



Ecological restoration of wetlands in Europe

significance for implementing the Water Framework Directive in the Netherlands



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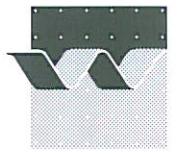
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Hugo Coops and Gerben van Geest

Report

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Client:	Rijkswaterstaat RIZA				
Title:	Ecological restoration of wetlands in Europe				
Abstract:					
<p>This report presents an international survey of wetland restoration projects, in view of measures that can be helpful for the implementation of the EU Water Framework Directive in the Netherlands. The survey lists restoration projects in European wetlands in rivers (194 cases), lakes (99 cases) and transitional waters (35 cases) that can be considered relevant for wetlands in the Netherlands (according to wetland types and pressures). Five case-studies are presented in more detail: the Skjern River restoration project (Denmark), Donau-Auen (Austria), Norfolk Broads (UK), lake restoration in Finland, and the Zeeschelde (Belgium).</p> <p>Learning points include: 1) Learning innovative methods and techniques; 2) Elimination of potentially unsuccessful restoration measures; 3) Technical issues; 4) Basic data for economic analysis; 5) New ways to involve stakeholders in a restoration project; 6) Data for empirical and theoretical relationships between measure and effect.</p> <p>In many cases wetland restoration has been carried out in isolation from other management objectives at the scale of water bodies or river basins. Particularly instructive are those cases where objectives for functions like flood protection, navigation, and recreation have been linked. In those cases, mostly the restoration efforts have been spatially segregated from measures to enhance those other functions. Also, integration of water management objectives (WFD) and nature conservation objectives (N2000) has been rarely addressed in the case studies.</p> <p>For larger wetland restoration programmes, there is usually a long time lag between initial planning, operationalisation, and ecological effect. This implies that to optimally benefit from wetland restoration for WFD objectives a period beyond the current planning period of 2015 should be addressed.</p>					
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Ver	Author	Date	Remarks	Review	Approved by
	Hugo Coops			H. Duel	C.A. Bons
	Gerben van Geest				
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Summary

Experiences with wetland restoration in other countries in Europe may be useful for the implementation of the Water Framework Directive (WFD) in the Netherlands. To improve the understanding of effective measures to achieve Good Ecological Status of water bodies, the available knowledge of relationships between hydromorphology and ecology, and experience with the effects of restoration measures, both on a national and on an international level, should be used fully.

The present study should contribute to designing effective wetland restoration measures in the Netherlands. The study presents an overview of relevant restoration measures that have been applied in various wetland restoration projects in Europe. The Ramsar database 'Wetlands of International Importance' and other entries were consulted to collate a list of wetland restoration projects.

The role of wetlands in the WFD is elaborated in the CIS 'Horizontal Guidance Document for the Role of Wetlands in the Water Framework Directive' (2003). Wetlands play a role in different parts of the river basin. Wetland ecosystems adjacent to a water body which influence the status of that water body should be encompassed in riparian, lakeshore, or intertidal zone, and thus are part of that water body. Also ecosystems that are not adjacent to a water body may have an influence on it because of hydrological connections. Alternatively, the water body may have an influence on an adjacent or more distant wetland, either through surface water or groundwater connections. In those cases the quality of water entering the water body should be ensured, and relevant action should be taken to protect, enhance, restore or create such ecosystems.

A broad survey was made of restoration projects in wetlands in rivers, lakes (including peat lakes) and transitional waters (estuaries), focussed on types of wetlands that can be considered relevant for wetlands in the Netherlands. The resulting database consists of 312 relevant projects (194 riverine wetlands, 99 lake-associated wetlands and 35 wetlands associated with transitional water bodies). A variety of pressures was addressed: chemical pressures (excess nutrient levels, micropollutants, etc.) in 25% of the cases, morphological pressures (alteration of bank/floodplain or shore profiles) in 32%, hydrological pressures (regulation of water levels, desiccation, etc.) in 36%, biological pressures (invasive species, forest encroachment) in 13%, and human use (disturbance by recreation, agricultural land-use, navigation) in 24%.

Five case-studies of wetland restoration projects that tackle different pressures are further elaborated. These large-scale projects included comprehensive approaches with different inter-related actions to improve the ecological status. Learning points from each case-study are highlighted.

The Skjern River restoration project (Denmark) may provide data for dose-effect relationships to be used in the WFD implementation process. The project gives (quantitative) insight in efficacy of nutrient retention and removal by restored wetland. The approach incorporates changes in land use into a program of measures for achieving ecological objectives for water bodies. It shows that floodplain wetland restoration has clear benefits in terms of water quality improvement and enhancement of ecological quality elements (e.g. fish); moreover it shows that WFD objectives can be integrated with flood protection and socio-economic functions.

The case-study Donau-Auen (Austria) demonstrates that initial agreement on a conceptual management framework incorporating objectives for water quality (WFD), flood protection, navigation and nature conservation can be essential to carry out wetland restoration. The programme incorporates restoration on a large scale (Austrian sector of Danube River) in which lateral connectivity between river and floodplain is restored for several subsequent

side channel systems. Particularly relevant is the approach of ‘learning by doing’, involving scientific support by extensive monitoring and research programme.

In the Norfolk Broads (UK) a long tradition of lake restoration methods exists. WFD measures focus on external nutrient control and biomanipulation. In this case wetland restoration (reedbed, carr and wet meadow management) is based on biodiversity objectives (N2000), and is not integrated with WFD measures.

Lake restoration in Finland has been conducted in more than 1000 lakes and included many (novel) techniques. Particularly interesting is the decentralised organisation of lake restoration, with strong participation of local stakeholders.

For the Zeeschelde, plans for restoring tidal wetlands by reconnecting embanked wetlands to the river may only be operationalised when water quality, nature conservation, flood control, and navigation objectives are integrated in the planning and decision-making process. It has been proposed to express wetland restoration objectives by area to be reconnected to the tidal river, and quantify the extent of that area by its relationships to the functional role of tidal wetlands in nutrient reduction.

In summary, the main conclusions are:

1. Because most types of wetland restoration have their analogues in cases in the Netherlands, we can learn from experiences and details concerning technical operation of measures. Benefits from exploring cases in other countries in Europe (and beyond) are: 1) Learning innovative methods and techniques, of which a few are presented in this study; 2) Elimination of potentially unsuccessful restoration measures; 3) Technical issues; 4) Basic data for economic analysis; 5) New ways to involve stakeholders in a restoration project; 6) Data for empirical and theoretical relationships between measure and effect.
2. In many cases wetland restoration has been carried out in isolation from other management objectives at the scale of water bodies or river basins. Particularly instructive are those cases where objectives for functions like flood protection, navigation, and recreation have been linked. In those cases, mostly the restoration efforts have been spatially segregated from measures to enhance those other functions
3. Integration of water management objectives (WFD) and nature conservation objectives (N2000) has been rarely addressed.
4. For larger wetland restoration programmes, there is usually a long time lag between initial planning and operationalising of measures, and then to achieving the intended effects. Typically the timespan between decision and completed restoration is 10-15 years. This implies that to include wetland restoration in WFD measures a longer time horizon than the current period till 2015 should be addressed.

Samenvatting

Ecologisch herstel van wetlands in Europa: belang voor de implementatie van de Kaderrichtlijn water in Nederland

Ervaring met het projecten voor wetlandherstel in andere landen in Europa kan nuttig zijn voor de implementatie van de Kaderrichtlijn Water in Nederland. Om effectieve maatregelenpakketten op te kunnen stellen voor het bereiken van de GET in waterlichamen is het nodig dat de beschikbare kennis van de relaties tussen hydromorfologie en ecologie en de ervaringskennis van herstelmaatregelen optimaal gebruikt wordt. Deze studie beoogt daaraan bij te dragen middels een overzicht van relevante herstelmaatregelen die elders in Europa genomen zijn, en een indicatie van hoe deze maatregelen gekoppeld zijn aan ecologische doelen.

De rol van wetlands in de Kaderrichtlijn Water is uitgewerkt in de 'Wetlands Guidance' (2003). Hierin wordt gesteld dat wetlands die grenzen aan een waterlichaam en de toestand daarvan beïnvloeden, als oeverzone of getijdezone onderdeel zijn van dat waterlichaam. Ook wetlands die niet direct aan een waterlichaam grenzen kunnen invloed hebben door hydrologische verbindingen. Daartegenover kan het waterlichaam via grond- of oppervlaktewaterverbindingen een aangrenzend of verder weg gelegen wetland beïnvloeden. In dat geval vereist de KRW dat de kwaliteit van het binnenkomende water goed moet zijn, en dat relevante acties moeten worden genomen om dergelijke ecosystemen te beschermen of herstellen.

Voor het overzicht van wetland-herstelprojecten zijn verschillende bronnen geraadpleegd waaronder de Ramsar database 'Wetlands of International Importance'. Het overzicht betreft herstelprojecten in en langs rivieren, meren (inclusief laagveenplassen) en overgangswateren, met nadruk op die wetland-typen die als relevant voor de Nederlandse situatie kunnen worden beschouwd. De resulterende spreadsheet bevat 312 relevante projecten (194 in rivieren, 99 in meren en 35 in overgangswateren). De projecten zijn gericht op het verminderen van verschillende drukken: chemisch (overmatige nutriëntengehalten, microverontreinigingen, enz.) in 25%, morfologisch (veranderingen aan oevers en uiterwaarden) in 32%, hydrologisch (waterpeilregulering, verdroging, enz.) in 36%, biologisch (exoten, verbossing) in 13%, en druk vanuit menselijk gebruik (verstoring door recreatie, landbouwgebruik, scheepvaart) in 24% van de gevallen.

Aan de hand van vijf case-studies die verschillende pressures aanpakken en een omvattende aanpak bevatten, worden lessen getrokken die van belang kunnen zijn voor de Nederlandse KRW-implementatie.

Het herstelproject in de Skjern Aa (Denemarken) kan belangrijke informatie opleveren voor dosis-effect relaties. Het project geeft met name inzicht in de effectiviteit van nutriëntenretentie en -verwijdering in herstelde wetlands langs de rivier. In het project waren veranderingen in landgebruik de aanzet voor het maatregelenprogramma gericht op ecologische doelen. Het laat zien dat herstel van de overstromingsvlakte duidelijke voordelen geeft zoals verbetering van de waterkwaliteit en van de ecologische kwaliteitselementen (zoals vissen). Bovendien laat het zien dat KRW doelen geïntegreerd kunnen worden met bescherming tegen overstroming en sociaal-economische versterking.

De case-studie Donau-Auen (Oostenrijk) laat zien dat overeenstemming over een gezamenlijk conceptueel raamwerk waarvan de KRW doelen onderdeel zijn, maar ook hoogwaterbescherming, scheepvaart en natuurbescherming, essentieel kan zijn om herstelprojecten daadwerkelijk van de grond te krijgen. Het herstelprogramma omvat een grootschalig herstel van de verbindingen tussen rivier en uiterwaarden door het aantakken van een reeks opeenvolgende nevengeulen. Van belang is hier dat van de tijdens de

uitvoering opgedane ervaringen geleerd wordt door een uitgebreid monitoring- en onderzoeksprogramma.

In de Norfolk Broads (Groot-Brittannië) bestaat al een lange traditie met het herstel van meren. De KRW maatregelen richten zich hier op beheersing van externe nutriëntenbelasting in combinatie met biomanipulatie. Daarnaast wordt er ook een groot aantal projecten uitgevoerd om rietlanden, broekbossen en natte graslanden te herstellen, met het oog op biodiversiteitsdoelen (N2000). Opvallend is dat deze twee benaderingen niet geïntegreerd worden.

Meerherstel in Finland is uitgevoerd in meer dan 1000 meren, soms met innovatieve technieken. Bijzonder interessant is de gedecentraliseerde organisatie van het herstel van meren, waarin lokale groepen het voortouw hebben.

Plannen voor de Zeeschelde (België) om getijdenmoerassen te herstellen door ontpoldering of het maken van gecontroleerde overstromingsgebieden kunnen alleen gerealiseerd worden door het integreren van de doelen voor waterkwaliteit, natuur, hoogwaterbescherming en scheepvaart (haven Antwerpen) met elkaar te verbinden. Een voorstel is om de oppervlakte van de ontpolderingen te kwantificeren op basis van relaties met de functionele rol die deze wetlands kunnen hebben bij het reduceren van nutriëntengehalten.

Samenvattend zijn de conclusies:

1. Omdat de meeste herstelprojecten in veel opzichten vergelijkbaar zijn met projecten in Nederland valt er veel te leren van de ervaringen die zijn opgedaan in het buitenland en van technische uitvoeringsdetails. Het bekijken van buitenlandse cases is nuttig voor: 1) het leren van innovatieve methoden en technieken, waarvan deze studie een aantal voorbeelden geeft; 2) het afschrijven van potentieel niet succesvolle herstelmaatregelen; 3) technische uitvoeringszaken; 4) basisgegevens voor economische analyse; 5) nieuwe manieren om partijen bij herstelprojecten te betrekken; 6) gegevens die gebruikt kunnen worden bij het opstellen van empirische en theoretische kennisregels voor maatregel-effect relaties.
2. In veel gevallen werden en worden wetlandherstel-projecten uitgevoerd zonder veel oog voor andere beheersdoelen op het niveau van waterlichamen en stroomgebieden. Cases waarin doelen voor verschillende functies zoals hoogwaterbescherming, scheepvaart en recreatie aan elkaar worden verbonden kunnen bijzonder instructief zijn. Het lijkt vaak alleen maar mogelijk om herstelprojecten uit te voeren door maatregelen ten behoeve van de verschillende functies ruimtelijk te scheiden.
3. Doelen voor het waterbeheer (KRW) en natuurdoelen (N2000) worden (nog maar) zelden geïntegreerd.
4. Bij de grootschaliger wetlandherstelprojecten is er gewoonlijk een lange tijdsduur tussen de planvorming en het uitvoeren van maatregelen, en vandaar tot het daadwerkelijk bereiken van de beoogde effecten (zeker 10-15 jaar). Dit betekent dat voor het inzetten van wetlandherstel binnen KRW maatregelpakketten verder in de toekomst moet worden gekeken dan de periode tot 2015.

I Introduction

The implementation of the EU Water Framework Directive in the Netherlands is in full swing. To develop effective measures to achieve Good Ecological Status, it is important to understand the relationships between the hydromorphological state of water bodies and the ecological (biological and supporting physico-chemical) targets. To improve that understanding, the available knowledge of relationships between hydromorphology and ecology, and experience with the effects of restoration measures, should be used fully.

The policy framework of “Wise Use and Conservation of Wetlands” is prevalent in the EU since 1995. This has been affirmed in the Water Framework Directive’s ‘Horizontal Guidance Document for the Role of Wetlands in the Water Framework Directive’ (2003). The functional role of wetlands within water bodies or river basins is particularly relevant for the WFD implementation. This applies not only to the WFD objectives of protection, development and restoration of the status of surface water bodies, but additionally to the relations with and through the groundwater.

The project “BOA Water en kwaliteit 2007 – onderdeel Ecologie; Hydromorfologie (& klimaat)”, initiated by the Directorate-General Water of the Ministry of Transport and Public Works, contributes to establishing biological and physico-chemical objectives for Heavily Modified Waterbodies. It does so by highlighting the relationships between hydromorphology and the achievable ecological state of water systems. This includes the prospected effects of climate change on water quality and ecology. Hydromorphology and climate affect the ecological target variables of the WFD and water quality-related user functions via steering variables.

As part of the programme to assemble available expertise and experiences useful for the implementation of the WFD in the Netherlands, WL/Delft Hydraulics has been requested to assemble international experiences with restoration in wetlands. Such a study should contribute to designing effective wetland restoration measures in the Netherlands.

The objective of this study is to collate experiences with wetland restoration projects in an international context. The insights delivered by the results of these restoration actions may be very useful for the implementation of the Dutch implementation process of the EU Water Framework Directive. In particular this refers to hydromorphological measures that work on longer-term restoration perspectives. Additionally mitigation options for irreversible changes in water bodies and river basins are at stake.

The study presents an overview of relevant restoration measures, and translates the effects of these measures on ecological objectives. The links between surface water and groundwater objectives and specific wetland objectives (Birds and Habitats Directive / N2000, Ramsar, etc.) will be highlighted, as well as issues of scale, and the potential significance of climate change on wetlands.

2 Wetlands in the Water Framework Directive

The European Water Framework Directive (2000/60/EC) has the ambitious objective to reach the good status for all water bodies in the EU in 2015 by establishing a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater. By adopting the Water Framework Directive, the EU member states have committed to take the necessary actions to achieve the good status for water quality in all waters in Europe.

Protection, restoration and enhancement of wetlands is a direct consequence of this objective, as Article 1 states that the EU Member states will “prevent further deterioration and protect and enhance the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems”. The surface water and groundwater objectives will be achieved under the WFD’s environmental objectives, and protection and restoration of wetlands should help to achieve these objectives in a sustainable and cost-effective way.

Other Directives, such as the Birds- and Habitats Directive, similarly set objectives for the conservation and enhancement of wetlands and their flora and fauna. In many cases, measures to achieve objectives of Water Framework Directive and Natura 2000 should benefit each other. The program of actions should be implemented in national policy.

The role of wetlands in the WFD is elaborated in the CIS Guidance Document no. 12 “The role of wetlands in the Water Framework Directive”. No definition of wetlands is presented, but wetlands are regarded from their functional role in relation to the WFD. This means both the relations between water bodies and an adjacent wetland, and the role of a wetland in the hydrological cycle of a river basin. In the WFD context, wetlands are relevant where there is a relation with WFD targets for surface water, groundwater, transitional and coastal waters.

This role is represented in Figure 2.1 and 2.2, showing the different ecosystems that may be present in a river basin and that may be relevant to achieve the WFD objectives:

- a. Wetland ecosystems identified as water bodies (or several water bodies)
- b. Riparian, shore, and intertidal zone quality elements of surface water bodies (wetlands that are part of water bodies)
The WFD hydromorphological quality elements include the structure and condition of riparian zone of rivers, shore zone of lakes, and the intertidal zone of transitional- and coastal waters.
- c. Terrestrial ecosystems directly depending on groundwater bodies
These should be restored to avoid or remedy significant damage.
- d. Small elements of surface water connected to water bodies but not identified as water bodies

- e. Ecosystems significantly influencing the quality and quantity of water reaching surface water bodies, or surface waters connected to surface water bodies
Wetland ecosystems adjacent to a water body influencing the status of that water body should be encompassed in riparian, lakeshore, or intertidal zone, and thus are part of that water body. In the Netherlands' usually heavily modified water bodies (HMWB), these ecosystems have been reduced strongly in size and also in effect on the water body due to embankment, infilling, or lack of water-level fluctuations. Therefore restoration/mitigation of hydromorphology of these areas should be one of the priority issues of the WFD implementation.

However, also ecosystems that are not adjacent to a water body may have an influence on it because of hydrological connections. Alternatively, the water body may have an influence on an adjacent or more distant wetland, either through surface water or groundwater connections. In those cases the quality of water entering the water body should be ensured, and relevant action should be taken to protect, enhance, restore or create such ecosystems.

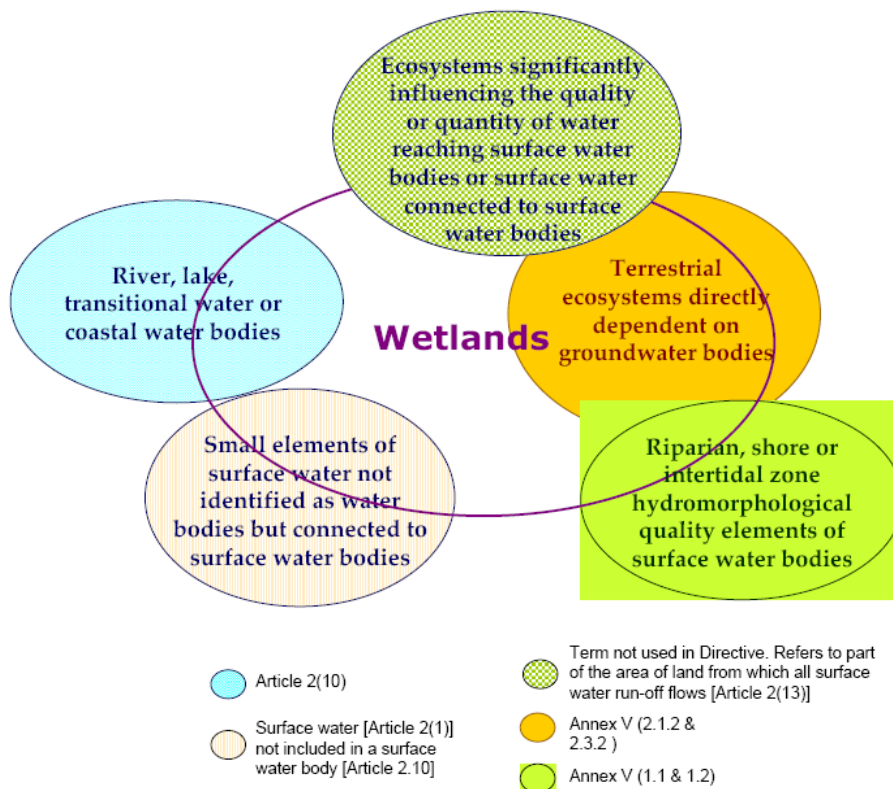


Figure 2.1 Ecosystems that may be present in a river basin and that may be relevant to achieve the WFD objectives (source: CIS Wetlands Guidance, 2003)

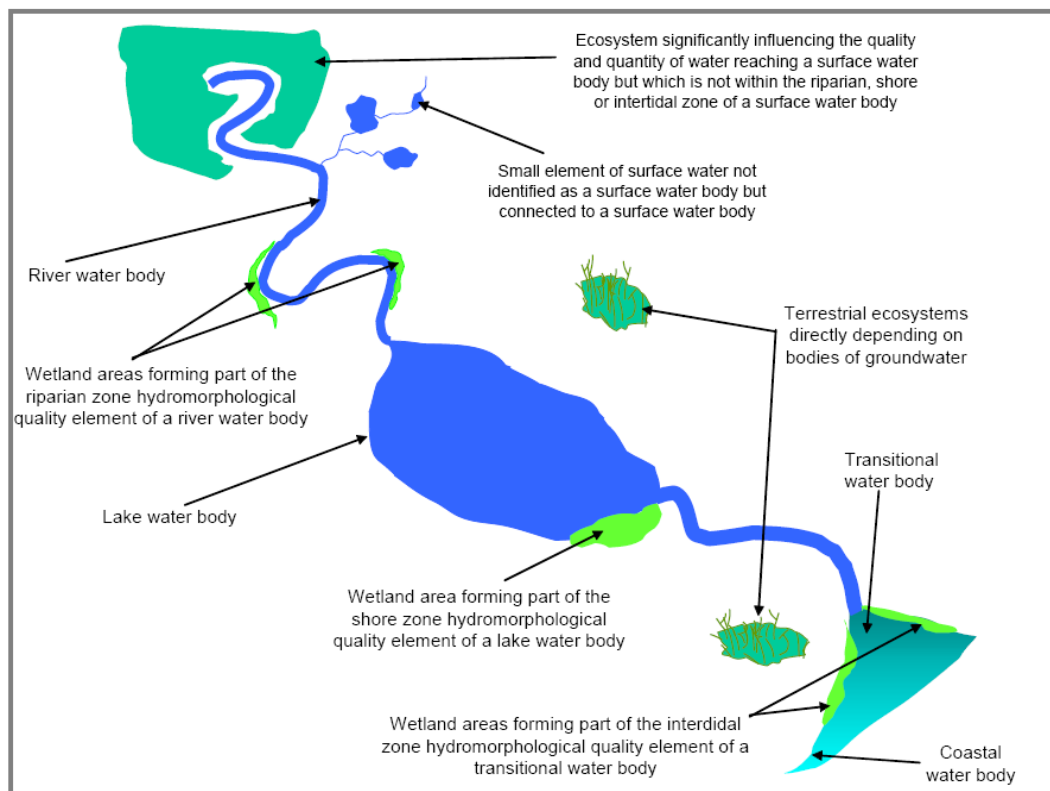


Figure 2.2 Ecosystem types within a river basin that may be relevant in the context of the WFD (source: CIS Wetlands Guidance, 2003)

3 Wetland restoration projects: an overview

A major marking point in the conservation of wetlands is the Convention on Wetlands, signed in Ramsar in 1971. The ‘Ramsar Convention’ is an international treaty providing a framework for the conservation and wise use of wetlands. The Ramsar Convention includes the collation of a database of ‘Wetlands of International Importance’(currently 1700 worldwide). Designation as a Ramsar site should provide a special protection status for a wetland (to be incorporated in national legislation), and is often the basis for the development of management plans that address the need for specific restoration actions.

Large-scale wetland restoration usually is an amalgamate of actions that address local ecosystem degradation. However as problems of ecosystem degradation often occur at the scale of catchment areas, larger visions and restoration schemes have been developed that attempt to integrate various restoration projects on a national, regional, or transboundary scale. In Europe such schemes are for instance the Rhine Action Program, the Danube Green Corridor program, various national biodiversity action plans, or various European visions for Living Rivers.

On a global scale, large-scale wetland restoration projects have been initiated as well. Particularly ‘grand projects’ are some North American projects that have provided new concepts and experience with ecological restoration.

The largest wetland restoration project today is the Comprehensive Everglades Restoration Project (CERP; <http://www.evergladesplan.org/index.aspx>) funded by 8,000 M\$ from the US federal government, aimed at the qualitative and quantitative recovery of the natural water flows in central and south Florida (see Box).

Other ambitious large-scale wetland restoration projects in the US include the restoration of San Francisco Bay (<http://www.sfwetlands.ca.gov/>), Chesapeake Bay (<http://www.chesapeakebay.net/>), Delaware Bay, Colorado River, Upper Mississippi River, and the anticipated restoration activities in the Mississippi Delta and other Gulf coast wetlands.

Large-scale wetland restoration in Southern Florida



The CERP (Comprehensive Everglades Restoration Project) includes measures to reduce nutrient emissions from agricultural lands, the re-meandering of the channelised Kissimmee River, recovery of the aquatic system of Lake Okeechobee, enhancement of freshwater deliveries to coastal lagoons along the Atlantic and Caribbean coasts, creation of large-scale stormwater retention areas, and provision of a nutrient-poor water sheet-flow to the Everglades National Park. One of the pillars of CERP is the Kissimmee River Restoration Project, which has the central goal to restore ecological integrity of the river/floodplain ecosystem. The former wetland reclamation project, conducted in the 1960's, had resulted in the elimination of water-level fluctuations and the loss of 140 km² of wetlands (Koebel 1995).

A general conceptual model was developed that links hydrology and habitat structure with floodplain structure. The main objectives for the restored system are:

- Reestablishment of inflows similar to historical discharge characteristics.
- Acquisition of approx. 34,000 ha of land in the upstream lakes and river valley.
- Continuous backfilling of 35 km of canal.
- Removal of 2 water control structures.
- Recarving of 14.5 km of former river channel.

The restoration started in 1997 (5 years after the project was approved) and involved the removal of weirs, infilling of a straightened channel and restoring the old meandering channel over a distance of 90 km long Kissimmee River (central Florida). The construction phase is expected to be completed in 2010. A major component of the restoration project is an extensive ecological evaluation programme, designed to assess the success in restoring ecosystem integrity and to provide finetuning and adaptive management of the recovering ecosystem during and after restoration. Various 'targets of success' have been established and will be monitored during and after the construction.

4 Wetland restoration database

A broad survey was made of restoration projects in wetlands in rivers, lakes (including peat lakes) and transitional waters (estuaries), focussed on types of wetlands that can be considered relevant for wetlands in the Netherlands. The starting point of the survey was the database of Ramsar-sites (www.ramsar.org), and a variety of restoration projects were found on various books and websites. The largest number of wetland projects were encountered for neighbouring countries Germany (68), United Kingdom (57) and France (40). Ramsar information sheets were an important source of information. These documents often include descriptions of impacts and (proposed) restoration measures.

Additionally, 45 EU-Life projects were included that involved relevant wetland restoration actions. Further sources of information were the nature restoration overviews of EAF (European Action Fund), WWF (World Wide Fund for Nature), Wetlands International, ECNC (European Center for Nature Conservation), RSPB (Royal Society for the Protection of Birds), and RCC (The River Conservation Center). Valuable information was also retrieved from national government programmes: the German 'Living Rivers' factsheets, the British UKBAP (UK Biodiversity Action Plan) and factsheets, and the French 'Plan Loire Grandeur Nature'.

The data can be found in a spreadsheet 'Wetland restoration projects.xls'.

The spreadsheet currently consists of 312 relevant projects, selected on the basis of potential relevance for the Netherlands. The list includes 194 riverine wetlands, 99 lake-associated wetlands and 35 wetlands associated with transitional water bodies (N.B. some wetlands represent more than one water body category).

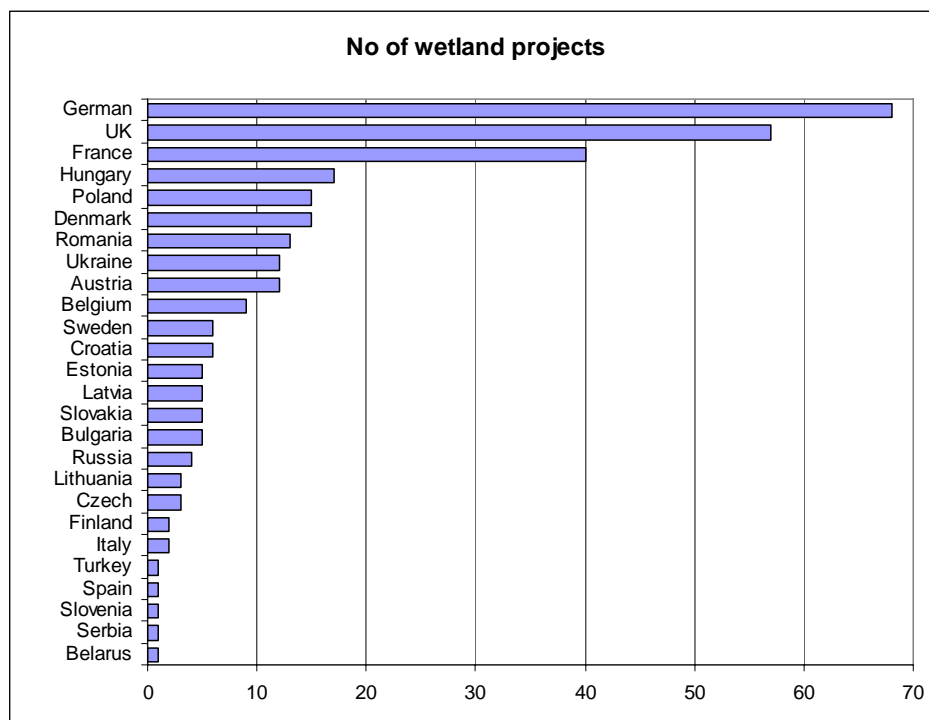


Figure 4.1 Number of wetland restoration projects in the spreadsheet by country

General indicative information that was obtained, was included in the spreadsheet, including descriptions of:

- Type of water body (river, lake, or transitional).
- Habitat types in the wetland.
- Impacts.
- Restoration and enhancement actions.
- Time and duration of project.
- Availability of monitoring data.
- Project costs.
- Documentation, web resources.

Various kinds of impact were mentioned in the sources. The Ramsar database, as well as other sources of information provided by wetland managers, lists many impacts. The next step was to categorise impacts according to pressures acting on the wetland. Five types of pressure were recognised:

- Chemical pressures.
- Hydrological pressures.
- Morphological pressures.
- Biological pressures.
- Pressures derived from human use.

Because of different naming of measures, we distinguished different categories of impacts and measures as listed in Tables 4.1 and 4.2.

Table 4.1 Impacts on wetlands mentioned for individual wetlands (Ramsar Information Sheets; impacts mentioned > 3x)

CHEMICAL PRESSURES	HYDROLOGICAL PRESSURES	MORPHOLOGICAL PRESSURES
Eutrophication	Changed hydrology	Bank reinforcement
Increased salinity	Disconnection of floodplain	Disconnection of sidechannels
Low sediment stability	Disconnection of sidechannels	Floodplain modification
Water pollution	Drainage/lowering groundwater level	Land reclamation
	Lowering groundwater level along river	Low sediment stability
	Reservoirs for hydropower	Reduced sediment supply
	River regulation	River incision
		Road construction
		Sand/gravel extraction
		Siltation

BIOLOGICAL PRESSURES	HUMAN USE PRESSURES	
Barriers for fish migration	Disturbance	
Construction of fishponds	Forestry	
Decline of meadows	Hunting	
Loss of species and habitats	Intensified agricultural use	
Succession	Lack of eco-agricultural management	
Exotic species	Poaching	
	Tourism	
	Urbanisation	
	Fisheries	

Table 4.2 Measures taken to improve wetland status

Bank naturalisation	Forest naturalisation	Restore morphology
De-embankment	Habitat construction	Retain water
Enhance lateral connectivity	Invasive species control	Riverbed reconstruction
Extensive agriculture	Mowing/haymaking	Species reintroduction
Extensive grazing	Naturalise water-level regime	Water-level increase
Fine sediment removal	Reduce external nutrient load	Weir/dam operation
Fish migration	Reed management	Miscellaneous
Fish stocking/removal		

5 Pressures and impacts

In the case when water bodies do not have the good status, the Water Framework Directive stresses the need to identify pressures and impacts on water systems. A proper program of measures should address these pressures and impacts.

From the description of each restoration project the pressures that were acting in that specific case were identified. These were categorised according to the five general groups of pressures addressed in Table 4.1.

Table 5.1 shows that all groups of pressures were well represented in the wetland restoration projects, with chemical pressures in 25% of the cases, morphological pressures in 32%, hydrological pressures in 36%, biological pressures in 13%, and human use pressures in 24% (total 407 pressures identified in 312 cases).

Table 5.1 Frequency of types of pressure in restoration cases of river-, lake- and transitional water-associated wetlands

	chemical pressures	morphology	hydrology	biology	human use
total (312)	78 (25%)	101 (32%)	111 (36%)	42 (13%)	75 (24%)
rivers (194)	24 (12%)	89 (46%)	71 (37%)	22 (11%)	45 (23%)
lakes (99)	53 (54%)	14 (14%)	31 (31%)	18 (18%)	26 (26%)
transitional (35)	8 (23%)	6 (17%)	14 (40%)	5 (14%)	12 (34%)

In general the pressures and impacts applying to the European wetland cases show similarity to those identified for the Netherlands (STOWA 2005).

Eutrophication and its effects can be considered a main topic on which restoration is targeted in lakes. Other chemical pressures, such as high levels of pesticide residues, heavy metals, or antifouling residues, were found to be regarded an issue for restoration in only a few wetland cases. Hydrological pressures (water-level regulation, reduced groundwater flow) are an important problem as well. In the European context, biological pressures (invasive species) and human use (overfishing, disturbance, forestry, intensive agriculture) are addressed in only a limited number of cases.

Similarly analogous to the Dutch situation is that restoration issues in rivers are dominated by morphological pressures and impacts, such as modification of channel and riverbanks. Also hydrological pressures (flow regulation, disconnection of floodplain waters, lowered groundwater level) are prominent. In several cases, human use differs from the Dutch situation, for instance for mostly eastern European floodplains where forestry is a major form of land use.

In transitional waters, water pollution (including eutrophication), embankment and changed hydrology are the most commonly identified pressures. This is also similar to the pressures perceived in the Netherlands.

6 Restoration measures

In this section an overview of measures is presented. The list of categories presented in Table 4.2 is further detailed below.

Generally the majority of measures applied to restore wetlands is similar to methods already applied in the Netherlands. In lakes the main measures are aimed at combating eutrophication: reduction of external nutrient sources, biomanipulation, and in several cases methods to prevent internal recovery of nutrients (dredging, chemical stabilization of sediment, etc.). Also various cases apply to vegetation management of marginal wetland (extensive grazing, reedbed creation, reedbed and meadow management methods, etc.).

In rivers, major approaches are the enhancement of lateral connectivity (increase flooding, reopen lateral channels), habitat creation, bank naturalization, and extensive grazing in the floodplain.

For transitional waters, less cases were available. Major approaches include opening or removing embankments, habitat creation, and dredging of accumulated sediment.

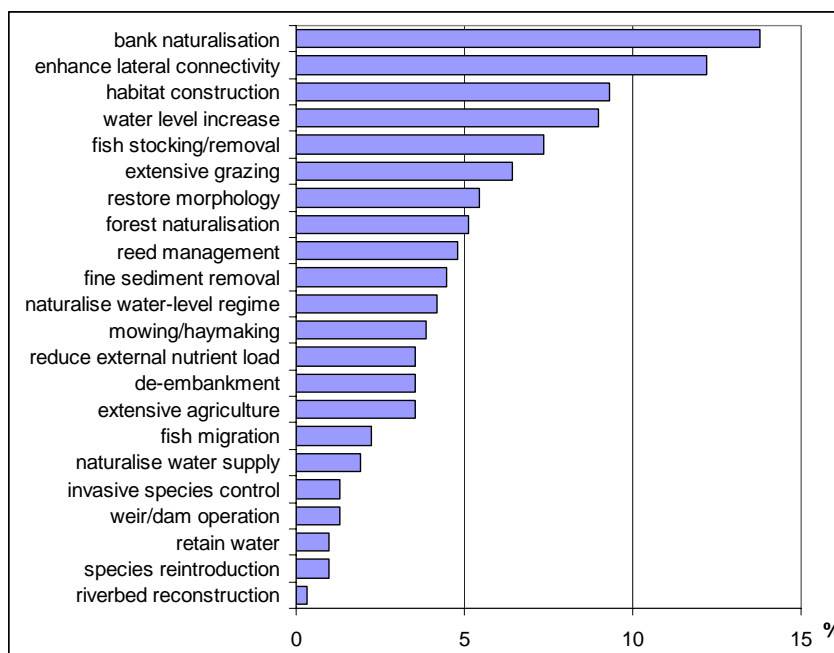


Figure 6.1 Categories of wetland restoration measures in 312 cases

Bank naturalisation

Along many rivers, in particular in western Europe, the banks are reinforced by stones, gravel, concrete or other hard materials to fixate the navigation channel and prevent erosion. Naturalisation measures include replanting of vegetation (several French rivers), removal of bank constructions (Rhine, Ems, Lippe, Mura, Isar), allowing a certain degree of erosion (Ain, Spree, Mur), reconstruction of groynes (Drau, Pitealven), re-creation of sandbanks (Ems), and various low-impact constructions (also referred to in UK as environmentally-

friendly or bio-engineering methods, and in Germany and Switzerland as ‘ingenieurbologische Methoden’).

Some projects involve the shoreline of lakes, e.g. construction of breakwaters (Lac du Bourget), or removal of bank linings (Bautzen reservoir).

De-embankment

Large areas along the main rivers in Europe have been isolated from the active floodplain due to past embankment. Opening of major embankments is locally applied to restore functional floodplain areas. Several of such projects have been completed in the Romanian Danube Delta (reconnecting of former agricultural polders, embanked in the 1980's: Cernovca, Fortuna, and Babina; or former fishpond complexes: Holbina-Dunavat, Popina). The Lenzener Elbaue, along the River Elbe (Germany), is a major de-embankment project is in the stage of completion. Another example is the Severn river restoration (UK), where at 18 sites the embankments along the channel will be opened. De-embankment of freshwater tidal floodplains has been completed at Hahnöfersand (Elbe, Germany), Donges-Est (Loire estuary, France), and is intended along the Zeeschelde (Belgium).

Enhance lateral connectivity

The active floodplain in almost all rivers in Europe has been strongly reduced in size. Floodplain areas have become hydrologically isolated from rivers, and restoring lateral connections has been the objective of many restoration projects.

In many cases old river branches have been reopened, either by restoring the in- and outflow (Danube-Wachau and Untere Lobau, Weser-Fulda, Rhône-Rossillon), or by digging out the silted-up channel course (Ain, Rhein-Karlsruhe). Also, cut-off meanders have been reactivated in several cases (Drau, Meuse-Haute Marne).

Other cases imply the new construction of side-channels (Rhein Bislich-Vahnum,)

Other possibilities are restoring natural drains in the floodplain (Ems, Weser-Fulda, Rhein-Karlsruhe), or making connections between river and gravel pits in the floodplain (Tisza, Weser-Heinsen)

Extensive agriculture

One of the overall goals of EU agricultural policy is to reduce the ecological impacts of agricultural land-use (loss of habitats, runoff of nutrients, pesticides). For that reason, large areas are taken out of intensive culture. Many of such areas are part of, or connected to, important wetlands. In those cases, transition to forms of extensive agriculture may be included in wetland restoration schemes. Usually the transition consists of creating extensive grazed lands, though other sustainable farming schemes are sometimes aimed at as well. Examples of transition to low-impact agriculture are the Eider Valley (Germany), Kalimok marshes (Bulgaria), Fertő (Hungary), Matsalu Bay (Estonia), and Oder Delta (Poland). Grazing using various kinds of animals (traditional cattle, horses, sheep, wisent) has been applied in many wetlands (examples are Elbe-Sudeniederung, Kühkopf-Knoblochsaue, Ostufer Müritz, Peene Valley (Germany), Hortobagy, Tisza river (Hungary), Pape wetland (Latvia), Middle Loire (France), Narew (Poland)).

Fine sediment removal

In many lakes and regulated rivers and estuaries problems with accumulated fine sediments are manifest, and prohibit the chances of recovery of ecologically diverse ecosystems.

Local dredging of accumulated sediment layers has been applied in many cases, though mostly not primarily for ecosystem enhancement but e.g. for navigation or water supply instead. Dredging for restoration usually requires extensive effort since it implies removing as much as possible silt from a lake. Examples are Grand'Mare lake and Lac de Grand Lieu (France), Lake Brabrand (Denmark), and Srebarna (Bulgaria).

In the case of accumulation of fluid mud (a common legacy of severe eutrophication), mudpumping has been applied in several lakes. Examples are Cockshoot Broad (UK), De Blankaart (Belgium), and marsh ponds in Baie de Somme (France).

Fish migration

In order to reestablish the migration routes for migratory fish species (such as Atlantic Salmon (*Salmo salar*)), barriers have been made passable by constructing various kinds of fish ladders. Programmes for reconnecting upstream and downstream parts of river basins are well under way along the Rhine, Meuse, and Vistula rivers including their tributaries. One step further is the complete removal of obstacles for fish, which has been conducted on a smaller scale in rivers and streams such as the Mur River (Austria).

Fish stocking/removal

There is a wealth of cases where manipulation of the fish stock has been applied to restore lakes and rivers.

Biomanipulation includes the removal of planktivores and/or benthivores, and/or the stocking of piscivorous fish, in order to alter the trophic chain in a lake. Many studies, including syntheses, have been published, and various cases have been included in the data, although the overview is far from complete.

Stocking of fish for population recovery is included under 'Species reintroduction'.

Forest naturalisation

Floodplain forests along many rivers has been transformed into tree plantations, in particular for the cultivation of poplars. Reversion of cultivated forest into natural forest after cutting of exotic trees has been part of several floodplain restoration projects e.g. along the rivers Danube and Drau in Austria.

Habitat construction

Habitat creation for specific flora and fauna groups has been applied in many wetland restoration cases, often as the result of hydromorphological actions. For this purpose, we restrict the term 'habitat construction' here to (usually) small-scale physical creation of biotopes. Examples are the creation of bare soil surface on which specific vegetation may establish (Hortobagy, Hellegrabenmundung), creation of small ponds (Donaumoos, Ill River, Swabian Danube Valley, Severn, Prut River), small sand or gravel islands (Danube floodplain, Kopacki Rit, Lac du Bourget), or the input of large woody debris (Danube floodplains, various rivers and streams in Germany). Some habitat construction is specifically aimed at species conservation, e.g. nest sites for Black tern *Chlidonias niger* (Rochefort Marshes), or breeding habitat for Bittern *Botaurus stellatus* (Norfolk Broad)

Invasive species control

In many disturbed wetlands severe problems of invasive species occur, including exotic flora and fauna. In many floodplains massive cover of alien vegetation has developed, extinguishing local flora including protected species. Particularly troublesome species in Europe are Giant Hogweed (*Angelica archangelica*), Japanese Knotweed (*Fallopia japonica*), Himalayan balsam (*Impatiens glandulifera*), and Floating pennywort

(*Hydrocotyle ranunculoides*). Efforts to eliminate invasive flora have been included e.g. in the Morava River LIFE-project (Slovakia). Eradication often is not successful, and longer established species often become a persistent but not dominant feature of the vegetation. Fauna invasions may threaten biodiversity of flora and fauna as well. No attempts to eliminate macroinvertebrate invaders were found in the literature. Particularly in eastern European countries, local management measures often include measures to eradicate Muskrat (*Ondatra zibethicus*), Coypu (*Myocastor coypus*) and Raccoon (*Procyon lotor*), but effectiveness often is doubtful.

Naturalise water-level regime

Many lakes in Europe have been affected by water-level regulation and the consequent reduction in seasonal flooding of marginal wetlands. Due to water-level regulation, emergent vegetation and flood-meadows have disappeared or undergone succession, and impacts on fish populations and waterbirds have been severe. A good example of the effects of restoring large natural water-level fluctuations is Lake Hornborgasjön (Sweden). Partial restoration of natural water-level fluctuations has been applied in Lake Taakern (Sweden). Managed (seasonal) water-levels have been applied to restore natural wetland vegetation in some cases (example: Walberswick Marshes (UK)).

Water-level increase

To rehabilitate wetlands after desiccation, an (temporary or permanently) increase of the water level has been applied often. In rivers this has been done by replacing or constructing weirs (for instance log-weirs, gravel dams or sills (e.g. Drau river, Austria)). There are many examples of wetlands where the groundwater has been raised to improve the moisture condition for the vegetation (Baie de Somme (France), Galenbecker Lake (Germany), Costuleni wetland, Prut River (Romania)), Tatham Moor and Otmoor). The Polder Randow-Rustow (Germany) will be rewetted in a very controlled way over the course of 15 years.

Reducing external nutrient load

Reducing the inflow of nutrients is usually conditional for the restoration of eutrophied waters. Apart from emission reduction and decoupling of sewage overflow, inflow of nutrients into lakes has been reduced by diverting eutrophied water (Lake Vaeng) or constructing a marsh (helophyte) filter (Galenbecker Lake (Germany), Swidwie (Poland)), or inlet lake (Lake Brabrand (Denmark)). At the Blankaart (Belgium), small brooks discharging into the lake were decoupled.

No records were found on chemical treatment at lake inflow.

External nutrient inflow reduction can also be achieved by creating buffer strips between agricultural (fertilised) fields and a stream (River Dijle (Belgium), R. Skjern (Denmark), R. Narew (Poland), R. Rur (Germany/Netherlands)).

Reduce internal nutrient loading

Reduction of nutrient concentrations is usually conditional for the restoration of lakes. Apart from reducing the external inputs into lakes through stream inflows, runoff and precipitation, internal measures can be taken to prevent nutrients to reach the water phase. Several physico-chemical methods have been applied for the reduction of internal nutrient mobilisation in lakes. Bottom oxygenation (increasing P-binding to sediment) has been applied e.g. in Lake Fure and Lake Hald (Denmark). Aluminium or gypsum treatment also has been applied in to lake sediments for that purpose (e.g. Lake Sonderby (Denmark) and Norfolk Broads (UK)).

A potentially applicable method, reported from Finland, is ploughing of the sediment, by which a) the nutrient-saturated top-layer is worked down, and b) anoxic sediment is oxidated.

Stabilisation of lake sediment prevents resuspension and reduces fluxes of P to the water layer. to reduce resuspension, various measures can be taken such as benthic barriers (Finland), promoting macrophyte cover (Norfolk Broads (UK)), sediment compaction through temporary drawdown (Finland), or compartmentation of lakes.

A recent development is the application of Phoslock, a modified clay (bentonite) with strong P-binding agent (lanthanum).

Reed management

Reed marshes decline is usually related to eutrophication and water-level regulation. To maintain healthy reed stands, reed cutting or burning (every 2-3 years) and removal of trees and shrubs from reedbeds are common methods. Extensive reed management practices are traditionally applied in reed-dominated wetlands such as Danube Delta (Romania, Ukraine), Neusiedlersee / Fertő (Austria, Hungary) and Norfolk Broads (UK).

To prevent terrestrialisation of reedbeds, litter scraping and increased harvest frequency (Neusiedlersee) have been applied.

Restore morphology / Riverbed reconstruction

Remeandering of streams and small rivers has been widely applied in lowland areas. Large-scale naturalisation of river-floodplain systems has been carried out in the Skjern River (Denmark) and Slampe River (Latvia). On a smaller scale, river sections have been reshaped or remeandered (River Cole (UK), R. Skerne (UK), R. Brede (Denmark)). Numerous smaller scale projects have been carried out, in particular in smaller streams. New meanders are created, the riverbed is widened and substrate is added.

A special case is elevation of the riverbed of incised rivercourses by sediment deposition (examples: Lippe River (Germany), Stöbbertal (Germany)).

Species reintroduction

Stocking of fish to enhance indigenous populations has been applied, in particular in many rivers. Examples are the stocking of migratory salmon applied in several rivers and their tributaries in Europe (Rhine, Loire, Vistula), in combination with restoring their migration pathways. Various fish species have been stocked in the framework of the Donau-Auen restoration project (see chapter 7).

Reintroductions of mammal species in wetlands are relatively rare. Beaver *Castor fiber* reintroduction programmes have been carried out in Germany (Bayern), France (Loire) and the Netherlands.

The issue of genetic conservation of European Black poplar *Populus nigra* has been subject to extensive research by EUFORGEN Populus network and resulted in several planting trials in floodplains of large rivers.

Miscellaneous

Various methods for ecological restoration of wetlands not related to the above-mentioned categories have been identified. Examples:

- Adjustment of weir operation, to allow minimum or seasonal flows (Drava river (Croatia), Scandinavian rivers)

- Replacing weirs or dams by riffle-bars (River Brede (UK), River Evenlode (UK), Lippe (Germany)), boulder cascades (Afon Ogwen (UK)) or log-weirs (River Wylfe (UK)).
- Transplantation of submerged macrophytes (applied in Lake Engelsholm, Denmark).
- Artificial macrophytes (Alderfen Broad, UK).
- Ditch restoration (Avon, UK).
- Vegetation removal, to optimise hydrological connectivity (L'Isle de la Platière, Rhone (France)), or removal of reed to create a mosaic landscape (Leighton Moss (UK)).
- River narrowing, to obtain more natural flow conditions (River Rhee (UK), R. Glaven (UK)).
- Combining wetland creation with flood-water retention (Ouse Washes (UK)).
- Connecting fen fragments by enlargement of reserves (Great Fen Project, UK).

7 Case studies

The links between wetland restoration projects and water quality objectives will be further highlighted in five case studies. The selection of cases has been made based on the following criteria:

- Selected restoration projects (or cluster of projects) should tackle clearly defined pressures and include a comprehensive approach with different inter-related actions to improve ecological status.
- Selected projects should include river-, lake-, and estuarine wetlands; likewise include different types of pressure (chemical-, hydrological- morphological-, biological- and human-use pressures).
- Selected projects should be well documented and sufficient data should be available.
- For selected projects a clearly defined responsible authority can be identified with accessible contact person.

Based on the total list of wetland restoration projects, a list of potential case studies was made and five were selected based on the above criteria

Table 7.1 Selection of case studies on wetland restoration

Project area	Country	Water category	Pressures	Contact
Donau-Auen	Austria	river	chemical pressure: eutrophication hydrological pressure: loss of flow in floodplain morphological: loss of floodplain channels biological pressure: threatened populations; invasive species human use: recreation	Nationalpark Donau-Auen GmbH Orth an der Donau, Österreich
Lake restoration projects	Finland	lake	chemical pressure: eutrophication hydrological pressure: water-level regulation	Finnish Environment Institute Helsinki, Finland
Norfolk Broads	UK	lake	chemical pressure: eutrophication morphological pressure: mud accumulation human use: recreation	Broads Authority Norwich, UK
Skjern Aa	Denmark	river	chemical pressure: eutrophication morphological pressure: channelisation, floodplain embankment and drainage biological pressure: blocked fish migration	National Environmental Research Institute Silkeborg, Danmark
Zeeschelde	Belgium	river/transitional	chemical pressure: water pollution hydrological pressure: regulated water levels morphological pressure: embankment of tidal areas, bank construction, channel deepening biological pressure: blocked fish migration	Instituut voor Natuur- en Bosonderzoek Brussel, België

The selected wetlands are described in the next sections. A general description will be followed by an overview of the stated ecological objectives and related actions that were or will be taken. If applicable, restoration results are briefly presented.

Relevant literature of the wetland restoration cases, additional information from internet and from local wetland managers or experts was used.

Particular attention is paid to the issue of how experiences from these restoration cases could be helpful for the implementation of the Water Framework Directive in the Netherlands.

Case study: Skjern Aa (Denmark)



The Skjern Aa restoration project involves the restoration of the lower reaches of a lowland river system that was heavily impacted by hydrological regulation, channelisation and eutrophication. The case highlights the significance of the restoration of an entire river valley and of its connections with upstream and downstream water bodies for achieving the good quality of water systems.

The Skjern river basin is the largest river basin in Denmark, 2500 km² of sandy plains that are predominantly in agricultural use. The lower part of the river, before it discharges in the Ringkøbing Fjord (North Sea coast), has been channelised in the 1960s and large part of the adjoining floodplain wetlands was reclaimed for agriculture. Since the 1980's water quality in streams and lakes over Denmark improved considerably, but stream recovery was very limited due to hydromorphological changes.

The Skjern River restoration project was initiated in 1987 (by decision of the Danish parliament). The objectives were 1) to restore the nutrient retention capacity of the river and river valley, 2) to restore internationally important habitats for wetland birds, 3) to improve fisheries in the downstream estuary Ringkøbing Fjord (including the conservation of the trout and salmon populations), and 4) to increase recreational value of the area. A key requirement of the project was that no decrease in the flood protection standard would be acceptable outside the project area.

The lower 19 km of the river was restored into a 26 km meandering river in 1999 -2002. The restoration consisted of re-creating the former meandering channel, infilling of the existing straight channel, and removal of a weir and two pumping stations. Along the river, inundable areas were created by shallow excavation. In total 22 km² of the former 40 km² of embanked meadows were rewetted. Additionally a new permanent shallow lake was created in the lowest part of the river valley. After the project was completed, extensive grazing management was started on most of the meadowlands.

The cost of the project were estimated at 37.7 M€ of which 16.1 M€ was needed for the actual construction works (Pedersen et al 2007); 3.3 M€ was cofinanced by EU-LIFE.

In a study of nitrogen removal in Danish restoration projects, the increase of nitrogen removal in floodplain wetlands has been estimated between 200 and 500 kg N ha⁻¹ year⁻¹ for distinct wetland types (Hoffmann & Baattrup-Pedersen 2007). These estimated values form the basis for the wetland restoration projection by the Danish government of 16000 ha to be restored to meet nutrient reduction objectives. However, according to this study the actually measured nitrogen removal rates might be lower than assumed. Though with a very crude figure, it was estimated that after completion of the restoration project the total discharges of N and P to the receiving water system were ≈10% lower than prior to it (Andersen 2006).

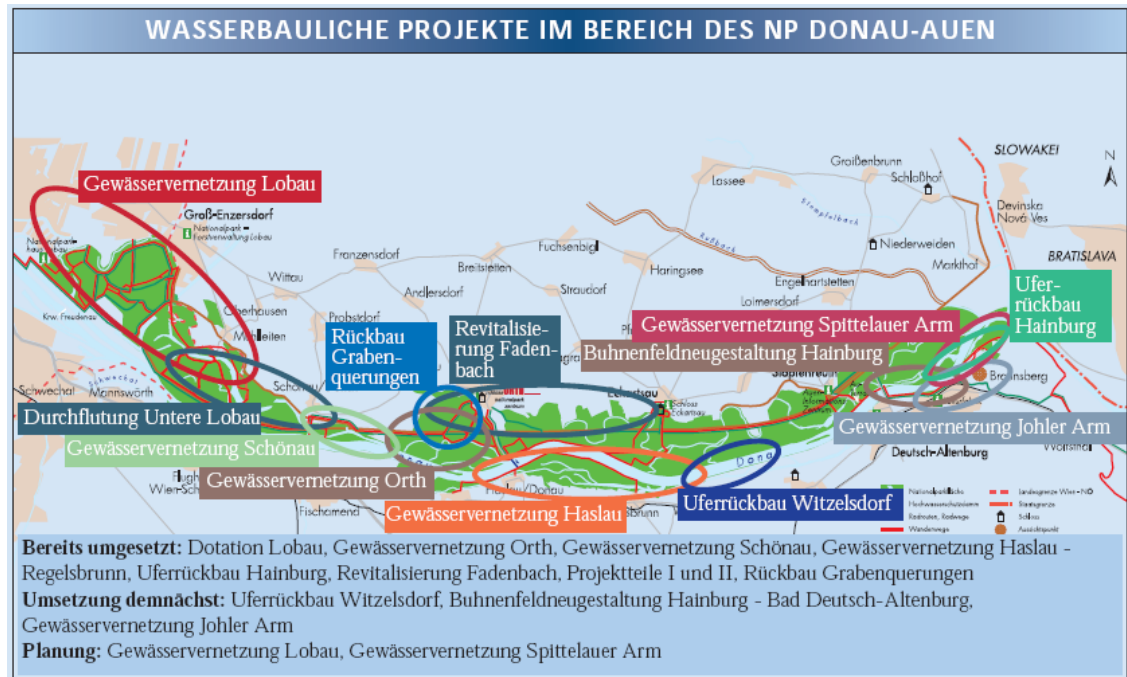
Surveys made after completion of the restoration project showed beneficial short-term effects on biological diversity, including the establishment of vegetation cover and recovery of macroinvertebrate communities (Pedersen et al 2007). However, it may be too early yet to assess fully the effects of the restoration on the ecological status of the Skjern River and Ringkøbing Fjord. A negative short-term effect was the redistribution of sediment in the newly created channel, obscuring biotic responses to restoration. It is uncertain how long it will take to reach a new hydromorphological equilibrium.

River restoration of the Skjern River has benefits for society through improved water quality and quantity, fisheries, recreation and flood risk reduction. After being restored from canalised and surrounded by intensive agriculture, to its natural profile in a valley with meadows and shallow lakes, the created annual net benefits for society were estimated at M€ 30 (according to cost-benefit analysis for the Danish Ministry of the Environment; Dubgaard et al 2003).

Learning points:

- Long-term monitoring may provide data for dose-effect relationships to be used in the WFD implementation process.
- More (quantitative) insight in effective nutrient retention and removal by restored wetland was acquired.
- Establishing a new hydromorphological equilibrium may take a long time which in turn may affect the long-term effects of restoration.
- Approach to incorporate changes in land use into program of measures for achieving ecological objectives for water bodies.
- Floodplain wetland restoration has clear benefits in WFD terms of water quality improvement and enhancement of ecological quality elements (e.g. fish); moreover it can be integrated with flood protection and socio-economic functions.
- In the Skjern Aa restoration case, the estimated monetary benefits (M€ 30) are remarkably high relative to the costs (M€ 37.7) of the restoration project.

Case study: Donau-Auen (Austria)



The restoration project Austrian Donau-Auen National Park shows the potential of different floodplain restoration measures and the potential links of specific actions with the ecological status of the Danube River, the largest river in Europe. An conceptual framework ('Gesamtkonzept') was developed to integrate the objectives and actions for ecosystem restoration, water quality management, flood protection, navigation interests, and recreational use of the area.

The hydromorphology of the Danube river has been altered significantly over the past centuries by the construction of dams and weirs, canalisation and riverbank constructions, riverbed incision and lowering of water tables, and the disconnection of floodplains and old river branches. Four major impacts can be recognised: 1. changes in channel morphology, 2. reduced longitudinal connectivity, 3. changes in bank morphology, and 4. reduced lateral connections. The latter three may potentially be rehabilitated. In particular, floodplains could be reconnected with the main channel, enhancing retention of floodwater and nutrients, fish migration and habitats of flora and fauna in the floodplain. Many species in the Danube floodplains have high conservation status and many wetland complexes are protected under EU legislation, including the Austrian Donau-Auen National Park.

The Donau-Auen National Park is situated along the Austrian section of the Danube River. The National Park was established in 1997. It includes floodplain forests, flood meadows, and inactivated river channels. The natural flooding regime has been impaired by the construction of dams along the main channel, effectively disconnecting the floodplains from the river.

A major part of the restoration project consists of reinstating (part of) the connectivity between the Danube River and the floodplain by reconnecting old floodplain channels ('Gewässervernetzung'). This includes the removal of all 'unnecessary' constructions along the river, or modification of structures to a state that least affects the natural river dynamics.

Three side-channels (Lobau, Orth, and Schöna) have been reconnected by opening of embankments near the inflow, and by removal of dams ('Traversen') along the channels. Several other reconnections are in preparatory stage.

Other actions involved the creation of specific biotopes by digging out ponds, restoration of small watercourses (Project Revitalisierung Fadenbach), wet-grassland management, and removal of bank constructions (e.g. Uferrückbau Hainburg, naturalisation of approximately 3 km of riverbank in 2005-2006).

Also, special programmes were set up for promoting several target organisms by re-introduction (particularly threatened and locally extinct species: Huchen or Danube salmon *Hucho hucho*, Wildkarpfen *Cyprinus carpio m. hungaricus*, Weatherfish *Misgurnus fossilis*, Sterlet *Accipenser ruthenus*, Mudminnow *Umbra krameri*, European pond terrapin *Emys orbicularis*), or specific management measures (Black poplar *Populus nigra*, Vine *Vitis vinifera*, Wild pear *Pyrus pyraeaster*; dead-wood insects, Sea eagle *Haliaeetus albicilla*, Corncrake *Crex crex*). Also, control measures for invasive neophytes were taken.

Additionally, the restoration project included the provision of visitor facilities and educational activities.

The restoration project supplemented the regular management programme of the National Park, and was also connected to water management actions: removal of oil tanks, flood prevention and navigation channel maintenance. In the future all actions on this stretch of the Danube will be integrated under the 'Flussbauliches Gesamtprojekt', including flood protection, navigation, water quality and nature). Innovative methods have been proposed and are being implemented: bottom sediment stabilisation (by mixing silt and gravel layers), and the construction of groynes that minimize ecological impact.

The Donau-Auen restoration project has been accompanied by an extensive monitoring programme. Particularly relevant studies have been made on the effects of side-channel reconnection on suspended matter and nutrient flows, and the effects on riverine fish populations. Reconnection of sidechannels was followed by a strong morphological response in the floodplains: gravel banks, eroding banks, formation of large woody debris and pool formation. Floodplain-specific flora and fauna responded rapidly but further succession is expected.

Parties involved in the restoration programme are the Nationalpark Donau-Auen (National Park Authority), Gemeinde Wien, Wasserstrassendirektion (WSD), Bundesministerium für Land und Forstwirtschaft, Umwelt und Wasserwirtschaft, and Bundesland Niederösterreich. Major restoration was done between 1997 and 2001, and was supported by EU-LIFE.

Learning points:

- Agreement on a Conceptual Framework ('Gesamtkonzept') incorporating objectives for water quality (WFD), flood protection, navigation and nature conservation.
- Restoration on large scale (Austrian sector of Danube River) in which lateral connectivity between river and floodplain is restored for several subsequent side channel systems.
- Scientific support by extensive monitoring and research programme.
- Inclusion of visitor facilities and educational activities in the restoration project.

Case study: Norfolk Broads (United Kingdom)



The Trinity Broads

The Norfolk and Suffolk Broads consist of several wide river valleys with a mosaic of lowland rivers, shallow freshwater to brackish peat lakes, reedbeds, carr forest and wet meadows. By the 1970s, many lakes in the Broads were severely affected by decades of nutrient enrichment with nitrates and phosphates, from water running off agricultural land and from sewage treatment works. During the last decades, many efforts have been made to restore the lakes from severe eutrophication.

The Broads is Britain's largest protected wetland and third largest inland waterway, with the status of a national park and Natura 2000 area. The main habitats are rivers and connected broads, fens, carr woodlands, drained marshlands (grazing marsh), and estuary, including a variety of habitats, supporting diverse plants and animals. The area is renowned for many species of wetland bird species (such as Bittern, Marsh harrier, Reed warbler, Sedge warbler). Several nationally protected plant species occur, such as Fen orchid (*Liparis loeselii*).

Nutrient enrichment has severely affected many lakes in the Broads since the 1970's. This led to excessive growth of algae and occasional blooms of blue-green algae, and the loss of aquatic vegetations dominated by water lilies and submerged plants. During the last decades, various measures have been taken to restore the lakes; part of the restoration actions was financed by EU-LIFE.

Restoration methods that have been applied in the Broads (only those measures that are not commonly used, are explained in more detail):

- *external nutrient reduction* (runoff from agricultural land and sewage treatment plants).
- *biomanipulation*: removal of cyprinid fish.
- *reducing the fetch distance of waves by means of barriers*, resulting in reduced wave energy and lower suspended solid concentrations in the water column.

- *mud pumping* (mainly for navigational purposes).

With mud pumping, water is injected into the riverbed sediments in river stretches that are exposed to tidal currents. As a result the mud becomes more fluid and is carried out to the sea by the forces of tides and gravity.

- *reedbed management* (EU-LIFE Bittern).
- *use of artificial plants* as substrate for macroinvertebrates.

In the Broads, it has been tested if artificial macrophytes could improve water quality by providing zooplankton refugia. Plastic brushes installed in a lake in eastern England resulted in a short term reduction in phosphates as they were absorbed by the periphyton growing on the brushes. They also initially provided a refuge for a variety of invertebrate taxa. After two years, the brushes became colonised by sponges, which greatly reduced the diversity of invertebrates using them. The use of this type of artificial refugia is unlikely to be repeated due to the short term beneficial nature of the effects, the expense and the practical difficulties of installation and removal.

- *excavation of peat ponds*, to reverse the succession from open water to fens.
- *creation of floating islands for helophytes*.

An island made of coir pallets supported by PVC floats was created with the objectives of producing an island of emergent vegetation which would also cover a boat navigation hazard. Many of the planted species grew well and resulted in a reasonable cover of emergent vegetation. The island edges needed replanting where eroded by wave action. Overall, the use of this technique to establish emergent plants was successful. However, the location of the floating island was not ideal as it was rather exposed. It is believed that a more sheltered area would be more effective as this would reduce the need to continually replant island edges affected by wind and wave action, as was required in this case.

- *restoration of helophyte vegetation in lake margins by removal of trees*.

Removal of overhanging Alder *Alnus glutinosa* and Grey sallow *Salix cinerea* trees from the edges of Cockshoot Broad and Hoveton Great Broad led to a vigorous growth of helophytes around the water's edge (mainly large *Carex* spp, in addition to small patches of *Phragmites australis* and *Typha angustifolia*). Hence, removal of trees from the edges was a simple and effective method for improving the vegetation in the littoral zone of the Broads. It has been important to monitor the site in order to control any woody regrowth.

In the near future, the focal points for restoration remain to be external nutrient reduction (improved sewage treatment and extensified agricultural land use), and biomanipulation. There is also a programme focused on rehabilitation of reedbeds and the creation of new peat-ponds. However, these measures are not related to WFD objectives but relate to other nature conservation targets for the area.

Learning points:

- Long tradition of lake restoration methods; ultimately WFD measures focus on external nutrient control and biomanipulation.
- Wetland restoration (reedbed, carr and wet meadow management), partly initiated before WFD was adopted, is based on biodiversity objectives (N2000), and has not been integrated with WFD measures.

Case study: Finnish lakes (Finland)



In the last few decades, in Finland almost one thousand lake restoration projects have been carried out in a wide array of different lake types. In this case, we focus on the importance of some novel restoration methods which have been used, as well as the organisation of communication within these projects. Many of the restoration measures could only be realized because of a good cooperation between authorities and local inhabitants: many local lake protection associations have been established and people spend a lot of time discussing their lakes.

In the last few decades almost one thousand lake restoration projects have been carried out in Finland. Initially, the objective of individual projects usually was enhancement of recreational use. Currently, the main objective of lake management is to achieve the good ecological status of surface waters. Owing to various successful restoration measures, the ecological status of many lakes has improved. Recently the most commonly applied restoration methods have been removal of aquatic plants, removal of cyprinid fish species, and oxygen enrichment. In addition, some novel techniques have been used, that have been rarely or never applied in The Netherlands. Examples are chemical precipitation of nutrients with iron-containing chemicals, temporary lake drainage, ploughing of bottom sediment, and injection of chemicals to stabilise the bottom sediment. Below, the application of these methods, as well as their (short-term) results, is discussed in some more detail.

Lake restoration in Finland started in the late 1960's. Over the subsequent decades favourable conditions have been restored in an increasing number of lakes, using an increasingly wide range of methods (e.g. aeration, dredging, raising water levels, macrophyte control). The intensity of lake restoration has doubled from approximately 20 projects (1970-1995) to approximately 45 projects per year (1998-2002). By 2002, restoration work had been carried out or planned for a total of some 800 lakes or lake waters.

The high number of restored lakes is largely owing to the initiative and independent restoration actions of water-area owners and other beneficiaries; private restoration efforts have been publicly encouraged since 1996. Consequently, low-tech and rather labour-intensive restoration methods such as mechanical control of macrophytes and manual removal of cyprinids have become quantitatively the most frequently used methods. Another

method that currently is promoted is biomanipulation by selective fish removal and actively increasing the stocks of piscivorous fish.

So far, lake restoration schemes do not include measures taken on the broader scale of catchment areas of lakes, such as the various steps to reduce nutrient or pollutant discharges from point sources or diffuse sources. However it is realized that for lake restoration projects to succeed, external loads must be limited; in practice the measures carried out to restore natural conditions in catchment areas are very closely linked with water quality management.

Novel restoration measures

- *Chemical precipitation of nutrients with iron-containing chemicals*
Restoration using what is referred to as ‘emerging methods’ such as the chemical precipitation of nutrients with aluminium chloride and gypsum containing iron (Fe) as an ingredient. The effects of chemical precipitation methods are rapidly apparent, which may encourage the use of other precipitation methods to ensure and maintain the achieved restoration results.
- *Temporary lake drainage*
The complete temporary drainage of a lake is an efficient way of settling and compacting the bottom sediment. This method provides dry work areas for shoreline restoration, which is a significant practical advantage.
- *Ploughing of the bottom sediment*
A new method of ploughing the bottom sediment is also promising. The aim is to enhance the sediment mineralisation rate and decrease gas formation, thus increasing the nutrient retention of the sediment.
- *Injection of chemicals to stabilise the bottom sediment*
It is also possible to inject chemicals to stabilise the bottom sediment in connection with fluffing.

Organisation of stakeholder communication

Lake restoration in Finland is more intensive and regular than in most other countries. There is a long tradition of cooperation and neighbour help in Finnish village communities, including the tradition of common work called talkoo. The initiative for restoration projects usually comes from people with permanent or holiday homes by a lakeshore, when their opportunities to swim or enjoy other recreational activities become restricted due to poor water quality or characteristics of the lake bed.

Many local lake protection associations have been established. The commitment of local people in Finland to lake management is an internationally significant phenomenon that can serve as an example for other countries. Besides the ‘talkoo’ tradition, an active information policy of the environmental authorities has contributed to the activity.

Learning points:

- Lake restoration in Finland has included many (novel) techniques.
- Decentralised organisation of lake restoration, with strong participation of local stakeholders.

Case study: Zeeschelde (Belgium)



Along the lower Schelde River, plans for wetland rehabilitation address the objectives of the Belgian national conservation policies, Birds- and Habitats Directive, as well as the Water Framework Directive. Moreover, restoration is connected to flood protection, harbour expansion and enhancement of navigation access to the harbour of Antwerpen.

The lower Schelde (Zeeschelde) is a unique tidal freshwater to brackish river with remnants of tidal wetlands along the banks. The river is heavily modified due to embankment of tidal wetlands, disconnection by upstream and tributary weirs, and ecosystems have been severely affected by pollution.

The objectives presented in the long-term ecosystem vision (Van den Bergh et al. 2003) are to optimise estuarine processes and the estuarine foodweb, including the filter function and connectivity for migratory fish. This objective is also the basis for the Maximum Ecological Potential. Accordingly, WFD measures comprise of improvement of the nutrient status (to reach natural ratios of N, P and Si) to reduce nuisance algal blooms, by reducing external sources and enhancing internal nutrient processing by zooplankton and zoobenthos. Studies are underway that should quantify the areal requirements of this process-based restoration:

- Spatial expansion of the estuarine area by relocating dykes and excavating unembanked elevated sites.
- Creation of controlled inundation areas (with reduced tide).
- Connections between embanked wetlands and the river.

Some recent study reports propose quantitative targets for ecological restoration (in terms of ha wetland) to be derived from functional contributions of tidal wetlands to a good ecological state of the river, from the viewpoint that tidal wetlands play a key role in the processing and immobilisation of N, P and Si.

In the first stage, four areas have been restored starting in 2002: Ketenissepolder, Paardenschor, Paddenbeek and Heusden. Larger scale projects are in initial stage: Kruibeke-Bazel-Rupelmonde (600 ha, under construction), Durmevallei and Prosperpolder. The realisation of (tidal) inundation areas is controversial because of a negative public perception of intentional flooding.

Long-term monitoring programmes will be started to address the lack of experience with reinstating (controlled) tidal wetlands. Important issues are:

- The impact of poor-quality river water on ecosystems in the inundated areas.
- The contribution of inundation areas to improvements in water quality and ecological status of the Schelde.

The restoration of tidal areas has been underpinned by both N2000 (protection and development of priority habitats and species) and WFD (improvement of water quality) objectives. The implementation of tidal ecosystem restoration measures will be linked to programmes for flood protection and enhanced accessibility of the harbours. Current projects have been initiated as compensation measures for dredging the navigation channel to the harbours of Antwerpen.

The programme has a strong transboundary element, and compensation measures have been negotiated between Belgium and the Netherlands.

Learning points:

- Wetland restoration objectives are expressed as areas to be reconnected to the tidal river. The extent of that area is related to functional role (i.e. nutrient reduction).
- Operationalising is only possible when integrated planning includes water quality, nature conservation, flood control, and navigation objectives.

8 Linking wetland restoration to WFD objectives

According to the Water Framework Directive, restoration measures in water bodies are required when the state of the ecosystem does not meet the Good Ecological Status. Wetland restoration measures may contribute to ecological status improvement of the associated water body or downstream in the river basin. The WFD's Wetlands Guidance therefore states that the WFD requires the restoration of wetlands within river basins that are part of water bodies, as well as of wetlands that influence the status of these water bodies. In the Netherlands water bodies have usually been designated as Heavily Modified, i.e. where human use has led to irreversible changes. Hydromorphological modifications, e.g. the loss of connected wetland, can be the reason why a water body is designated as a Heavily Modified Water Body. Such modifications may in some cases be reversed, but more commonly they should be regarded as irreversible. In the latter case the potential for mitigation measures should be investigated.

The most relevant aspect of hydromorphological condition of a water body is the fact that hydromorphology is a steering variable for ecological condition. Hydromorphology is also an important determinant of the ecological status of a water body. However, the use of hydromorphology as a quality element is only relevant in case the objective is to achieve the High Status. As some of the examples shown in this study demonstrate, the state of wetlands influences the status of the aquatic system and hence the ecological and chemical state of a water body. As wetlands play a crucial role in the nutrient economy of river basins, they may be important for achieving the objectives of downstream water systems (river, lake, transitional- and coastal waters).

To assess which measures may help achieving the good status, experiences from wetlands abroad may be extremely helpful as they provide information on the efficacy, feasibility and cost that may be indispensable for improving the design of new restoration programmes. Unfortunately, due to the time scale of the implementation of restoration measures and the monitoring of their effects, and the fact that the WFD was signed by the EU member states only seven years ago (in 2000), hardly any experiences have yet been reported with the effects of wetland restoration in terms of WFD objectives. In the case of Skjern River, estimations have been made on the quantitative impact of the restored system on the nutrient status of the river and downstream lagoon; similarly, in the Norfolk Broads restoration actions (nutrient input control, biomanipulation) are linked to water quality objectives. In the latter case, however, the benefits of restoring aquatic – terrestrial interfaces is not included in the considerations.

On the other hand, actions to improve the ecological status of a water body may be highly relevant to reach conservation targets, such as the protection of species or communities. Therefore there is a strong link between WFD objectives and those related to other international and national laws and treaties (e.g. EU Birds- and Habitats Directive, Ramsar Convention, Biodiversity Convention) that enforce the protection of wetland status. Generally, actions to improve the status of water bodies may affect the conservation status of wetlands. Also negative impacts are possible. For example, actions enhancing lateral connections between large rivers and floodplains may threaten protected flora and fauna in floodplains because of floodwater of insufficient quality, whereas on the opposite side the rewetting of former agricultural areas where a high nutrient accumulation had occurred may have adverse effects on water quality in the river. Particularly in Heavily Modified Water

Bodies there is a potential for conflict, especially when water quality has not improved while hydromorphological restoration or mitigation is already starting.

Another important aspect of the feasibility of wetland restoration is the importance of spatial and temporal scales. Small-scale wetland restoration projects, the majority of projects listed in the database collated for this project, generally will not result in significant improvement of the ecological quality at the scale of a water body or river basin. As is shown by case-studies (Skjern River, Donau-Auen, Zeeschelde), when the scale of wetland restoration approaches the scale of water bodies, significant benefits are to be expected. Unfortunately, no studies exist yet that evaluate the success of wetland restoration from this perspective. Moreover, different objectives should be stated for different-scale restoration projects, and it is unclear to what extent those objectives contribute to the achievement of an overall objective for a water body or river basin (Table 5).

Temporal scales may be highly relevant also. The WFD objectives have a distinct time horizon (in 2015 water bodies should be in good status, with possible extension to 2027). However, as the large-scale restoration cases show, the time span between initial planning and completion, and between completion and achieving the intended effect, can be considerably longer than this WFD time horizon. For example, the Skjern River restoration was decided upon in 1987, restoration activities started in 1999 and were completed in 2002, while the final ecological effect still is establishing itself. Likewise, the Donau-Auen project started in 1997 and its full execution is still underway.

Table 8.1 Spatial scales and objectives for wetland restoration (after Coops et al 2006). Generally the time scale of response to restoration increases with increasing scale.

River system	Gradients	Rehabilitation targets	Management actions	Biological indicators
River basin (10 ² -10 ⁴ km ²)	Longitudinal gradient, stream/river order, river to estuary transition	Improved water quality, reinstated upstream-downstream connectivity (corridor and flyway protection)	Emission control (legislation), dam removal, designation of conservation areas	Regional biodiversity, migratory fish, birds
River section (10-100 km ²)	Transverse gradient, river to hillslope transition, flooding intensity, minimum discharge	Undisturbed river-floodplain ecotone, landscape complexity	Mitigation of hydrological alterations (e.g. dam or weir operations, removal of minor embankments)	Resident fish, mammals, birds, flora
Local reach or floodplain (1-10 km ²)	Geomorphic variability, surface and subsurface flow, flow velocity (flow-reduced areas)	Enhanced connectivity (Geomorphology, hydrology) of channels, naturalised vegetation dynamics	Introduction of large herbivore grazers, sediment displacement, creating side-channels	Vegetation patterns, reptiles, amphibians, birds
Site or ecotope (0.01-1 km ²)	Patterns in soil and vegetation structure	Maintenance/creation of local structures and ecotones	Localised management (mowing, tree-cutting), reconnection of single oxbows or pools	Plant species composition, invertebrates, algal communities
Eco-element (< 0.01 km ²)	Microgradients related to humidity, nutrient availability, flow velocity, water depth, etc.	Maximum habitat availability, species conservation	Local management (mowing, fertilisation, tree-cutting), naturalising structures, pool maintenance	Plant species composition, macroinvertebrates

9 Lessons for WFD implementation in the Netherlands

An overview of wetland restoration projects in Europe was made for this study. Although there are far more projects than could be incorporated in the spreadsheet, and the various methods are probably not represented proportionally to their application, still a good impression can be obtained of the scope of wetland restoration activities in Europe over the past decade. The problems encountered in the assembling of such an overview highlights the potential role of wetland conservation organisations (such as the Ramsar Bureau, Wetlands International, and ECRR) in stimulating the integration and synthesis of results of restoration projects.

We may draw a number of general conclusions:

1. Because various types of wetland restoration have their analogues in cases in the Netherlands, we can learn from experiences and details concerning technical operation of measures.
2. In many cases wetland restoration has been carried out in isolation from other management objectives at the scale of water bodies or river basins. Particularly instructive are those cases where objectives for functions like flood protection, navigation, and recreation have been linked. In those cases, mostly the restoration efforts have been spatially segregated from measures to enhance those other functions
3. Integration of water management objectives (WFD) and nature conservation objectives (N2000) has been rarely addressed. This may be (partly) due to the fact that the WFD was signed only as recently as in 2000.
4. For larger wetland restoration programmes, there is usually a long time lag between initial planning and operationalising of measures, and then to achieving the intended effects. Typically the timespan between decision and completed restoration is 10-15 years. This has implications for the application of wetland restoration measures in the WFD, where the time horizon of achieving the objectives is 2015, with possible extension to 2027.

The implementation of the WFD in the Netherlands may benefit from exploring international case studies. Currently, we have the impression that results from international research on ecosystem restoration (e.g. EU-Framework Programmes, EU-LIFE projects; various journals, newsletters and other publications) are little used by water managers in the Netherlands. This would imply that dissemination of results from wetlands restoration projects could be improved. The current database may be an instrument that can be further developed to assist in knowledge sharing among those involved in wetland restoration. We would therefore recommend the adoption and expansion of the current database for further use.

The benefits from exploring cases in other countries in Europe (and beyond) can be summarized as follows:

- *Proven and innovative methods and techniques*

Several decades of wetland restoration in Europe have produced a wide body of knowledge and experience on restoration methods and techniques. However, this understanding is not readily accessible and only limited attempts have been made to synthesise them. In this report, only an overview of methods was given on what we regard as potentially useful innovative methods for the Dutch situation, without pretending to be complete and without attempting to give technical details. A recommendation would be to setup a platform for exchange of restoration experiences, bridging the gap between water / nature managers working with restoration planning, design and implementation.

It is obvious that potentially useful restoration methods to be applied in a project can never be exactly copied from an earlier project, because the differences in place and time always ask for location-specific solutions. Table 9.1 summarises approaches that are applicable in the Netherlands and experience gained with them.

- *Elimination of potentially ineffective restoration measures*

A multitude of methods has been applied for wetland restoration. Many of these methods do not, or hardly, have an influence on the status of the water body in the sense of the Water Framework Directive, e.g. measures to create habitat for specific flora or fauna. In other cases the effectiveness is unclear, and further studies including the collection of monitoring data are needed to know if such measures have any potential to be applied for contributing to good status achievement.

- *Technical issues*

By studying analogous cases water managers may learn how to optimally work out and apply certain restoration techniques.

- *Basic data for economic analysis*

Particular focus in the WFD is put on economic analysis; to achieve the objectives, a program of cost-effective measures should be proposed. For most restoration actions, only very crude estimates for both sides, cost and effect, can be made, complicating the design of feasible programs of measures. For some wetland restoration projects (Donau-Auen, Lower Elbe, Skjern Aa) monetary data are available that could aid the economic analysis of wetland restoration

- *New ways to involve stakeholders in a restoration project*

To gain support from stakeholders for restoration projects, the Finnish model could be worthwhile to consider.

- *Empirical and theoretical relationships*

Data of ecosystem effects of wetland restoration cases after completion can be very helpful in establishing dose-effect chains and ex-ante evaluation of (combinations of) measures. This is particularly so in the absence of such data from the Netherlands.

Table 9.1 Approaches for wetland restoration of which experiences can be useful for wetland restoration in the Netherlands

Approach/method	application / Europe	application / Netherlands	experience
Biomanipulation methods: <ul style="list-style-type: none"> - reduction of cyprinids - stocking piscivores 	Many cases throughout Europe	Many cases e.g. Wolderwijd, Terra Nova, managed fisheries	Better understanding of conditions for successful application; local conditions for lake structure and functioning are essential
Reduction of nutrient fluxes sediment - water: <ul style="list-style-type: none"> - injection of chemicals / fluffing - sediment ploughing - temporary drainage - benthic barriers 	Finland; Norfolk Broads		Locally successful; problem is sustainability
Reduction of nutrients in lake inflow: <ul style="list-style-type: none"> - precipitation with iron (aluminium-chloride or gypsum) - marsh filter at inflow 	P-precipitation: Finland	Botshol, Naardermeer	Efficiency of nutrient reduction; treatment of residues
Integrating wetland creation and floodwater retention	Schelde, Ouse Washes.	Aalkeetbuitenpolder, Blokslootpolder	Risk of import of pollution; internal biogeochemistry under inundation stress
Tidal de-embankment	Hahnöfersand, Schelde	Mariapolder (Biesbosch)	Risk of import of pollution; morphological adjustment and succession of ecosystem
Reversal of agricultural land into (mosaic) reedmarsh	Danube Delta, Severn In the Netherlands: Brabantse Biesbosch	Various projects	Hypertrophic conditions; vegetation succession
Dyke relocation	Lenzener Elbtalaue	Dombosch and several RvR projects	Long preparatory planning; modeling of future landscape
Removal of fine sediment <ul style="list-style-type: none"> - dredging - mudpumping - mudflushing 	Norfolk Broads;	Sanitation of sediments in the Biesbosch; dredging of various fen areas (e.g. Naardermeer).	Recovery of aquatic communities; dispersal of suspended material
Water-level manipulation <ul style="list-style-type: none"> - natural water-level fluctuations - rewetting - temporary/seasonal inundations - temporary drawdown 	Hornborgasjön, Taakern; rewetting projects in Germany; lake drawdown projects in Finland	Rewetting projects (e.g. randzone Naardermeer)	Effects of water-level manipulation on target organisms and water quality; responses to rewetting in desiccated areas; drawdown effects on sediment characteristics
Buffer strips along rivers	Skjern River, Dijle, Rur;	In the Netherlands along many streams	Efficiency of nutrient entrapment; effects of upscaling
Side channels	Donau-Auen	Nevengeulen Waal and IJssel	Impacts of side channels on nutrients and suspended matter; morphol development
Morphological naturalisation of river channel: <ul style="list-style-type: none"> - remeandering - infilling of incised river channel - channel widening and reprofiling - allowing channel and bank erosion 	Skjern River, R. Cole, R. Brede, R. Slampe, R. Lippe, Stöbbertal	Remeandering projects Grote Beerze and other small rivers	Establishing boundary conditions for dynamic processes; effects of dynamic morphology on ecosystem state.

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WEB RESOURCES

Austria

- Donauauen und Donaumoos: <http://www.neuburg-schrobenhausen.de/index.php?id=1590,109>
- Donau-March Auen: <http://www.nationalpark.or.at/article/archive/7147>
- Danube floodplain: <http://www.donauauen-projekte.at/>
- Danube River: Wachau: <http://www.life-wachau.at/>
- March-Thaya Auen: <http://bgm.distelverein.at/>; <http://www.march-thaya-auen.at/>
- Mur River: <http://www.murerleben.at/life.php>
- Neusiedlersee-Seewinkel: <http://www.nationalpark-neusiedlersee.org/>

Belgium

- Dijle: http://www.inbo.be/content/page.asp?pid=GEB_RIV_dijle
- Blankaart en IJzerbroeken - De Blankaart: <http://www.mina.be/>
- Meuse River: dry grasslands: <http://users.skynet.be/life.hautemeuse/>
- Grensmaas: www.maaswerken.nl
- Zeeschelde: <http://www.inbo.be/>

Bulgaria

- Belene Island:
- Kaikusha Marshes: http://www.icwrp.org/files/ramsar_sites_small-scale.pdf
- Danube River: Ibisha Island:
<http://chm.moew.government.bg/nnp/files/List%20of%20Wetlands%20of%20International%20Importance%20in%20Bulgaria.doc>
- Kalimok Marshes: <http://www.eeconet.org/eaf/bulgaria/index.html>
- Srebarna: http://www.ramsar.org/wurc/wurc_mgtplan_bulgaria1a.htm

Croatia

- Kopacki Rit: <http://www.kopacki-rit.com/>
- Lonjsko Polje: http://www.pp-lonjsko-polje.hr/Lonjsko_polje_english/Menu_english.asp
- Sava Wetlands: <http://www.eeconet.org/eaf/croatia/index.html>

Czech Republic

- Morava River: Litovelske Pomoravi: http://www.ramsar.org/wn/w.n.czech_mr.htm

Denmark

- Lake Fure: <http://www.furesoeprojekt.dk/>
- Lake Stubbe: <http://webd.savonia-amk.fi/projekt/markkinointi/lakepromo/users/material/Lake%20Restoration%20And%20Management/Info%20package%20Denmark.pdf>

Estonia

- Emajoe Suursoo Mire: http://www.ctc.ee/pub/Natura_2000_English5.pdf
- Matsalu Bay: <http://www.eeconet.org/eaf/estonia/index.html>
- Matsalu Riverdelta: <http://www.matsalu.ee/?id=739>

Finland

- Lakes in Finland: <http://www.ymparisto.fi/default.asp?contentid=241915&lan=en>

France

- Ain River: lower Ain: http://www.bassevalleedelain.com/life/en/informer_public.php
- Allier: <http://www.riviere-allier.com/>
- Baie de Somme: http://www.baiedesomme.org/html/fr/approche-carto/index_milieux.htm
- Grande Briere: <http://www.parc-naturel-briere.fr/>
- Grand'Mare lake: http://www.ramsar.org/mtg/mtg_france_seine2006.htm
- Loire estuarienne: <http://www.rivernet.org/loire/plgn.htm#La%20nature>; http://www.plan-loire.fr/upload/documentconcertation/fichiers/Developpement_specifique_estuaire_280906.pdf
- Loire: Allier Valley between Jozes and Maringues:
http://www.rivernet.org/loire/lifeloire/wholn_e.htm
- Loire: Allier Valley between Varennes and Moulins:
http://www.rivernet.org/loire/lifeloire/wholn_e.htm
- Loire: Bec d'Allier: http://www.rivernet.org/loire/lifeloire/wholn_e.htm
- Loire: Ecozone of the Forez: http://www.rivernet.org/loire/lifeloire/wholn_e.htm
- Loire: Loire riverbed upstream from Decize:
http://www.rivernet.org/loire/lifeloire/wholn_e.htm

- Loire: Loire's islands between La Charite and Sancerre: http://www.rivernet.org/loire/lifeloire/wholn_e.htm
- Loire: Middle Loire: <http://www.rivernet.org/loire/plgn.htm#La%20nature>
- Loire: Upper Allier Basin: http://www.rivernet.org/loire/lifeloire/wholn_e.htm
- Poitevin marshes: http://www.parc-marais-poitevin.fr/approfondir/les_dossiers/index.phtml?id_dossier=7
- Rhone: <http://www.iucn.org/themes/wani/flow/cases/France.pdf>
- River Rhine: Haguenau: <http://www.onf.fr/reg/alsace/index.htm>

Germany

- Anklamer Stadtbruch: http://www.uni-greifswald.de/SER2006/excursion_anklam.html
- Danube River: Swabian Danube valley
- Eider Valley: <http://www.weidelandschaft-eidertal.de/englisch/index.htm>
- Elbe - Sudeniederung
- Elbe River: freshwater estuary: <http://borghorster-elbwiesen.hamburg.de/>
- Elbe River: Klieken Aue: http://www.elbebiber.de/contentido_468/cms/eu_life_projekt_renaturierung_46.html
- Elbe River: Lenzener Elbaue: <http://www.duh.de/1081.html>
- Ems River: <http://www.emsland.de/life/index.html>
- Galenbecker Lake: http://www.uni-greifswald.de/SER2006/excursion_galenbecker.html
- Lippe River: <http://www.hamm.de/lifelippeaue.html>
- Peene Valley: <http://laoek.botanik.uni-greifswald.de/literatur/arbeiten.htm>
- Polder Randow-Rustow: http://www.uni-greifswald.de/SER2006/excursion_peene.html
- Recknitz Valley: http://www.mv-regierung.de/staeun/stralsund_n/pages/abt2_eu_life_recknitz.htm
- Renaturierung Feuchtgebiete Brandenburg: http://www.mluv.brandenburg.de/cms/media.php/2320/luab_d50.pdf
- Beekerwerth: <http://www.lebendiger-rhein.de/sub-10-79.shtml>
- Bislich-Vahnum: <http://www.lebendiger-rhein.de/sub-10-46.shtml>
- Budenheim: <http://www.lebendiger-rhein.de/sub-8-89.shtml>
- Emmerich: <http://www.lebendiger-rhein.de/sub-10-83.shtml>
- Fulder-Ilmenaue: <http://www.lebendiger-rhein.de/sub-8-86.shtml>
- Heidenfahrt: <http://www.lebendiger-rhein.de/sub-8-88.shtml>
- Ingelheim-Nord: <http://www.lebendiger-rhein.de/5-8.shtml>
- Murgmündung: <http://www.lebendiger-rhein.de/sub-7-94.shtml>
- Ballauf-Wilhemsworth: <http://www.lebendiger-rhein.de/sub-7-73.shtml>
- north of Bingen: <http://www.lebendiger-rhein.de/sub-9-92.shtml>
- Ölgangsinsel: <http://www.lebendiger-rhein.de/5-10.shtml>
- Plittersdorfer Rauhehle bei Rastatt: <http://www.lebendiger-rhein.de/sub-7-82.shtml>
- Reissinsel/Silberpappel: <http://www.lebendiger-rhein.de/sub-7-74.shtml>
- Rheinhausen: <http://www.lebendiger-rhein.de/sub-10-45.shtml>
- Thurchens / Auf der Schottel: <http://www.lebendiger-rhein.de/sub-9-91.shtml>
- Rhine floodplain Karlsruhe: <http://www.lebendiger-rheinauen.de/index.php?id=30>
- Rhine valley: <http://www.rhinvariant.com/>
- Spree von Cottbus bis Berlin: <http://www.bioblatt.de/hintergrund/161204renaturierung.shtml>
- Unteren Havel: http://www.nabu.de/m01/m01_14/
- Weser – Heinsen: http://www.nabu-holzminden.de/4_0/4_3.htm
- Weser - Hellegrabenmündung/Monchewerder: http://www.nabu-holzminden.de/4_0/4_3.htm
- Wollmatinger Ried: <http://www.nabu-wollmatingerried.de/index.html>

Hungary

- Middle Part of Kisköre Reservoir (Poroszló-basin)
- Northern Part of Kisköre Reservoir (Tiszafüred Bird Reserve)
- River Drava: <http://www.econet.org/eaf/drava/index.html>
- Tisza River: <http://www.aquamedia.at/templates/index.cfm/id/6442>
- Tisza: Bodrogzug: http://www.ramsar.org/wn/w.n.tisza_transboundary.htm
- Tisza: Felso-Tisza (Upper Tisza): http://www.ramsar.org/wn/w.n.tisza_transboundary.htm

Latvia

- Lake Engure: http://www.ldf.lv/pub/?doc_id=27945

- Lake Kanieris: <http://www.kemeri.gov.lv/life/Dokumenti/projektsENG.htm>,
<http://www.eeconet.org/eaf/kanieris/index.html>
- Lake Pape: <http://databases.eucc-d.de/plugins/projectsdb/>
- Pape Wetland Complex:
http://www.panda.org/about_wwf/where_we_work/europe/where/latvia/lake_pape/area/lake_pape/index.cfm
- Slampe River: <http://www.kemeri.gov.lv/life/Jaunumi/indexENG.htm>

Lithuania

- Rusne Island, Nemunas Delta: <http://www.eeconet.org/eaf/nemunus/index.html>

Moldavia

- Dnester Delta: <http://www.eeconet.org/eaf/moldova/index.html>
- Prut River - lower Prut lakes: <http://www.iucn-ce.org/econets/database/?id=6>

Poland

- Druzno Lake: http://www.ramsar.org/wn/w.n.poland_five.htm
- Karsiborska Kepa: <http://www.eeconet.org/eaf/poland/index.html>
- Modla Lake: <http://www.eeconet.org/eaf/poland/index.html>
- Narew River: <http://www.npn.pl/index.php?lang=en>
- Oder Delta: <http://www.eeconet.org/eaf/oder/index.html>
- Swidwie: http://nature.poland.pl/regions/pobrzeza_pd/jezioro_swidwie/description.htm
- Wigry: <http://www.wigry.win.pl>

Romania

- Danube Delta: <http://rcrr.mobius.ro>
- Prut River: Costuleni Wetland Project:
<http://rcrr.mobius.ro/ViewTopic.asp?Topic=1017&lang=EN>
- Strachina Lake: <http://www.eeconet.org/eaf/romania/index.html>
- Vadu and Chituc Wetlands: <http://www.eeconet.org/eaf/romania/index.html>

Russia

- Pskovsko-Chudskaya Lowland: <http://www.worldlakes.org/lakedetails.asp?lakeid=8767>
- River Iput: <http://www.eeconet.org/eaf/iput/index.html>
- Volga Delta: <http://www.eeconet.org/eaf/russia/index.html>

Slowakia

- Danube River: Danube floodplains (Dunajske luhy): <http://www.soprs.sk>
- Tisa River : http://www.ramsar.org/wn/w.n.tisza_transboundary.htm

Slovenia

- Mura River : <http://www.biomura.si>

Sweden

- Hornborgasjön: <http://www.hornborga.com/>
- Klingavalsan-Krankesjön: <http://www.limnol.lu.se/kranke/page/background.asp>
- Piteälven: http://www.emg.umu.se/research/river/publikationer/Master_Johanna%20Engstr%C3%B6m.pdf
- Taakern: <http://www.takern.se/>

Turkey

- Lake Uluabat: http://www.toprak.org.tr/isd/can_49.htm

United Kingdom

- Avon River: <https://www.english-nature.org.uk/lifeinukrivers/strategies/Avon/avon.html>
- Great Fen: <http://www.greatfen.org.uk/>
- Norfolk Broads: www.broads-authority.gov.uk
- Pevensey Levels: <http://webd.savonia-amk.fi/projektit/markkinointi/lakepromo>
- Severn: <http://www.severnwetlands.org.uk>
- Tadham Moor and Otmoor: http://www2.defra.gov.uk/research/Project_Data

Ukraine

- Dnestr Delta: <http://www.eeconet.org/eaf/dnester/index.html>
- Izmail Islands: http://www.icwrp.org/files/ramsar_sites_small-scale.pdf
- Katlabuh Liman: http://www.panda.org/about_wwf/where_we_work/europe/news/
- Kugurlui Lake: <http://www.nefisco.org/Ukraine.htm>
- Polesia Wetlands: <http://www.eeconet.org/eaf/polesia/index.html>

A Verslag workshop KRW Internationale Wetlands

Datum: 1 november 2007

Plaats: Den Haag

Opgemaakt door: Gerben van Geest.

Aanwezigen: Monique Berendsen (DGW), Marcel van den Berg, Tom Buijse, Maarten Platteeuw, Rob Portielje, Theo Vulink (RWS Waterdienst), Henk van Bommel (RWS Zuid-Holland), Hugo Coops, Gerben van Geest (WL).

Hugo Coops presenteert de voorlopige conclusies van het project KRW-International Wetlands.

Maarten Platteeuw geeft een overzicht van het project dat als doel heeft inzicht krijgen in essentiële processen en patronen voor waardevolle wetlands.

Deze processen zijn beschreven vanuit landschapsecologisch perspectief (in tegenstelling tot KRW en Natura 2000). In de aansluitende discussie wordt nader ingegaan op de vraag in hoeverre de hydromorfologische ingrepen die in Nederland zijn uitgevoerd, een belemmering vormen voor het natuurlijk functioneren van watersystemen. Met andere woorden: kunnen de patronen en soorten van wetlands duurzaam in stand worden gehouden, zonder dat deze ingrepen (deels) teniet worden gedaan?

Tom Buijse draagt de Kissimee River in Florida aan als voorbeeldproject waar de herstelverwachting goed is gekwantificeerd en onderbouwd. Deze studie zal als intermezzo in de rapportage worden meegenomen.

Discussie over de rapportage

Nagegaan wordt of van de volgende punten meer informatie kan worden verkregen:

- Maatregelen buiten waterlichamen die effect hebben op de kwaliteit van het waterlichaam.
- Ruimtelijke samenhang tussen kleinere projecten.
- Mix van methodes en uitvoeringsaspecten.
- Aandacht voor succes- en faalfactoren.
- Effect van maatregelen op de maatlatscore.
- Aangeven welke relevantie de maatregelen hebben voor de Nederlandse situatie;
- Communicatie/proces (wordt zijdelings meegenomen in rapportage).
- Presentatie van resultaten op platform ecologisch herstel meren en bij de Waterdienst. Verspreiden rapportage zowel binnen KRW als Natura 2000 circuit.
- Case studies Zeeschelde, Donau en Skjern akkoord in huidige vorm.

Bij Finland vooral aandacht voor innovatieve technieken, die momenteel nog niet/weinig in Nederland worden toegepast. Aanvullend kort aandacht voor het proces.

Broads: over herstelmaatregelen in 'the Broads' is al relatief veel bekend in Nederland; In dit gebied nadruk op combinatie van maatregelen, en de relatie tot de doelstellingen van de KRW.