Ecohydrological monitoring of water bodies in the context of the Water Framework Directive - international aspects

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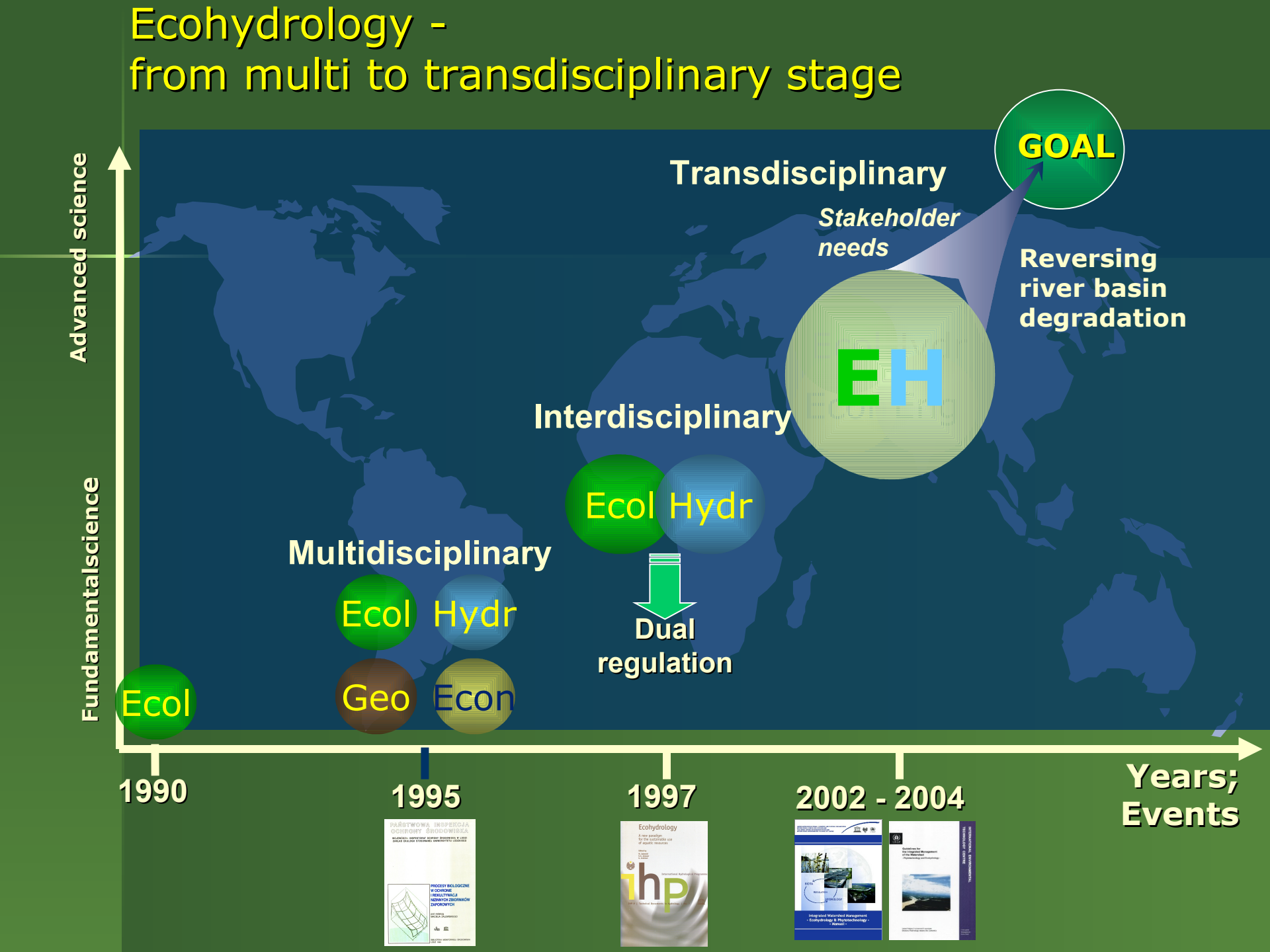
Ecohydrology - from multi to transdisciplinary stage



European Water Policy
from sectorial to holistic approach

1990 – 1980 - 1975

- Directives adressing specific issues
-
-
- Integrated River Basin Management
- International Co-operation
- Regional variability of regions
- Sustainable economy

European Water Framework Directive (EC/2000/60)

The Water Framework Directive is the most substantial piece of water legislation ever produced by the European Commission, and will provide the major driver for achieving sustainable management of water in the Member States for many years to come.

http://www.euwfd.com

All types of water bodies…

Surface waters

Lakes

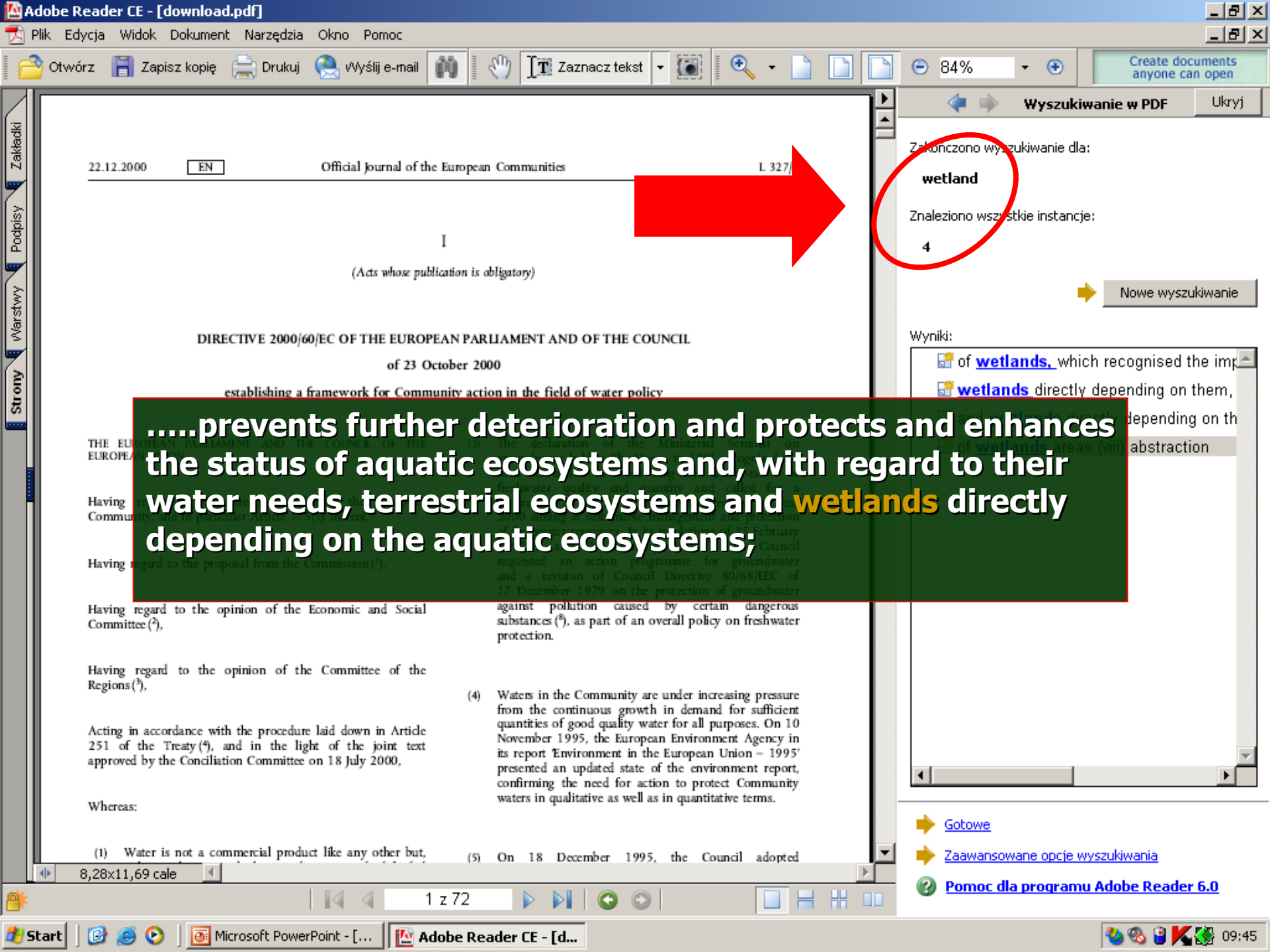
Rivers

Artificial **or** heavily modified surface water bodies

Transitional waters

Coastal areas

Ground waters



.....prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems;

WFD establishes a framework….

- **prevents further deterioration** and enhances the status of aquatic ecosystems (and terrestrial ecosystems and wetlands directly depending on them);

- promotes **sustainable water use**;

- **enhances protection and improvement** of the aquatic environment, through specific measures;

- ensures the progressive **reduction of pollution of groundwater** and prevents its further pollution, and

- Contributes to mitigating the effects of **floods and droughts**

The major purpose

Reaching
good ecological status
or **good ecological potential**
for every surface water body
by 2015

A new approach

TRADITIONAL PERCEPTION
of biological parameters
in WRM

Water quality assessment
based on
chemical water quality

ECOLOGY ROLE NOWADAYS
e.g., EU WFD regulations

Good ecological status

Habitat & biota structure

**Monitoring based on such components of aquatic systems,
that responds to overall conditions
of a whole river ecosystem**

Monitoring requirements in WFD

Monitoring requirements

- Article 8 of the Directive establishes the requirements for the monitoring of surface water status, groundwater status and protected areas

"Monitoring programmes are required to establish a coherent and comprehensive overview of water status within each river basin district„

Monitoring means the gathering of data and information on the status of water, NOT direct measurement of emissions and discharges to water.

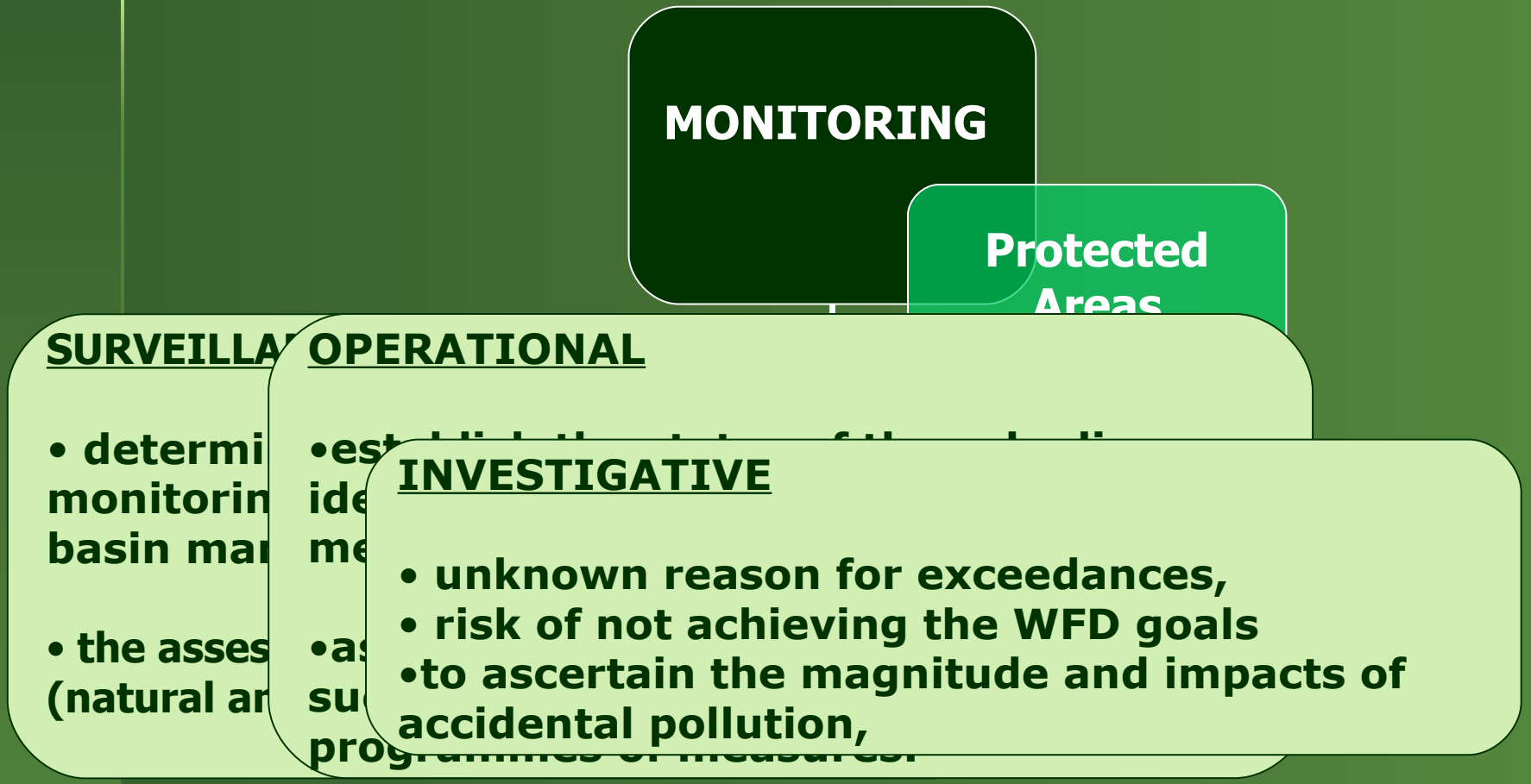
The programmes have to be operational at the latest by 22 December 2006, and must be in accordance with the requirements of Annex V.

Why to monitor?

- Monitoring should permit the classification of all surface water bodies and groundwater into the respective classes reflecting their status.

- Where monitoring data indicate that the objectives set under Article 4 for the water body are unlikely to be achieved, the Member State shall undertake appropriate actions

Types of monitoring



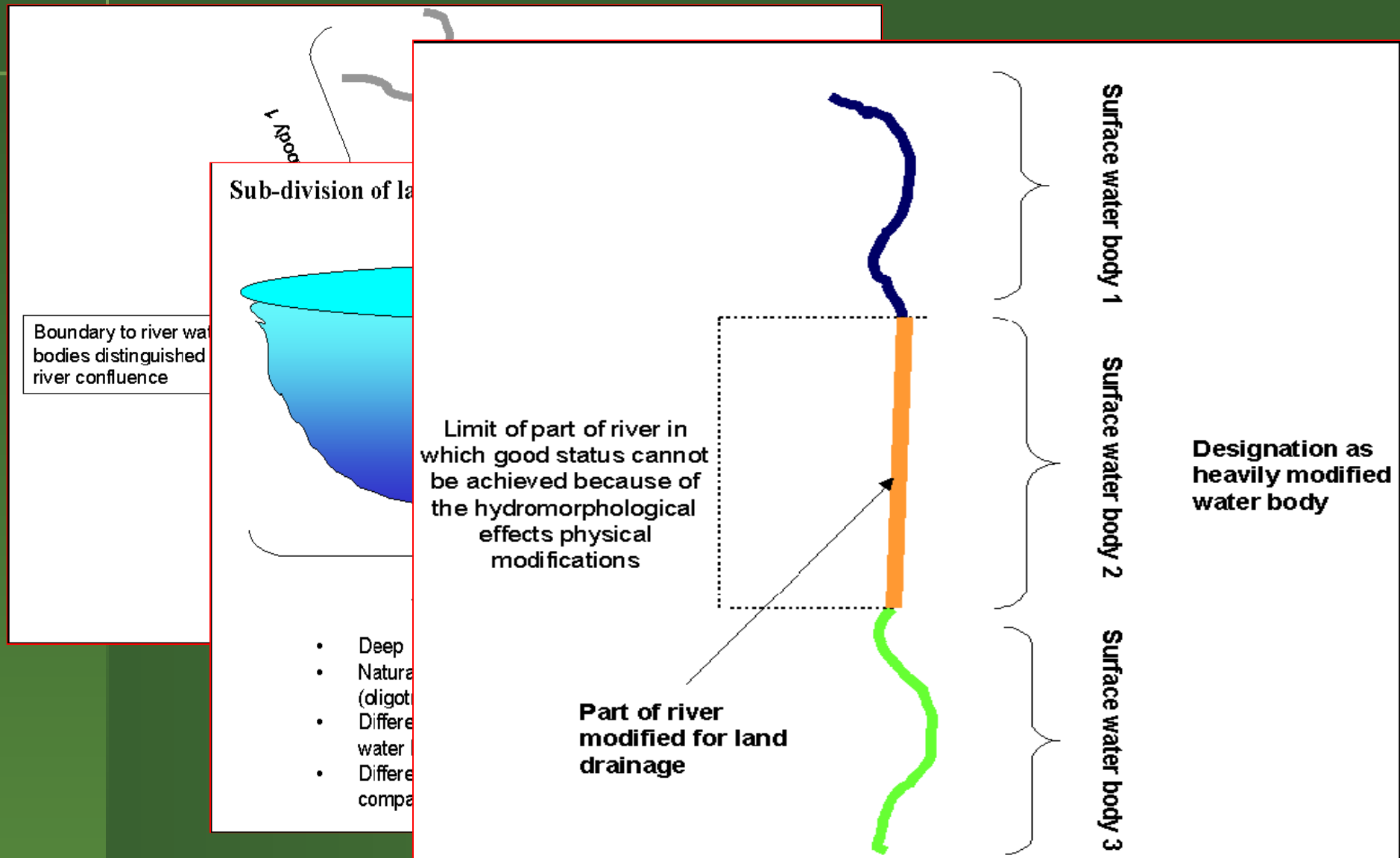
What to monitor?

The ‘water body’

- a coherent sub-unit in the river basin (district) to which the environmental objectives of the Directive must apply.

- the main purpose of identifying ‘water bodies’ is to enable the status to be accurately described and compared to environmental objectives.

The ‘water body’

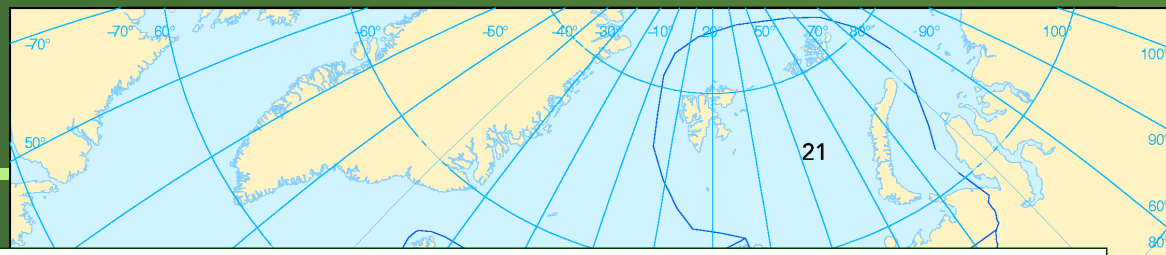


Defining typology

Water body category

Relevant ecoregions

Water body type



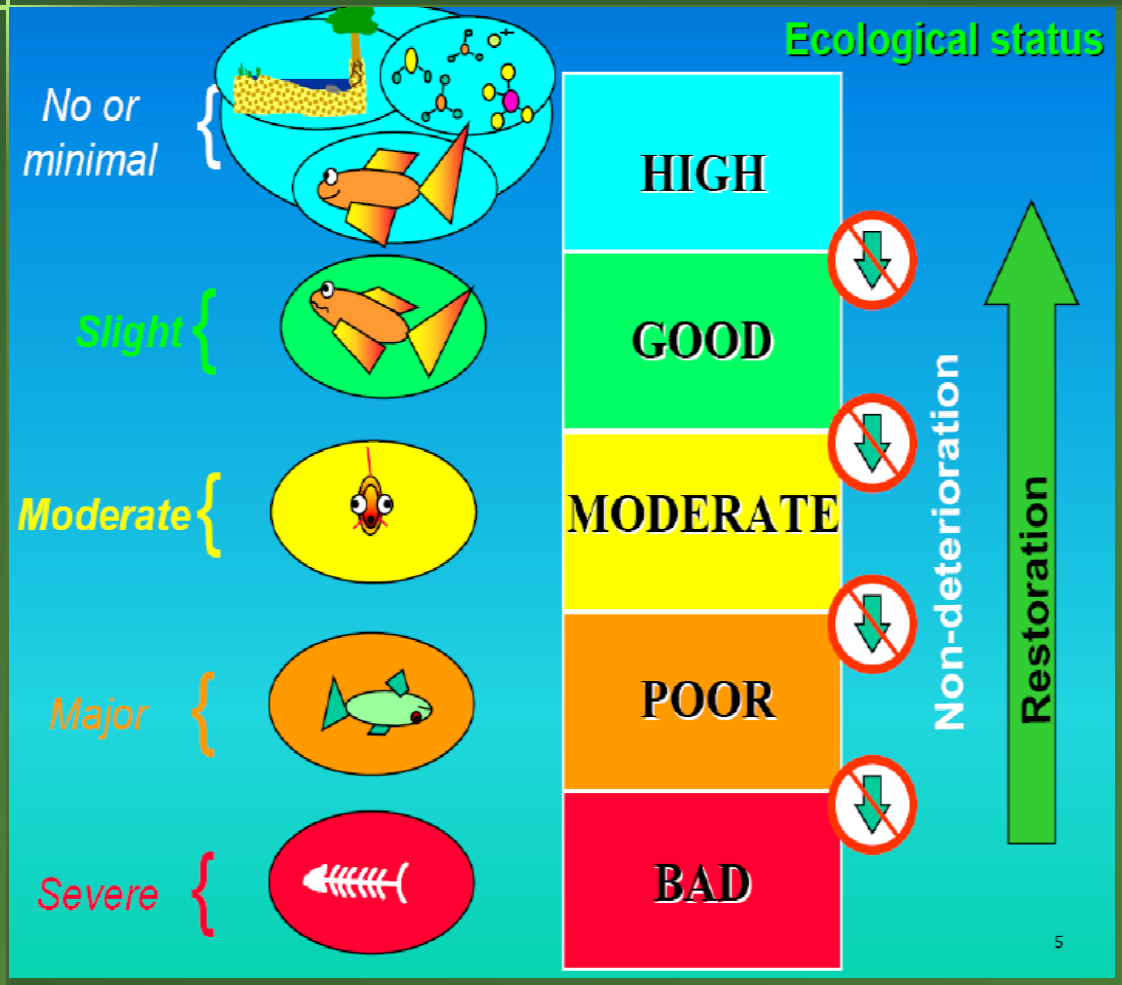
1.2. **Ecoregions and surface water body types**

1.2.1. Rivers

System A

Fixed typology	Descriptors
Ecoregion	Ecoregions shown on map A in Annex XI
Type	Altitude typology high: > 800 m mid-altitude: 200 to 800 m lowland: < 200 m Size typology based on catchment area small: 10 to 100 km² medium: > 100 to 1 000 km² large: > 1 000 to 10 000 km² very large: > 10 000 km² Geology calcareous siliceous organic

Type-specific reference conditions



Peter Pollard

Ecological Quality Ratio (EQR):

$$\frac{\text{Observed biological value}}{\text{Reference biological value}}$$

Quality elements for the classification of ecological status

- 1.1.2. L a k e s

- **Biological elements**
  - Composition, abundance and biomass of phytoplankton
  - Composition and abundance of other aquatic flora
  - Composition and abundance of benthic invertebrate fauna
  - Composition, abundance and age structure of fish fauna

- **Hydromorphological elements supporting the biological elements**
- Hydrological regime
  - quantity and dynamics of water flow
  - residence time
  - connection to the groundwater body
- Morphological conditions
  - lake depth variation
  - quantity, structure and substrate of the lake bed
  - structure of the lake shore

Quality elements for the classification of ecological status

- 1.1.2. L a k e s….. cont

- **Chemical and physico-chemical elements supporting the biological elements**
- General
  - Transparency
  - Thermal conditions
  - Oxygenation conditions
  - Salinity
  - Acidification status
  - Nutrient conditions
- Specific pollutants
  - Pollution by all priority substances identified as being discharged into the body of water
  - Pollution by other substances identified as being discharged in significant quantities into the body of water

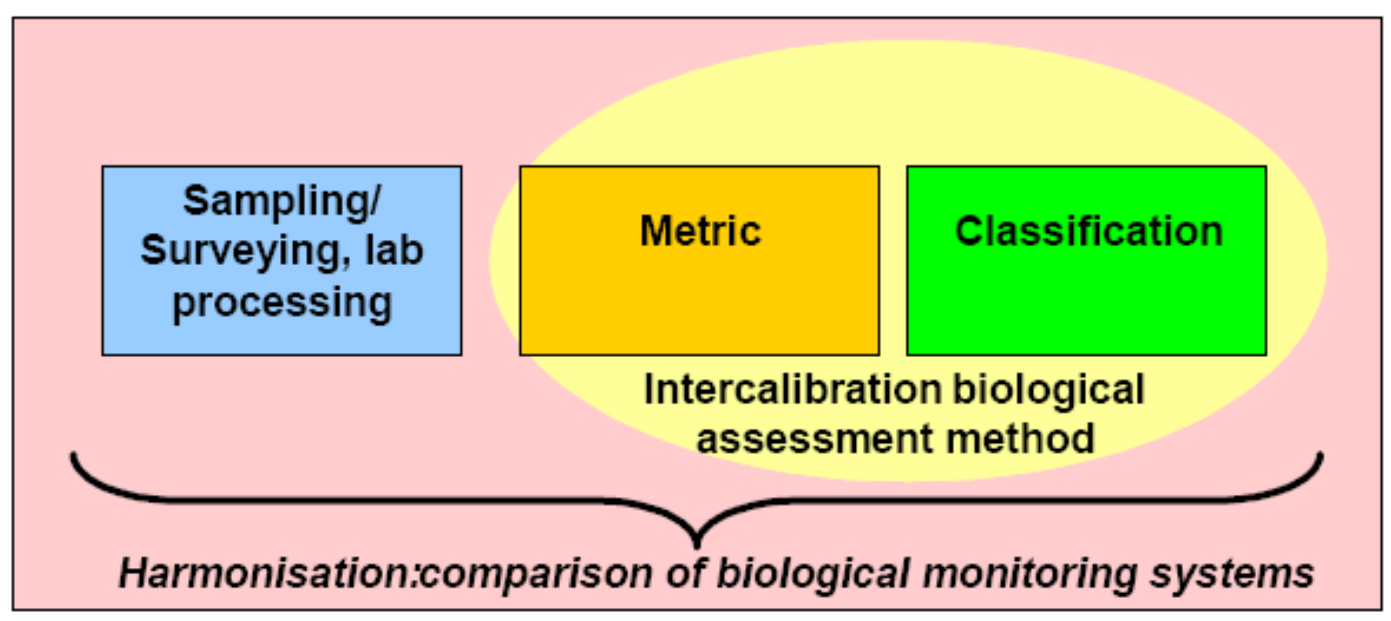
Variety of monitoring systems in the member countries

- There are a number of existing classification systems already in use throughout the EU;
- local natural variations in biological communities, hydromorphological conditions and physico-chemical variables;
- need for different indicators depending on their sensitivity to natural variation in habitat conditions;
- existing international, European and national standards for a number of the required quality elements.

Standarisation of methods

Common Implementation Strategy (CIS)

The three steps in the biological monitoring systems for the harmonisation task



Lake biological methods employed in different EU countries

Biological element	Pressure	Country	Sampling	Metric	Assessment
Phytoplankton	Eutrophication	AT, EE, FIN, IE, IT, LV, LT, NO, PT, SE, SL, SP, UK	Interests differ Lake areas, frequencies, qualitative or quantitative samples. Using national Std or published methods	Chl as biomass, taxonomic composition, abundance and biovolume	Ref. Cond not considered or only for limited No of lakes. None WFD compatible
Aquatic plants	Eutrophication	EE, DE, IE, FIN, LV, LT, SE, SL, UK	Different strategies, influence on plants in transect from shore to deep water	ID to species, abundance as % coverage	One considers ref cond. but for limited No of lakes, mostly used to monitor changes. Not WFD compatible
Benthic Macro-invertebrates	Eutrophication,, acidification	IE, SE, NO UK,	Different sampling according to lake area of interest International or National Std	Species abundance, presence or absence of sensitive species	Species Applicable to different areas (littoral or profundal) ref. cond. or need to develop type specific ref. cond., 5 quality classes. 2 WFD compatible
		CY, LV,	Hand net or beaker,	Family, genus,	Applicable to

Key features for Quality Elements (QE) for Rivers

Guidance Document No. 7
Monitoring under the Water Framework Directive

Table 3.1 Key features of each biological quality element (QE) for rivers

Aspect/feature	Benthic invertebrates	Macrophytes	Benthic Algae	Fish	Phytoplankton
Measured pa indicative of					
Supportive/ir parameters r sampled at t					
Pressures to responds					
Mobility of Q					
Level and so variability of					
Presence in					
Sampling me					
Habitats sam					
Typical samp					
Time of year					
Typical samp					
Ease of samp					
Laboratory o measuremen					
Ease and lev					

Guidance Document No. 7
Monitoring under the Water Framework Directive

Table 3.2 Key features of each hydromorphological quality elements for rivers

Aspect/feature	Quantity and dynamics of water flow	Connection to groundwater bodies	River Continuity	River depth and width variation	Structure and substrate of the river bed	Structure of the riparian zone
Measured parameters indicative of QE	Historical flows, modelled flows, real-time flow, current velocity	Water table height, surface water discharge	No and type of barrier and associated provision for fish passage	River cross section, flow	Cross section, particle size, presence and location of CWD	Length, width, species present, continuity, ground cover
Pressures to which QE responds	Used to detect impact of water storage, abstraction and discharge on biota, hydropower regulation	Provides information on surface-groundwater relationship	Used to detect impact on upstream migration of fish	Used to detect impact on biota from changing flows and habitat availability	Determines impact on biota from changing habitat availability	Influences structure of banks, provides habitat and shading for biota, filters diffuse runoff
Level and sources of variability of QE	Highly variable depending on geographical and climatic conditions. Variations reduced as response to barriers	Moderate variability	Low variability. Based on presence/modification of infrastructure	Moderate variability. Influenced by hydropower regulation	Variable depending on particle size and flow (e.g. gravel/sand scour/sedimentation prevalent following high flows)	Variable. Possibility of physical clearing, accessibility from livestock, erosion etc
Sampling methodology	ISO standard for current velocity. No common methodology for dynamics	No common methodology	No common methodology	No common methodology	No common methodology	No common methodology
Typical sampling frequency	In-situ, real time	6 monthly, depending on climatology and geology	Every 5-6 years	Annual	Annual	Annual
Time of year of sampling	All year	Winter and summer	varied	varied	varied	varied
Typical "sample" size or survey area	Common standard for No of monitoring points in cross sections developed	Not defined	Entire reach	No common agreement	No common agreement	50m in headwaters 100m in middle and lower reaches
Ease of sampling /measurements	Simple using in-situ flow gauging stations in small rivers. Greater effort required for large rivers.	Simple. Measurement of groundwater height (boreholes) and river flow	Simple. Survey to determine location and type of structures and abstraction sites/volumes	Can be simple using observation and measurement or detailed using laser survey equipment	Simple following minimal training	Simple following minimal training. Collection and laboratory identification of species may be required
Basis of any comparison of results/quality/stations e.g. reference	No	No	No	No	No	No

Other methods of survey to be standarised

Table 2. CEN/TC 230/WG 2 formal work programme (July 2005).

CEN Reference	Work item	Comment
CEN230217 prENXXX	Water Quality – Guidance standard for the surveying of macrophytes in lakes	NWIP approved
CEN 230175	Water Quality – Guidance standard on the routine sampling of benthic algae in fast flowing, shallow waters to include laboratory procedures	Original WI deleted but NWIP will be requested to include expanded scope
CEN 230171 PrEN14962	Water Quality – Guidance on the scope and selection of fish sampling methods.	
CEN 230169 prEN/ISO16665	Water Quality – Guidelines for quantitative investigations of marine soft-bottom benthic fauna in the marine environment	ISO lead but proposed for parallel adoption
CEN 230216 prEN/ISO 19493	Water Quality – Guidance on marine biological surveys of littoral and sublittoral hard bottom	CEN lead
CEN 230207 prEN15204	Water Quality – Guidance standard for routine analysis of phytoplankton abundance and composition using inverted microscopy (Utermöhl technique)	
CEN230209 prEN 14996	Water Quality – Guidance on assuring the quality of biological and ecological assessments in the aquatic environment	
CEN 230208	Water Quality – Guidance standard for the routine	

key criteria for the programmes of measures

- An assessment on the deviation of observed conditions to those that would normally be found under reference conditions;
- Provides for natural and artificial physical habitat variation;
- Accounts for the range of natural variability and variability arising from anthropogenic activities of all quality elements in all water-body types;
- Accounts for interactions between surface and groundwaters; and,
- Provides for detection of the full range of potential impacts to enable a robust classification of ecological status.

Ecohydrology and WFD

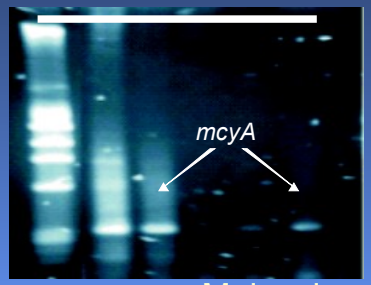
First step

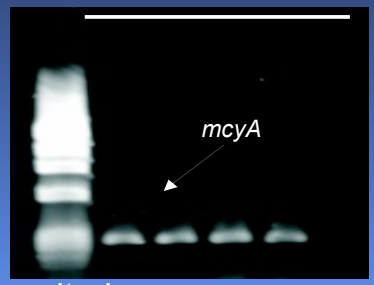
- assessment of the quality of aquatic habitats and ecosystems
- integrative analysis of the hydrological and ecological dynamics of the catchment,

Monitoring of threats

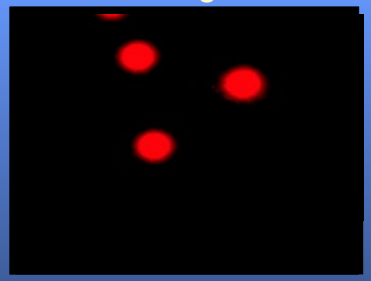
Application of molecular methods for risk assessment and an early warning system

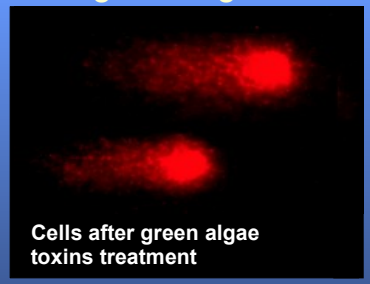
Blue-green algae blooms due to reservoir eutrophication





Molecular monitoring as an early warning system against toxic blue-green algae blooms

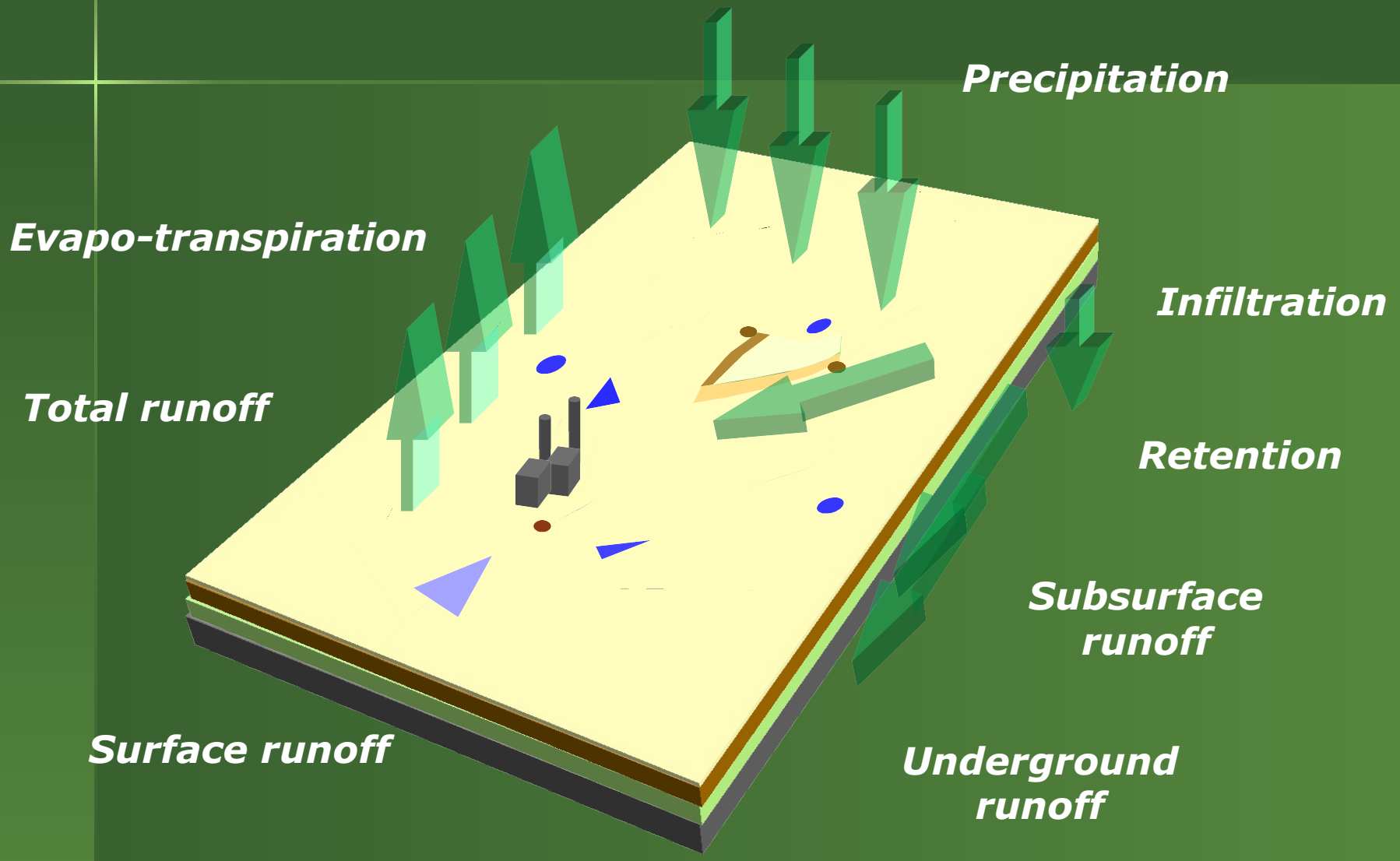




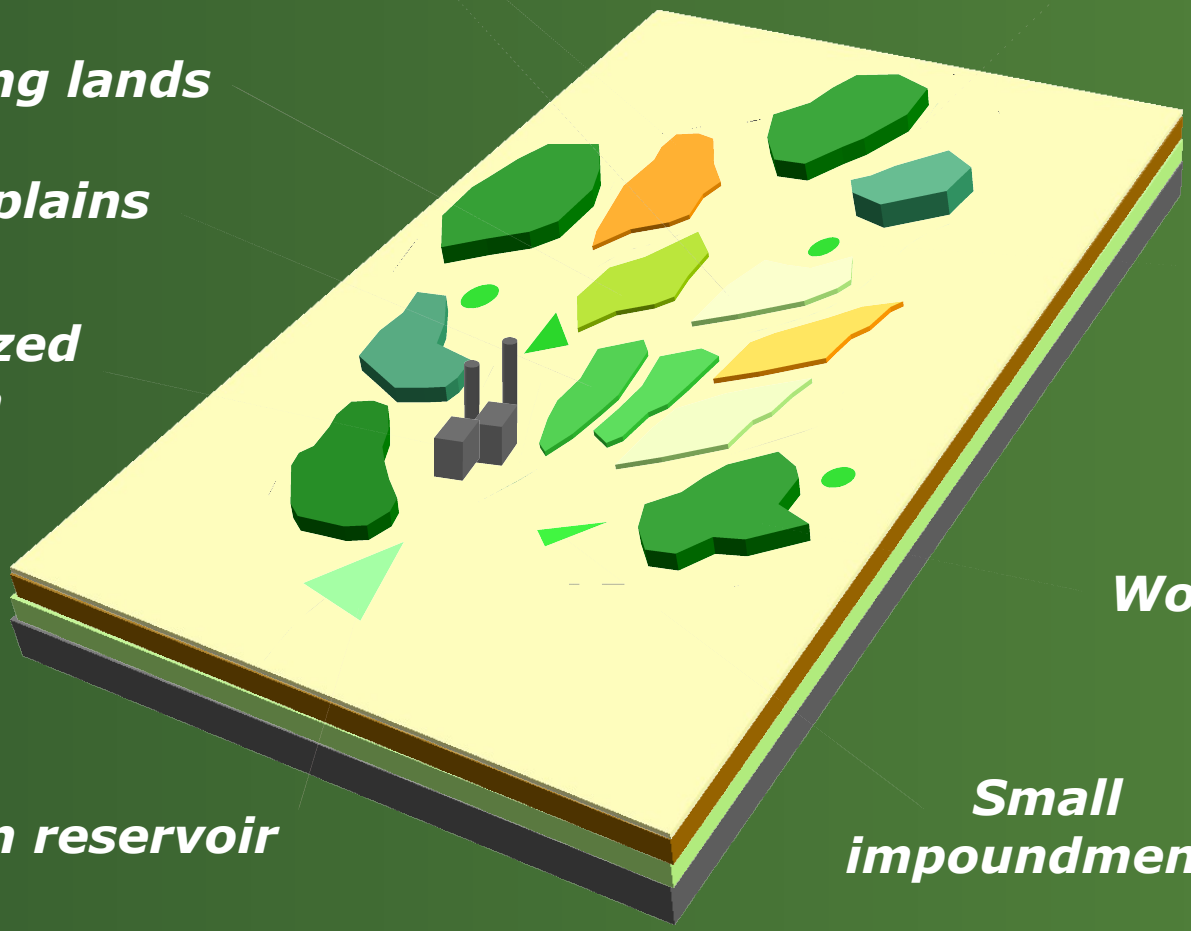
Demaged DNA in human limphocyts

(*Zalewski 1999; Mankiewicz et al., 2005*)

Quantification of hydrological cycle as a template for biogeochemical cycle in a catchment scale.



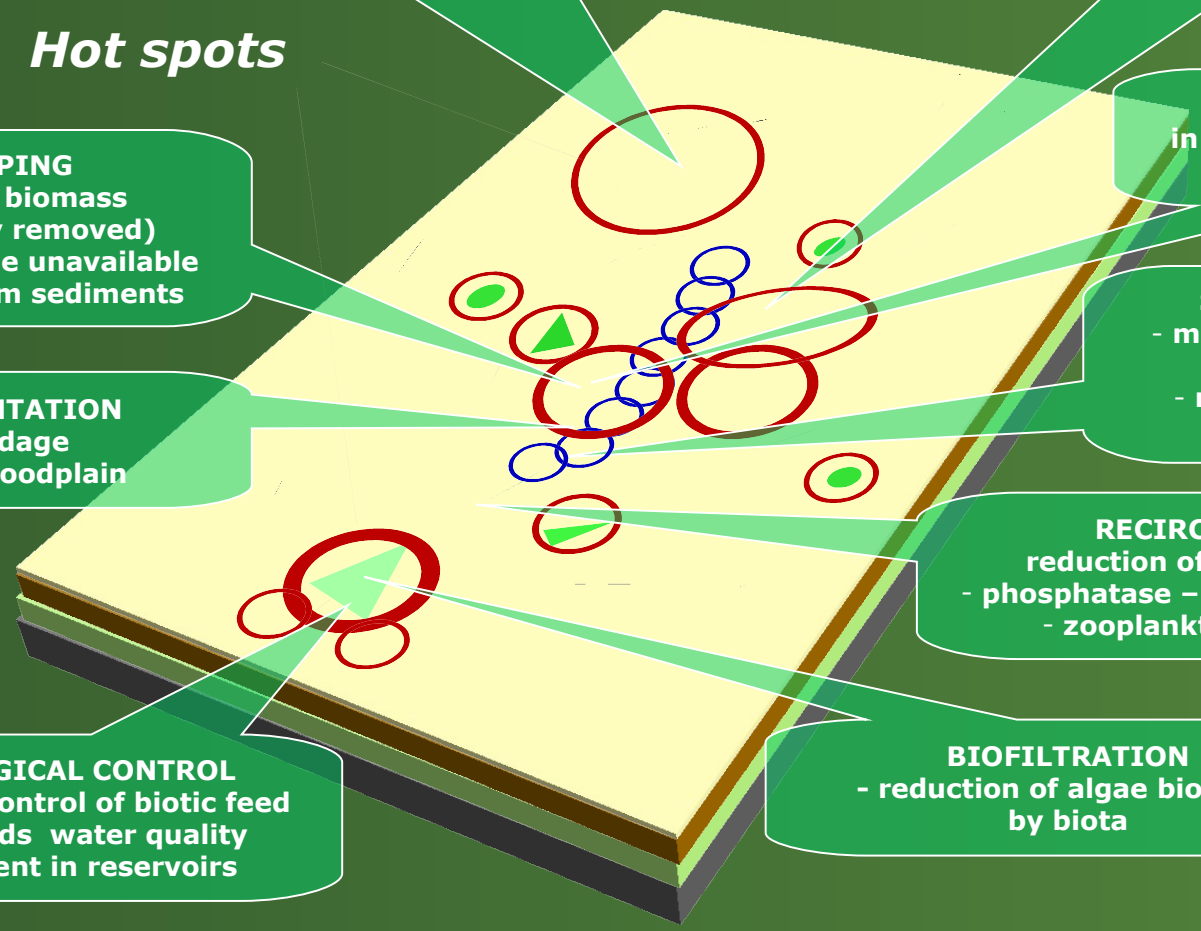
Biocenosis spatial distribution in river basin.



Second step

integrative analysis of the dynamics of hydrological and biological processes

Identification of the potential areas for the enhancement of ecosystem absorbing capacity



Hot spots

RETENTION IN THE CATCHMENT
by enhancement of landscape diversity

TRANSFORMATION
into biomass in land water ecotones

TRAPPING
- in plant biomass (seasonally removed)
- storage in the unavailable pool in bottom sediments

DENITRIFICATION
in anaerobic conditions of wetlands

SEDIMENTATION
- pondage
- at the floodplain

SELFPURIFICATION
- mineralisation of organic matter
- reduction of spiralling transport rate

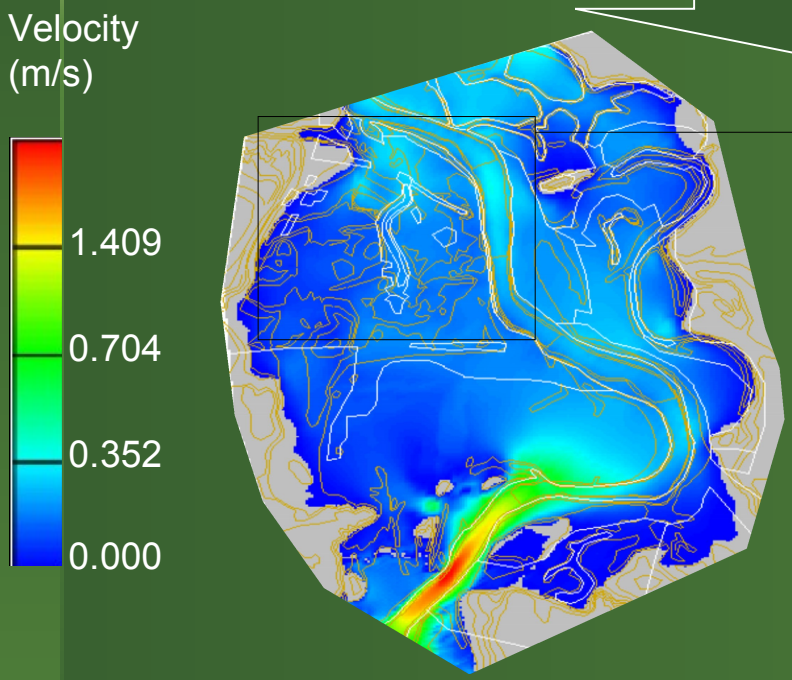
RECIRCULATION
reduction of resuspension
- phosphatase – enzymatic release
- zooplankton excretion

HYDROLOGICAL CONTROL
hydrological control of biotic feed back towards water quality improvement in reservoirs

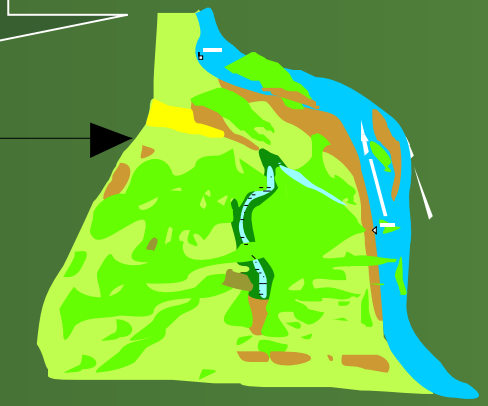
BIOFILTRATION
- reduction of algae biomass by biota

Elaboration of methods

Optimization of the biological structure
of the Pilica River floodplain
for the enhancement of self-purification



Distribution of water velocities on the floodplain during floods and high discharges



Legend:

- Mown meadows
- Caricetum gracilis
- Phragmitetum australis
- Scirpetum silvatici
- Riverine bush with Salix sp.
- Mixed wood

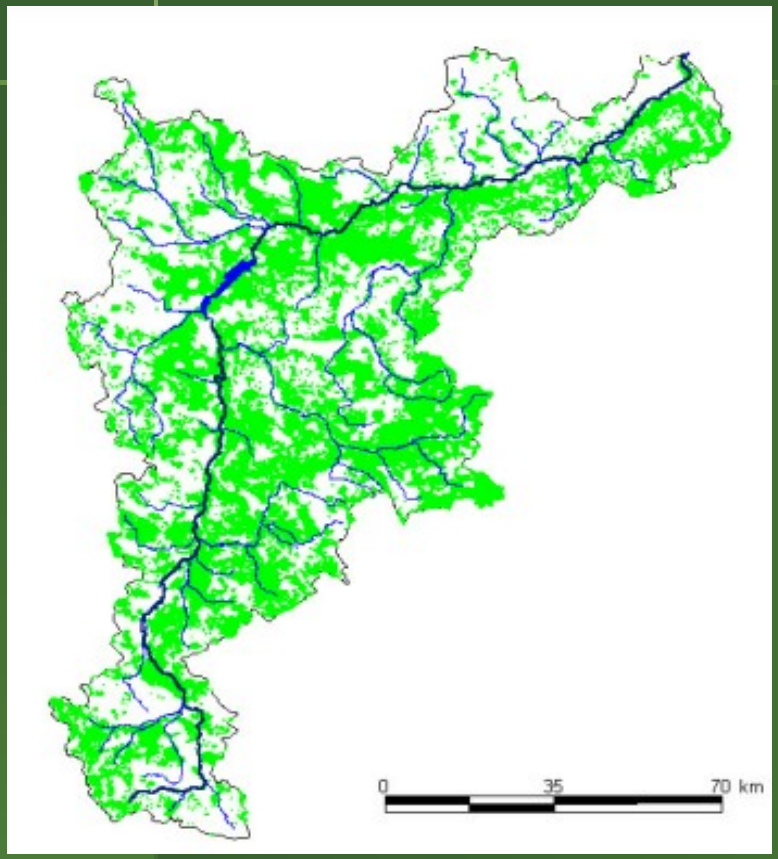
Distribution of wetland vegetation corresponding to the sequence of floodplain inundation

(Magnuszewski et al.. 2005; Kiedrzyńska et al., in press)

Third step

Implementation plans in the river basin distrcicts (catchment)

EU – WATER FRAMEWORK DIRECTIVE



Article 13:
River basin management plans

River basin management plan is to be produced for each river basin.

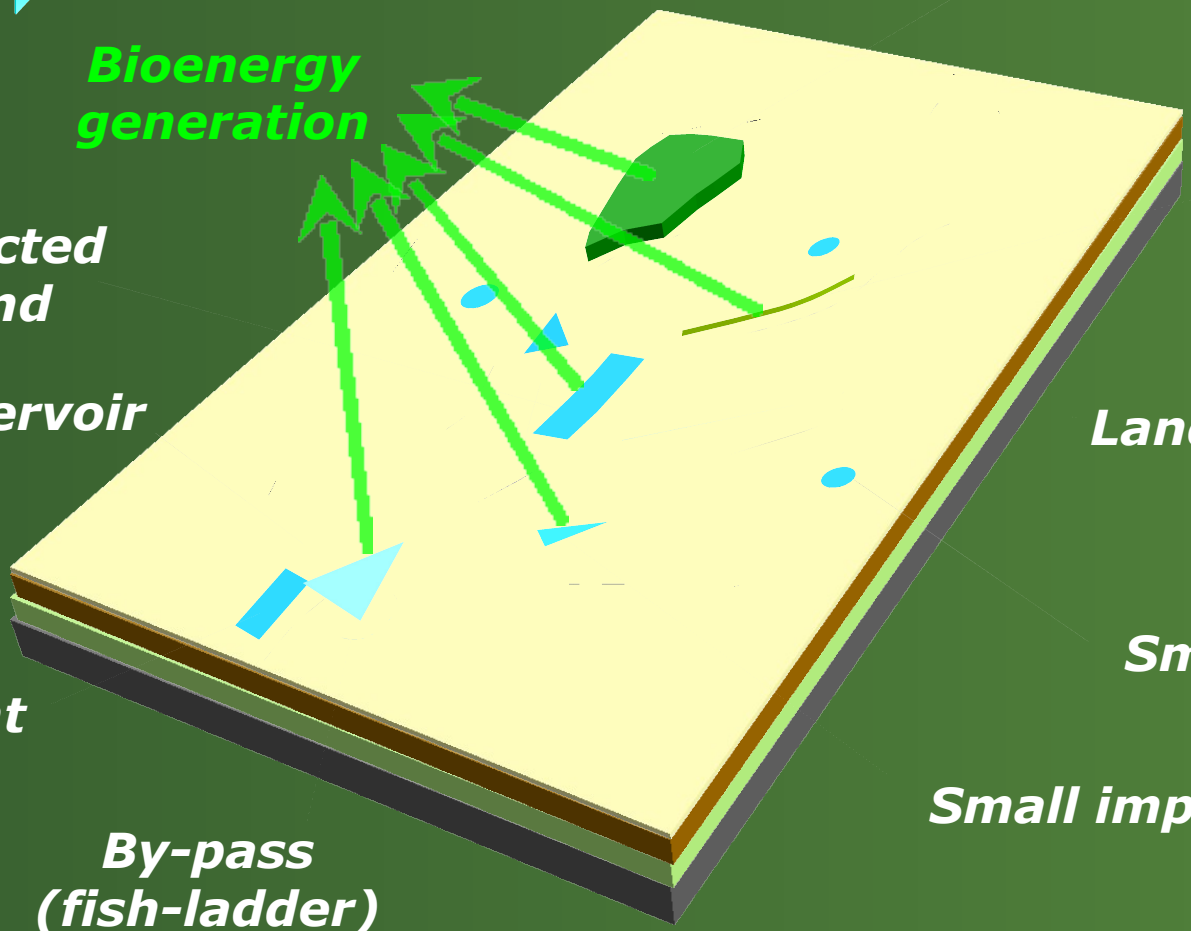
More detailed programmes and management plans may be produced:

- *for sub-basin, sector, issue, or water type,*
- *to deal with particular aspects of water management.*

The using of biota to control hydrological processes and vice versa, using hydrology to regulate biota.

Dual regulation

H REGULATION B



Woodlands

Bioenergy generation

Buffer stripes (ecotones)

Constructed wetland

Main reservoir

Land reclamations

Small ponds

Sediment release system

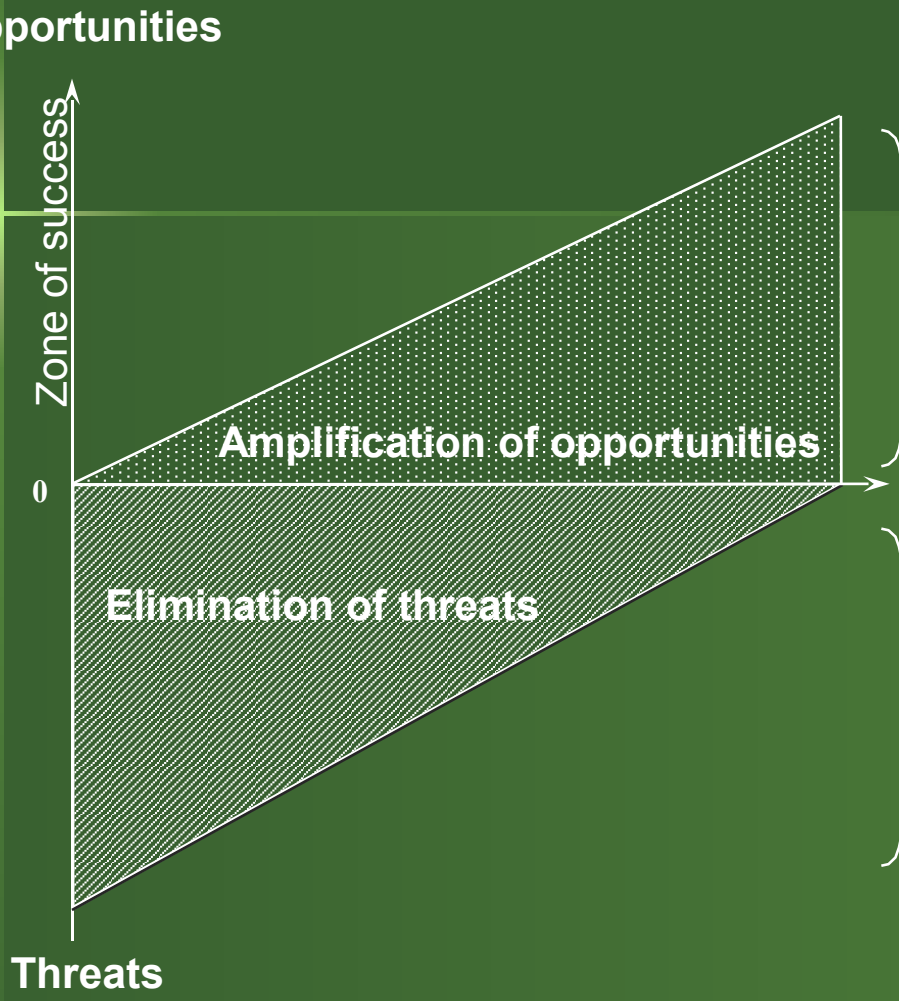
Small impoundments

By-pass (fish-ladder)

Ecohydrology

Contribution to achievement of good ecological status

ECOHYDROLOGY
Minimising threats and maximising opportunities



- The use of ecosystem properties as management tool

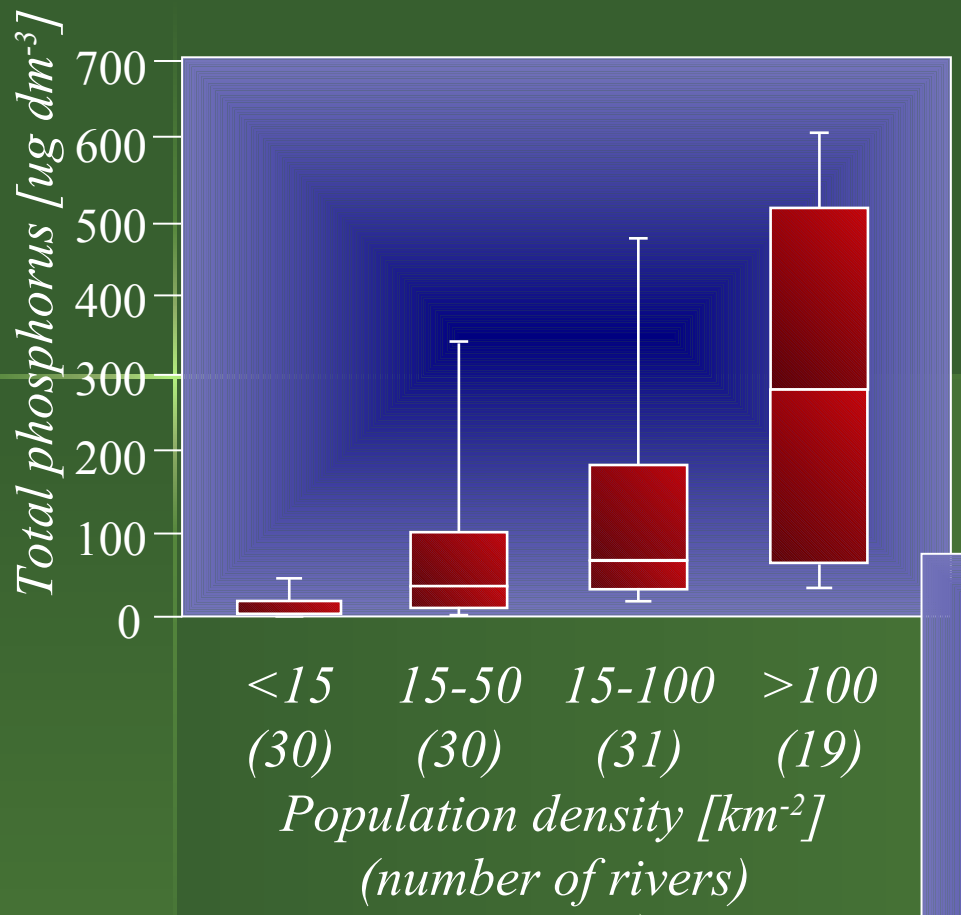
- Mitigation of non-point pollution and erosion

- Elimination of catastrophic floods and droughts

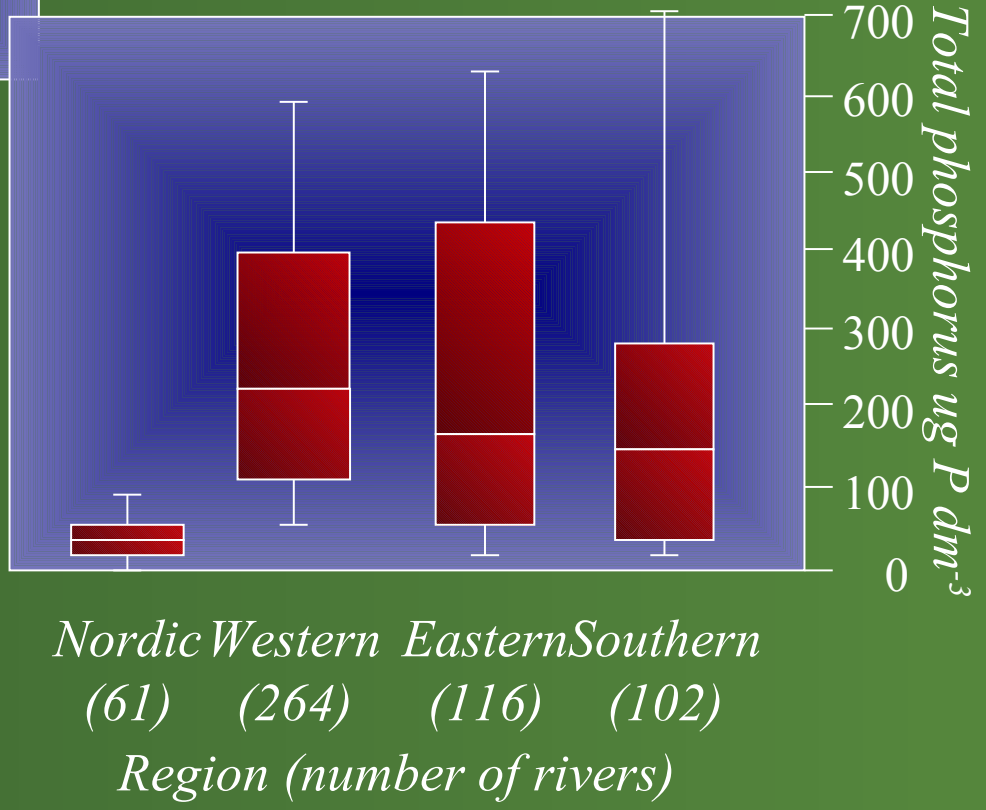
Application of Ecohydrology as a factor maximising opportunities
in the successful strategic scenario of sustainable freshwater management

Zalewski, 1997

Relationship between annual mean TP concentration and population density in the river catchments

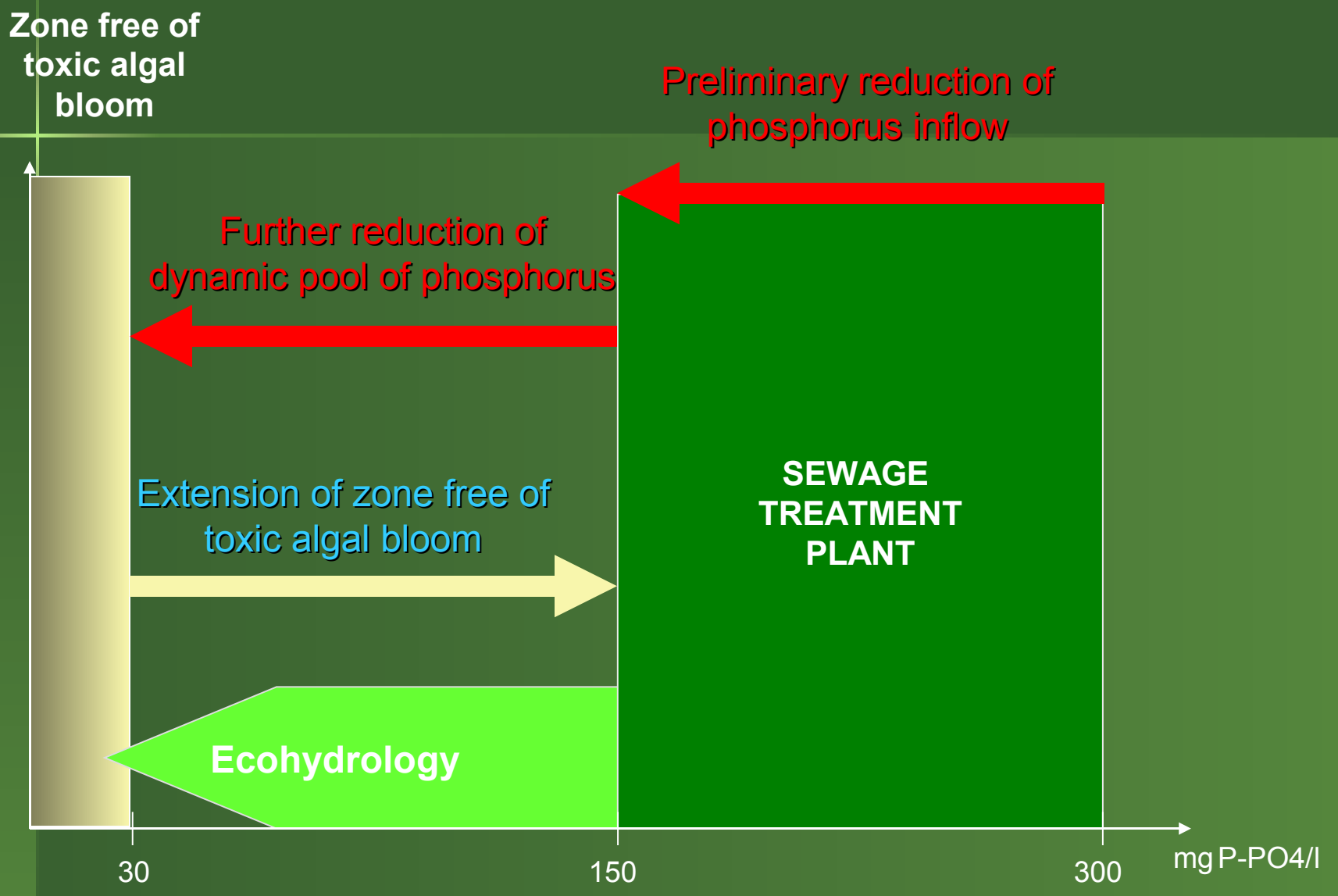


Annual mean total phosphorus levels in four European regions



ECOHYDROLOGY

Use of ecosystem properties as management tool



AVALIABLE OPTIONS

➔**„Business as usual”:** Mechanistic approach = high cost, low efficiency; declining water resources and ecosystem services

➔**Appreciating biota as an indicative system:** Hydrology – elimination of floods and droughts; some restoration efforts for flood reduction, biodiversity and aesthetic values
(e.g EU directive „good ecological status”)

➔**Ecohydrology:** Interdiscilpinary system approach for regulation processes towards reversing water and ecosystem degradation by conversion of environmental threats in to socio-economic opportunities

- ➔*e.g. Eutrophication factor – conversion of phosphorus excess into bio-energy.*
- ➔*Additional benefits: increased biodiversity, reduction CO_2 emission; and providing employment opportunities, low cost technologies.*

ECOHYDROLOGY
general framework for implementation

PROBLEM

scarcity of water of good quality of and related ecosystem services

VISION

Millenium goals

POLICY

eg. Water Framework Directive

ASESSMENT

- Ecological status
- Hydrology
- Hydrochemistry
- Biomonitoring

Considering remote sensing data on catchment and specific of its antropogenic modifications from the point of view of integrity

ECOHYDROLOGY

Integrative analysis of

DYNAMICS OF HYDROLOGICAL AND BIOLOGICAL PROCESSES

Identification of

REGULATORY FEEDBACS

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

MDG, good ecological status

(Zalewski 2004)

http://eur-lex.europa.eu/

http://ec.europa.eu/environment/water

List of published CIS Guidance Documents

http://circa.europa.eu/