

# ECOHYDROLOGY -

*Integrative tool for achieving*

*good ecological status of freshwater ecosystems*

**MACIEJ ZALEWSKI**

*International Centre for Ecology Polish Academy of Sciences, Warsaw/Lodz  
Department of Applied Ecology University of Lodz*



ECOHYDROLOGY





„Twentieth-century water policies relied on the construction of massive infrastructure in the form of dams, aqueducts, pipelines, and complex centralised treatment plants (...). Many unsolved water problems remain and past approaches no longer seem sufficient. A transition is under way to a „soft path“ that complements centralised physical infrastructure with lower cost community scale systems (...) and environmental protection.”

**GLOBAL FRESHWATER RESOURCES: SOFT-PATH SOLUTIONS FOR THE 21<sup>st</sup> CENTURY  
(SCIENCE: 14 Nov. – 5 Dec. 2003, Peter H. Gleick)**

**GLOBAL CLIMATE CHANGES**  
instability of hydrological processes  
increase of temperature

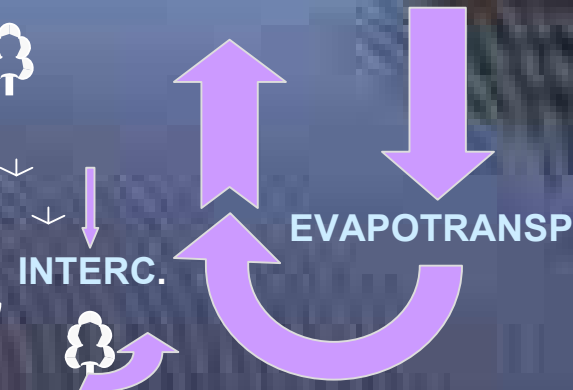
**AGRICULTURAL LANDSCAPE**



INTERNAL  
NUTRIENT  
CYCLING

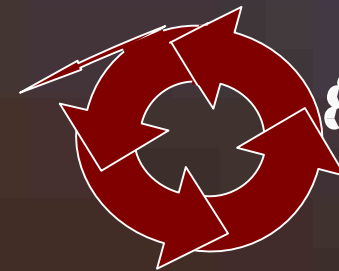


**DIVERSIFIED LANDSCAPE**



Surface runoff

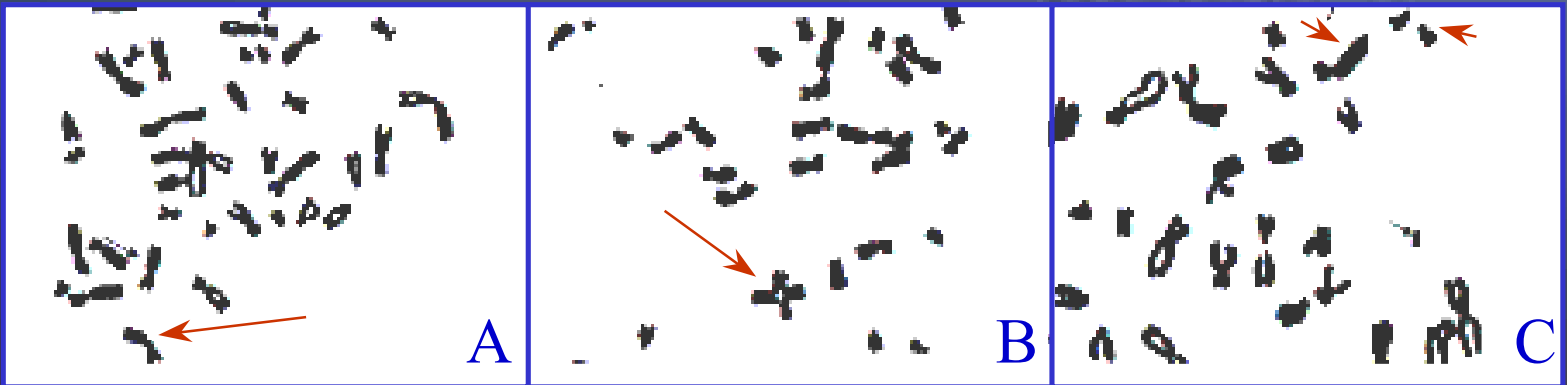
Groundwater flow



# EUTROPHICATION

## CHROMOSOMAL ABERRATION INDUCED BY EXTRACT FROM CYANOBACTERIAL BLOOM in *in vitro* human lymphocytes

A - chromatid breaks, B - chromatid exchanges, C- dicentric chromosome and acentric fragment.



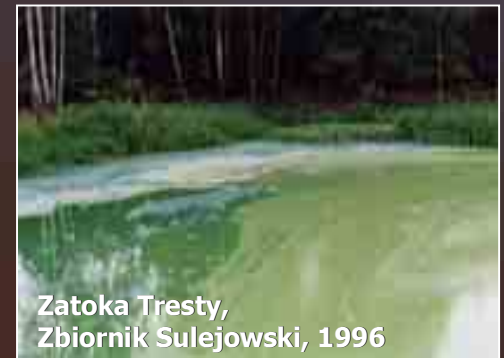
(Osiecka, Zalewski, Tarczyńska, 1996)



*Microcystis aeruginosa* Kutz.



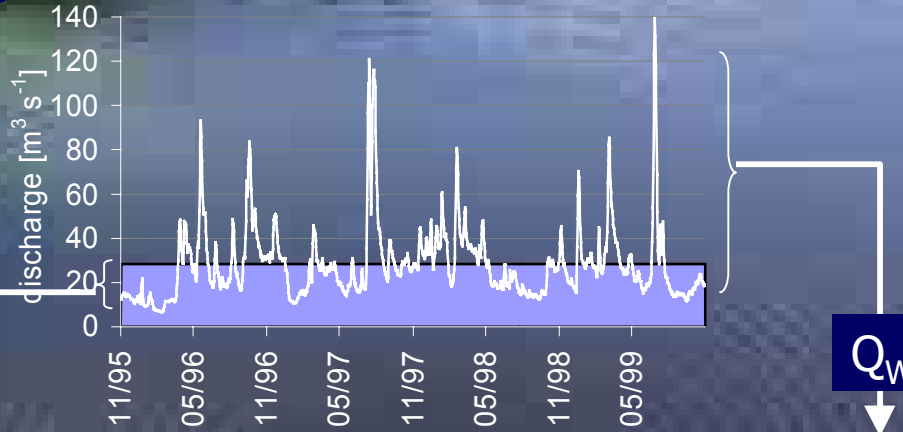
Ujęcie wody pitnej,  
Bronisławów, IX 1999



Zatoka Tresty,  
Zbiornik Sulejowski, 1996

# HIERARCHY OF FACTORS

## determining TP and TSM concentrations in the Pilica River



WINTER

PÓLROCZE: zimowe (XI - IV)

	PPO4	DP	TP	TSM	M5M	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

PÓLROCZE: zimowe (XI - IV)

	PPO4	DP	TP	TSM	M5M	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

PÓLROCZE: letnie (V - X)

	PPO4	DP	TP	TSM	M5M	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						

PÓLROCZE: letnie (V - X)

	PPO4	DP	TP	TSM	M5M	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

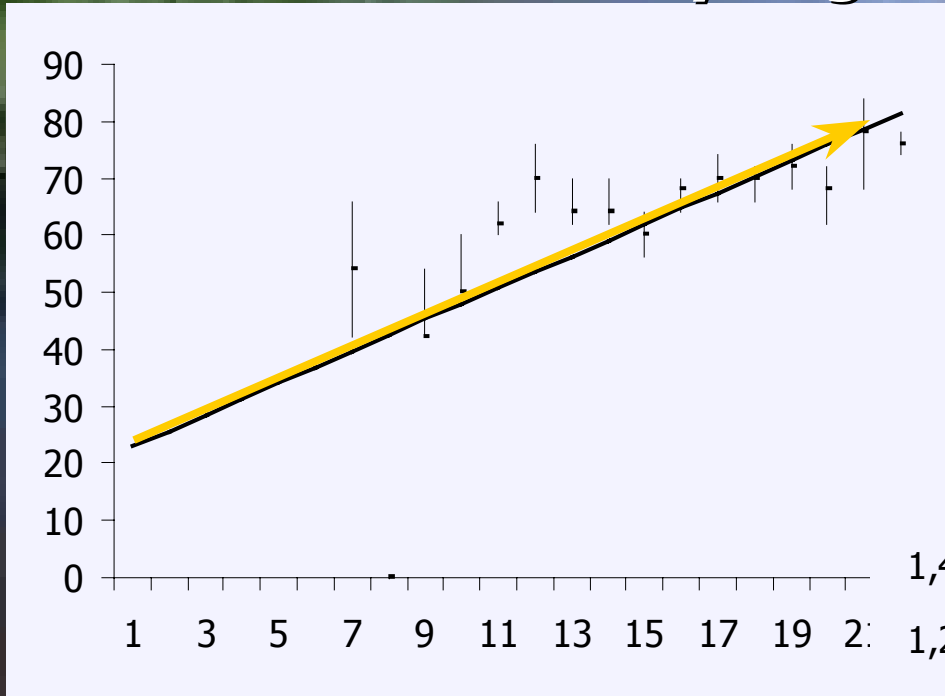
HYDROLOGICAL  
FACTORS

TEMPERATURE

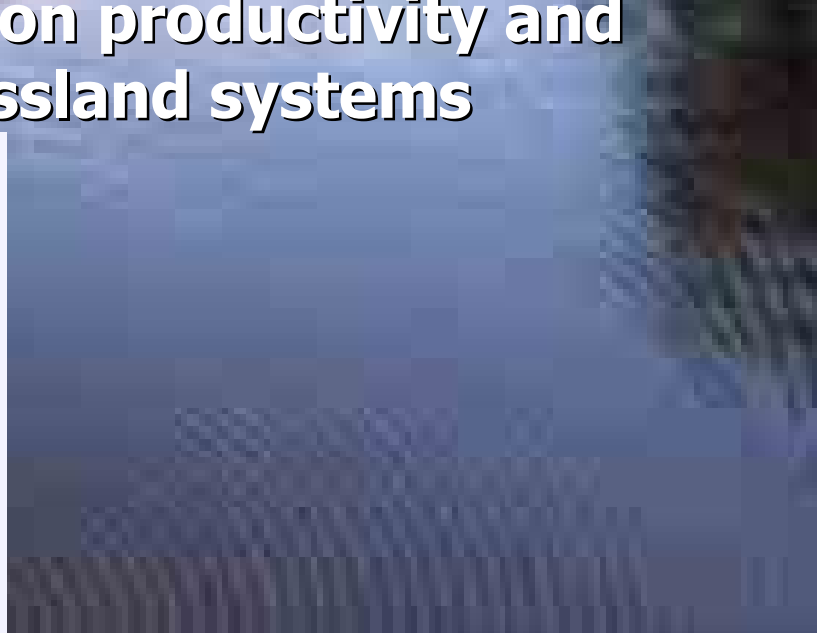
PRECIPITATION

# Influence of biodiversity on productivity and sustainability of grassland systems

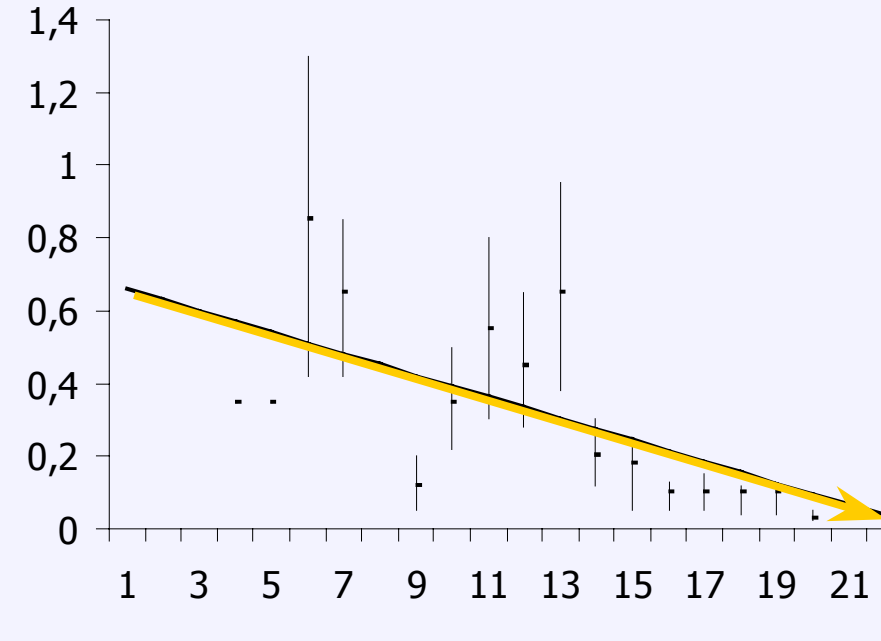
total plant cover [%]



species richness



nitrate in rooting zone (mg kg<sup>-1</sup>)

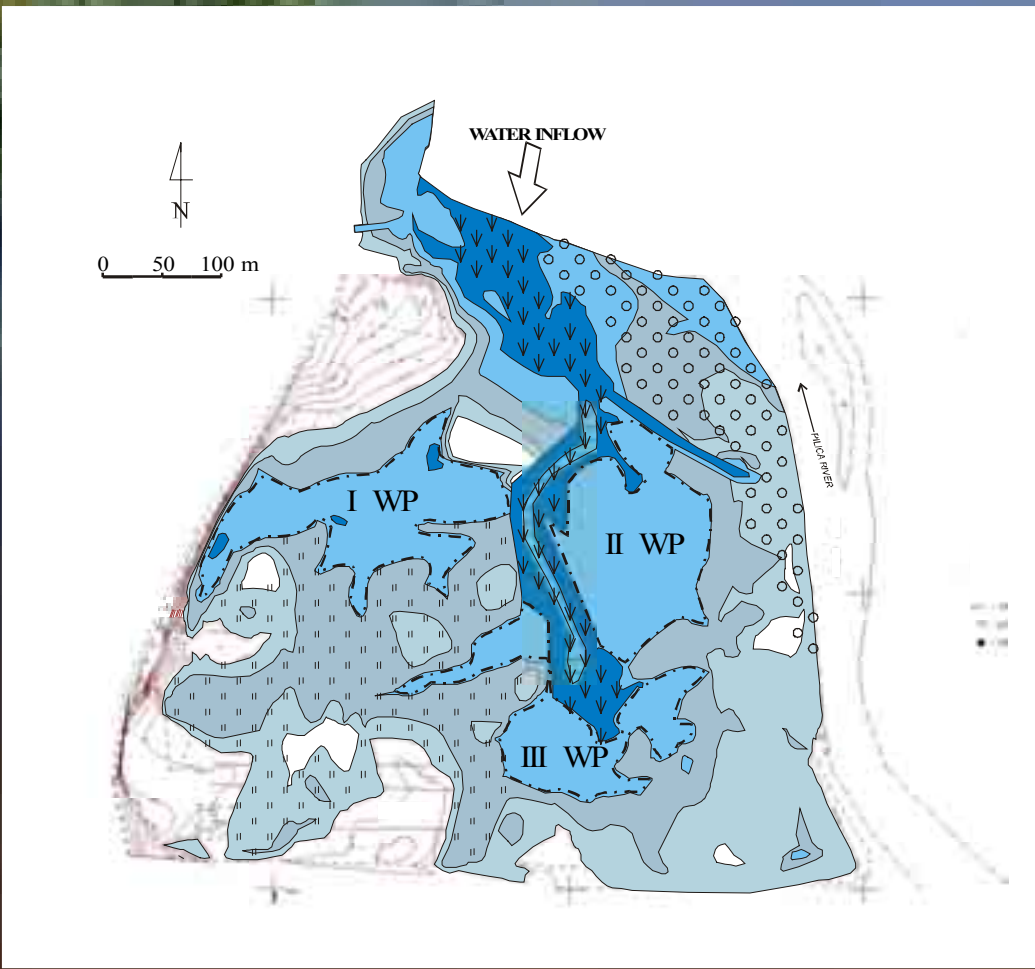


species richness



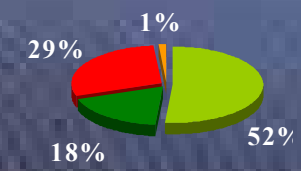
*I. Wagner-Łotkowska*

# ENHANCEMENT OF ABSORBING CAPACITY OF FLOODPLAIN for nutrients trapping



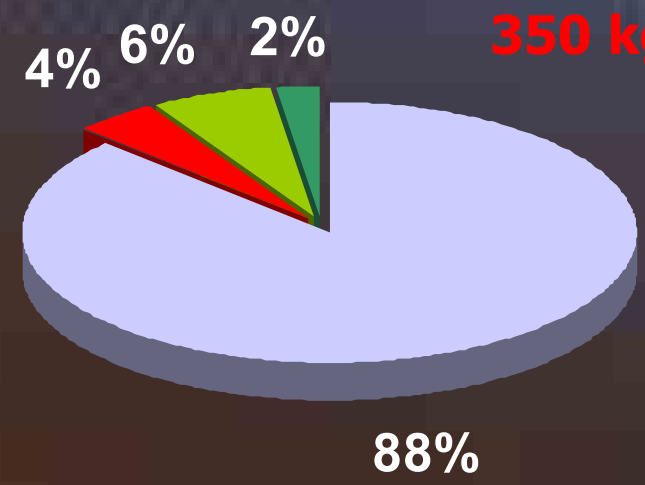
## TOTAL PHOSPHORUS ACCUMULATION IN FLOODPLAIN BIOMASS

### INITIAL



**164 kg P**

### ENHANCED

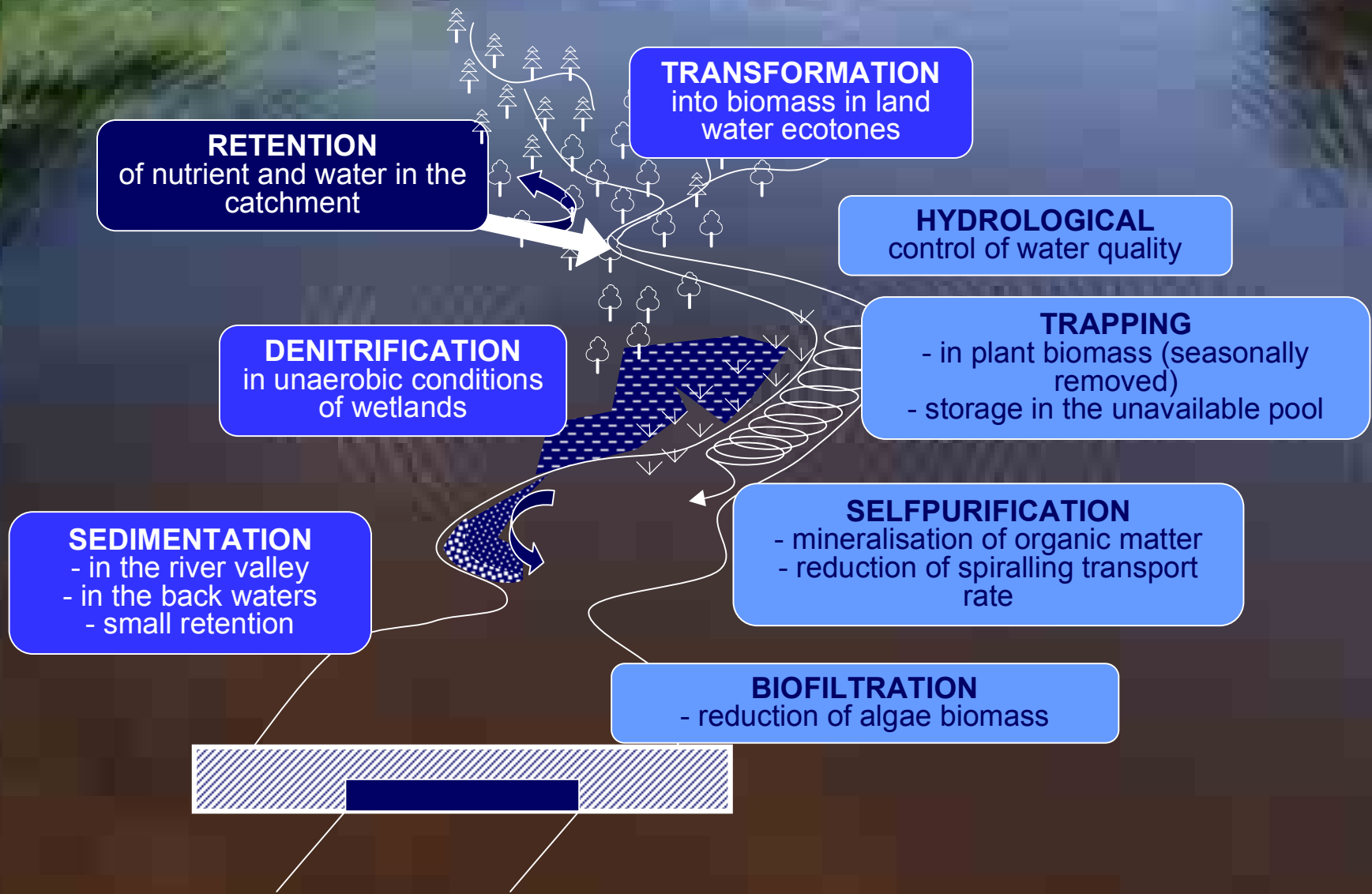


**350 kg**

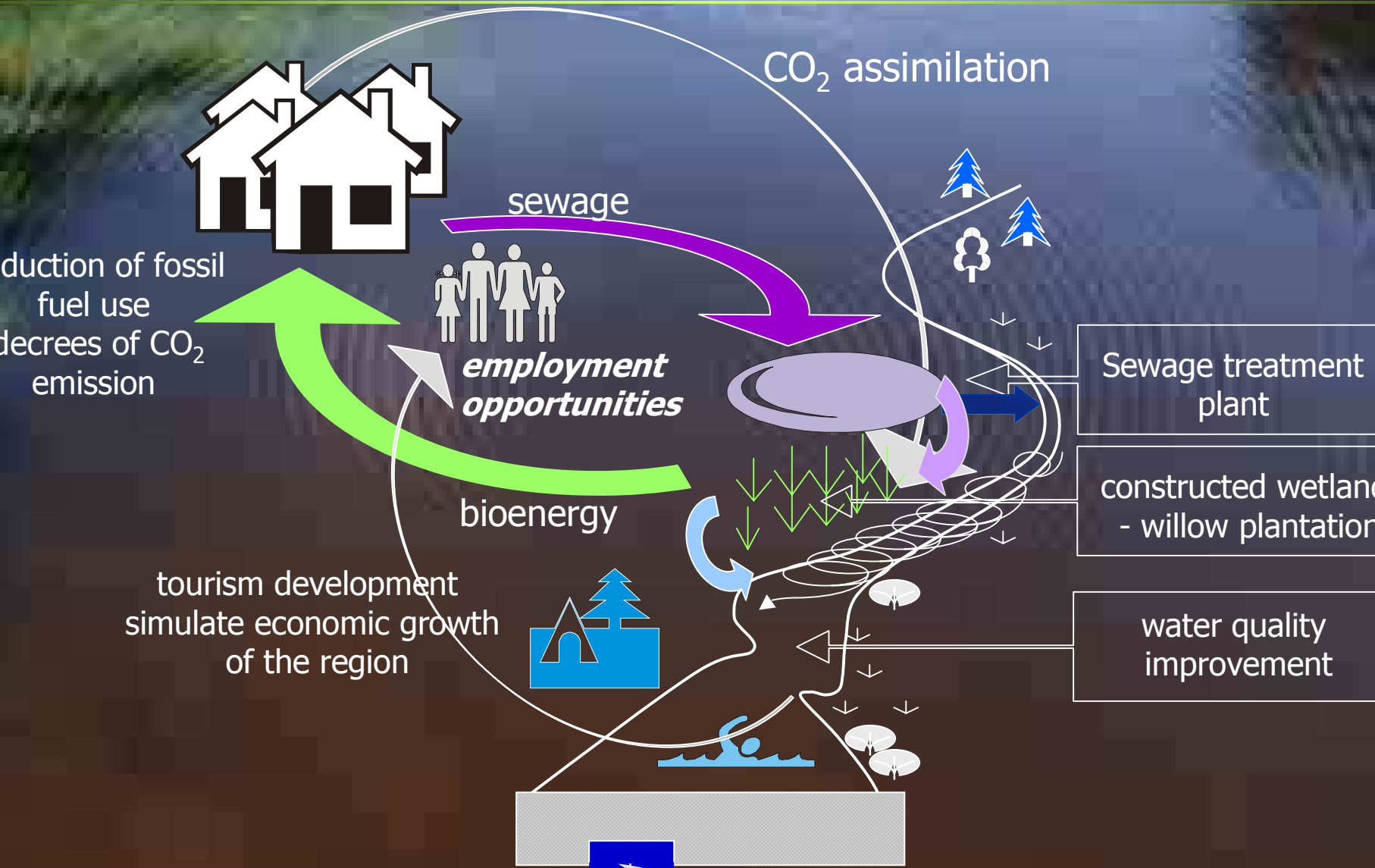
- Meadow species
- Carex gracilis et vesicaria*
- Phragmites australi*
- Salix sp.*



# ECOHYDROLOGICAL APPROACH FOR FRESHWATER ECOSYSTEM MANAGEMENT AND RESTORATION



# APPLICATION OF ECOHYDROLOGY AND PHYTOTECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT



POTENTIAL ENDUSERS  
OF BIOENERGY

WATER TREATMENT PLANT  
500 m<sup>3</sup>/day

PLANNED  
WILLOW PLANTATIONS

Pilica River

# Ecohydrology of river basin

## for sustainable water biodiversity and ecosystem services

### PROBLEM

scarcity of water of good  
quality of and related ecosystem services

#### VISION

Millenium goals

#### POLICY

eg. Water Framework Directive

#### ASSESSMENT

- Ecological status
- Hydrology
- Hydrochemistry
- Biomonitoring

Considering remote sensing  
data on catchments and  
specific of its anthropogenic  
modifications from the point  
of view of integrity

Integrative analysis of  
**DYNAMICS**  
of hydrological and  
biological processes

### ECOHYDROLOGY

#### REGULATORY FEEDBACKS

Identification of  
between hydrology and biota for potential application  
in water management

#### INTEGRATION AND HARMONISATION

all range of regulatory feedbacks (E-H) and  
hydrotechnical facilities in basin scale for restoration  
and enhancement of carrying capacity considering  
socio-economic and climatic scenarios

#### ADAPTATIVE IMPLEMENTATION

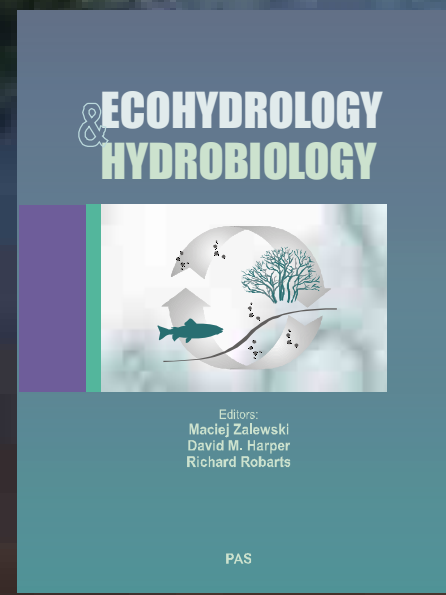
The use of ecosystem properties as an  
complementary tool to hydrotechnical solutions:  
- Consultation with authorithies, stakeholders  
- Adaptative assessment and management

### GOAL

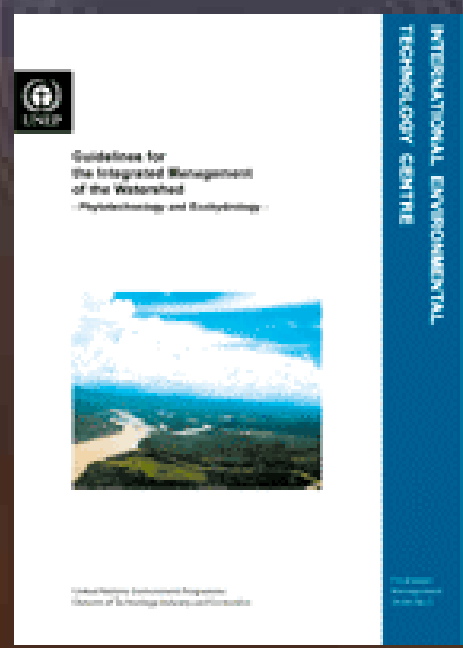
Millennium goals & good ecological status



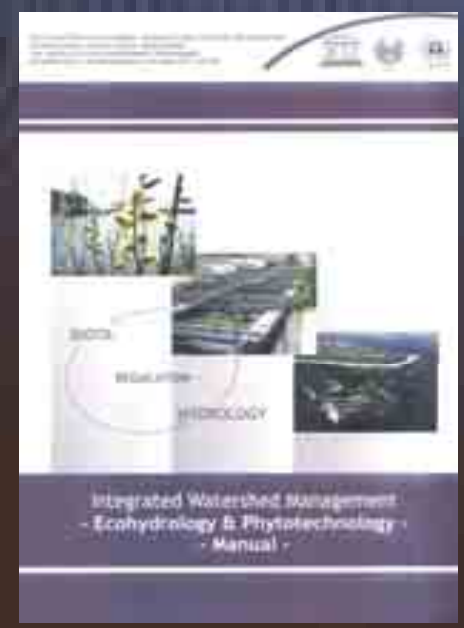
# International Journal of ECOHYDROLOGY & HYDROBIOLOGY



Guidelines for the Integrated  
Management of the Watershed  
– Phytotechnology and Ecohydrology



Integrated Watershed  
Management  
- Ecohydrology and Phytotechnology  
Manual





# Location

of the Centre for Ecohydrology under the auspices of UNESCO in Poland



Centre for Ecological Studies,  
Polish Academy of Sciences  
u. Konopnickiej 1,  
Dziekanow Leśny, Warsaw, Poland



Department of Applied Ecology,  
University of Lodz  
ul. Banacha 12/16, 90-237 Lodz, Poland

Campus of the Lodz Branch of  
Polish Academy of Sciences,  
Lodz, ul. Tylna 3

UNESCO & UNEP Demonstration Project:

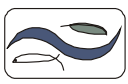
APPLICATION OF ECOHYDROLOGY AND PHYTOTECHNOLOGIES FOR WATER RESOURCES MANAGEMENT AND SUSTAINABLE DEVELOPMENT

MAIN MENU:

- CONCEPTS
- GENERAL INFO
- IMPLEMENTATION
- WHO IS WHO
- LINKS
- MEMBERS AREA ONLY



Latest News:  
**27.07.03**  
**WILLOW FESTIVAL**  
 The Municipal and Commune Office in Sulejow Town and Agrotouristic Foundation "Kraina Kugla" (NGO) organized a WILLOW FESTIVAL at the Pilica River. The landowners of the



**UNESCO - UNEP Demonstration Projects**

Demonstration projects on Ecohydrology and Phytotechnologies are developed by co-operation between the United Nations Educational, Scientific, and Cultural Organization - Regional Bureau for Science in Europe (UNESCO-ROSTE) and the United Nations Environment Programme - Division of Technology, Industry and Economics - International Environmental Technology Centre (UNEP-DTIE-IETC). The projects aim at the development, dissemination and implementation of the Ecohydrology and Phytotechnologies concepts for Integrated Water Resources Management (IWRM).

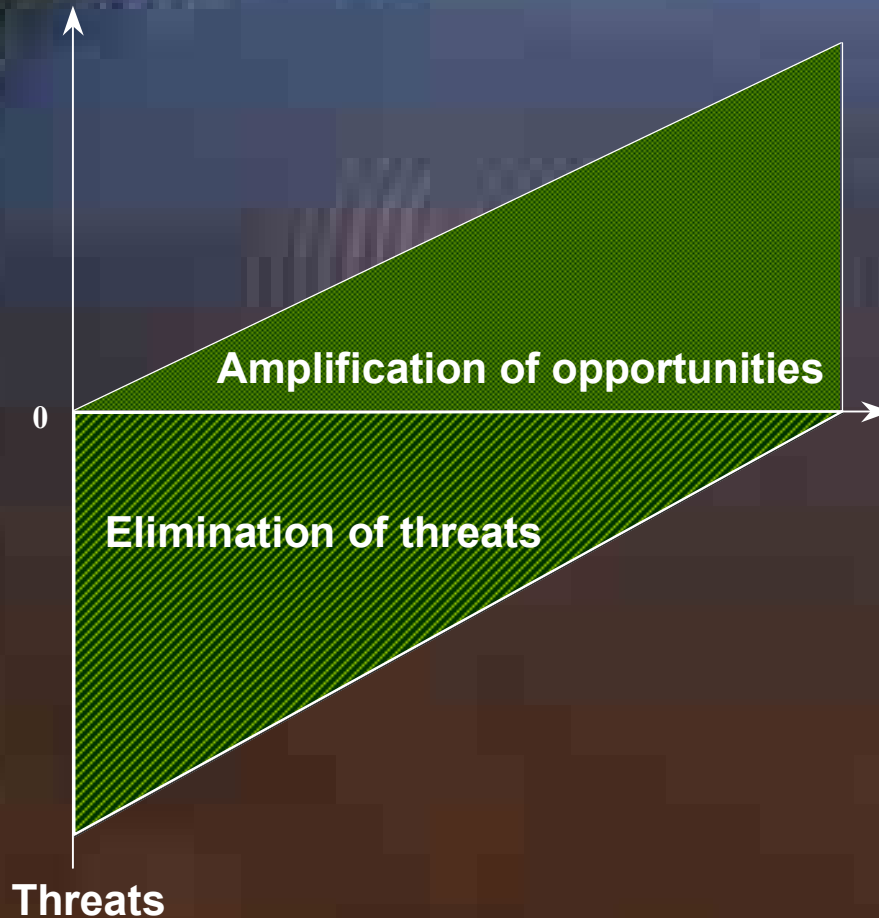
**Pilica River Demonstration Project**

The demonstration project "Application of Ecohydrology and Phytotechnologies for Water Resources Management and Sustainable Development" is developed in the river-reservoir system at the Pilica River Basin (central Poland). It facilitates verification of the concepts and demonstrate the validity of the methods used for:

- improvement of water quality and reduction of eutrophication of the Pilica River;
- reduction of health hazards due to the presence of toxic algal blooms in the lowland Sulejow Reservoir
- recreational area the City of Lodz (800 000 inhabitants);

# SUSTAINABLE MANAGEMENT OF FRESHWATER RESOURCES in the context of the decision making theory

Opportunities



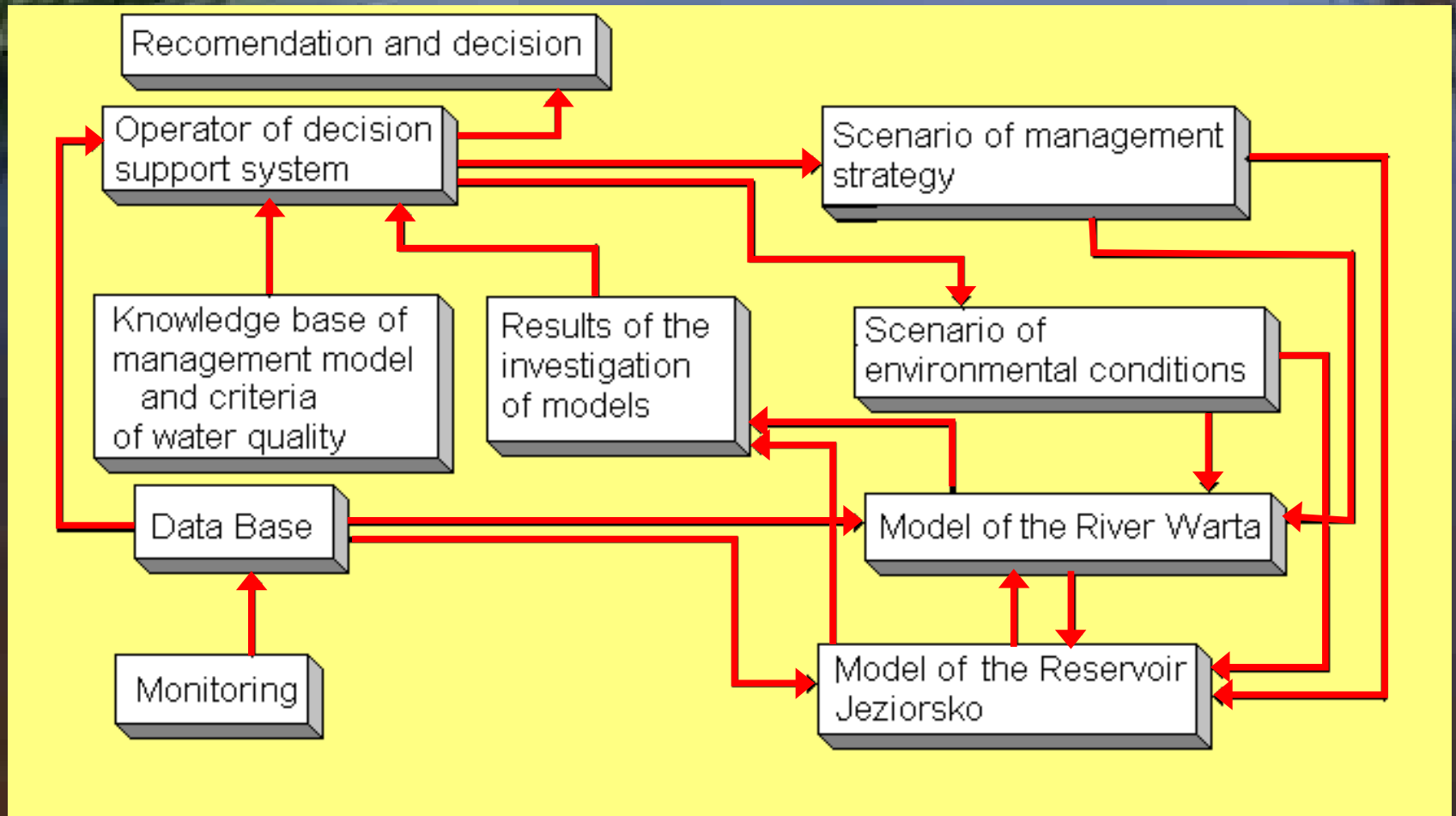
- The use of ecosystem properties as management tool

- Mitigation of point and non-point pollution and erosion

- Elimination of catastrophic floods and droughts



# Computer modelling a DSS for optimisation of ecological and economical systems



# THE NAIIVASHA LAKE



# Ruduction of eutrophication by conversion nutrients into agricultural production and bioenergy

Sequential constructed wetland for organic mater and nutrient trapping conversion into biomass (agriculture)

Organic matter and nutrients Transfer into the river

Agricultural and pastoral land use

Deforestation

Eutrophication of lake - decline of water quality

Human population growth (10x/20years)

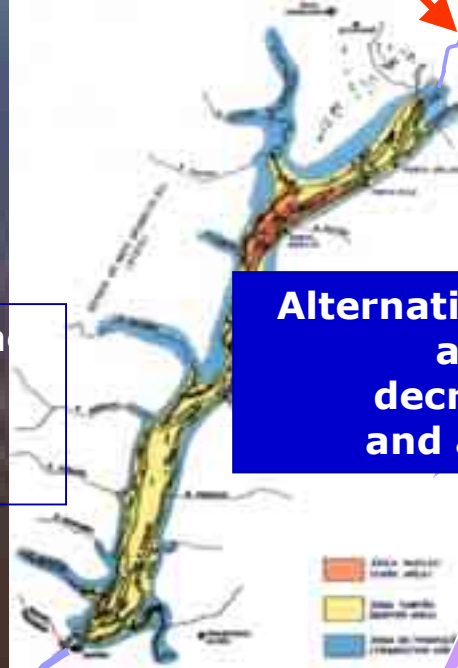
horticulture development



# PARANA RIVER



**Proposed Parana floodplain  
Biosphere Reserve**



**Reduction of human impact  
on the floodplain  
biodiversity protection**

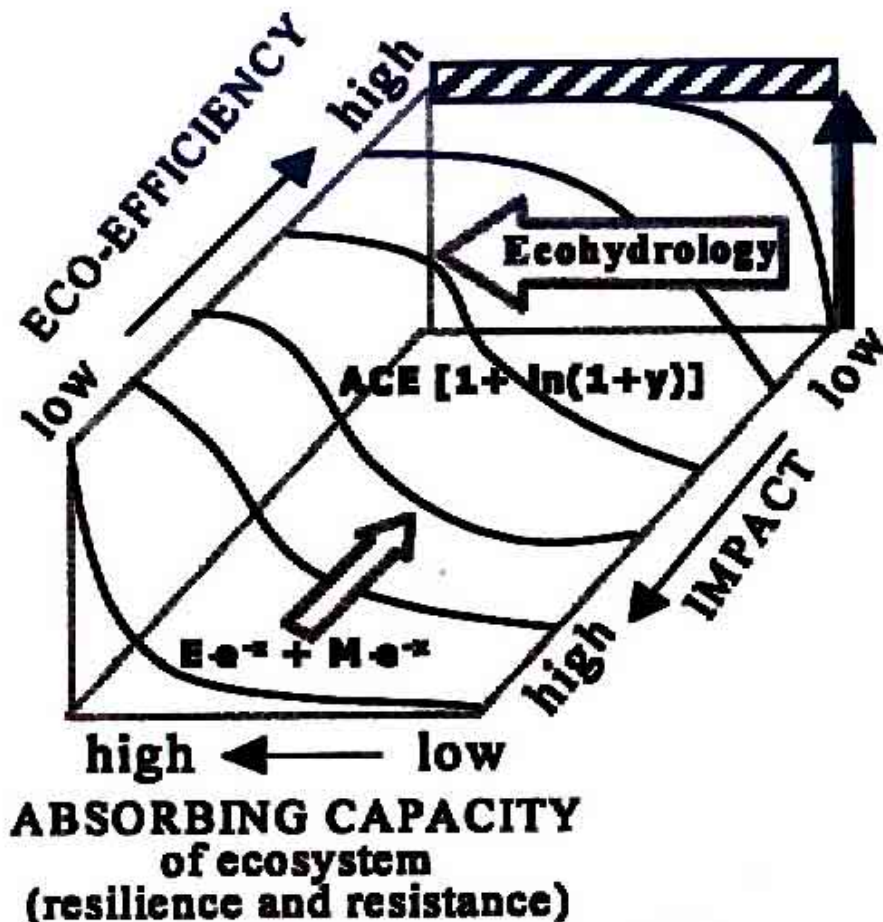
**Alternative economic development  
and social feedback  
decrease of deforestation  
and agricultural pressures**

**0,2 mln tourists  
per year**

**2 mln tourists  
per year**

**Itaipu Reservoir**

# Ecohydrology and Eco-efficiency concepts for sustainable water resources management



Sustainable Water Resources  
 $SWR = Ee^{-x} + Me^{-x} + ACE [1 + \ln(1+y)]$

The Ecohydrology principle as component of the equation of sustainability water resources (SWR) in the face of global change

- ACE – increase of ecosystem absorbing capacity against human impact
- E – reduction of energy use
- M – reduction of material use

Reduction of impact  
**ECO-EFFICIENCY**

+

Enhancement of ecosystem  
**ABSORBING CAPACITY**  
 EH principle

# Conclusions –

The cooperation in the framework of UNESCO IHP provided background to formulate principles of Ecohydrology

- FRAMEWORK – Integration of water and biota interactions using as template the mezcycle of water circulation within a basin (scale, dynamics, hierarchy of factors)
- TARGET – increase of carrying capacity of ecosystems – biodiversity and „ecosystem services“ on the basis of understanding evolutionary established resistance and resilience to stress.
- METHODOLOGY using ecosystem properties as management tool – hydrology to regulate biotic interactions and biota to control hydrology.



# Major International Co-operation of the ICE PAS and CEHS UL





# Contact us:



Department of Applied Ecology,  
University of Lodz  
ul. Banacha 12/16, 90-237 Lodz, Poland  
tel. +48 42 635 44 38/39  
fax. +48 42 66 55 819  
e-mail: [mzal@biol.uni.lodz.pl](mailto:mzal@biol.uni.lodz.pl)



International Centre for Ecology,  
Polish Academy of Sciences  
3, Tylna Street,  
90-950 Lodz, Poland  
tel./fax. +48 42 681 70 07  
e-mail: [mzal@biol.uni.lodz.pl](mailto:mzal@biol.uni.lodz.pl)