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Institute for Sustainable Water
Integrated Management and
Ecosystem Research
SWIMMER



The challenges for application of the Ecosystem Approach in Wetlands

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Biodiversity of surface waters,
floodplains and groundwater

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www.liv.ac.uk/swimmer



Wetlands are diverse and range across a wide range of landscape units.

Floodplains are a prominent and complex element of the European wetland resource forming just part of the river marginal wetland environment.

Floodplain wetlands demonstrate key classical features of wetland ecosystems

- interface between terrestrial and aquatic surface and groundwater
- high vulnerability to change/alteration
- have been subjected to massive historical losses

Biodiversity perspective – Species (genetic)

Ecosystem (habitats/assemblages)

Functional (ecosystem services)

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Natural riverine systems

- Dynamic
- Productive
- Diverse
- Connecting
- Transforming

Benefits provided include:

- Water
- Food
- Energy
- Transport
- Ecosystem Services

Human exploitation

- Sectoral

Agriculture + Industry + Urbanisation = Degradation



Natural Riverine Systems

Dynamic systems

- Continually evolving
- Variable hydrology, water quality, morphology and ecology
- Variable timescales of change ($1^{-6} \rightarrow 1^{+4}$ years)

Connectivity between channel and floodplain

- Controls ecological integrity
- Affects both in-channel and floodplain communities
- Long distance linkages

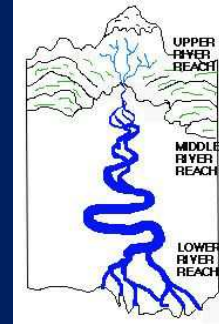
Terrestrial-hydrological boundary interactions

- Nutrient, sediment and organic matter fluxes
- Flooding regimes
- Fish and other organisms

Often highly productive

- Fertile soils

May be naturally unproductive



Floodplain wetlands

- Interface: terrestrial – aquatic
surface – groundwater
- Extreme vulnerability
- Massive historical losses



The Development Process

Dynamism of fluvial hydrosystems has resulted in their degradation because it threatens the stability required for exploitation



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The Challenge Of Floods

Causes

- Climate change
- Land use change
- Floodplain loss/degradation



Cures

- Floodplain restoration/natural flooding
- Best management practices
- Integrated catchment management

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Consequences Of Mis-management - Increased Flooding

Despite increased flood prevention schemes, the occurrence of damaging floods is also increasing, e.g. Elbe, August 2002.



The cost of floods

Cost of damage estimated at hundreds of billions of Euros over last decade



Charles River, Massachusetts

1983 decision to protect wetlands for flood control 1970's study

Increase in flood damage \$3 million /year if wetlands destroyed

Increase in flood damage \$17 million /year if all wetlands removed

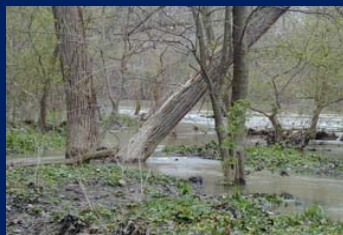
Wetlands flood control function least expensive option



Traditional nature conservation and water management approaches alone have been insufficient to protect and maintain the quality of floodplain wetlands.



Good ✓



Bad X

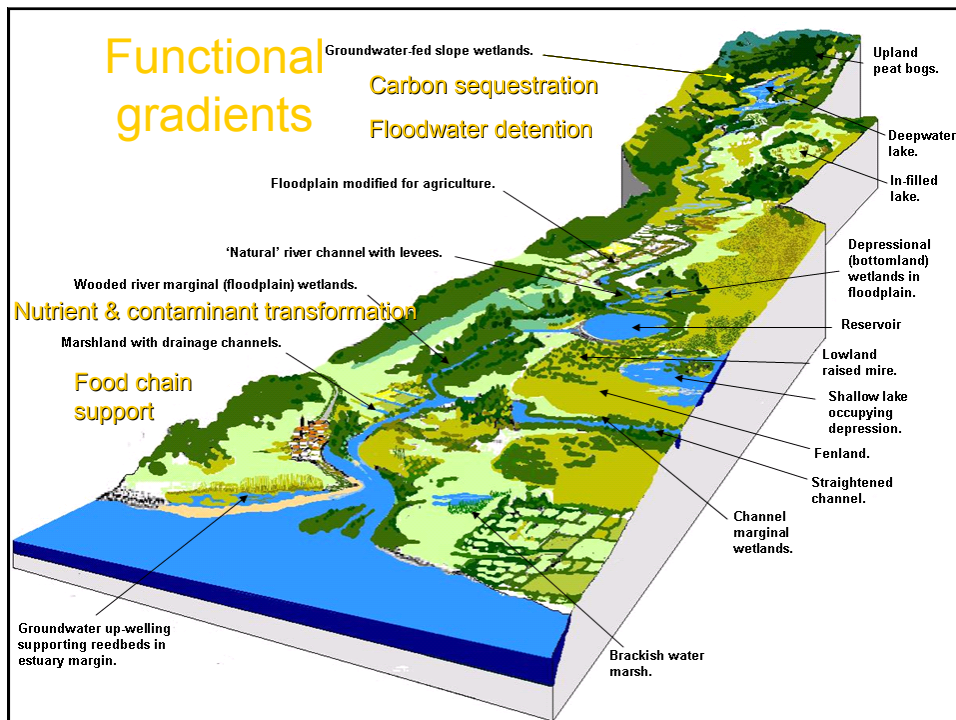


Biodiversity perspective

Species (genetic)

Ecosystem (habitats/assemblages)

Functional (ecosystem services)



Key Challenges

Public support

Scientific Understanding

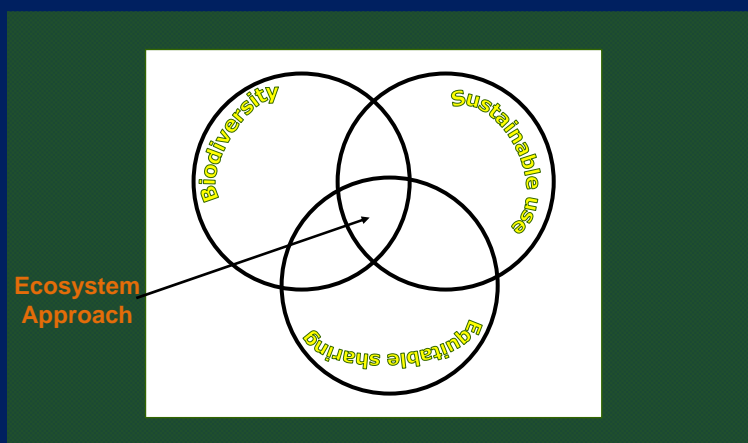
Translation of the evidence base

Dealing with trade-offs

Institutional response and coherence



New Policy Thinking – The Ecosystem Approach



A strategy for integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way

The Ecosystem Approach (EA)

Embraced by Convention on Biological Diversity (CBD)

Considers ecological, economical and social considerations within a single framework

It recognises that humans, with their cultural diversity, are an integral component of ecosystems.

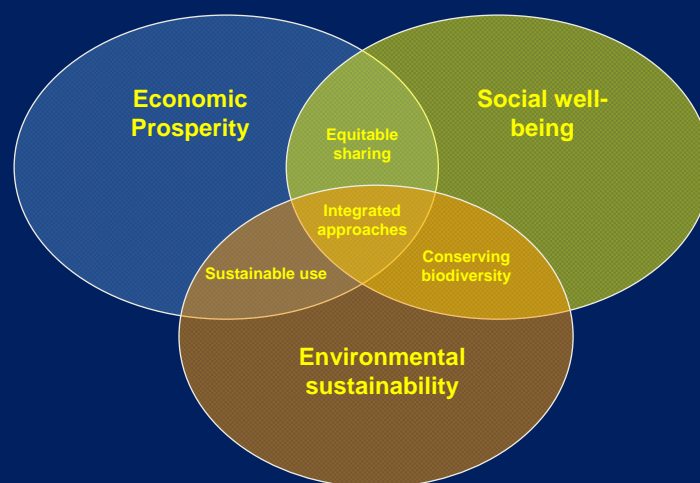
Emphasis on broad based, integrated and flexible methodologies

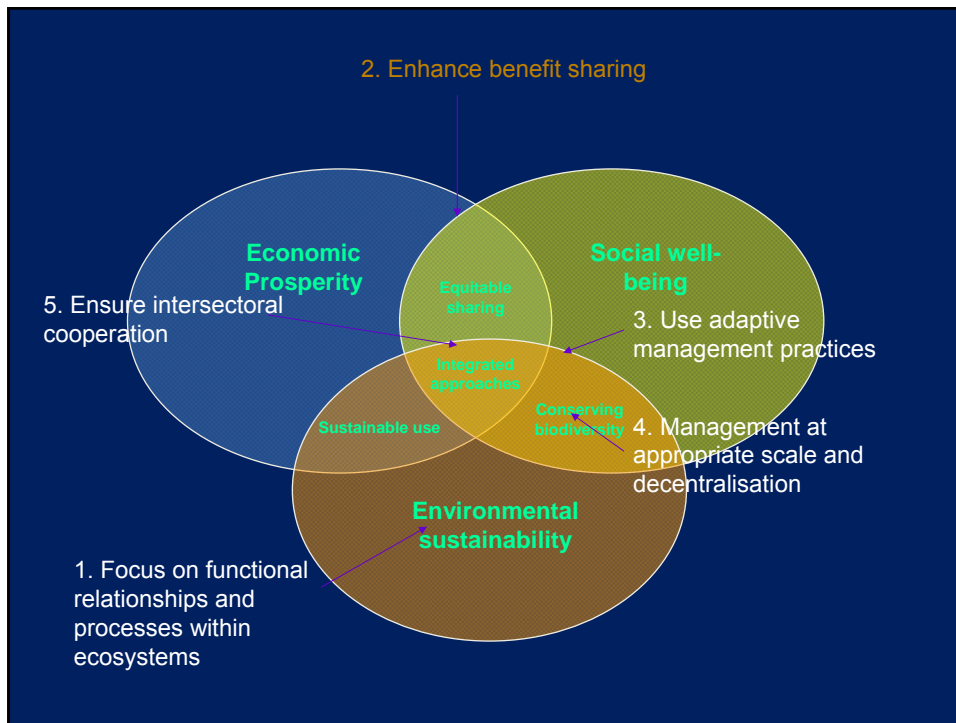
Involves a wide range of stakeholders at different scales of application

Directly applicable to the management of catchments



Structure and outcomes of the Ecosystem Approach





Why take an ecosystem approach?

Classical natural resource approaches as sole tool may:

- Lack recognition of importance of ecosystem functioning and services.
- Ignore site interlinkage.
- Ignore interlinkage of nature & society
- Lack of stakeholder participation in management of ecosystem
- Inappropriate division of costs & benefits
- Sectoral interests not integrated



Scientific Understanding

- Rapid acceleration
 - Often Fragmented
 - Insufficient linkages to policy
 - Inadequate translation for public/decision- makers
- Need for integrated knowledge in usable forms

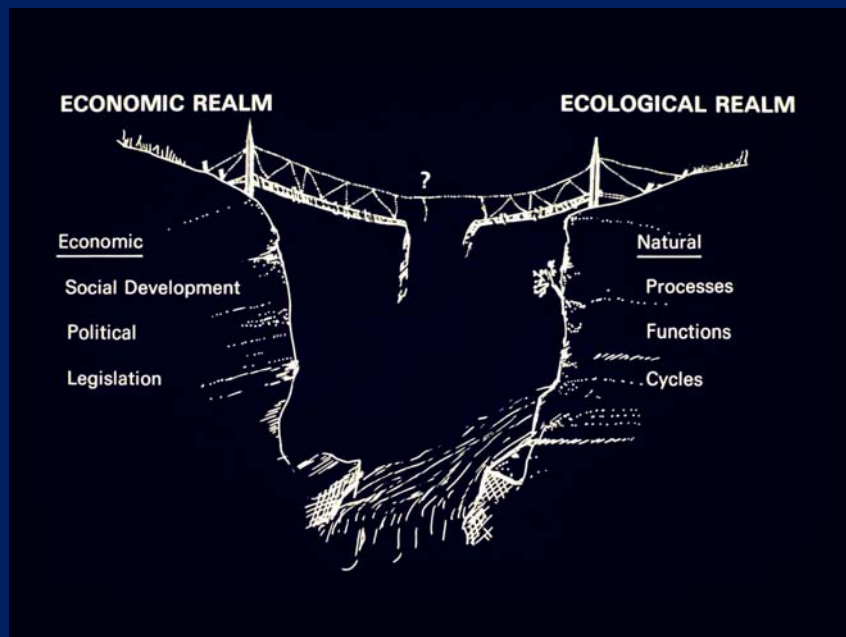


ECONOMIC REALM

Economic
Social Development
Political
Legislation

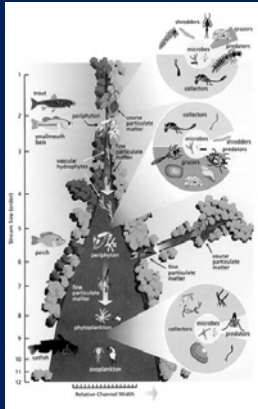
ECOLOGICAL REALM

Natural
Processes
Functions
Cycles

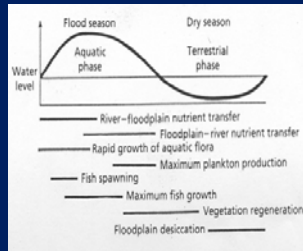


Some Important Concepts

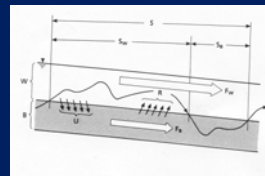
River continuum concept spiralling



Floodpulse concept



Nutrient



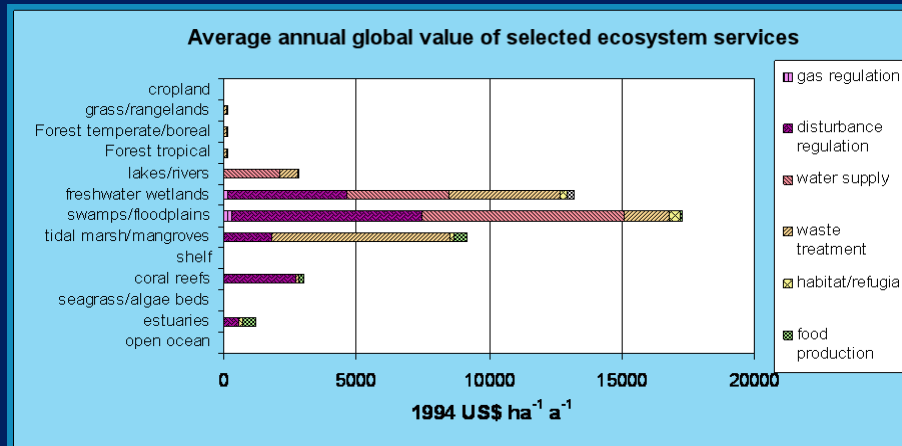
Natural Functions And Benefits

Function		Environmental significance	Societal significance
Flood control		Description	Reduces flooding downstream
Groundwater recharge	Infiltration to groundwater	Natural flooding allows detention of floodwater	Water supply
Maintenance of water quality	Removal of pollutants from runoff	Maintains good water quality	Good water quality, supports other natural resources
Habitat for flora and fauna	Supports important and/or rare habitats	Maintains biodiversity	Natural resources e.g. food, timber
Sustainable tourism and recreation	Hunting, fishing, boating, walking, birdwatching	Maintains natural functioning	Source of income
Support for sustainable agriculture	Low intensity agriculture does not affect other functions	Maintains natural functioning	Food supply, source of income

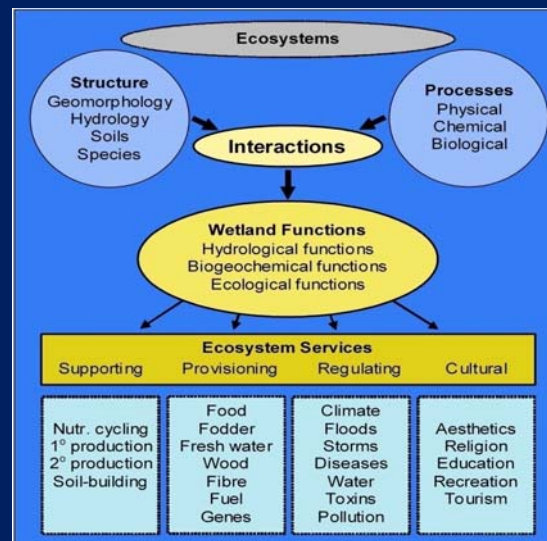


Average global value of selected annual ecosystem services

Costanza et al. 1997



The source of ecosystem services



Ecosystem services derived from inland rivers, lakes and wetlands

Provisioning services

<i>Food</i>	fish, game, fruit, grain etc.
<i>Fresh water</i>	storage, retention, provision
<i>Fibre and fuel</i>	timber, fuel, peat, aggregates
<i>Biochemicals</i>	materials from living things
<i>Genetic materials</i>	medicine, resistance to pathogens, ornaments

Cultural services

<i>Spiritual</i>	well-being, religion
<i>Recreation</i>	tourism, activities
<i>Aesthetic</i>	appreciation
<i>Education</i>	opportunities

Supporting services

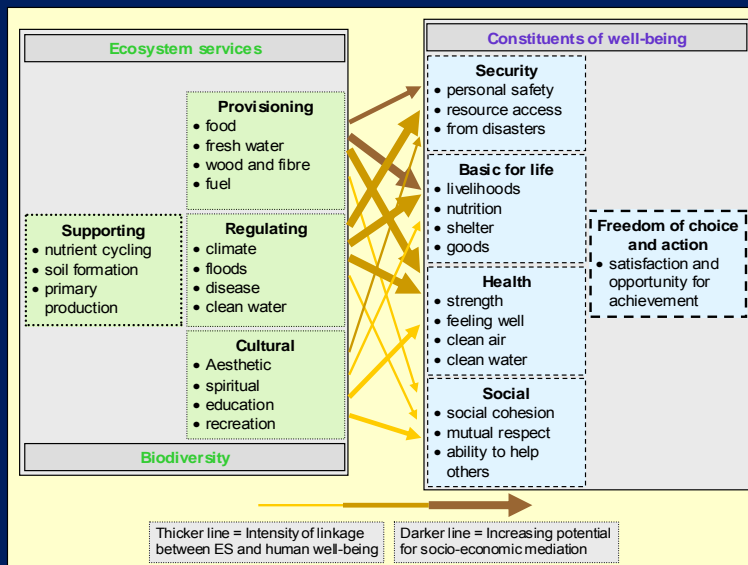
<i>Biodiversity</i>	habitats
<i>Soil formation</i>	retention, accumulation
<i>Nutrient cycling</i>	storage, processing
<i>Pollination</i>	habitat & support

Regulating services

<i>Climate</i>	GHGs, temp., rain, CO ₂ .
<i>Hydrology</i>	recharge, discharge, storage
<i>Pollution</i>	retention, removal, recovery
<i>Erosion</i>	protection, retention
<i>Natural hazards</i>	floods, storms

Adapted from Millennium Ecosystem Assessment 2005

Links between ecosystem services and human wellbeing



Adapted from Millennium Ecosystem Assessment

How should ecosystem services influence wetland management and restoration?

- Assist in societal priority-setting
- Establish 'real' values
- Enable 'appropriate' balances
- Support sustainable development
- Guide management
- Aid public understanding



Some Reasons For Floodplain Degradation

- Inappropriate use of floodplains driven by
 - Population growth
 - Economic development
- Lack of scientific understanding
 - Poor understanding of floodplain functioning
 - Poor knowledge of impacts of proximal and distal actions
- Inadequate link between science and policy
 - Policy does not reflect scientific research
- Inappropriate management structures
 - Inefficient decision making systems
- Competing/conflicting stakeholder interests
- Limited political will
 - Governments reluctant to tackle sustainability issues



Examples of restoration and conservation priorities

CATCHMENT

Flood risk reduction
 Fisheries alleviation
 Wildlife reduction
 Amenity, culture heritage
 Quality of life

Stakeholder defined

COUNTRY

Water resources
 Sustainability
 Carbon capture
 Human well-being

Politically defined

GLOBAL

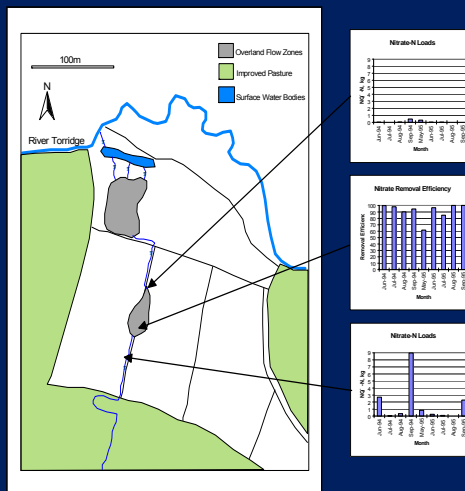
Biodiversity
 Poverty
 Conflict
 Adaptation to global change

International agreements

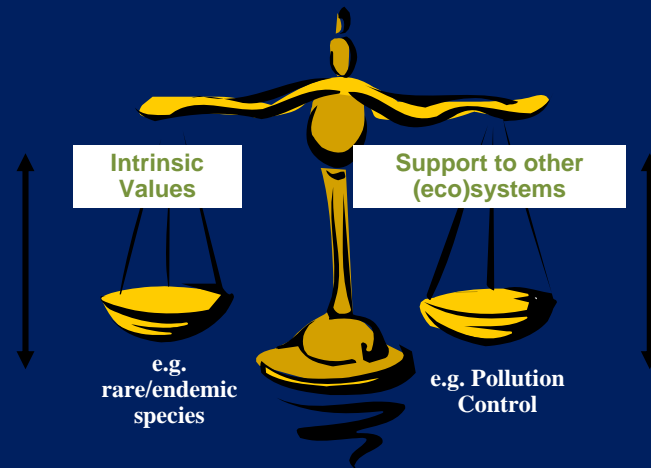


The Challenge Of Management For Environmental Benefit

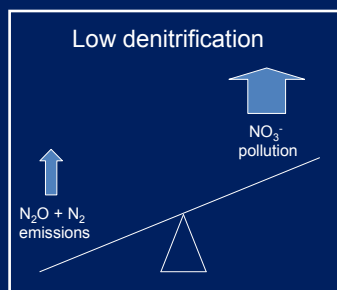
- Incongruity between science and policy
- Imperfect guidance – e.g. buffer zones



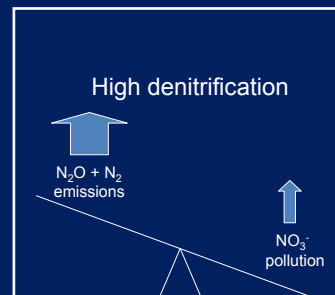
Wetlands - Questions of Balance



Balancing processes



Factors decreasing denitrification:
acidity
oxygen



Factors increasing denitrification:
temperature
soil moisture
nitrate

These factors also affect the $\text{N}_2\text{O} / \text{N}_2$ ratio
(the end products of denitrification)

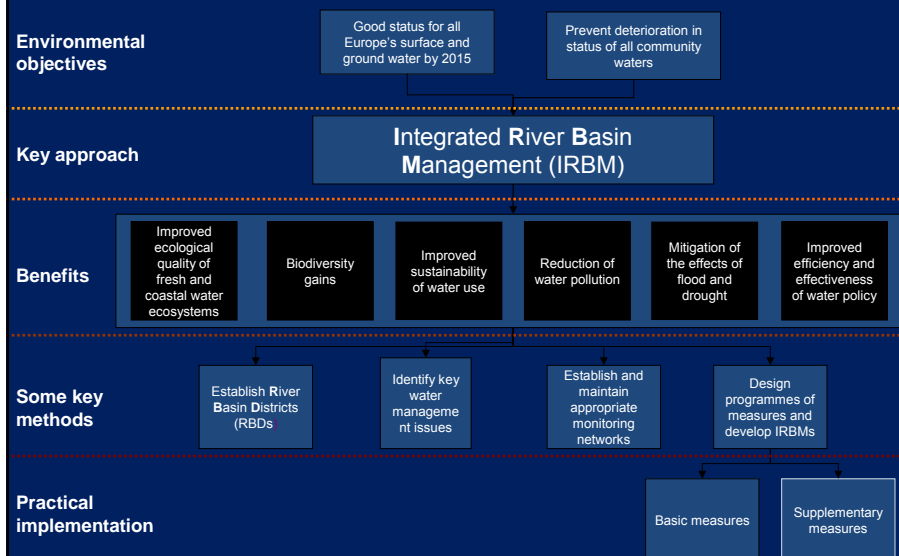


EA demands paradigm shift

FROM	TO
Preservation	Adaptive Management
Sectoral	Integrated
Scientific	Multifaceted Knowledge
Environmental	People and Environment
Top Down	Both Directions
National	Appropriate Level
Conservationist	All Stakeholders
Nature	Social and Environmental well-being



Floodplains And The WFD



How The Ecosystem Approach Can Help

- Produce integrated strategies and actions for ecosystems, eg basins, mountains, coasts
- Focus on functional relationships
- Assess natural resource capacity
- Use scientific knowledge
- Develop monitoring and review mechanisms
- Raise awareness and build capacity



Some comparisons

EA	WFD
Societal choice, consider all information	Public consultation
Economic context	Economic analysis
Structure and functioning	Ecological quality
Appropriate scale effects on other ecosystems	River basin
Change inevitable long-term	Review planning
Involve all relevant sectors	Best practice by sector, issue and joined-up action
Manage within functional limits	Derogations
Management at lowest appropriate level	Appropriate administrative arrangements



What are the key ideas?

Highly flexible organisational methodology

Adaptable to a wide range of situations and challenges

'Problemshd' oriented – ensures entire sphere of influence of management included

Links evidence-based science with societal priorities

Maximises ownership of issues



The Functional Analysis Procedures

Wetland ecosystems – extremely diverse, thus not all perform same functions and to the same degree.

Procedures/methods are needed to:

- predict the likelihood of functioning for a particular wetland
- assess the magnitude of functioning for a particular wetland
- assess to what extent a function may provide goods and/or services (economic value)
- evaluate the extent that functioning may be impacted on (management scenarios).

Requirements for a wetland evaluation methodology:

- To aid appropriate decision-making
- Legislation implementation
- Wetland-functioning protection
- Rapid, user-friendly assessment (detailed evaluation – time-consuming/resource intensive)



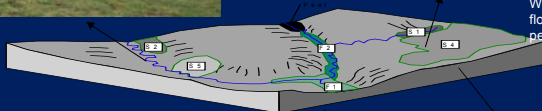
Functional Landscape units



Wetland developed in zone of strong groundwater seepage adjacent to floodplain.



Wetland in valley bottom lacking floodplain development, can be peat-filled.



Floodplain of flashy river system can experience short periods of inundation from over-bank flooding.



Fen and wet grassland on soils of low permeability on gently-sloping interfluvial running down to stream headwaters.



Recording sheet 1. Land use and management

LAND USE AND MANAGEMENT		
RECORDING SHEET 1		
RS1-2: Landuse and Management		
RS ENTRIES	FIELD CODE	DATA
Inorg. fertiliser AA	1C3-2.1a	c
Inorg. fertiliser HG MU	1C3-2.1b	c
Composition of Fertiliser in AA	1C3-2.2a	c
Composition of Fertiliser in HG MU	1C3-2.2b	a
Rate of N Applied AA	1C3-2.3a	b
Rate of P Applied AA	1C3-2.3a(i)	c
Rate of N Applied HG MU	1C3-2.3a(i)	b
Rate of P Applied HG MU	1C3-2.3a(i)	b
Org. Fert. Spray AA	1C3-2.4a	c
Org. Fert. Spray HG MU	1C3-2.4b	b
Org. Inj. AA	1C3-2.5a	c
Org. Inj. HG MU	1C3-2.5b	b
Org. Ind. AA	1C3-2.6a	c
Org. Ind. HG MU	1C3-2.6b	b
Lime App. AA	1C3-2.7a	a
Lime App. HG MU	1C3-2.7b	a
Inorg. Fertiliser CA	1C3-2.8	b
Comp. Fert. CA	1C3-2.9	b
Org. Inj. CA	1C3-2.10	b
Org. Ind. CA	1C3-2.11	b
Org. Ind. CA	1C3-2.12	b
Lime App. CA	1C3-2.13	b
Burning Frequency in AA	1C3-3.1a	b
Burning Frequency in HG MU	1C3-3.1b	b
Harvesting Frequency in AA	1C3-4.1a	b
Harvesting Frequency in HG MU	1C3-4.1b	a
Harvesting Practices AA	1C3-4.2a	b
Harvesting Practices HG MU	1C3-4.2b	b
Harvesting Time and Freq. AA	1C3-4.3a	b
Harvesting Time and Freq. HG MU	1C3-4.3b	b
Ploughing Frequency in AA	1C3-5.1a	b
Ploughing Frequency in HG MU	1C3-5.1b	b
Ploughing Frequency in CA	1C3-5.2	b
Forestry Frequency in AA	1C3-6.1a	b
Forestry Frequency in HG MU	1C3-6.1b	b
Livestock Density in AA	1C3-7.1a	b
Livestock Density in HG MU	1C3-7.1b	b
Production in AA	1C3-7.2a	b
Production in HG MU	1C3-7.2b	n
Feed in Rest/Sleep area AA	1C3-7.3a	u
Feed in Rest/Sleep area HG MU	1C3-7.3b	y
Livestock Density in CA	1C3-7.5	u
Large Bird Population in AA	1C3-8.1a	u
Large Bird Population in HG MU	1C3-8.1b	n
Bird Population Density in AA	1C3-8.2a	u
Bird Population Density in HG MU	1C3-8.2b	b
Surface Drainage in AA	1C3-9.1	u
Surface Drainage Within CA	1C3-9.3	u
Sub-surface Drainage in AA	1C3-9.5a	u
Sub-surface Drainage in HG MU	1C3-9.5b	n
Sub-surface Drainage Within CA	1C3-9.7	u
Peat Cutting and Extraction in AA	1C3-10.1a	u
Peat Cutting and Extraction in HG MU	1C3-10.1b	u
Peat Cutting and Extraction in CA	1C3-10.2	u
Mining and Extraction Within AA	1C3-11.1a	u
Mining and Extraction Within HG MU	1C3-11.1b	b
Mining and Extraction Within CA	1C3-11.2	u
Frequency of Inorg. Waste Appl. In AA	1C3-12.1a	u
Frequency of Inorg. Waste Appl. In HG MU	1C3-12.1b	u
Frequency of Inorg. Waste Appl. In CA	1C3-12.2	u
Construction Work in AA	1C3-13.1a	u
Construction Work in HG MU	1C3-13.1b	n
Construction Work in CA	1C3-13.2	u
Extent of Hunting, Shooting, Fishing in AA	1C3-14.1	u
Extent of Recreation in AA	1C3-15.1	u

Entries are case-sensitive; please keep to the format indicated in the yellow tooltip.

SAVE Data Management Menu [Exit] NEXT Previous HG MU: 1

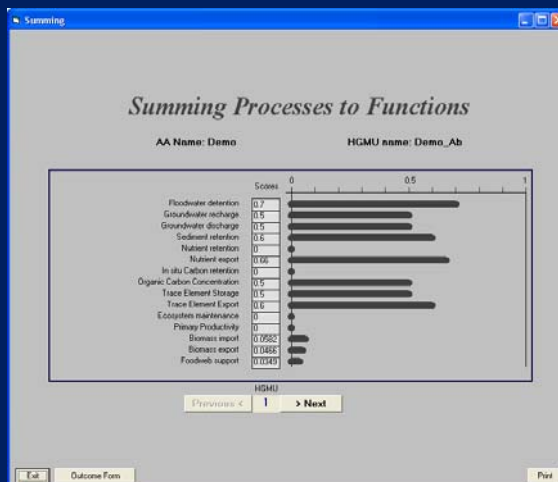


Part Two – assessment stage

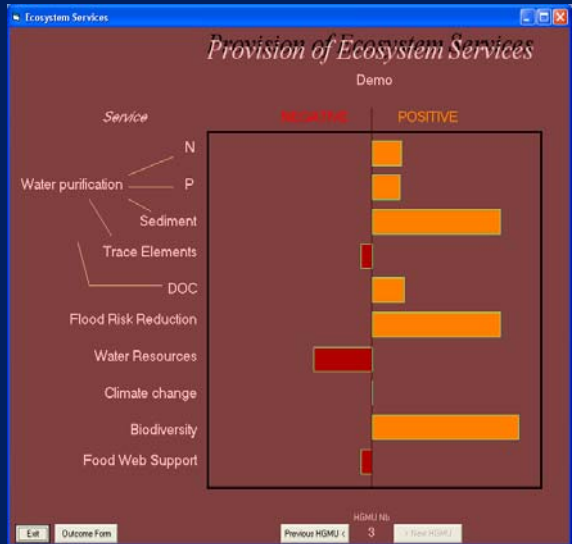
The outcomes display page.
From here, a choice of output type can be made.



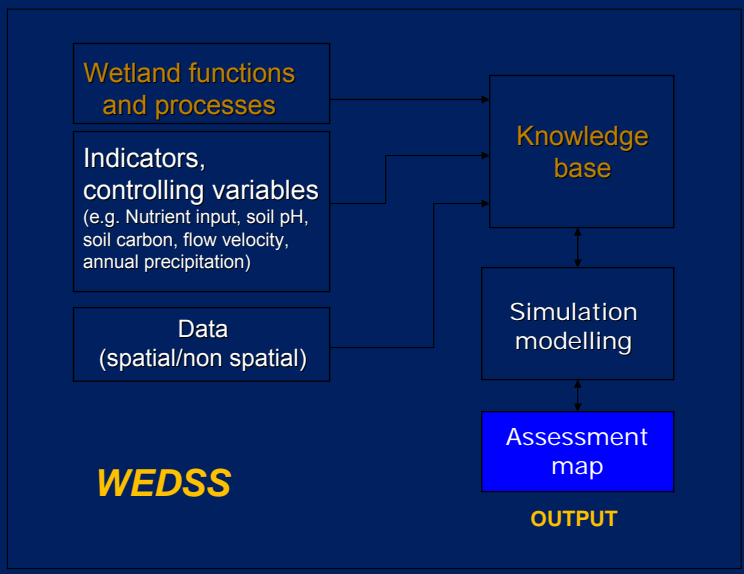
Screen showing the scores (0-1) assigned for each function



Screen showing the assessment of provision of ecosystem services by the HGMU.



Knowledge base and WEDSS

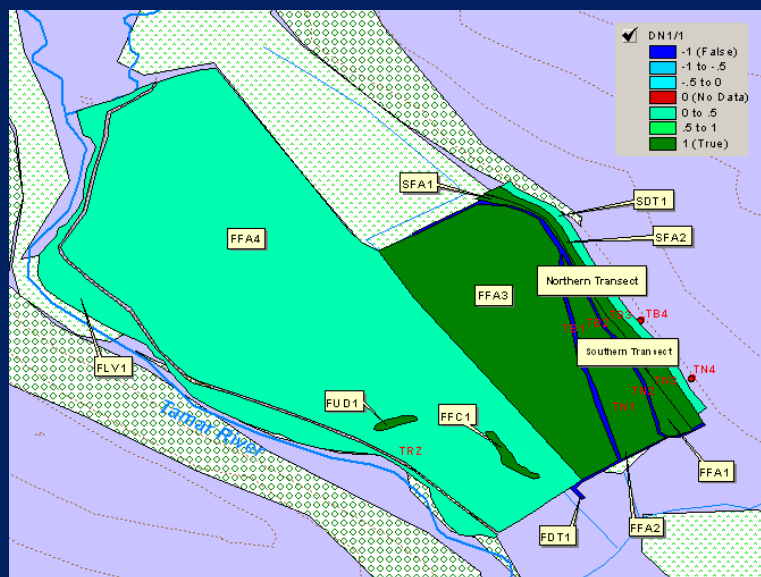


Categories and criteria

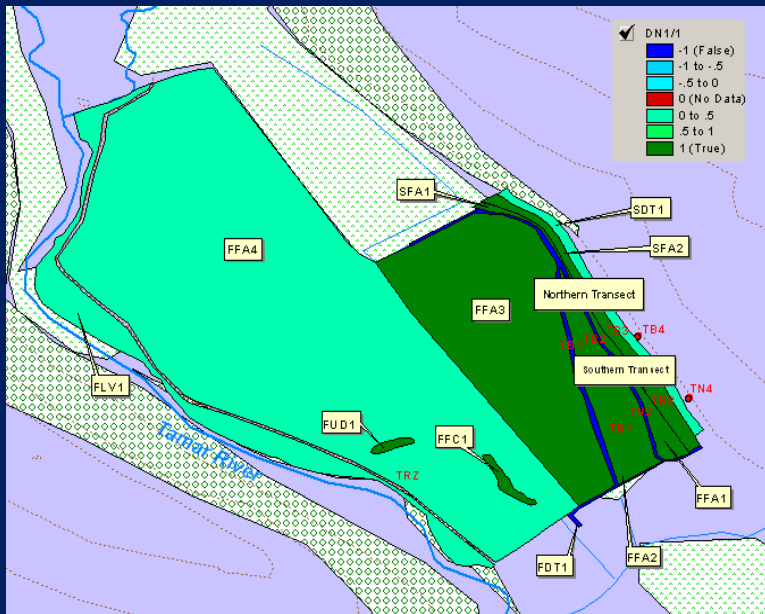
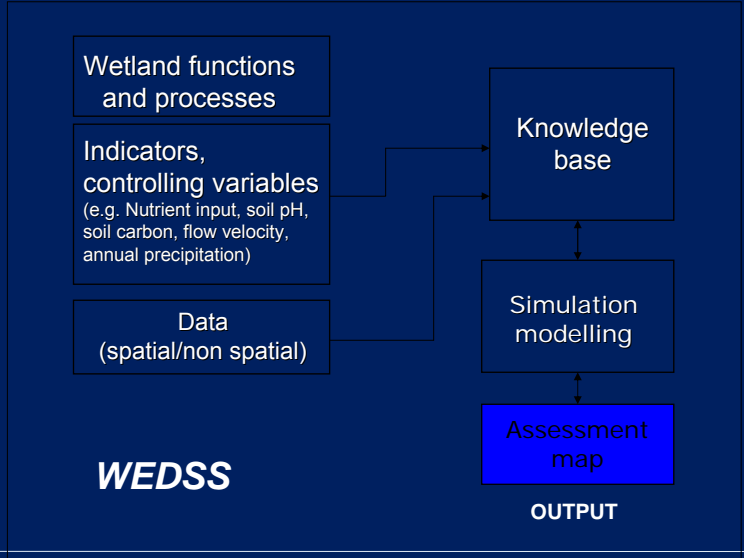
Category	Criteria	Category	Criteria
Water Quality	WQ-N WQ-P WQ-Sediment WQ-Trace Elements WQ-DOC	Water Quantity	Flood risk reduction Groundwater maintenance Base flow support Water supply
Climate change	Carbon retention Greenhouse gas emissions	Heritage	Cultural heritage Landscape Pres. of arch. remains Pres. of paleo-env
Biodiversity and biomass	Habitat diversity Sp. diversity – flora Sp. diversity – fauna Biomass	Socio-economic	Agriculture Natural Harvest Forestry Shipping Residential Recreation Tourism



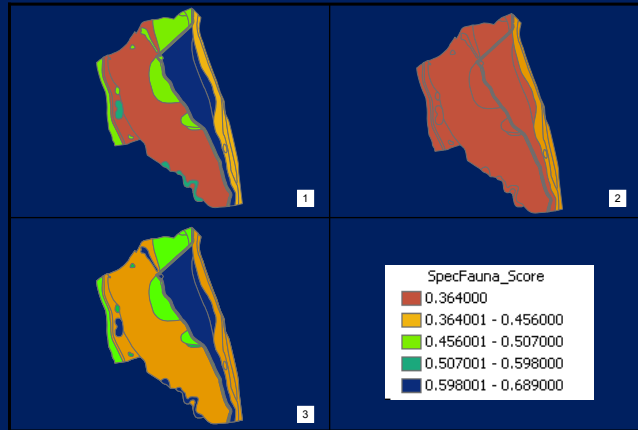
Assessment Outcome



Knowledge base and WEDSS



Species diversity - Fauna



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Tamarmangement2 - ArcMap - ArcView

File Edit View Insert Selection Tools Window Help

New Data Frame 6 Analysis6 - Priority Value - wetland

Priority Analyst - [Analysis6: wetland] - PA Manager

Select Priority Analyst Model for selected database

Priority Analyst Model	Features DB	CDP Path/FileName	PA
wetland	OUT.DBF	E:\weds\storspead\weds\Model6\1Mo...	1
wqn	OUT.DBF	E:\weds\storspead\weds\Model6\3W/a...	2
wqp	OUT.DBF	E:\weds\storspead\weds\Model6\3W/a...	3
wqsedi	OUT.DBF	E:\weds\storspead\weds\Model6\3W/a...	4
floorR	OUT.DBF	E:\weds\storspead\weds\Model6\3Flo...	5

Results

- Truth Values
- Influence Values
- Tables
- Priority Analyst Models
 - wetland
 - wqn
 - wqp
 - wqsedi
 - floorR
 - aroundW

Contributions in PA Model wetland for Feature 2

Contributions of [Level 2] to Restoration Priority

WQuality	0.15
WQuantity	0.10
Climate Change	0.01
Biodiversity and Bio	0.13
Total Priority	0.39

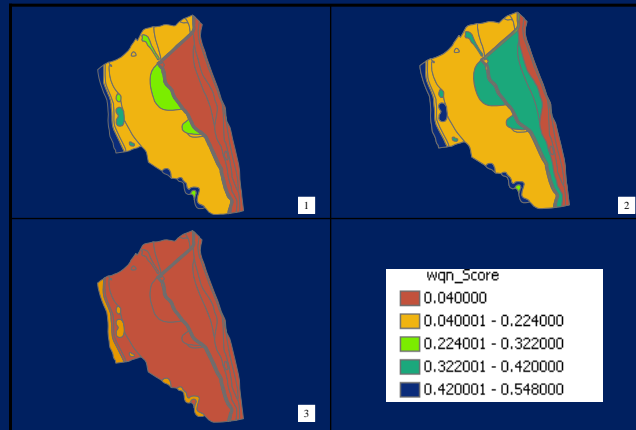
Priority Analyst - [Analysis6: wetland] - Contributions

Contributions to Criterion [Goal] from [Level 2]

Features	Score	SMART Pro	Criteria Legend
2	0.399		WQuality
3	0.369		WQuantity
8	0.338		Climate Change
6	0.310		Biodiversity and Bio
19	0.210		
5	0.205		
20	0.206		

Contributions Target Criterion: L1: Goal Source Level: Level 2

Water quality enhancement (N)



Potential Application of the Wetland Ecosystem Decision Support System (WEDSS)

- Groundwater recharge/discharge
- Protection surface water quality
- Maintenance of biodiversity
- Amenity values
- Restoration potential
- Cost-effectiveness of programme of measures (WFD)
- Suitability of conditions for archaeological preservation



