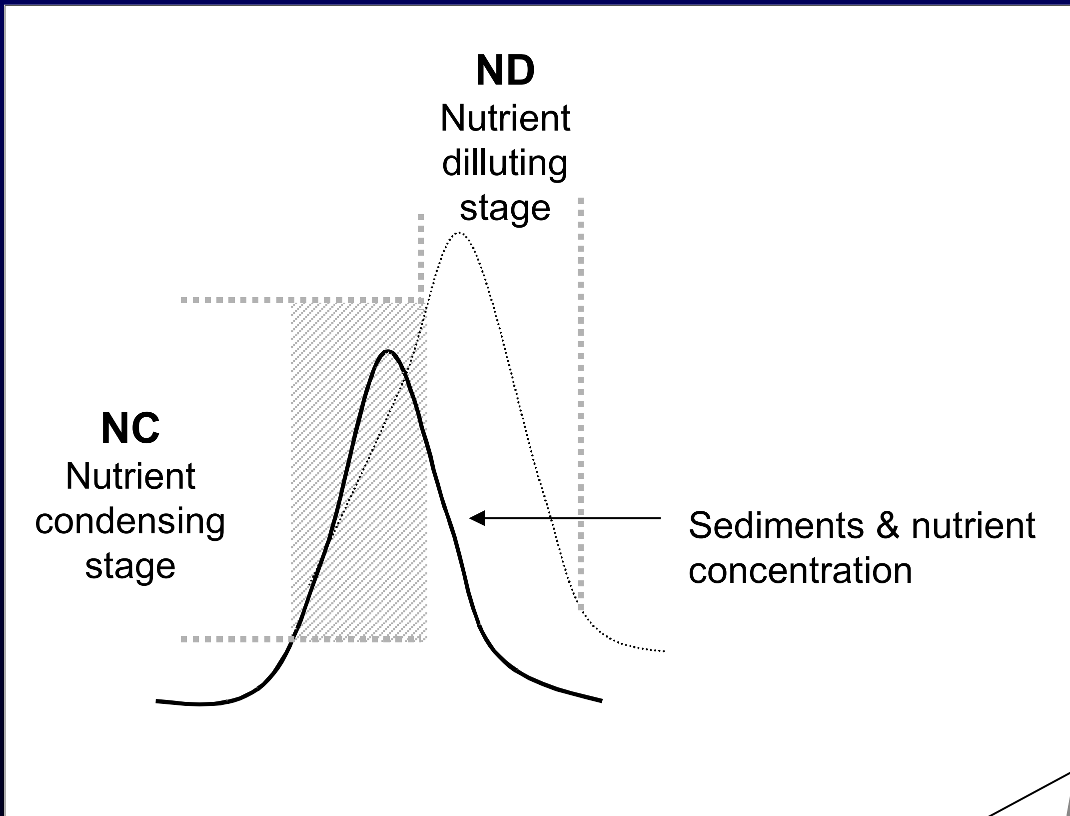
FLOODPLAIN HYDRAULICS AS SEDIMENTATION DETERMINANT

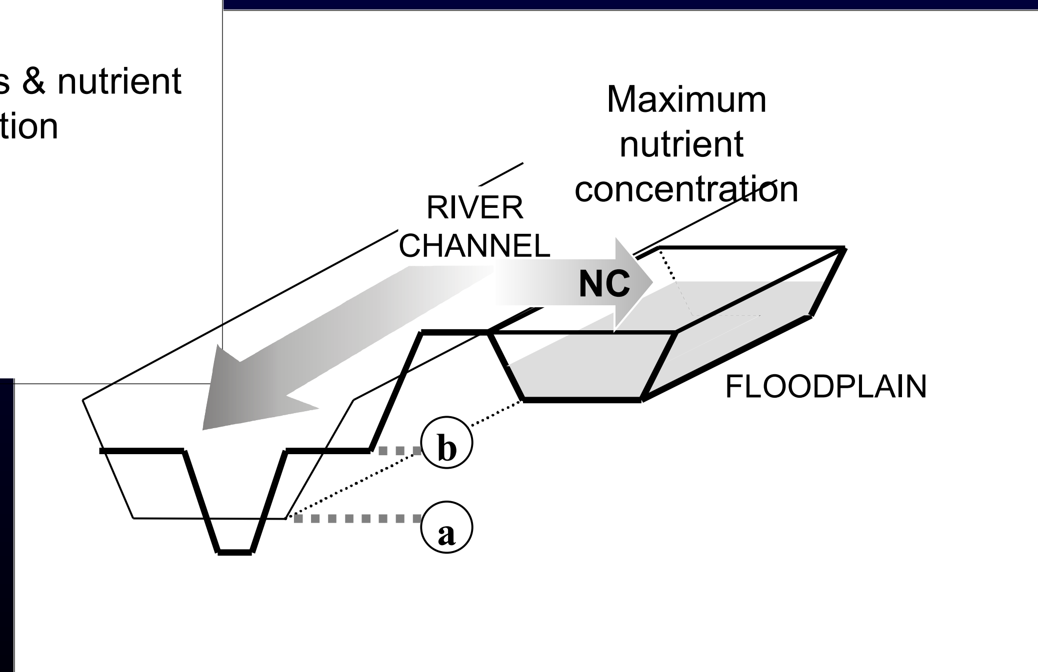


SEDIMENTATION ENHANCES WITH

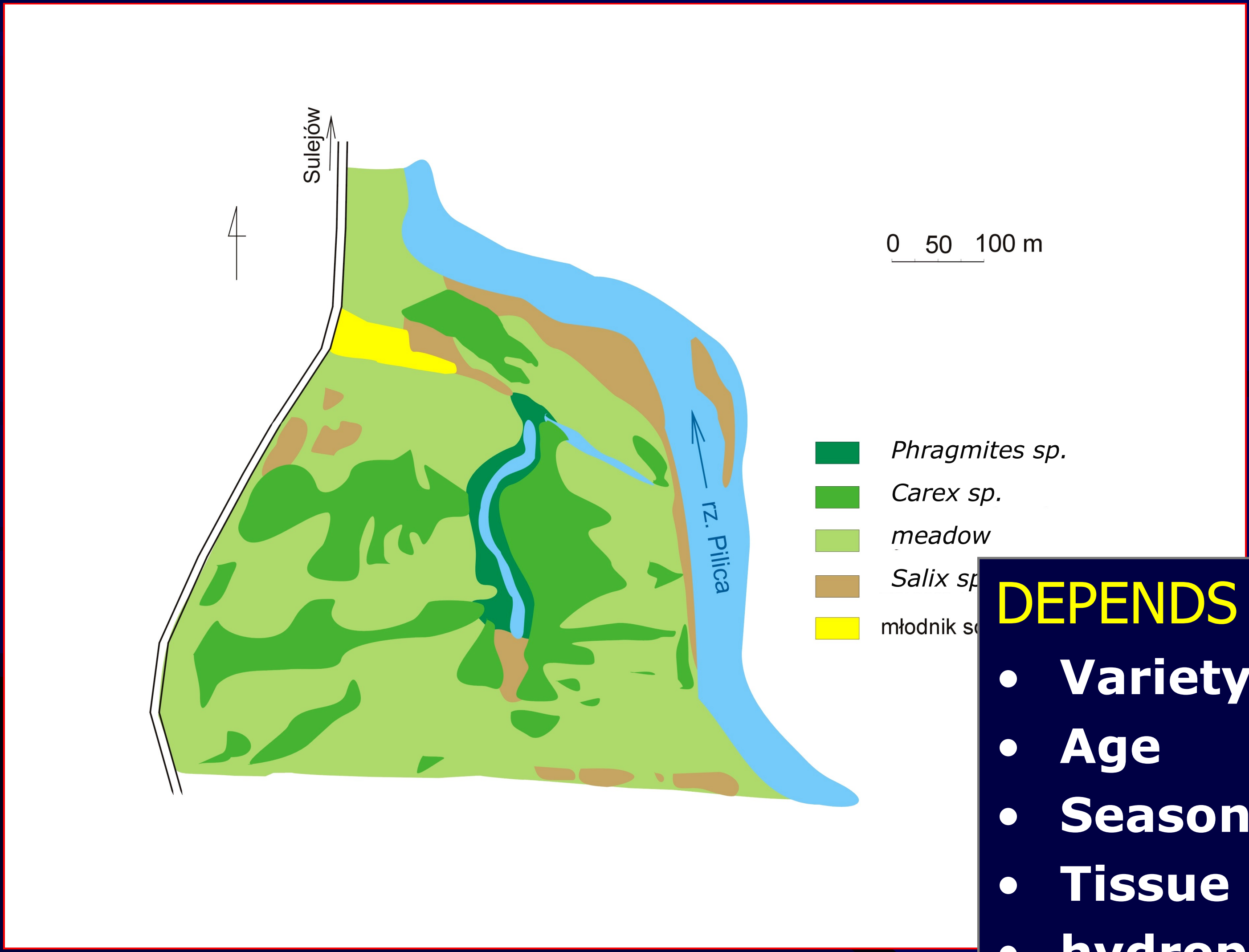
- **Morphological diversity**
- **Vegetation presence**
- **Low flows and latitudes**
- **OM deposition – at high latitudes**

IDENTIFICATION OF TIMING FOR IMPROVEMENT OF FLOOD WATERS MANAGEMENT



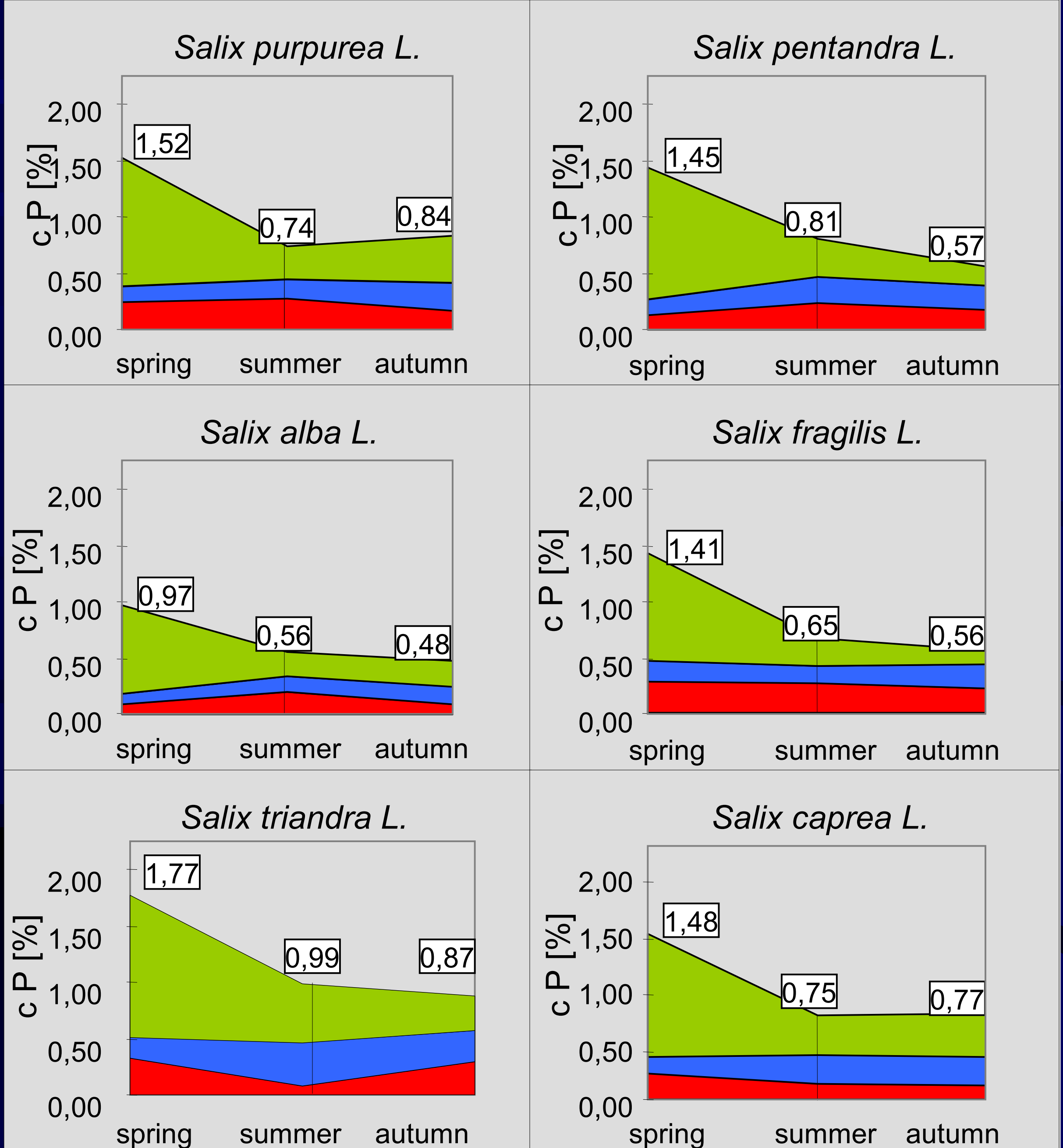


PLANT COMMUNITIES ON THE FLOODPLAIN AND THEIR ABILITY TO PHOSPHORUS ASSIMILATION

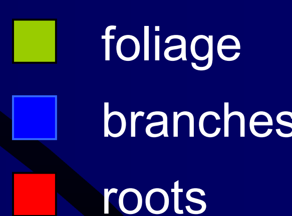


DEPENDS ON:

- **Variety / species**
- **Age**
- **Season**
- **Tissue**
- **hydroperiod**

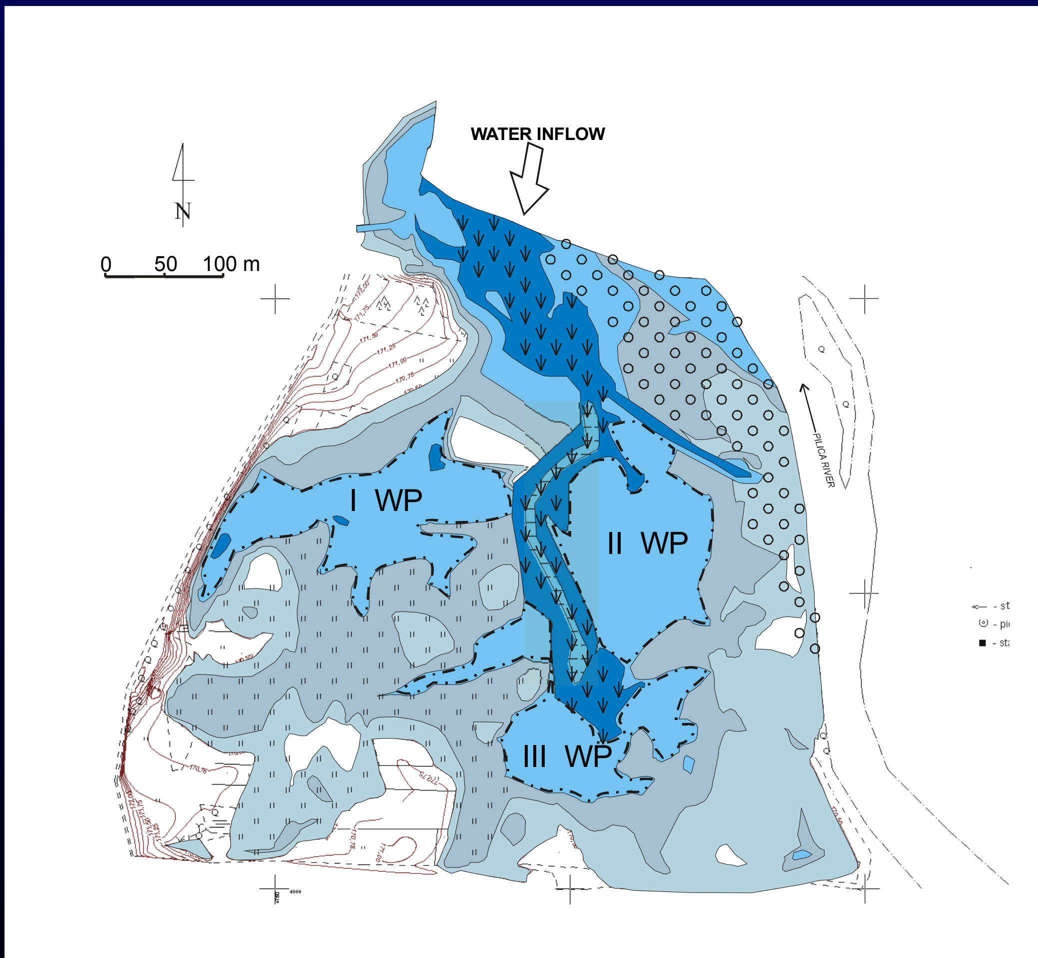


TOTAL PHOSPHORUS CONCENTRATION IN 6 SPECIES OF *SALIX*



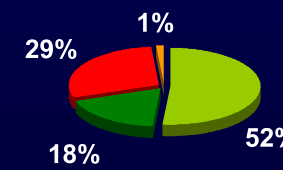
ENHANCEMENT OF ABSORBING CAPACITY OF FLOODPLAIN

for nutrients trapping



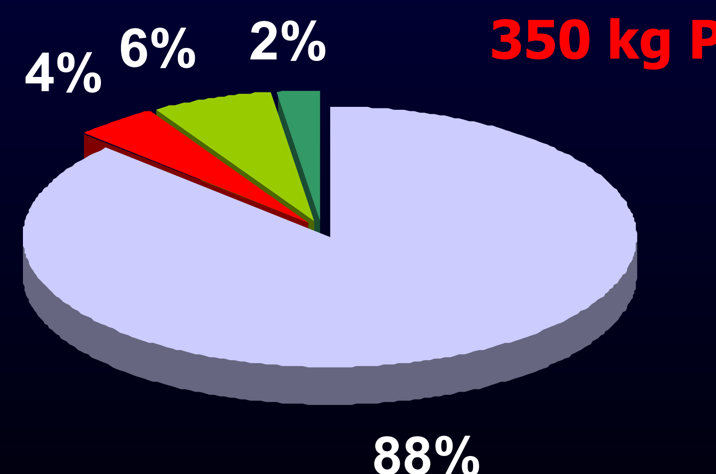
TOTAL PHOSPHORUS ACCUMULATION IN FLOODPLAIN BIOMASS

INITIAL



164 kg P

ENHANCED



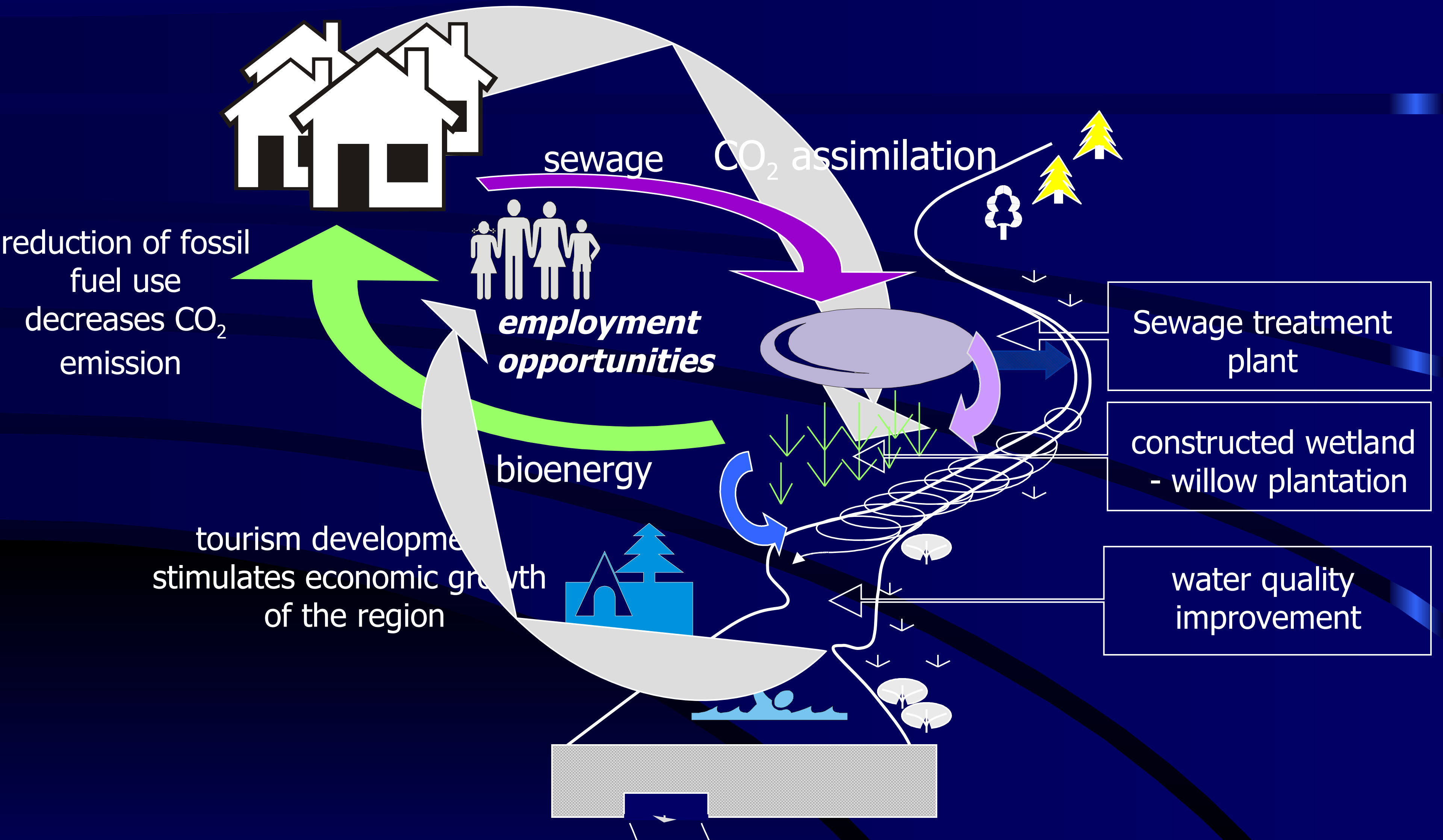
350 kg P

Meadow species | *Carex gracilis et vesicaria* | *Phragmites australi* | *Salix sp.*

European Regional Centre for Ecohydrology UNESCO / Lodz, Poland

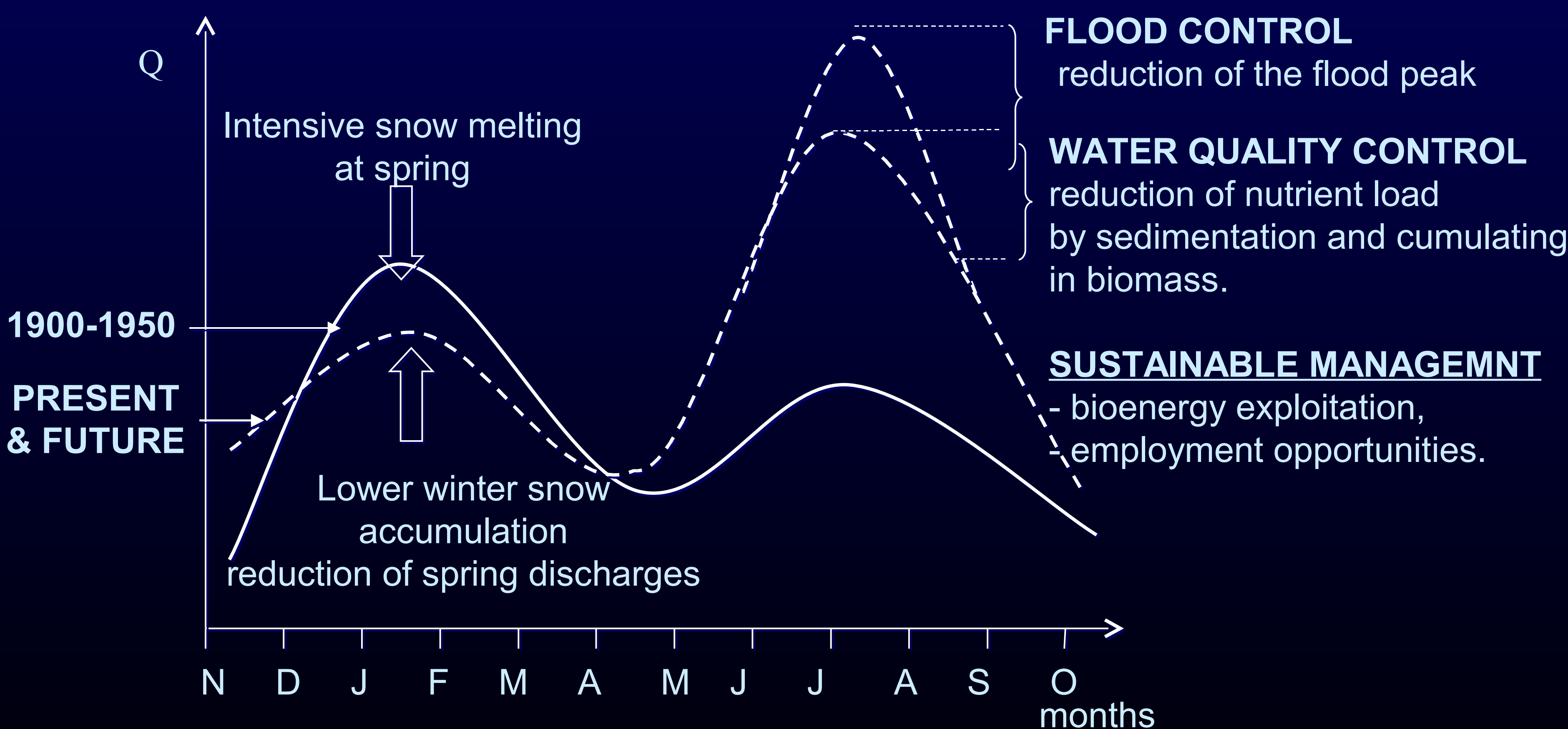
Koch, Wagner, 2001

Conversion of nutrients into biomass and bioegenrgy for regional sustainability



(Zalewski, 2000)

WATER QUALITY AND FLOOD CONTROL BY WETLANDS
in the context of hydrological pattern due to global changes



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